POLICY SUCCESS FACTORS FOR GEOTHERMAL ELECTRICITY DEVELOPMENT IN THE APEC REGION

An Assessment of Public Policies on Geothermal Electricity in Six APEC Economies

ASIA PACIFIC ENERGY RESEARCH CENTRE

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Asia Pacific Energy Research Centre (APERC)
Institute of Energy Economics, Japan
Inui Building, Kachidoki 11F, 1-13-1 Kachidoki
Chuo-ku, Tokyo 104-0054, Japan
Tel: (813) 5144-8551
Fax: (813) 5144-8555
Email: master@aperc.ieej.or.jp (administration)
Website: http://aperc.ieej.or.jp/

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FOREWORD

At the 22nd Asia-Pacific Economic Cooperation (APEC) Economic Leaders' Meeting in Beijing, China on 10–11 November 2014, the APEC Economic Leaders agreed to reinforce the trend toward low-carbon and clean energy production and consumption; develop renewable energy; and double the share of renewables in the APEC energy mix, including power generation, from 2010 levels by the year 2030 (the Beijing Declaration).

This commitment is significant, in view of the APEC region's continued high dependence on fossil fuel, and the recognition that CO_2 emissions increase with increased use of fossil fuels, potentially leading to massive environmental deterioration if the use of fossil fuels is not minimised. Moreover, the increased volatility of oil prices due to geopolitical events has resulted in the instability of energy security for some APEC member economies, making renewable energy more important to consider.

One form of renewable energy available to the APEC economies for development is geothermal energy, as the region is well-situated geographically to have abundant potential reserves of geothermal energy, estimated at more than 16 000 GW. However, APEC's total current installed capacity of geothermal electricity is only approximately 9 GW, and only 11 of APEC's 21 economies have developed geothermal electricity. APEC member economies have the opportunity before them to develop their untapped potential reserves of geothermal energy for electricity in the near future, to help address the region's energy challenges.

This report examines policy success factors for geothermal electricity development based on the experiences of six APEC member economies: the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan. The experience of these economies includes potentially valuable lessons that could benefit other APEC economies that want to accelerate their plans for geothermal electricity production, or to start developing geothermal electricity for the first time.

Takato OJIMI
President, APERC

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AUTHORS:

Mr Chrisnawan Anditya, Dr Ralph Samuelson, Ms Elvira Torres Gelindon and Dr Yeong-Chuan Lin.

EDITED BY:

Cactus Communications K.K, Ms Elvira Torres Gelindon and Ms Naomi Wynn

COVER DESIGN BY:

Mr Takashi Otsuki and Dr Dmitry Sokolov

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APEC	Asia-Pacific Economic Cooperation
CH_4	Methane
CO_2	Carbon dioxide
EGS	Enhanced Geothermal System
EIA	Environmental Impact Assessment
FIT	Feed-in Tariff
GW	Gigawatt
GWe	Gigawatts of electricity
HAS	Hot Sedimentary Aquifers
HDR	Hot Dry Rock
H_2	Hydrogen
H_2S	Hydrogen sulphide
IPP	Independent Power Producer
kWh	Kilowatt hour
LCOE	Levelised Cost of Electricity
MW	Megawatt
MWe	Megawatts of electricity
MWh	Megawatt-hour
NH_3	Ammonia
N_2	Nitrogen
ORC	Organic Rankine Cycle
$PM_{2.5}$	Particulate matter 2.5
PM_{10}	Particulate matter 10
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
RPS	Renewable Portfolio Standard
SOE	State-owned Enterprise
TWh	Terrawatt-hour

Executive Summary

At the same time as energy demand is steadily on the rise in the Asia-Pacific Economic Cooperation (APEC) region, its member economies are facing increasing challenges with regard to energy security, the impact of energy on the economy and environmental sustainability. In this context, APEC energy development must address several significant issues:

- Dependence on fossil fuel remains high, as it is forecast that approximately 82% of APEC energy demand will continue to be supplied by fossil fuels in 2035;
- Environmental deterioration is projected to be massive, due to increased CO_2 emissions, which are projected to rise by approximately 32% between 2010 and 2035 as a result of the increased reliance on fossil fuels; and
- The increased volatility of oil pricing due to geopolitical events has resulted in instability in energy security and economic burdens for some APEC member economies.

To address these challenges, the APEC economic leaders have committed to encouraging each member economy to promote, develop and deploy low-emission energy supplies, including clean and renewable energy. Under the 2014 'Beijing Declaration', they agreed to double the share of renewable energy in the APEC energy mix, including power generation, from the 2010 levels by 2030. One form of renewable energy available in the region is geothermal energy, a low-carbon energy resource that can be used to fulfil the significant and growing energy demand, particularly electricity demand, in APEC economies in the future.

With the advantage of a favourable geographic location and features, the APEC region has abundant potential for geothermal energy. The APEC region aligns almost perfectly with the 'Pacific Ring of Fire', where much of the world's geothermal energy potential is concentrated. It is estimated that APEC's geothermal potential is more than 16 000 GW. Moreover, geothermal electricity has potential benefits over other energy forms, such as:

- Energy security: There would be no need to import energy from outside the region;
- Small land footprint: It requires very little land use—7.5 km^2/TWh per year—compared to other energy sources;
- Employment and economic development: It creates more jobs per megawatt (MW) than natural gas (27 050 person-years for every 500 MW capacity of geothermal power plant);
- Near-zero emissions: It boasts extremely low emission rates (between 0–396.3 lbs/MWh for CO_2), depending on the type of geothermal power plant technology), especially when compared with traditional fossil fuels that involve direct combustion of the primary resource;
- Reliable and flexible power sources: It can produce electricity 24 hours a day, seven days a week, regardless of weather conditions, and, in addition to providing base load power, it has the ability to operate in a flexible mode that can quickly adapt to variability in the power system.

Currently, of the 21 APEC economy members, only 11—Australia; China; Indonesia; Japan; Mexico; New Zealand; Papua New Guinea; the Philippines; Russia; Thailand; and the United States—have experience in developing and using geothermal energy for power generation. These economies have a total installed capacity of geothermal electricity of 9354 MW as of 2014, having increased at an average rate of 2.1% per year since 2004. With this total installed capacity, the APEC region has contributed nearly 74% of the world's geothermal installed capacity, which was approximately 12 594 MW in 2014. However, given the APEC region's geothermal potential, its current total installed capacity for geothermal electricity is relatively low. APEC member economies have the opportunity to take steps to develop more geothermal electricity in the near future, to address the region's energy supply security challenges.

The nature of geothermal resources, however, presents certain issues that make the development of geothermal electricity economically challenging, often presenting barriers that can hinder its development. Consequently, in some economies, the development of geothermal electricity has been slow or stagnant, and in some, has not been undertaken at all.

Some of the particularly challenging characteristics of geothermal resources are:

- The resource is stored in the earth.
    - Exploration and drilling are required, and a single well may cost between USD 3 million and USD 8 million. Typically two, or more often three, deep wells are drilled to demonstrate the feasibility of commercial production and injection of geothermal resources;
    - The legal definition of geothermal resources varies among economies, jurisdictions and agencies, creating complications with regard to the ownership of the resource, especially for those economies that categorise geothermal resources as 'sui generis'. The sui generis categorisation clouds the ownership question, as in some cases it leaves little guidance for the resolution of disputes between surface and subsurface owners; and
    - It is necessary to consider the environmental impact assessment, as it can be time consuming.
- The resource is often located in remote, difficult-to-access areas, such as in the mountains.
    - The necessary infrastructure, such as site access and base camps, must be developed; and
    - Connection to a transmission network can be an issue, especially if the companies that develop the geothermal power plant are different from the company that operates the transmission network.
- In some areas, development of the resource may conflict with other land uses.
    - Development may be limited or prohibited in protected areas;
    - It may face resistance from existing or other possible resource uses; and
    - It may require several regulatory permissions from various agencies, involving a time-consuming permitting process.

Because of these and other characteristics of geothermal resources and the risk factors that are introduced as a result, the development of geothermal power plants is very challenging for investors or developers, compared to the development of other power plants.

Another factor that can influence the development of this particular form of renewable energy is the business model of geothermal electricity development used to manage the risks associated with initial exploration and drilling. For instance, if a private developer becomes the resource developer or steam-field operator, she or he may be able to accept the risk of drilling, but the total cost of resource development, including the risk, must later be reflected in the overall power price. If a private developer becomes only the power plant developer, she or he may find it easier to raise commercial financing. The geothermal electricity business model varies from economy to economy, depending on the government's public policy.

Based on the current assessment of six APEC economies—the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan—some specific factors have led to their success in the development of geothermal electricity, in comparison with other APEC economies. These factors are summarised in Table 1.

Table 1: Geothermal electricity development, assessment of policy success factors

Factors	The United States	The Philippines	Indonesia	New Zealand	Mexico	Japan
Policy Infratsructure						
- Legal Basis	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
- The Government Strategy	Green	Yellow	Yellow	Yellow	Yellow	Green
- The Government Commitment to Investors	Green	Yellow	Yellow	Yellow	Yellow	Yellow
- Institutions	Green	Green	Yellow	Green	Yellow	Yellow
Resources Access						
- Access to Geothermal Resources	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
- Secure and Exclusive Rights to Resources	Green	Green	Green	Yellow	Yellow	Yellow
Environmental and Other Development Permitting						
- Permitting Time Limits	Red	Red	Red	Green	Red	Red
- One-Stop Permitting	Red	Red	Red	Green	Red	Red
- Inter-Agency Cooperation	Yellow	Yellow	Yellow	Green	Yellow	Yellow
Government Support for the Geothermal Industry						
- Database	Green	Green	Red	Green	Yellow	Green
- Research and Development (R&D)	Green	Green	Red	Green	Green	Green
- Human Resources Development (HRD)	Green	Yellow	Red	Green	Yellow	Yellow
- Financial Incentives	Green	Yellow	Yellow	Red	Yellow	Green
Access to the Electricity Market						
- Transmission Network	Green	Green	Yellow	Green	Yellow	Yellow
- Electricity Sales Contracting	Green	Green	Yellow	Green	Yellow	Green

Green: indicates that the economy's public policy on geothermal electricity meets the overall expectations of developers (scale 5)

Yellow: indicates that the economy's public policy on geothermal electricity meets the expectations of developers in some respects (scale 4)

Red: indicates that the economy's public policy on geothermal electricity does not meet the expectations of developers at the moment, there is room for improvement (scale 0-3)

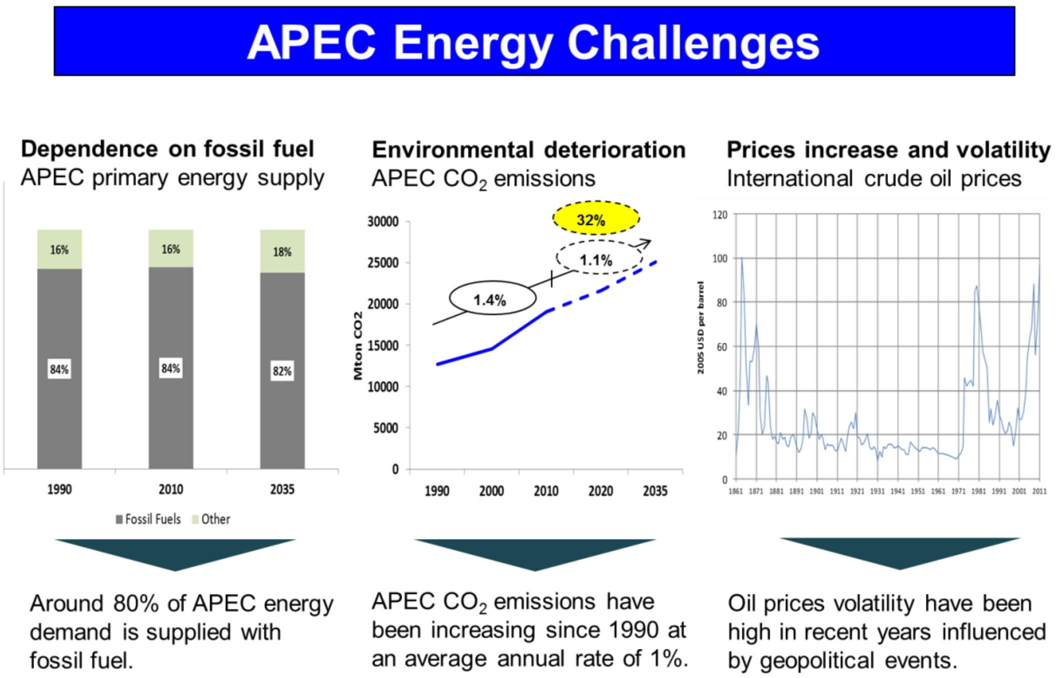
INTRODUCTION

At the same time as the demand for energy is steadily on the rise in the Asia-Pacific Economic Cooperation (APEC) region, its member economies are facing increasing challenges with regard to energy security, the impact of energy on the economy and environmental sustainability. Based on the APEC Energy Demand and Supply Outlook ('the APEC Outlook'), 5th Edition, 2010–2035 (APERC, 2013b, p. 6, p. 18, p. 27), approximately 84% of APEC energy demand was supplied by fossil fuels in 2010, much as it was in 1990. With these levels of fossil fuel consumption, the CO_2 emissions of APEC economies have increased at an average annual rate of 1.4% since 1990, and are expected to increase at an average annual rate of 1.1% as we approach the year 2035 (APERC, 2013b).

Regarding energy development, APEC has faced several challenges, as follows:

- Although already decreased from 2010 levels, dependence on fossil fuel remains high, with approximately 82% of APEC energy demand forecast to be supplied by fossil fuels in 2035 (Ibid, p. 18).
- Environmental deterioration is projected to be massive, due to increased CO_2 emissions as a result of increased reliance on fossil fuels. Based on the APEC Outlook, the region's CO_2 emissions from fuel combustion are projected to rise by approximately 32% between 2010 and 2035 (Ibid, p. 6).
- The increased volatility of oil prices, which is largely attributable to geopolitical events, has resulted in instability in energy security and an economic burden for some APEC member economies (Ibid, p. 27).

Figure 1. APEC energy challenges



Finding and implementing win-win solutions for these challenges are sometimes very difficult, especially if changing energy use might destabilise the economic situation. However, APEC members should take note that there are alternative energy options to address these challenges.

One of these options is geothermal energy, a renewable, low-carbon energy source that can satisfy the steadily increasing energy demand (particularly the electricity demand) in APEC economies in the future. The APEC region has the advantage of being almost aligned with the 'Pacific Ring of Fire', which is where most of the geothermal energy resource potential is concentrated. Currently, of the 21 APEC economy members, only 11—Australia; China; Indonesia; Japan; Mexico; New Zealand; Papua New Guinea; the Philippines; Russia; Thailand; and the United States, —have experience in developing and using geothermal energy for power generation. While not all of these 11 economies have developed their geothermal resource potential to a great extent, some, such as Australia; Indonesia; New Zealand; Papua New Guinea; the Philippines; Russia; and the United States, have shown progress in developing geothermal electricity over the last 10 years. Moreover, Indonesia; Japan; Mexico; New Zealand; the Philippines; and the United States each have plans in place to increase their existing installed capacity for geothermal energy production by another 100 or even 1000 MW. Fully recognising the potential benefits of geothermal electricity, other APEC economies, including Chile; Chinese Taipei; and Peru are considering developing their first geothermal power plants.

The potential benefits of developing geothermal energy include:

- Energy security;
- Small land footprint;
- Employment and economic development;
- Near zero emissions; and
- Reliable and flexible power sources.

However, because of the nature of geothermal resources, the development of geothermal electricity can be very challenging, often presenting barriers that hinder its development. As a result, harnessing the geothermal resource for power can be slow or stagnant, or seemingly impossible in some economies.

Characteristics of geothermal resources that are potential barriers to development include:

- The resource is stored in the earth.
    - Exploration and drilling are required, and a single well may cost between USD 3 million and USD 8 million. Typically two, or sometimes three, deep wells are drilled to demonstrate the feasibility of commercial production and injection for geothermal resources;
    - The legal definition of geothermal resources varies, creating complications with regard to the ownership of the resources, especially for those economies that categorise geothermal resources as 'sui generis'. This sui generis categorisation clouds ownership in some cases, as it leaves little guidance for the resolution of disputes between surface and subsurface owners; and
    - The environmental impact assessment process must be considered, as it can be time consuming.
- The resource is often located in a remote, difficult-to-access area, such as in the mountains.
    - The necessary infrastructure, such as site access and base camp, must be developed; and

- Connection to transmission networks can be an issue, especially if those companies that develop geothermal power plants are different from the company that operates the transmission network.

- In some areas, the development of the resource may conflict with other land uses.
  - Development may be limited or prohibited in protected areas;
  - It may face resistance from existing or other possible resource uses; and
  - It may require several regulatory permissions from various agencies, with time-consuming permitting processes.

To address the issues related to the nature of geothermal resources, government intervention through the development of public policies is necessary. Such policies should aim to not only minimise or reduce the barriers that can hinder the development of geothermal electricity, but also create a good investment environment for private participation, while said policies also protect the environment and the needs of other land users.

Without a doubt, good public policies to accelerate plans to encourage the development of geothermal electricity have been established and implemented by some APEC geothermal economies. These policies may serve as positive examples or provide lessons learned for other APEC economies that want to accelerate their own plans for geothermal electricity or to begin developing geothermal electricity for the first time. The present research project, 'Policy Success Factors for Geothermal Electricity Development in the APEC Region' was undertaken by the Asia Pacific Energy Research Centre (APERC) to identify and assess such policies for this reason.

The main objectives of this project are:

- To assess current geothermal electricity development processes in the APEC region;
- To identify policy success factors in these geothermal electricity development processes;
- To evaluate how each APEC economy rates against the policy success factors by providing a summary matrix; and
- To propose a set of recommendations for geothermal electricity development in each APEC economy and in the APEC region as a whole.

This project focuses on six APEC economies—the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan—that have developed 100 to 1000 MW of geothermal electricity over many years, and whose experiences may serve as positive examples for assessing policy success factors that led to this achievement. In addition, the current project examines Chinese Taipei, which has a plan in place to re-start their geothermal electricity program, after many years of closure, as explained later.

Five key factors representing the expectations of geothermal developers in conducting geothermal business activity are analysed for these seven APEC economies, in order to assess the current geothermal electricity development process and determine success factors and/or barriers.

Finally, to accelerate the process of geothermal electricity development in each APEC economy and in the APEC region, policy recommendations are provided, which can be implemented not only by the governments in six of the APEC economies on a voluntary basis but will also be useful for other APEC economies.

The current research project is also intended to contribute to APEC priorities in the areas of energy security, sustainable development of energy and promoting low-emission energy supply. Thus, the project is aligned with current APEC and Energy Working Group (EWG) priorities, namely:

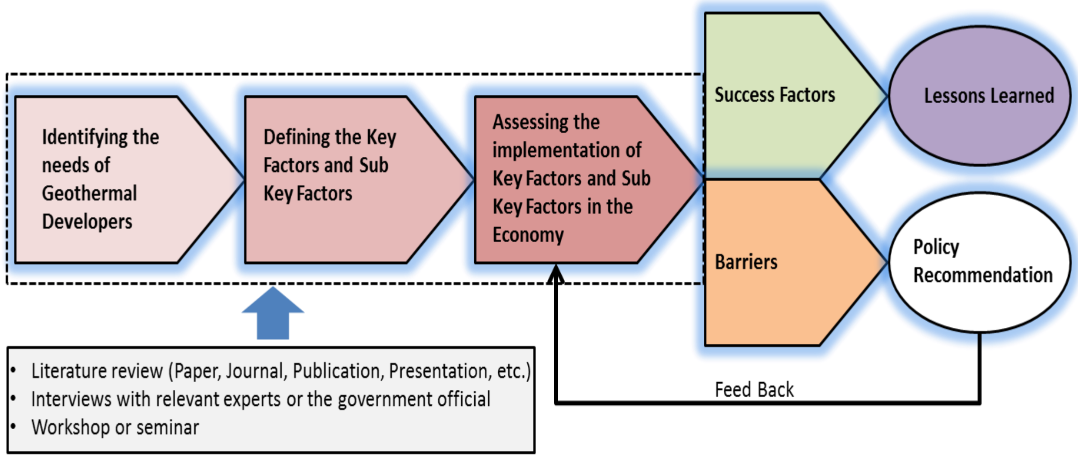
- The 2010 APEC Growth Strategy (the Yokohama Declaration) defines sustainability as one of the five growth attributes. This growth strategy includes enhancing energy security and promotion of energy-efficiency and low-carbon policies, as well as developing a low-carbon energy sector by introducing low-emission power sources and assessing the potential of renewable energy options to reduce carbon emissions as an important action within the sustainable growth agenda (APEC, 2014a).
- The 2010 Fukui Declaration of the APEC Energy Ministers also recognized that the use of low-emission power sources should be promoted, since a cleaner energy supply also boosts both sustainable development and energy security. This declaration further acknowledged that the development of renewable energy technologies should be continued to further reduce their costs. At this meeting, the APEC Energy Ministers also instructed the EWG to continue its assessment of renewable energy options for reducing carbon emissions, promoting investment and creating new jobs (APEC, 2014b).
- The 2011 APEC Economic Leaders' Declaration (the Honolulu Declaration) called on economies to speed up the transition toward a global low-carbon economy in a way that enhances energy security and supports APEC's aspiration to reduce aggregate energy intensity by 45% by 2035 (APEC, 2014c).
- The 2012 APEC Economic Leaders' Declaration (the Vladivostok Declaration) also recognized the need to promote technology development and deployment of a low-emission energy supply, including carbon capture, storage and use, and renewable energy sources (APEC, 2014d).
- The 2013 APEC Economic Leaders' Declaration (the Bali Declaration) recognized the need to invigorate work to develop clean and renewable energy through public-private partnerships, as a promising approach to ensure sustainable investment and development of new technology, and to promote energy security and efficiency and the lowering of greenhouse gas emissions (APEC, 2014e).
- The 2014 APEC Economic Leaders' Declaration (the Beijing Declaration) recognized the need to reinforce trends toward low-carbon and clean energy production and consumption; develop renewable energy; and doubling the share of renewables in the APEC energy mix, including power generation, from 2010 levels by 2030 (APEC, 2014f).

METHODOLOGY

To assess current geothermal development processes in the seven APEC economies listed above and identify whether the public policies already established by those governments meet the expectations of geothermal developers as important actors in this business, this study approached the topic from the perspective of a geothermal developer who wants to invest in geothermal electricity in a specific economy. As such, assurances are necessary that investment will be secure and will offer the expectation of a reasonable financial return, since the nature of geothermal resources poses significant challenges to the development of geothermal electricity. It becomes critical to be familiar with current public policies established by the government, and to analyse certain specific factors.

Hence, the methodology of the project is as follows:

Figure 2. Project methodology



The research for this project consists of:

- **Literature review**

  Relevant information on geothermal electricity, based on available papers, journals, publications, presentations and internet news.

- **Interviews with relevant experts or government officials**

  Relevant information on geothermal electricity, based on interviews through teleconferences and/or meetings with experts and government officials, using specific questionnaires.

- **Workshops or seminars**

  Relevant information on geothermal electricity from experts and government officials by conducting and attending geothermal workshops and seminars.

Through these activities, five key factors consisting of 15 sub-key factors were identified as the most critical to the success of geothermal electricity development from the perspective of developers. These factors are as follows:

- **Policy infrastructure**
  - Legal basis;
  - Government strategy;
  - Government commitment to investors; and
  - Institutions.
- **Access to geothermal resources**
  - Access to geothermal resources; and
  - Secure and exclusive rights to those resources.
- **Environmental and other development permitting**
  - Permitting time limits;
  - 'One-stop permitting'; and
  - Inter-agency cooperation.

- **Government support for the geothermal industry**
  - Database;
  - Research and development – R&D;
  - Human resources development – HRD; and
  - Financial incentives.
- **Access to the electricity market**
  - Transmission network; and
  - Electricity sales contracting.

ORGANISATION OF REPORT

The chapter on **Geothermal electricity: The reality versus the current potential** explains the nature of geothermal resources, which often present challenges for the use of geothermal energy; the potential benefits of geothermal electricity; and an overview of geothermal electricity development in the APEC region, including discussion of the potential geothermal resources therein and the current status of their use.

The chapter on **Background on geothermal electricity generation** discusses the process of geothermal electricity development; how geothermal electricity is produced today; a cost comparison between geothermal power plants vs. other plants; future trends and the developing technology of geothermal electricity.

The chapter on **Needs of geothermal developers: Policies for successful geothermal electricity development** explains how the five key factors and 15 sub-key factors can determine the success of geothermal electricity development.

The chapter on **Public policies on geothermal electricity development in the APEC region** assesses geothermal electricity development in the six selected APEC economies— the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan—that have already developed geothermal electricity over several years, with regard to the 15 sub-key factors. Chinese Taipei, which does not yet have commercial geothermal electricity production, will also be analysed.

The chapter on **Assessment of policy success factors for geothermal development** examines the policy successes and remaining barriers to geothermal electricity development in the past 10 years with regard to the 15 sub-key factors. In addition, this chapter explains the matrix used to evaluate how each of the economies (excluding Chinese Taipei) rated against the 15 sub-key factors, as an overall summary.

Finally, the chapter on **Conclusions and recommendations** explains general policies that need to be considered by the APEC economies if they wish to accelerate the development of geothermal electricity or to begin development of geothermal electricity for the first time. This chapter also provides general conclusions regarding geothermal electricity development in each of the six APEC economies. This includes some policy recommendations in response to the identified barriers to developing geothermal electricity.

CHAPTER 1
GEOTHERMAL ELECTRICITY: THE REALITY VERSUS THE CURRENT POTENTIAL

Geothermal energy is thermal energy that is generated and stored in the earth, the main sources of which are the heat flow from the earth's core and mantle (approx. 40%), and that generated by the gradual decay of radioactive isotopes in the earth's continental crust (approx. 60%). Together, these heat sources can produce enormous amounts of energy that can be used for power generation (geothermal electricity) and direct heat use (IEA, 2012, p. 4).

Geothermal energy is readily found in the vicinity of volcanoes, hot springs and other thermal phenomena. This energy form is not new for human use; according to the existing literature and evidence, geothermal energy has been used as a direct heat source for bathing, cooking and heating by the Romans, Japanese, Turks, Icelanders, Central Europeans and the Maori of New Zealand for over 10 000 years (Lund, 2007, p. 1).

The first use of geothermal electricity occurred in Italy, with experimental work by Prince Gionori Conti between 1904 and 1905; the first commercial power plant (250 kWe) was commissioned at Larderello, Italy in 1913. After these experimental achievements in Italy, other countries began to develop geothermal electricity, including at Wairakei, New Zealand in 1958; an experimental plant at Pathe, Mexico in 1959; at The Geysers in the United States in 1960; and with 23 MWe at Matsukawa, Japan in 1966 (Lund, 2007, p. 1).

THE NATURE OF GEOTHERMAL RESOURCES – CHALLENGES FOR THEIR DEVELOPMENT

The nature of geothermal resources presents challenges for their use that need to be understood by developers, for successful development of this energy.

The characteristics of geothermal resources that need to be taken into account include:

- The resource is stored in the earth;
- It is often located in remote, difficult-to-access areas, such as in the mountains; and
- In some areas, its development may conflict with other land uses.

THE RESOURCE IS STORED IN THE EARTH

- **Exploration and drilling is required.**

One of the biggest challenges facing geothermal energy developers is the high level of risk and cost related to the upfront resource determination phase. Because geothermal resources are underground, exploration and drilling are necessary to develop, produce and use this energy form, as with oil and gas development. Geothermal exploration (including geological, geochemical and geophysical surveys) must be conducted to identify and rank prospective geothermal reservoirs prior to drilling, and to provide data for characterizing reservoirs (including information relevant to the properties of the fluids) and enabling estimates of geothermal reservoir performance and lifetime. Exploration of a prospective geothermal reservoir involves estimating its location, lateral extent and depth with geophysical data, and then drilling exploration wells to test its properties in order to minimise risk (Goldstein, et al., 2011, p. 411). These exploration and drilling phases typically last several years, and drilling costs increase exponentially with increased well depth. The total drilling costs might be 35–40% of the total project cost. A single well may cost between USD 3 million and USD 8 million, depending on the geographic location, well depth and diameter, and local geology (Matek, 2014, p. 5, p. 8, p. 13; Lawless, 2015). Unlike oil and gas, which may be immediately produced and sold after discovery and extraction, however, a geothermal resource cannot generate a return on investment until a suitable power plant has been constructed and connected to the electrical grid, presenting a significant challenge before any revenue can be realized. As a result, a significant financial commitment must be made before the characteristics of the resource can be fully known (Matek, 2014, p. 8, p. 13).

A major uncertainty in geothermal electricity project development concerns the volume and quality of the geothermal fluids that can be extracted from the underground resource. This uncertainty affects the design parameters of the power plant downstream. Unlike a fossil fuel plant where burning X amount of coal may produce Y amount of power, with geothermal energy, it is the resource quality and quantity that determine the power plant size, technology and other engineering aspects. Therefore, the accuracy of resource information that is obtained in the exploration and drilling phases can lead to more accurate reservoir models, thus lowering the risk and uncertainty associated with the geothermal power project (Matek, 2014, pp. 10–11).

- **The legal definition of 'geothermal resource' varies, complicating ownership of the resource.**

Economies have different legal definitions of geothermal resources. Geothermal resources may be considered to be: (1) a part of the mineral estate, and handled by mineral legislation; (2) equivalent to water resources, and thus handled by water legislation; or (3) unique in themselves (sui generis), neither a mineral resource nor a water resource, and thus declared to be the private property of the holder of the title to the surface land above the resource. This categorisation is at the core of any legal framework addressing geothermal development and resource management (Haraldsson, 2012, p. 1), as well as key to determining the ownership of geothermal resources, both of which are critical for the developer to understand.

The problems associated with the establishment of ownership are greatly reduced when geothermal resources are categorized as either mineral or water, whereas the sui generis categorisation clouds the ownership question, as in some cases, it leaves little guidance for the resolution of disputes between surface and subsurface owners. Settling such disputes in court can be time consuming and cause serious delays to projects. For example, in the United States, the Geothermal Steam Act of 1970 and the California Geothermal Resources Act did not clearly determine the ownership of geothermal resources, which inhibited the sector until the courts decided that geothermal resources are mineral in nature and belong to the mineral estate. Following these court cases, the federal government in 1977 and the State of California in 1981 enacted provisions clarifying statutorily that geothermal ownership accrues to whoever holds the mineral estate (Haraldsson, 2012, p. 6).

Other problems arise if more than one owner has the rights to a single geothermal field/resource. This is a potential barrier to development, as it may complicate use rights and the issuance of permits.

- **Geothermal energy produces impacts on the environment that need to be mitigated.**

According to the Intergovernmental Panel on Climate Change (IPPC) Special Report on Renewable Energy Sources and Climate Change Mitigation (Goldstein, et al., 2011, pp. 419–420), environmental impact assessments for geothermal development involve the consideration of a range of local land and water use impacts during both the construction and operation phases that are common to most energy projects (for example, noise, vibration, dust, visual impacts, surface and ground water impacts, ecosystems and biodiversity), as well as specific geothermal impacts (for example, effects on outstanding natural features, such as springs, geysers and fumaroles). In addition, geothermal development may have other impacts, such as:

- **Other gas and liquid emissions during operation**

Geothermal systems involve natural phenomena, and typically discharge gases mixed with steam from surface features and minerals dissolved in water from hot springs. Apart from CO_2, geothermal fluids can, depending on the site, contain a variety of other minor gases, such as hydrogen sulphide (H_2S), hydrogen (H_2), methane (CH_4), ammonia (NH_3) and nitrogen (N_2). Mercury, arsenic, radon and boron may also be present in fluids. The amounts of such by-products depend on the geological, hydrological and thermodynamic conditions of the geothermal field, and the type of fluid collection/injection system and power plant used.

Of the minor gases, H_2S is toxic, but rarely of sufficient concentration to be harmful after venting into the atmosphere and dispersal, although it may constitute an odour nuisance. Removal of H_2S released from geothermal power plants is practised in parts of the United States and Italy. Elsewhere, H_2S monitoring is standard practice to provide assurance that concentrations after venting and atmospheric dispersal are not harmful. CH_4, which has warming potential, is present in small concentrations (typically, a minor percentage of the CO_2 concentration).

Most hazardous chemicals in geothermal fluids are in an aqueous phase. If present, boron and arsenic are likely to be harmful to ecosystems if released at the surface. In the past, surface disposal of separated water has occurred at a few fields. Today, this occurs only in exceptional circumstances, and geothermal brine is usually injected back into the reservoir to support reservoir pressures as well as avoid adverse environmental effects. Surface disposal, if significantly in excess of natural hot spring flow rates, and if not strongly diluted, can have adverse effects on the ecology of rivers, lakes or marine environments. By using cemented casings, shallow groundwater aquifers of potable quality are protected from contamination by injected fluids. Impermeable linings provide protection from temporary fluid disposal ponds. Such practices are typically mandated by environmental regulations. Geochemical monitoring is commonly undertaken by field operators to investigate, and if necessary mitigate, such adverse effects.

- **Potential hazards of seismicity and other phenomena**

Local hazards arising from natural phenomena, such as micro-earthquakes, hydrothermal steam eruptions and ground subsidence may be influenced by the operation of a geothermal field. As with other (non-geothermal) deep drilling projects, pressure or temperature changes induced by stimulation, production or injection of fluids can lead to geo-mechanical stress changes, and these can affect the subsequent rate of occurrence of these phenomena. A geological risk assessment may help to avoid or mitigate these hazards.

Routine seismic monitoring is used as a diagnostic tool, and management protocols are generally prepared to measure, monitor and manage systems proactively, as well as to inform the public of any hazards. In the future, discrete-element models may be able to predict the spatial location of energy releases due to injection and withdrawal of underground fluids. Over the past 100 years of development, although turbines have been tripped offline for short periods, no buildings or structures within a geothermal operation or local community have been significantly damaged by shallow earthquakes originating from geothermal production or injection activities (Goldstein, et al., 2011, p. 420).

The process of high-pressure injection of cold water into hot rock generates small seismic events, known as induced seismicity. The resulting ground vibrations or noise are issues that have been associated with some Enhanced (or Engineered) Geothermal System (EGS) demonstration projects (this technology will be explained in detail in Chapter 2), particularly in populated areas of Europe. Induced seismic events have not been significant enough to lead to human injury or significant property damage, but proper management of this issue will be an important step in facilitating the expansion of future EGS projects.

In addition, hydrothermal steam eruptions have been triggered at a few locations by shallow geothermal pressure changes (both increases and decreases). These risks can be mitigated by prudent field design and operation (Goldstein, et al., 2011, p. 420).

Land subsidence has also been an issue at a few high-temperature geothermal fields where pressure decline has affected some highly compressible formations, causing them to compact anomalously and form local subsidence 'bowls'. Some minor subsidence may also be related to thermal contraction, and minor tumescence (inflation) can overlie areas of injection and rising pressure. Management by targeted injection to maintain pressures at crucial depths and locations can theoretically minimize subsidence effects (Goldstein, et al., 2011, p. 420).

To avoid the adverse environmental impacts of geothermal electricity production, economies such as the United States; the Philippines; Indonesia; New Zealand; Mexico; Japan; and Chinese Taipei have established environmental regulations requiring geothermal developers to carry out environmental impact assessment and monitoring activity. It is critical to the development of geothermal resources that developers have information about existing environmental regulations in the economy in which their geothermal project is located, before the project begins. In some cases, the procedures for continual or repeated environmental impact assessments are time consuming. For example in Japan, the procedures of an environmental impact assessment can take three to four years for approval before developers can progress to the next step.

THE RESOURCE IS OFTEN LOCATED IN REMOTE, DIFFICULT-TO-ACCESS AREAS

- **The necessary infrastructure, including the transmission network, must be developed.**

Because geothermal resources are often located in remote, difficult-to-access areas, such as in the mountains, and because geothermal power plants must be placed near or above the geothermal resource (Matek, 2014, p. 5), many of the power plants are built in areas where no available infrastructure has been developed. This situation requires developers to develop the necessary infrastructure (for example, site access, base camp) before they can drill the wells, and in some cases, to develop a transmission network to the nearest grid system.

Access to a transmission network can be an issue that hinders the development of geothermal electricity, especially for geothermal energy development companies that are different from the company that operates the transmission network. In such cases, access to the transmission system from the different transmission company/provider is needed, which may require time for the construction of additional transmission facilities to accommodate the requested service. As long as the transmission capacity is available, access to the transmission system generally is allowed by the electricity regulator or transmission company/provider if the geothermal developers meet the stipulated requirements or standards and pay the transmission tariff under a contract/agreement with transmission company/provider before the geothermal developers begin generating the first MW of power. In some cases, such as in Indonesia, where the transmission network is owned and operated by an electricity utility company (in this case, by the State-owned electricity company-PLN), the geothermal developers are sometimes obligated to construct the associated transmission line to the nearest grid interconnection point together with their geothermal power plants. Even though the construction cost of this transmission network will be paid by PLN as an additional component of the electricity selling price, sometimes it can increase the risk assumed by the geothermal developers, since they need to deal with the landowners to secure the right of way for the transmission line. In all cases, the geothermal developers need to contact the primary electricity regulators or transmission company/provider where they want to develop their geothermal power plants for detailed information on existing regulatory or market design policies that are likely to impact their geothermal electricity development (NREL, 2011).

IN SOME AREAS, THE RESOURCE'S DEVELOPMENT MAY CONFLICT WITH OTHER LAND USES

As mentioned above, geothermal resources are most likely to be located in places where there are surface geothermal features such as geysers, hot springs or fumaroles. These features are usually regarded as significant natural features worthy of protection and preservation, and, in some economies, they may also have religious or cultural significance for the nearby population. This poses a dual challenge for geothermal developers. First, for their protection, these features, and therefore the geothermal resources generally, may be in national parks or other protected areas where development is not permitted. Second, even if development is permitted, the developer may be expected to show that the development will not affect these surface features. For example, in Indonesia, 44% of the total geothermal resources are in protected areas (conservation and protection forest areas) where development is limited or prohibited. In Japan, 80% of the geothermal resources exist within national parks where the exploitation of these resources, including surveying, is restricted. In New Zealand, based on the classification of geothermal systems in the Waikato region, the geothermal system located in Orakeikorako, Horomatangi, Taupo, Waikite-Waiotapu-Waimangu, Tongariro and Te Kopia is classified as protected (NZGA, 2014a) constituting approximately 50% of the total (Lawless, 2015).

In such cases, the developers need information on existing regulations in that economy to ascertain whether access for exploration and drilling activities in those areas is permitted, limited or prohibited, before starting to develop geothermal projects.

- **Geothermal electricity development may be presented with opposition from other existing or possible resource uses**

Potential conflicts may arise between geothermal developers and other existing or possible resource uses, such as when geothermal resources are found within or adjacent to tourist/recreational areas. For example, spa resort owners or hot spring industries are very sensitive to the possibility of depleted hot water resources. Potential pressure and temperature interference between adjacent geothermal developers and users can be another issue that affects all types of heat and fluid extraction, including heat pumps and EGS power projects (Goldstein, et al., 2011, p. 420). In such cases, developers should be aware of, and try to assess carefully, the possible impact of their project on other resource uses in a transparent manner. Conducting public campaigns that disseminate information about geothermal energy to the affected communities is also a useful way to gain their acceptance.

- **Access to a geothermal resource may involve regulatory or administrative procedures, such as for permits, land rights and so on**

The fact that geothermal resources can be found on land with different types of ownership, such as public land (central government and local government lands), private land and/or indigenous peoples' land, presents yet another challenge for developers. They must meet various requirements and follow various procedures to obtain permits, land rights and so on. There are sometimes no reasonable limits on the time these procedures may take. In some cases, the developer must deal with two or more agencies with overlapping jurisdictions and different land use plans. In addition, success in dealing with private landowners or indigenous peoples depends on gaining their acceptance and/or conducting negotiations, which can often take some time. Currently, land use issues still seriously constrain the development of geothermal electricity in most countries, including APEC member economies such as the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan, even though the actual land requirement for geothermal power plants is smaller than for other power plants (as explained later, in the section on 'Potential benefits of geothermal electricity').

Box 1: Geothermal energy, classification as a renewable energy source

According to the Intergovernmental Panel on Climate Change (IPPC) Special Report on Renewable Energy Sources and Climate Change Mitigation (Arvizu, et al., 2011, p. 38), renewable energy is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use.

Under this definition, geothermal energy is classified as a renewable resource because the tapped heat from an active reservoir is continuously restored by natural heat production, conduction and convection from surrounding hotter regions, and the extracted geothermal fluids are replenished by natural recharge and by injection of the depleted (cooled) fluids. Geothermal fields are typically operated at production rates that cause local declines in pressure and/or in temperature within the reservoir over the economic lifetime of the installed facilities. These cooler and lower-pressure zones are subsequently recharged from surrounding regions when extraction ceases (Goldstein, et al., 2011, p. 408).

While there are many examples where, for economic reasons, high extraction rates from hydrothermal reservoirs have resulted in local fluid depletion that exceeded the rate of its recharge, detailed modelling studies have shown that resource exploitation can be economically feasible in practical situations, and remain renewable on a time scale in the order of 100 years or less, when non-productive recovery periods are considered (Goldstein, et al., 2011, p. 408).

POTENTIAL BENEFITS OF GEOTHERMAL ELECTRICITY

Despite the challenges attributable to the nature of geothermal resources, the following potential benefits of geothermal electricity should be considered:

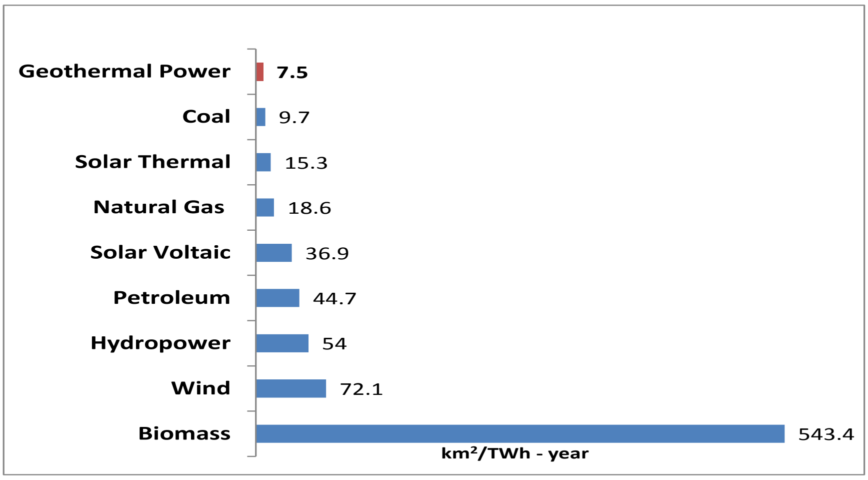
- **Energy security**

Since geothermal resources are stored in the earth under an economy's land, the economy does not need to import energy from outside its borders. Moreover, geothermal is classified as a renewable resource and restored continuously, thus providing energy security for the economy.

- **Small land footprint**

Geothermal power has a very small area of land usage compared to other energy sources, particularly when weighed against other renewables. Unlike solar, wind and biomass sources, which are predicated upon gathering diffuse ambient energy over large tracts of land, geothermal exploits a concentrated, subterranean resource. This plant design equates to the need for less terrain or surface area to produce comparable levels of power (Matek and Schmidt, 2013, p. 14). The Geothermal Energy Association Report on the Values of Geothermal Energy (Matek and Schmidt, 2013, p. 14), a recent study on the intensity of land use associated with various energy sources based on the anticipated state of technology in the year 2030, estimates that geothermal power has the smallest land area usage per unit of energy produced (see Figure 3 below). Due to directional drilling techniques and the appropriate design of pipeline corridors, the land above geothermal resources is not covered by surface installations and can still be used for other purposes, such as farming, horticulture and forestry, as occurs for example at Mokai and Rotokawa in New Zealand (Goldstein, et al., 2011, p. 420). In such cases, geothermal electricity projects can function harmoniously with other existing or possible land uses.

Figure 3. Land use based on anticipated state of technology, 2030



Source: Matek and Schmidt, 2013, p. 14.

- **Employment and economic development**

According to the Geothermal Energy Association Report on the Values of Geothermal Energy (Matek and Schmidt, 2013, pp. 13–14), geothermal power production creates a variety of jobs throughout its lifecycle. Examples of jobs created during each stage of geothermal electricity development include:

- Start-up phase: archaeologists, hydrologists, wildlife biologists, geologists, lawyers, National Environmental Policy Act (NEPA) coordinators;
- Exploration phase: geologists, geochemists, geophysicists, Geographic Information Systems (GIS) specialists, exploration drillers, engineers, sample analysts, consultants, management staff, clerical staff;
- Feasibility drilling phase: drilling engineers, rig hands, site managers, mud loggers, drilling fluids personnel, cementing personnel, casing crews, rig transportation, fuel transportation, welders, safety managers;
- Drilling and construction phase: engineers, power plant designers, document controllers, project managers, administrative support, safety managers, welders, steel erectors, concrete placers, assembly mechanics, inspection personnel; and
- Operation and maintenance: plant managers, engineers, technicians, site operators, service repair personnel.

In addition to the jobs created directly, geothermal electricity development also indirectly increases employment in a variety of industries that provide services to the companies performing exploration, construction, or operation and maintenance. Examples of these indirectly created jobs include equipment service personnel, security guards, lawyers and government regulators.

Many of these jobs are in rural communities, which can have its own unique set of challenges. Such communities are often plagued with high unemployment rates that are well above the national average. Seasonal employment is also a common practice in many rural locations. Because geothermal developers typically negotiate long-term agreements with power purchasers, many of the jobs they create can be guaranteed for decades. The development of geothermal resources in rural areas offers a vehicle for educating, training and employing the local population, in addition to increasing the diversity and stability of the local economy.

Moreover, geothermal electricity development creates more jobs per megawatt than natural gas, that is, 11 times more jobs than natural gas, as shown in the example of the United States, in Table 2.

Table 2. Geothermal and natural gas, comparative job creation, United States

Power Source	Construction Employment (jobs/MW)	O&M Employment (jobs/MW)	Total Employment for 500 MW Capacity (person-years)
Geothermal	4.0	1.7	27,050
Natural Gas	1.0	0.1	2,460

Source: Matek and Schmidt, 2013, p. 13.

- **Near-zero emissions**

Geothermal power boasts extremely low emission rates, especially when compared with traditional fossil fuels that involve direct combustion of the primary resource, as shown in Table 3.

Table 3. Pollutant and energy source of power plants, estimated emission levels

(lbs/MWh)	Geothermal*)	Natural Gas	Coal
CO_2	0 – 396.3	861.1	2,200
CH_4	0.0000	0.0168	0.2523
$PM_{2.5}$	-	0.1100	0.5900
PM_{10}	-	0.1200	0.7200
SO_2	0.0000 – 0.3500	0.0043	18.75
N_2O	0.0000	0.0017	0.0367

*) *Depends on the type of geothermal power plant technology (as explained in detail in Chapter 2)*

Source: Matek and Schmidt, 2013, p. 15.

The emission most frequently associated with geothermal electricity production is hydrogen sulphide, a naturally occurring gas in geothermal systems, which oxidizes into sulphur dioxide and sulphuric acid when released into the atmosphere. Known for its distinctive 'rotten egg' odour, hydrogen sulphide is a natural component of many volcanic and geothermal systems. Today, hydrogen sulphide abatement systems, such as LO-CAT[1] and Stretford,[2] are used extensively throughout the industry and have demonstrated a removal efficiency of more than 99.9%. Through such systems, hydrogen sulphide is converted to elemental sulphur, which can be used as a feedstock for fertilizers or as a soil amendment (Matek and Schmidt, 2013, p. 15).

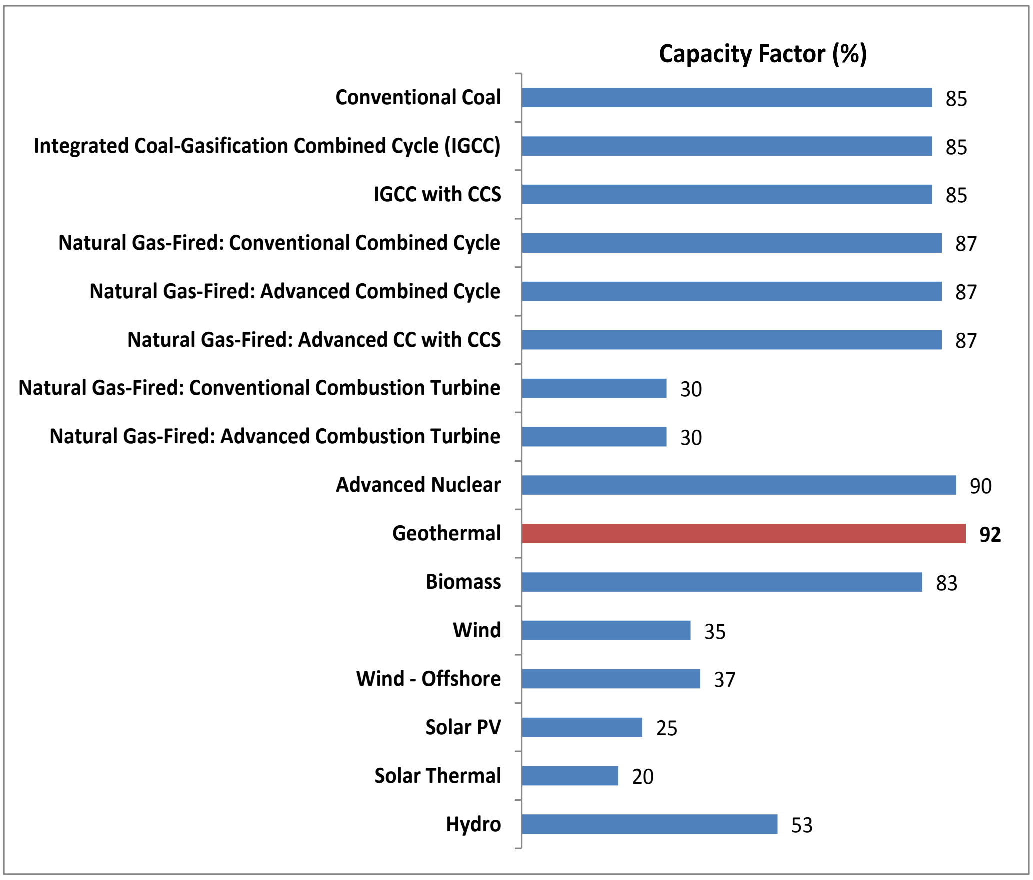
[1] LO-CAT is one of the processes used to remove H_2S for all types of gas streams in many different industries. The LO-CAT and LO-CAT II processes have achieved H_2S removal efficiencies of 99.9+% in many different applications and industries, including geothermal steam power production. Source: www.merichem.com/images/casestudies/Desulfurization.pdf

[2] The Stretford Process is a wet-type desulphurization process used in various industries in which hydrogen sulphide is removed from gas streams and sulphur is recovered. Source: nett21.gec.jp/AIR/data/Air-210.html

- **Reliable and flexible power source**

Geothermal power plants can produce electricity 24 hours a day, seven days a week, regardless of weather conditions, in contrast to other renewable energies such as solar, wind and hydro sources. With this potential benefit, geothermal power plants can provide base load power, which provides electricity all or most of the time. As a result, geothermal power plants have a high capacity factor compared to other power plants, as shown in Figure 4.

Figure 4. Capacity factor for power plants entering service, United States, 2019



Source: EIA, 2014.

In addition to providing base load power, geothermal power plants have the ability to operate in a flexible mode that can quickly adapt to variability in the power system. Geothermal power plants can provide regulation,[3] load following[4] or energy imbalance,[5] spinning reserve,[6] non-

[3] Regulation is the time frame during which generation (and potentially load) automatically responds to minute-by-minute deviations in a supply-demand balance.

[4] Load Following is a slower response (from several minutes to a few hours) whereby available resources are dispatched to follow system ramping requirements.

[5] Energy Imbalance Service is a market service that provides for the management of unscheduled deviations in individual generator output or load consumption.

[6] Contingency Spinning Reserve is generation (or responsive load) that is poised, ready to respond immediately, in case a generator or transmission line fails unexpectedly.

spinning reserve,[7] and replacement or supplemental reserve,[8] because they have minimal fuel costs.

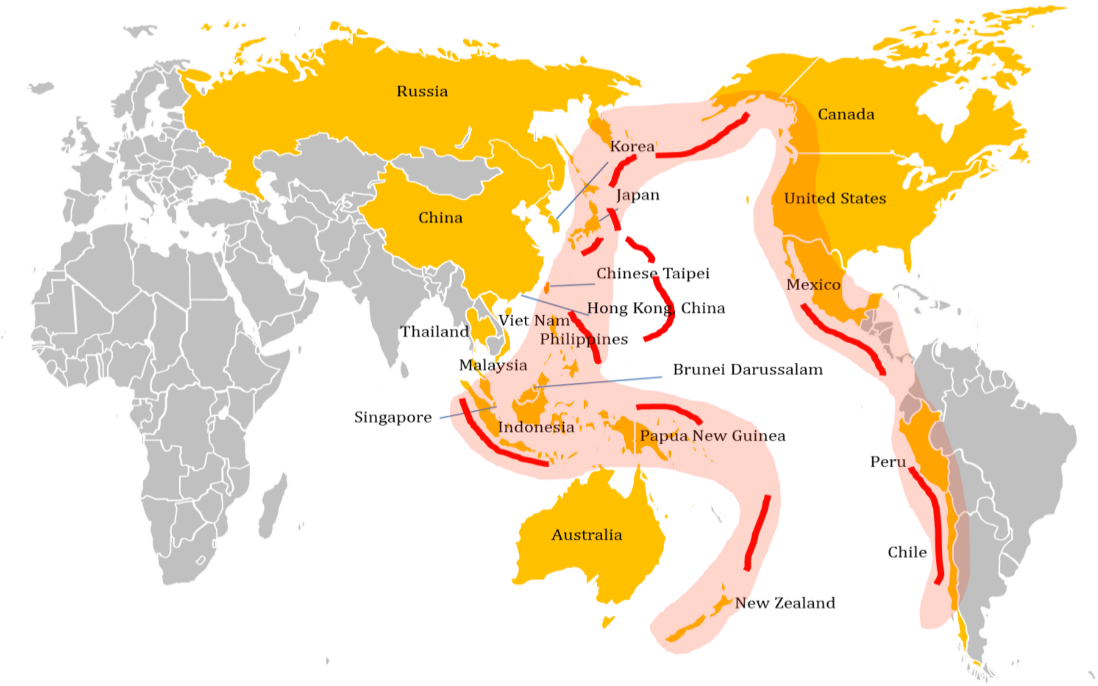
After the upfront capital investment for the well field construction, the operational costs of a geothermal power plant are nearly constant. As a result, the nominal flow of hot fluid can be circulated in the system even when only partial power is required. It does not affect operating costs to operate the plant at partial mode, as there is no cost for the unused geothermal fluid, or 'fuel', of a geothermal plant. In fact, 8 of the 16 MW of geothermal capacity at the Puna Geothermal Venture facility in Hawaii are currently used only to provide ancillary services for grid support, and provide services identical to oil-fired resources on the Big Island (Matek and Schmidt, 2013, pp. 11–12).

GEOTHERMAL ELECTRICITY DEVELOPMENT IN THE APEC REGION

GEOTHERMAL RESOURCES

Figure 5 is a map of the world showing the location of the 'Pacific Ring of Fire', along which active volcanoes are common and earthquakes occur frequently. This area is defined by the boundaries of tectonic plates that form the earth's crust. The APEC region aligns almost perfectly with the 'Pacific Ring of Fire', where much of the world's geothermal energy potential is concentrated. However, even though the greatest geothermal potential is within this ring, geothermal power plants have been developed outside this ring, in places such as Australia, China and Thailand.

Figure 5. Pacific Ring of Fire



[7] Non-Spinning Reserve is similar to spinning reserve, except that response does not need to begin immediately.

[8] Replacement or Supplemental Reserve is an additional reserve requirement.

Geothermal resources vary widely from one location to another, depending on the temperature and depth of the resources, the rock chemistry and the abundance of ground water. Since the resource is generally hidden (subsurface), it is difficult to accurately determine its potential on a global basis. This uncertainty is exacerbated by the reality that the technologies used to develop geothermal resources are evolving, extending capabilities and reducing costs, and thereby increasing technical and economic potential. Therefore, there is considerable uncertainty in estimating the global geothermal resource potential, and revisions are expected as more information and new technologies become available (IEA, 2012, p. 4).

According to the International Energy Agency report 'Technology Roadmap – Geothermal Heat and Power' (IEA, 2011, p. 9, pp. 11–12), until recently, geothermal energy use was concentrated in areas where geological conditions permit a high-temperature circulating fluid to transfer heat from within the earth to the surface through wells that discharge without any artificial lift, via hydrothermal resources. The fluid in convective hydrothermal resources can be vapour (steam) or water-dominated, with temperatures ranging from 75^{0}C to over 200^{0}C. High-temperature geothermal fields are most common near tectonic plate boundaries, and are often associated with volcanoes and seismic activity, as the crust is highly fractured and thus permeable to fluids, resulting in heat sources being readily accessible. Besides hydrothermal resources, another geothermal resource type can be used for producing electricity, called hot rock resources or Enhanced Geothermal System (EGS) resources. These resources are characterised by limited pore space and/or minor fractures, and therefore contain insufficient water and allow insufficient permeability for natural exploitation. Hot rock resources can be found anywhere in the world, although they are found closer to the surface in regions with an increased presence of naturally occurring radioactive isotopes (for example, South Australia) or where tectonics have resulted in a favourable state of stress (for example, in the western US).

APEC's geothermal resource potential is estimated at approximately 16 863 GW, consisting of 145 GW of hydrothermal resources and 16 718 GW of Enhanced Geothermal System (EGS) resources, as shown in Table 4 and Figure 6. This estimation is based on information from many sources, including official documents, papers, journals and presentations, which used varying assessment techniques. Although the resource potential is significant, only a fraction of this potential can currently be technically and economically developed as power generation, particularly with regard to EGS, Hot Dry Rock (HDR) and Hot Sedimentary Aquifers (HAS), which require major technological breakthroughs. Further investigation, through detailed survey, exploration and drilling, is necessary of the resources for which development is possible for power generation.

Table 4. Estimated geothermal resource potential, the APEC Region

Economy	Estimated Geothermal Potential (GW)		Note	Source
	Hydro-thermal	EGS/HDR/HSA		
Australia	-	754.7	Only for measured resource	Geoscience Australia, Australia Government (2014). *Geothermal Energy Resources*, Accessed on April 2014, www.ga.gov.au/energy/geothermal-energy-resources.html
Brunei Darussalam	-	-	No data available	

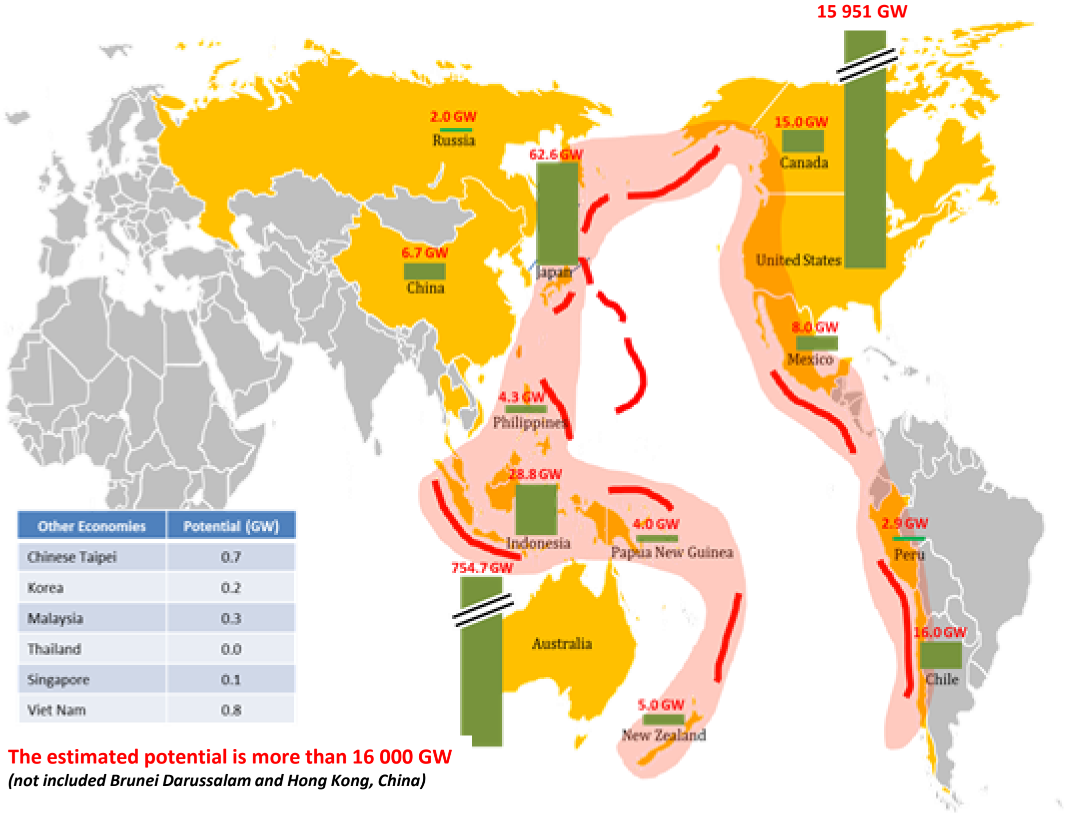
Canada	5.0	10.0		Canadian Geothermal Energy Association (CanGEA) (2014). *Geothermal Resources in the Different Regions of Canada: Potential Geothermal Applications in Canada*, Accessed on October 2014, www.cangea.ca/where-are-canadian-geothermal-resources-found.html
Chile	16.0	-		Allendes F (2013). President Chilean Association of Geothermal Energy. Creating a Chilean geothermal industry, geothermal resources, *Council Bulletin* 42(1), January/February 2013, www.geothermal.org/PDFs/Focus_on_Chile.pdf
China	6.7	-		Worldview (2012). Geothermal potential of China, *Worldview Report*, June 2012 www.nzgeothermal.org.nz/Publications/Industry_papers/Worldview-Report-Geothermal-Potential-of-China.pdf
Hong Kong, China	-	-	No geothermal energy sources for power generation	Electrical and Mechanical Service Department (2014). *Geothermal – FAQ*, Accessed April 2014 re.emsd.gov.hk/english/other/geothermal/geo_faq.html#
Indonesia	28.8	-		Geological Agency (2012). *Geothermal Area Distribution Map and Its Potential in Indonesia*. December 2012.
Japan	24.2	38.4		• Yasukawa K (2014). National Institute of Advanced Industrial Science and Technology, Japan. *Geothermal Development Activities in Japan after the Big Earthquake in 2011*. Accessed February 2014, www.geothermalconference.is/files/fyrirlestrar/130315_Iceland%20-%20Dr.%20Kasumi%20Yasukawa%20-%20updated.pdf • Yasukawa K and Sakaguchi K (2013).

				National Institute of Advanced Industrial Science and Technology, Japan. *Geothermal Potential and Resource Assessments in Japan*. Presented at IGA Workshop, Essen, 14 November 2013, www.google.co.jp/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CCMQFjAA&url=http%3A%2F%2Fwww.geothermal-energy.org%2Freserves_and_resources%2Fworkshop_essen.html%3Fno_cache%3D1%26cid%3D893%26did%3D337%26sechash%3Dad5194f2&ei=WMICU9zWB8mulAWB44GQDw&usg=AFQjCNHCT024HTxk8bBcmNDWyXtG6DOCYQ
Korea	-	0.2	Based on plan in 2030	Lee TJ and Song Y (2014). *Today and the Future of Geothermal Energy in Korea*, Accessed September 2014 www.geothermal-energy.org/pdf/IGAstandard/Japan/2012/p45-Lee_and_Song.pdf
Malaysia	0.3	-	Based on 10 year target	• Geothermal (2014). *Geothermal Energy for Asia*, Accessed September 2014 geothermal.com.my/asia/about/ • Think Geoenergy (2009). *Malaysia with Geothermal Potential at Tawau, Sabah*, 24 July 2009 thinkgeoenergy.com/archives/2121
Mexico	8.0	-		Secretaria de Energia (SENER, 2013). beta.energia.gob.mx/res/0/Geothermal_01.pdf
New Zealand	5.0	-		Lawless JV (2002). *New Zealand's Geothermal Resource Revisited*, New Zealand Geothermal Association Annual Seminar, Taupo, New Zealand

Papua New Guinea	4.0	-		McCoy-West AJ, Milicich S, Robinson T, Bignall G and Harvey CC (2011). *Geothermal Resources in the Pacific Islands: the Potential of Power Generation to Benefit Indigenous Communities*, Proceedings of the Thirty-Sixth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 31–February 2, 2011, SGP-TR-191, pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2011/mccoy.pdf
Peru	2.9	-		Matsuda K and Lima EML (2015). *The Master Plan for Development of Geothermal Energy in Peru*, Proceedings of the World Geothermal Congress 2015, Melbourne, Australia, 19–25 April 2015, www.geothermal-energy.org/publications_and_services/latin_america_gateway.html?no_cache=1&cid=1076&did=842&sechash=1507e05a
The Philippines	4.3	-		National Geothermal Association of the Philippines (NGAP) website (2011). www.ngaphil.org/download
Russia	2.0	-		Battocletti L (Bob Lawrence & Associates, Inc) (2000). *Geothermal Resources in Russia*, November 2000, bl-a.com/ecb/PDFFiles/GeoResRussia_2000.pdf
Singapore	-	0.1	Based on preliminary analysis	Palmer A, Grahame O, Tjiawi H and Zulkefli F (2014). *Geothermal Power Concept for Singapore*. National University of Singapore, Accessed in April 2014 esi.nus.edu.sg/docs/event/oliver-egs-hsa-concept-for-singapore-ppt-sg$-ppt-for-chevron.pdf?Status=Master
Chinese Taipei	0.7	-		Industrial Technology Research Institute (ITRI) (2013). www.egnret.ewg.apec.org/workshops/GeothermalEnerg

				y/05.Ouyang_Chinese%20Taipei%20Geothermal%20Status%20and%20Perspectives_20130625_final_sv_M.pdf
Thailand	0.005 (only in the San Kamphaeng area)	-		Singharajwarapan FS, Wood SH, Prommakorn N and Owens L (2012). *Northern Thailand Geothermal Resources and Development: A Review and 2012 Update*. Geosciences Faculty Publications and Presentations, Boise State University Scholar Work 9–30–2012, scholarworks.boisestate.edu/cgi/viewcontent.cgi?article=1123&context=geo_facpubs
United States	36.4	15 915		Augustine C (2011). *Updated U.S. Geothermal Supply Characterization and Representation for Market Penetration Model Input*, NREL Technical Report, October, 2011, www.nrel.gov/docs/fy12osti/47459.pdf.
Viet Nam	0.8	-		Cuong NT, Giang CD and Thang TT (2005). *General Evaluation of the Geothermal Potential in Vietnam and the Prospect of Development in the Near Future*. Proceedings of the World Geothermal Congress 2005, Antalya, Turkey, 24–29 April 2005, www.geothermal-energy.org/pdf/IGAstandard/WGC/2005/0101.pdf
Total	**145.2**	**16 718.4**		

Figure 6. APEC's geothermal potential, an estimation



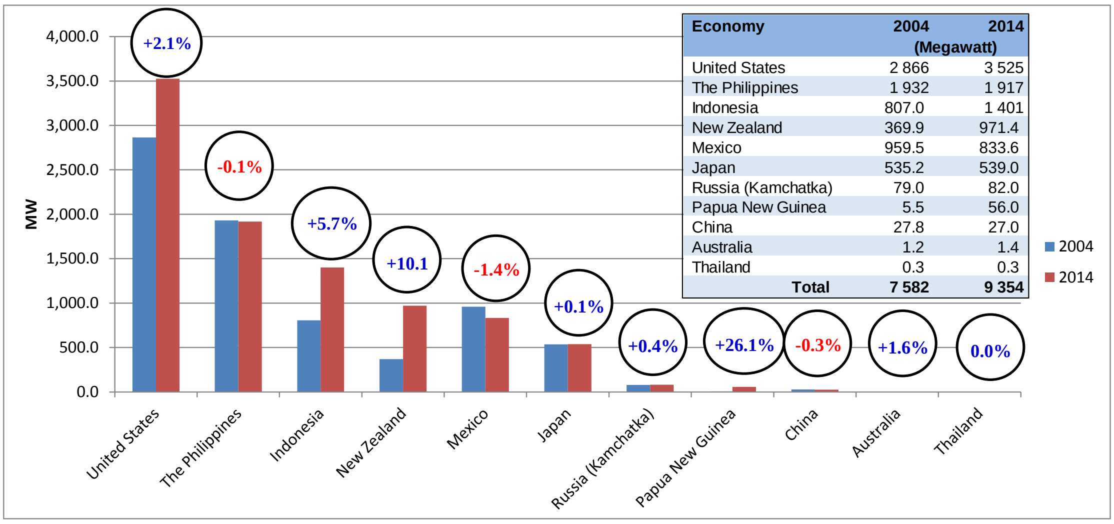
Other Economies	Potential (GW)
Chinese Taipei	0.7
Korea	0.2
Malaysia	0.3
Thailand	0.0
Singapore	0.1
Viet Nam	0.8

CURRENT STATUS OF GEOTHERMAL ENERGY USE

After the first commercial power plant (250 kWe) was commissioned at Larderello, Italy in 1913, some APEC economies began to develop geothermal electricity for the first time in the 1950s–60s, including New Zealand at Wairakei in 1958; Mexico, with an experimental plant at Pathe in 1959; the United States, with the first commercial plant at The Geysers in 1960; and Japan, with 23 MWe at Matsukawa in 1966 (Lund, 2007, p. 1). These economies of the APEC region have the longest historical involvement in the development of geothermal electricity in the world, with experience of more than 40 to 50 years.

According to the BP Statistical Review of World Energy (BP, 2015), the installed capacity of geothermal electricity in the APEC region was 9354 MW in 2014, increasing at an average annual rate of 2.1% per year since 2004 (see Figure 1.5). The increase of installed capacity of geothermal power plants in the APEC region over the last 10 years is mainly attributable to the increasing installed capacity in several economies (annual percentage growth is shown in parentheses) among others: Papua New Guinea (+26.1%); New Zealand (+10.1%); Indonesia (+5.7%); and the United States (+2.1%). With this total installed capacity, the APEC region has contributed nearly 74% of the world's geothermal installed capacity, which was approximately 12 594 MW in 2014.

Figure 7. Geothermal electricity development, current status, APEC Region



Economy	2004	2014
	(Megawatt)	
United States	2 866	3 525
The Philippines	1 932	1 917
Indonesia	807.0	1 401
New Zealand	369.9	971.4
Mexico	959.5	833.6
Japan	535.2	539.0
Russia (Kamchatka)	79.0	82.0
Papua New Guinea	5.5	56.0
China	27.8	27.0
Australia	1.2	1.4
Thailand	0.3	0.3
Total	7 582	9 354

Source: BP, 2015.

It should be noted, however, that even though the installed capacity of geothermal power plants in the APEC region has increased by approximately 1772 MW over the last 10 years, this number remains small compared to its potential. There is significant opportunity to develop more geothermal electricity in the APEC region in the near future. With the challenges facing the development of geothermal electricity as described herein, government intervention through public policy is necessary to minimise or reduce the barriers to the development of geothermal electricity and create a good investment environment for private participation.

CHAPTER 2
BACKGROUND ON GEOTHERMAL ELECTRICITY GENERATION

As mentioned in Chapter 1, geothermal resources are subterranean, and exploration and drilling stages or phases must be undertaken before power plants can be constructed and electricity produced.

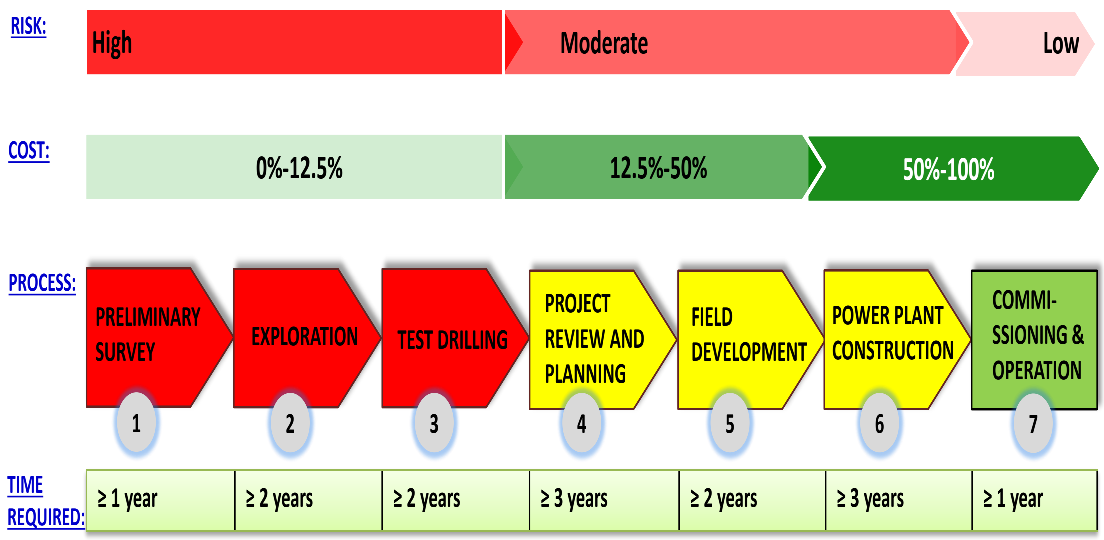
According to the BP (2015) Statistical Review of World Energy, the total installed geothermal electricity generation capacity was 12 594 MW in 2014; it is expected to grow to around 3.5% of global electricity production by 2050, as forecast by the IEA (2011, p. 5).

THE GEOTHERMAL ELECTRICITY DEVELOPMENT PROCESS

Each economy and/or agency with geothermal resources has different stages or phases of how to develop geothermal electricity. Many early geothermal electricity projects were developed in a non-systematic manner. Although there remain differences in methodologies and techniques between different economies and different agencies, at least geothermal electricity development stages or phases have become more clearly defined (IGA, 2013, p. 5).

According to the International Geothermal Association (IGA, 2013 p. 5) report on Geothermal Exploration Best Practices, there are seven stages in the process of developing a geothermal electricity project (see Figure 2.1): (1) Preliminary Survey; (2) Exploration; (3) Test Drilling; (4) Project Review and Planning; (5) Field Development; (6) Power Plant Construction and (7) Commissioning and Operation. Even though others may use a different characterisation of these stages, the underlying activities are the same.

Figure 8. Geothermal electricity development, the process



Source: Modified from ESMAT, 2012 and IGA, 2013.

- **Phase 1 – Preliminary survey**

The Preliminary Survey Phase involves a work program to assess the existing available evidence for geothermal potential. A literature review on the technical aspects (for example, geological, hydrological, thermal and drilling) and the non-technical aspects (for example, institutional and regulatory frameworks, and environmental, social and infrastructure issues) may be needed in order to identify possible barriers to development or potential roadblocks that might derail or slow down a development program. Based on this review and assessment, a developer may decide whether or not to proceed to the Exploration Phase (IGA, 2013, pp. 6–7).

This phase may be as short as several months, but if there are many potential sites to investigate, or the situation is otherwise complex (for example, the permitting processes), it may take a year or longer (IGA, 2013, p. 7). The risk of this phase is high, even though the cumulative investment cost is still small (ESMAT, 2012, p. 69).

- **Phase 2 – Exploration**

In order to further confirm the preliminary resource assessment and minimise risks related to the resource, the Exploration Phase, consisting of surface, geochemical and geophysical surveys needs to be conducted by the developer (IGA, 2013, p. 8). The objectives of exploration are to identify and rank prospective geothermal reservoirs prior to drilling, and provide data for characterising reservoirs to enable estimates of geothermal reservoir performance and lifetime (Goldstein, et al., 2011, p. 411).

This phase may take several months. However, if any barriers are encountered during the program, it may take two years or longer (IGA, 2013, p. 8). The risk during this phase is still high, and the expended cumulative investment cost is higher than in the Preliminary Survey Phase (ESMAT, 2012, p. 69).

- **Phase 3 – Test drilling**

To demonstrate the feasibility of commercial production and injection of geothermal resources, a Test Drilling Phase needs to be conducted. Typically, at least two and usually three deep wells are drilled. However, more wells may be required, depending on the size of the project to be developed and the success in finding a viable geothermal resource with the first series of wells (IGA, 2013, p. 10).

This phase may take two years or more, depending on the complexity of the situation and conditions (for example, the permitting process) or barriers encountered during the program. The risk of this phase is high, and the expended cumulative investment costs can also be high, depending on the location and depth of drilling (ESMAT, 2012, p. 52, p. 57, p. 69).

- **Phase 4 – Project review and planning**

This phase includes the evaluation of all existing data by the developer, including new data from the exploratory phases. The results from test drillings will enable the project developer to finish the feasibility study, including all financial calculations; the conceptual engineering for all components to be built; and the drilling program. In this phase, the project developer determines the most economically advantageous project size and the investments necessary (ESMAT, 2012, p. 57). Based on the feasibility study result and funding availability, the developer can make a decision as to whether the project will be developed (IGA, 2013, p. 11).

This phase may take three years or more, depending on the complexity of the situation and conditions (for example, the exploration permit) or barriers encountered during the program, since the developer needs to complete an Environmental Impact Assessment (EIA), a Power Purchase Agreement (PPA) and financial closing. The risk of this phase can be considered to be reduced from high to moderate. However, the cumulative investment cost is higher than in the Test Drilling Phase, since it includes all costs from phases 1 to 3, plus contingency costs (for example, financial, legal, environmental negotiation and permits) (ESMAT, 2012, p. 52, p. 57, p. 69).

- **Phase 5 – Field development**

Phase 5 marks the beginning of the actual development of the geothermal electricity project and consists of drilling production and reinjection wells (the geothermal fluids must return to the reservoir via injection wells to maintain the pressure and avoid reservoir depletion). In addition, this phase involves partially constructing the pipelines to connect the wells to the plant (ESMAT, 2012, p. 58, p. 60). For large projects, once the resource has been proven through several initial deep wells, it is common practice to have two or more drilling rigs operating in order to reduce the development time and earn revenue from generation as soon as possible (IGA, 2013, p. 11).

This phase is time consuming, and may take two years or more, depending on the complexity of the situation and conditions (for example, the exploitation permit) or barriers encountered during the program (for example, geological problems or the capability of the drilling rig(s) used). The risk of this phase is moderate, but costly (50% of cumulative investment cost) (ESMAT, 2012, p. 52, p. 60, p. 69).

- **Phase 6 – Power plant construction**

This phase involves installation of the steam-gathering system (that is, a system of steam pipelines from the well heads to the power plant and back for the re-injected fluids); the separators; the power plant with the turbine, generator and 'cold end', which consists of a condenser that needs either air (fan cooling) or water cooling (direct or by cooling tower) (ESMAT, 2012, p. 60). This installation is coordinated with any necessary civil works and infrastructure required to allow the power plant to be constructed, along with further testing of the wells (IGA, 2013, p. 12).

This phase may take three years or more, depending on the complexity of the situation and conditions (for example, the permitting process) or barriers encountered during the program (for example, construction of transmission). The risk of this phase is moderate to low, but the cumulative investment cost may exceed 80% (ESMAT, 2012, p. 52, p. 69).

- **Phase 7 – Commissioning and operation**

The operation of geothermal electricity generation begins in this phase. The main focus at this point is to optimise the production and injection scheme to enable the most efficient energy recovery and use, to minimise operational costs, maximise investment returns, and ensure the reliable delivery of geothermal power. If there is any decline in the productivity of the resource, new production wells may be required. New reinjection wells may also be required for adjustment of the reinjection strategy as the resource responds to exploitation (IGA, 2013, p. 12).

This phase may take a year or more, depending on the complexity of the situation and conditions (for example, the permitting process) or barriers encountered during the program. The project risk is already considered to be low, and the cumulative investment cost has already reached 100% (ESMAT, 2012, p. 52, p. 69).

Box 2: Assessing geothermal electricity development in one economy, questions to be answered
To identify possible barriers to development or potential roadblocks that might derail or slow down a geothermal electricity generation development project, the developer must gather as much information as possible—not only

regarding technical aspects, such as data on geological, hydrological, thermal and drilling conditions, but also regarding non-technical aspects. Some important questions related to the non-technical data are:

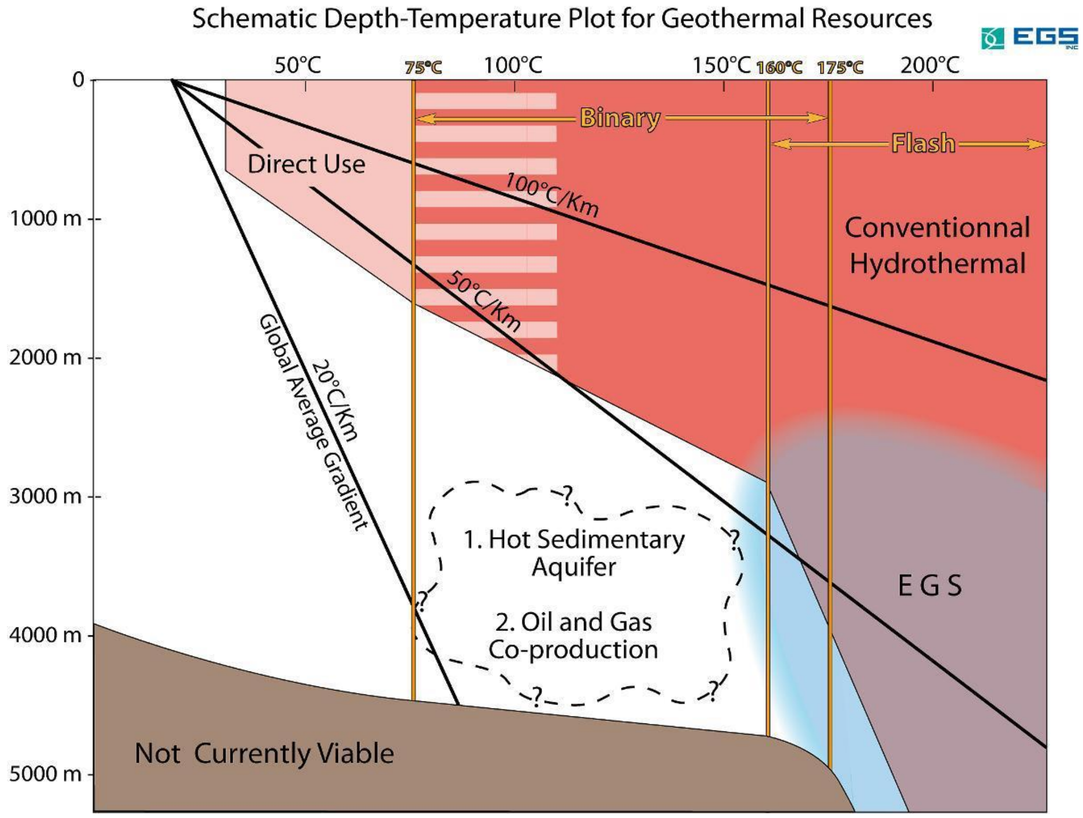
- *Are there any laws and/or regulations governing the development of geothermal electricity (laws, regulations, programs or targets/priorities)?*
- *Are there any institutions/agencies/organisations established to promote or regulate the development of geothermal electricity?*
- *Are there any databases provided by the government regarding the geothermal resource potential?*
- *Is there any investment in research and development (R&D)?*
- *Are there any additional incentives the company could receive from the government to encourage geothermal development?*
- *Who owns the geothermal resources legally?*
- *Are there policies that limit geothermal development in some areas?*
- *What is the permitting process for exploration of geothermal resources?*
- *Who can conduct pre-feasibility? (Foreigners?)*
- *Is there any government support for this activity?*
- *Is there any support from the government regarding financing early stage exploration for resources?*
- *What further permits are needed to develop the resource?*
- *Who is allowed to apply for and obtain such permits? (Foreigners?)*
- *What does one need to do to obtain such permits?*
- *Assume the company has invested money in exploration and has identified resources they wish to develop. Do they have exclusive rights to develop it, or can a competitor also move in to the same area?*
- *Once the company has developed the resource, who can they sell their power to?*
- *How will the power be priced?*
- *How long does the PPA approval process take before the agreement can be executed?*
- *Are there any tax exceptions/breaks for import of goods or equipment?*
- *If the company buying the power is different from the company that operates the transmission network, what does the geothermal company need to do to gain access to the transmission system?*
- *What royalties/taxes, if any, will the company be required to pay on their power production?*

CURRENT GEOTHERMAL ENERGY PRODUCTION METHODS

To generate electricity, a geothermal power plant requires fluid or steam from the geothermal reservoir to drive a turbine. Since the geothermal reservoir is underground, drilling activities must be undertaken to extract the fluid, or steam electricity can be produced. However, the uncertain quantity and quality of extractable geothermal fluids or steam affects the design parameters of the geothermal power plant downstream. Unlike a fossil fuel plant where burning X amount of coal may produce Y amount of power, with geothermal energy, it is the resource quality and quantity that determines the power plant size, technology and other engineering aspects (Matek, 2014, p. 10).

In most areas of the world today, projects rarely drill wells deeper than 4 km to extract geothermal fluids or steam, as shown in Figure 9; the technologies of geothermal power plants that will be used to generate electricity are chosen by considering the depth of the reservoir, temperature, pressure and nature of the entire geothermal resource, as well as economic feasibility (Matek, 2014, p. 8). Geothermal power plants today can use water in the vapour phase, a combination of vapour and liquid phases, or liquid phase only (IEA, 2011, p. 14).

Figure 9. Geothermal resources, depth-temperature plot



Note: New technologies have allowed for some scenarios where the 'Not Currently Viable' portion of Figure 2 and the 'EGS' portion at depths of 3000–5000 m and temperatures of 100–150°C become economical geothermal projects.

Source: Matek, 2014, p. 9.

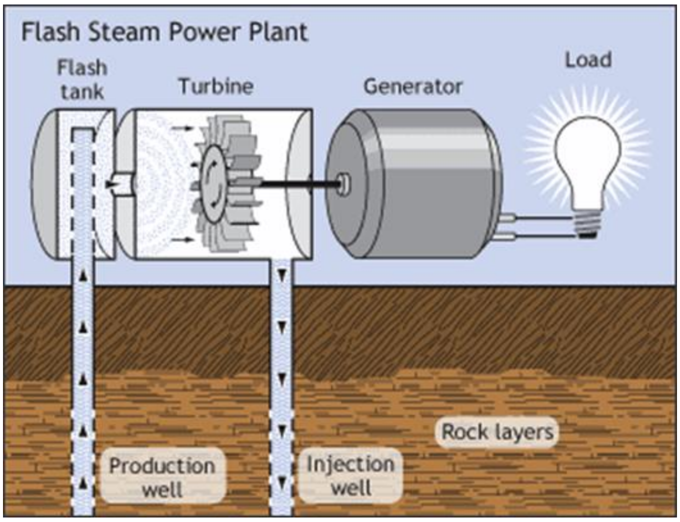
Currently, three main types of technology for geothermal power plants are commonly used to produce electricity: flash steam, dry steam and binary plants. The selection of the type of technology depends on reservoir temperatures and pressures in the fields. Each type of technology produces different pollution levels.

- **Flash steam plant**

The most commonly found geothermal resources contain reservoir fluids with a mixture of hot liquid (water) and vapour (mostly steam). Flash steam plants, making up about two-thirds of geothermal installed capacity today, are used where water-dominated reservoirs have temperatures above 160°C. In these high-temperature reservoirs, the liquid water component boils, or 'flashes', as pressure drops. Separated steam is piped to a turbine to generate electricity, and the remaining hot water may be flashed again twice (double flash plant) or three times (triple flash) at progressively lower pressures and temperatures, to obtain more steam. The cooled brine and condensate are usually sent back down into the reservoir through injection wells. Combined-cycle flash steam plants use the heat from the separated geothermal brine in binary plants to produce additional power before re-injection (IEA, 2011, pp. 14–15). The

Philippines; Indonesia; New Zealand; Mexico; and Japan mostly use this technology for their geothermal power plants.

Figure 10. Flash steam plant

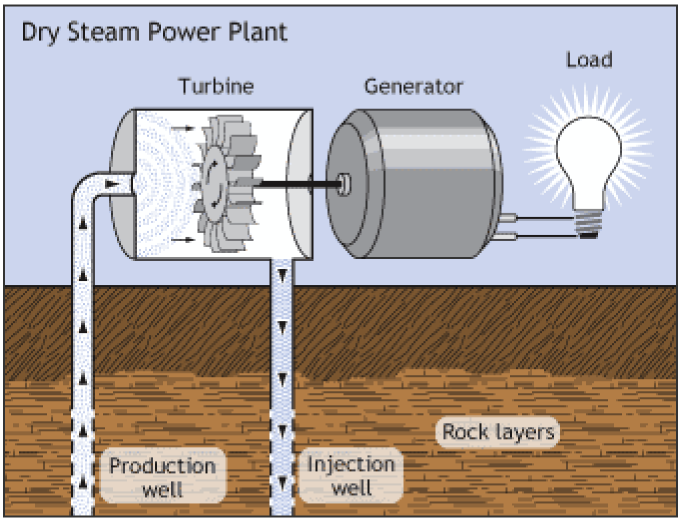


Source: EERE, 2014a.

- **Dry steam plant**

Dry steam plants, which make up about a quarter of geothermal capacity today, make direct use of the dry steam that is piped from production wells to the plant and then to the turbine. (No separation is necessary, because the wells only produce steam.) Control of steam flow to meet electricity demand fluctuations is easier than in flash steam plants, where continuous up-flow in the wells is required to avoid gravity collapse of the liquid phase. In dry steam plants, the condensate is usually re-injected into the reservoir or used for cooling (IEA, 2011, p. 15). The United States (mostly California), two plants in Indonesia and one power plant in Japan in Matsukawa Power Plant are using this technology.

Figure 11. Dry steam plant



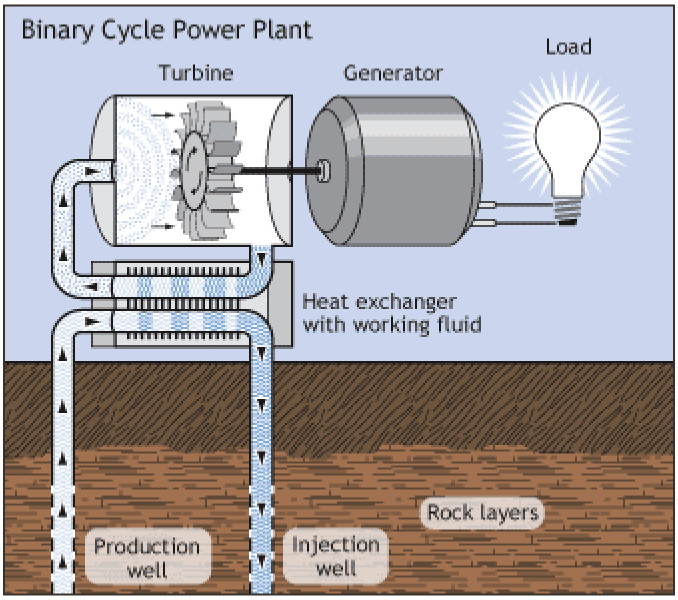
Source: EERE, 2014a.

- **Binary plant**

Electrical power generation units using binary cycles constitute the fastest-growing group of geothermal plants in terms of number, although perhaps not in megawatt capacity, as they are able to use low- to medium-temperature resources, which are more prevalent. Binary plants, using an organic Rankine cycle (ORC) or a Kalina cycle, typically operate with temperatures varying from as low as 75°C to 175°C. In these plants, heat is recovered from the geothermal fluid using heat exchangers to vaporise an organic fluid with a low boiling point (for example, butane or pentane in the ORC cycle and an ammonia-water mixture in the Kalina cycle), and drive a turbine. Although both cycles were developed in the mid-20th century, the ORC cycle has been the dominant technology used for low-temperature resources. The Kalina cycle can, under certain design conditions, operate at higher cycle efficiency than conventional ORC plants. The lower-temperature geothermal brine leaving the heat exchanger is re-injected back into the reservoir in a closed loop, thus promoting sustainable resource exploitation (IEA, 2011, p. 15). One challenge with developing binary plants is that the total cost to develop them is currently still higher than for flash steam plants. For example, the investment cost of binary plants ranges from USD 2400 per kW to USD 5900 per kW for Greenfield (new project) sites, while the cost for flash steam plants ranges from USD 2000 per kW to USD 4000 per kW. In terms of production cost, binary plant costs vary on average from USD 60 per MWh to USD 110 per MWh, while flash steam costs only average from USD 50 per MWh to USD 80 per MWh (IEA, 2011, p. 17). This cost difference is because binary plants can only produce a small megawatt capacity compared to flash steam plants and there are economies of scale.

Today, binary plants have an 11% share of the installed global generating capacity and a 44% share in terms of the number of plants (IEA, 2011, p. 15). This technology is already used in the Philippines (9%); New Zealand (17%); and the United States (15%) and most new plants that have come online have been binary plants, while in Japan, a binary plant with a capacity of 2000 kW has been in operation at Hatchobaru since 2006. In Indonesia, a binary plant is still in the R&D stage.

Figure 12. Binary plant



Source: EERE, 2014a.

In addition to these three technologies, there are also combined or hybrid plants, which comprise two or more of the above basic types, such as using a binary plant as a bottoming cycle along with a flash steam plant, to improve versatility, increase overall thermal efficiency, improve load-following capability and efficiently cover a wide resource temperature range (Goldstein, et al., 2011, p. 412). New Zealand has used a steam turbine combined with binary plant heat exchanger, for example.

Box 3: Technologies of geothermal power plants used by seven APEC economies

The selection of geothermal power plant technologies depends on reservoir temperatures and pressures in the geothermal field (quality and quantity of resource). Thus, with geothermal energy, it is the resource quality and quantity that determine the power plant size, technology and other engineering aspects. Since the geothermal reservoir is underground, drilling activities must be undertaken to extract the fluid or steam before the power plant can be constructed and electricity produced.

Some of the technologies for geothermal power plants that have been used or are planned for use in the seven APEC economies selected for this report are shown in Table 5 below.

Table 5. Geothermal power plant technologies, used or planned for use, the seven selected APEC economies

Economy	Technologies of Power Plant
United States	• Half in terms of megawatt capacity are dry steam (mostly in California). • Most new plants that have come online have been binary systems. • One EGS project is under development in Oregon.
The Philippines	• Mostly flash steam. • Only 9% of total installed geothermal power plants are binary systems. • EGS is currently under R&D.
Indonesia	• Mostly flash or dry steam. • Binary system is currently under R&D.
New Zealand	• Mostly flash steam. • 17% of total installed geothermal power plants are binary systems. • There are also geothermal combined cycle plants (a steam turbine combined with binary plant heat exchanger).
Mexico	• Mostly flash steam (92% of total installed geothermal power plants) • Binary systems only account for 3 MW
Japan	• Mostly flash steam. • Dry steam is used only at the Matsukawa power plant. • The first binary system with a capacity of 2000 kW in Hatchobaru was in operation in 2006. • EGS is currently under R&D.
Chinese Taipei	• A 50 kW geothermal demonstration plant and a 1 MW geothermal pilot plant are using binary systems. • Binary systems and EGS are under consideration for development in the future.

Box 4: Geothermal power plants, estimated emission levels, based on technologies

One of the potential benefits of geothermal electricity is near-zero emissions; estimated emission levels by pollutant for geothermal power plants are between 0–396.3 lbs/MWh for CO_2, depending on the technology used.

According to Argonne National Laboratory in the United States, when considering life cycle emissions, binary power plants have near-zero GHG emissions and minimal particulate matter emissions, thus being one of the cleanest forms of energy, while flash and dry steam power plants also represent a significant improvement over coal and natural gas, as shown in Table 6 (Matek and Schmidt, 2013, p. 14).

Table 6. Estimated emission levels by pollutant, geothermal power plants, based on technologies

(lbs/MWh)	Flash	Dry Steam	Binary	Natural Gas	Coal
CO_2	396.3	59.82	-	861.1	2,200
CH_4	0.0000	0.0000	-	0.0168	0.2523
$PM_{2.5}$	-	-	-	0.1100	0.5900
PM_{10}	-	-	-	0.1200	0.7200
SO_2	0.3500	0.0002	-	0.0043	18.75
N_2O	0.0000	0.0000	-	0.0017	0.0367

Source: Matek and Schmidt, 2013, p. 15.

COST COMPARISON: GEOTHERMAL POWER PLANTS VS. OTHER PLANTS

Geothermal power plants are competitive with other types of power plant, according to the US Energy Information Administration (EIA, 2014, p. 6) report on Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014; even with high upfront capital costs (USD 34.2 per MWh), geothermal power is a competitive renewable energy source. The absence of fuel cost and other variable costs over the long 30-year project life span gives geothermal power plants the lowest levelised costs (USD 47.9 per MWh) of any renewable energy technology, as well as of non-renewable energy technology entering service in 2019, as shown in Table 7 below. However, it is important to note that while Levelized Cost of Electricity (LCOE) is a convenient summary measure of the overall competiveness of different generating technologies, actual plant investment decisions are affected by the specific technological and regional characteristics of a project, which involve numerous other factors, such as projected utilisation rate, existing resource mix and policy-related factors (EIA, 2014, pp. 1–2).

According to Table 7, the capital cost of geothermal power plants accounts for 71% of the total cost. The magnitude of the capital cost is high due to the cost of the following components: (a) exploration and resource confirmation, representing 10–15% of the total capital cost, although for expansion projects it may be as low as 1–3%; (b) drilling of production and injection wells, representing 20–35% of the total capital cost; (c) surface facilities and infrastructure, representing 10–20% of the total capital cost, although in some cases these costs could be <10%, depending upon plant size and location; and (d) the power plant where this component varies between 40 and 81% of the total capital cost. Component costs and the factors influencing them are usually independent from each other. One additional factor affecting the capital cost of a geothermal electricity project is the type of project: field expansion projects may cost 10–15% less than a Greenfield project, since investments have already been made in infrastructure and exploration, and valuable resource information has been learned from drilling and producing start-up wells (Goldstein, et al., 2011, p. 424).

Fixed operation and maintenance (O&M) for geothermal power plants accounts for around 26% of the total cost, higher than for non-renewable energy technology; and compared to renewable energy, the fixed O&M of a geothermal power plant is higher than only solar PV and hydroelectric. This is because geothermal power plants have specific O&M costs that depend on the quality and design of the plant, the characteristics of the resource, environmental regulations and the efficiency of the operator. The major factor affecting these costs is the extent of work-over and make-up well requirements; that is, new wells to replace failed wells and restore lost production or injection capacity, which can vary widely from field to field and typically increase with time (Goldstein, et al., 2011, p. 425).

Since geothermal resources are often located in remote areas, such as in the mountains, and because geothermal power plants must be placed near or above the geothermal resource, transmission also needs to be developed. According to the US Energy Information Administration (EIA, 2014) report, transmission investment accounts for USD 1.4 per MWh or 3% of the total cost, and depends on the location of the power plant, the length of transmission that needs to be developed or upgraded and land acquisition costs.

Table 7. Estimated levelised cost of electricity (LCOE), new generation resources, 2019

Plant Type	U.S. Average Levelised Costs (2012 USD/MWh) for Plants Entering Service in 2019				
	Levelised Capital Cost	**Fixed O&M**	**Variable O&M (Including Fuel)**	**Transmission Investment**	**Total System LCOE**
Conventional Coal	60.0	4.2	30.2	1.2	95.6
Integrated Coal-Gasification Combined Cycle (IGCC)	76.1	6.9	31.7	1.2	115.9
IGCC with CCS	97.8	9.8	38.6	1.2	147.4
Natural Gas-fired					
- Conventional Combined Cycle	14.3	1.7	49.1	1.2	66.3
- Advanced Combined Cycle	15.7	2.0	45.5	1.2	64.4
- Advanced CC with CCS	30.3	4.2	55.6	1.2	91.3
- Conventional Combustion Turbine	40.2	2.8	82.0	3.4	128.4
- Advanced Combustion Turbine	27.3	2.7	70.3	3.4	103.8
Advanced Nuclear	71.4	11.8	11.8	1.1	96.1
Geothermal	**34.2**	**12.2**	**0.0**	**1.4**	**47.9**
Biomass	47.4	14.5	39.5	1.2	102.6
Wind	64.1	13.0	0.0	3.2	80.3
Wind – Offshore	175.4	22.8	0.0	5.8	204.1
Solar PV[a]	114.5	11.4	0.0	4.1	130.0
Solar Thermal	195.0	42.1	0.0	6.0	243.1
Hydroelectric[b]	72.0	4.1	6.4	2.0	84.5

a Costs are expressed in terms of net AC power available to the grid for the installed capacity.

b As modelled, hydroelectric is assumed to have seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

Source: EIA, 2014.

Box 5: Does the electricity market model/design impact geothermal electricity development?

One of the questions that is always asked regarding geothermal electricity development is whether the existing electricity market model/design impacts the development of geothermal power plants. Based on the current assessment, there is no correlation between the electricity market model/design and geothermal electricity capacity growth, as shown in Table 8 below. For example, even though the electricity market in Indonesia is not yet open, in the past 10 years, the average annual growth of geothermal power plant capacity has been approximately 5.7%, while in New Zealand, where the electricity market is open, the average annual growth of geothermal power plant capacity can be as high as 10.1%. This is because geothermal power plants can compete on price with other power plants even though no price incentives are provided by the government. Thus, no matter what the electricity market model/design, geothermal power plants can be competitive, compared with other resources. However, it should be noted that most of the impact on geothermal electricity development derives from the extent and strength of government commitments to geothermal developers, rather than the market model/design. If there are other negative factors, such as regulatory obstacles, tariffs may need to increase to compensate for this situation.

Another factor that can influence geothermal electricity development is the establishment of a business model to manage the risks associated with initial exploration and drilling. The question of who will become a resource developer, a steam-field operator or a power plant developer is related to the business model.

If a private developer becomes the resource developer or steam-field operator, she or he may be able to accept the risk for drilling, but the total cost of development of the resource, including the risk, will be reflected in the overall power price later on. If a private developer becomes a power plant developer, she or he may find it easier to raise commercial finance (Lawless, 2014b). Geothermal electricity business models vary, economy by economy. In some economies (for example, Mexico), the government serves as the resource and power plant developer through its State-owned Enterprise (SOE), essentially taking all the risk. Elsewhere, the government becomes a resource developer or steam-field operator, and assumes all risk of exploration and drilling. Furthermore, after the resource potential has been confirmed, the government offers power plant development to the private developer or SOE (for example, in the Philippines, 1990–2008). Another common business model variant is when the government issues a long-term concession based on a private developer's commitment to complete all exploration, development and operation of the power plant in exchange for a fixed sales agreement and other financial incentives, an arrangement used in the United States; the Philippines; Indonesia; and Japan. In another model, the private developer shares the risk of the initial exploration and drilling by forming equity partnerships, joint ventures or other business agreements to share the cost and risks of searching for and discovering a geothermal resource, as well as developing the power plant, without financial incentives provided by the government, such as in New Zealand (Matek, 2014, p. 6).

However, the risk-sharing mechanism between the government and private developer is a favourable business model for geothermal electricity development where the government, through its SOE, serves as the resource developer and takes a resource risk, while a private developer becomes the power plant developer (builds and operates the power plant), as in the case of the Philippines during the period 1990–2008 (Lawless, 2014b).

Table 8. Electricity market model/design vs. geothermal power plant capacity

Economy	Generators	Price Incentives for Renewable?	Vertically Integrated?	Electricity Market	Annual Average Growth of Geothermal Power Plant Capacity (2004-2014)
United States	IPPS & Utilities	Yes	Mostly	Open	2.1%
The Philippines	IPPS & SOEs	No	Some	Open	-0.1%
Indonesia	IPPS & SOEs	No	Some	State Monopoly	5.7%
New Zealand	Mostly IPPs	No	Yes	Open	10.1%
Mexico	SOE	No	Yes	State Monopoly	-1.4%
Japan	Mostly Utilities	No	Mostly	Open	0.1%

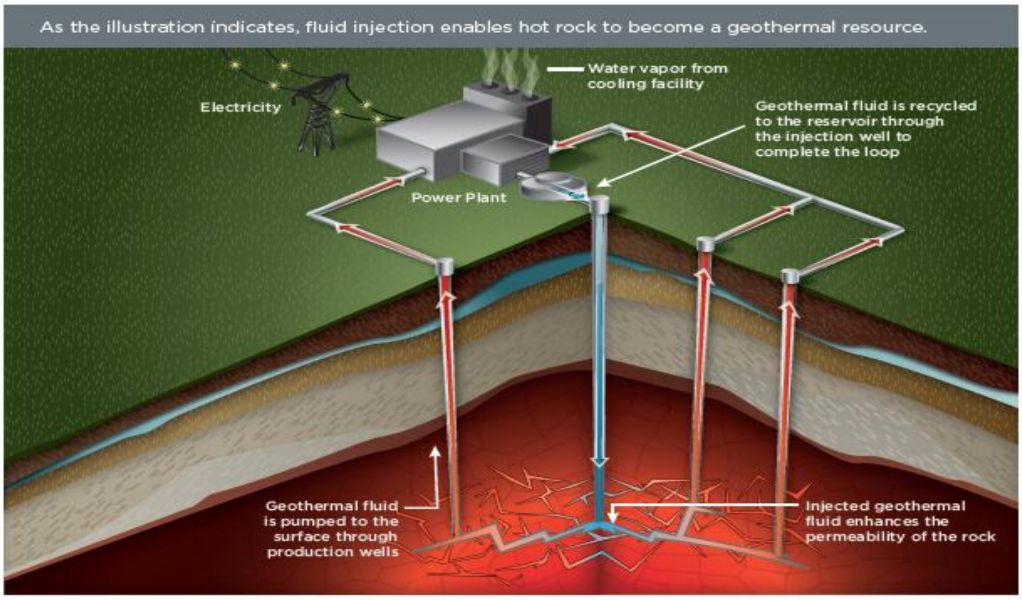
Source: Lawless, 2014, with some modification.

As mentioned above, there are currently three main types of technology for geothermal power plants that are commonly used—flash steam, dry steam and binary plants—with flash steam technology remaining the dominant type. Although each of these technologies allows energy to be tapped from hydrothermal resources, there is another geothermal resource type that can be used for producing electricity: hot rock, or EGS, resources. These resources are characterised by limited pore space and/or minor fractures. They therefore contain insufficient water and allow insufficient permeability for natural exploitation. Hot rock resources can be found anywhere in the world, although they are found closer to the surface in regions with an increased presence of naturally occurring radioactive isotopes (for example, in South Australia), or where tectonics have resulted in a favourable state of stress (for example, in the western US); the technology that allows energy to be tapped from hot rock resources is Enhanced (or Engineered) Geothermal Systems (EGS) (IEA, 2011, pp. 11–12).

EGS aim to use the heat of the earth where insufficient steam or hot water exists and where permeability is low. EGS technology is centred on engineering and creating large heat exchange areas in hot rock. The process involves enhancing permeability by opening pre-existing fractures and/or creating new fractures. Heat is extracted by pumping a transfer medium, typically water, down a borehole into the hot fractured rock and then pumping the heated fluid up another borehole to a power plant, after which it is pumped back down (re-circulated) to repeat the cycle. EGS can encompass everything from stimulation of pre-existing sites with insufficient permeability to developing new geothermal power plants in locations without geothermal fluids (IEA, 2011, p. 12).

The potential benefits of EGS include the fact that they emit little to no greenhouse gases. Since EGS plants use a closed-loop binary cycle power plant, they would have no greenhouse gas emissions other than the water vapour that may be used for cooling. In addition, EGS can facilitate geothermal development outside of traditional hydrothermal areas, thereby extending geothermal energy production worldwide (Nakagawa, 2014).

Figure 13. Enhanced geothermal system (EGS)



Source: GTO, 2014a.

Even though EGS have been under development since the first experiments of the 1970s, further work is needed to develop this technology to commercially viable levels. R&D support from the government will be necessary, especially to address the key challenges facing EGS development. These include the stimulation and maintenance of multiple reservoirs capable of producing sufficient fluid volumes to sustain long-term production at acceptable rates and flow impedances, while managing water losses and risks from induced seismicity (Goldstein, et al., 2011, p. 412).

In the APEC region, Australia; China; the Philippines; Japan; and the United States are the leading economies in the research and development of EGS by providing R&D funding. With the exception of the Philippines, these economies have already moved on to the next stage (testing), or in the case of Australia and the United States, to further stages (demonstration).

In Australia, the Habanero EGS pilot plant owned by Geodynamics Limited successfully generated 1 MW of electricity and operated for 160 days after its commissioning in 2013 (Geodynamics, 2014). In China, there are plans to test EGS in three regions where the geothermal gradient is high: in the northeast (volcanic rocks), the southwest (volcanic rocks) and the southeast (granite) (IEA, 2011, p. 12). In Japan, EGS projects have been carried out at Hijiori and Ogachi since 2003 at R&D power plants (Yanagisawa, 2011). In the United States, one example of a developing deep EGS project is Davenport Newberry Holdings LLC's Newberry Geothermal Project in Bend, Oregon, which is funded by USD 26 million from Google, Kleiner Perkins, Khosla Ventures and Vulcan Capital, as well as funds from the US Department of Energy (DOE). The Newberry project is still in the testing and research phase, but after this testing phase, AltaRock Energy (one of the companies who initiated this project along with Davenport Newberry) intends to build a demonstration power plant, and eventually a utility-scale power plant on-site (GEA, 2013a, p. 36). Currently, the US Department of Energy's Geothermal Technologies Office aims to secure the future for EGS by demonstrating 5 MW of reservoir creation by 2020 and by lowering the LCOE to USD 6 cents/kWh by 2030.

CHAPTER 3
NEEDS OF GEOTHERMAL DEVELOPERS: POLICIES FOR SUCCESSFUL GEOTHERMAL ELECTRICITY DEVELOPMENT

This chapter describes the needs of geothermal developers to avoid a failure or slowdown in the process of geothermal electricity development.

POLICY INFRASTRUCTURE

The development of geothermal electricity is a process that takes several years, even before a suitable power plant can be constructed and connected to the electricity grid, and before any revenue is realized by the investors or developers. Hence, before the investor or developer makes decisions about the development of a geothermal electricity project in one economy, they must study and assess the long-term policy infrastructures of the government to determine whether such infrastructures support their long-term business goals, activities and security needs. The particular policy aspects that are critical to assess within a particular economy at these preliminary stages of planning for geothermal electricity development are: legal basis, government strategy, government commitment to investors, and institutions.

- **Legal basis**

Legislation and/or regulations governing the development of geothermal electricity within the economy that wants it are critical, establishing the rights and limitations of geothermal electricity business activities regarding ownership of and access to the resource, permitting, environmental aspects and/or financial considerations (for example, rent, royalties, taxes, grants and loans). However, before the legal basis is established, the government must determine a clear definition of 'geothermal resources'. Different definitions of the resource can result in significantly different approaches in the legal framework regarding geothermal development and resource management, and in other cases it will determine the ownership of geothermal resources.

Difficult situations can arise in terms of ownership, if ownership of the land's surface rights is different from ownership of the underground geothermal resources, or if the geothermal resource is located on private land and the geothermal developer is not the landowner. In this case, the legal framework must provide clarity and certainty for all parties, those owning the resource, those owning the surface rights and the developers. In addition, legislation and/or regulations governing the development of geothermal electricity must be in harmony with other legal provisions, such as environmental or forestry regulations.

The expectation of the developer in this regard is that the legislation and/or regulations governing the development of geothermal electricity are established with clarity, and that such regulations should be harmonised with other related regulations, to give legal and business certainty to the investor or developer for the long-term. Without legal or regulatory clarity and certainty, the investor or developer will view the risk as high, potentially discouraging them from investing in or developing geothermal electricity in that economy.

- **Government strategy**

One factor that will be attractive to the investor or developer in making the decision to invest in or develop geothermal electricity is how serious the government is with regard to promoting its development within a particular economy. The seriousness of the government can be observed through a well-defined strategy consisting of policies and programs to be taken or implemented. The more positive the impact of the strategy on geothermal business activities, the more confidence the investor and developer will have to invest in or develop geothermal electricity in that economy, especially if there is an effort from the government to mitigate the high risk of the developer.

Some economies have established specific targets regarding geothermal electricity development to be achieved within a certain timeframe, either as a percentage of geothermal share in the power mix, or an amount of capacity to be developed. Such targets could be viewed as a positive indicator by investors and developers, as long as the government can further describe the implementation of this target in its policies, regulations and programs.

- **Government commitment to investors**

Once the legal basis has been established with clarity and certainty, and a well-defined strategy has been established by the government, the next level of scrutiny by investors and developers focuses on the government's commitment to investors. Even if the government has a sound legal basis and strategy to promote the development of geothermal electricity, if in the past the government has been inconsistent in keeping its commitments to investors, this will be viewed as increasing the country's risk rating. As a result, it could make it difficult for the developer to raise the investment funds from private investors or multilateral funding agencies. Even if the investors are willing to consider making investments in or developing geothermal electricity in that economy, they may insist on the means to recover a risk premium, such as through a higher electricity selling price. Alternatively, they may request a government guarantee to secure their business activities.

Inconsistency by the government in keeping commitments to investors will in practice also slow the progress of geothermal electricity development in the future. Thus, keeping previous commitments to existing geothermal developers is of high importance for the continuing development of geothermal electricity.

- **Institutions**

Given a clear and certain legal basis, a well-defined strategy and assurances of government commitment to investors, the next factor assessed by investors and developers of geothermal resources is the institutional framework for geothermal policy and regulation.

To implement the legal basis and strategy for developing geothermal resources, it is ideal for a specific institution to have lead responsibility for geothermal policy and regulation. However, since geothermal resource development has multiple impacts, in many economies, multiple institutions will be involved in regulating geothermal electricity development (for example, State government, local government, environment agency, land agency, forestry agency and electricity regulator). The problem for the developer occurs when each institution has its own administrative rules and permitting requirements that overlap with other institutions without effective coordination among them. This situation can be a special deterrent for developers or investors, if some of these institutions have inadequate institutional capacity for dealing with geothermal development, such as poorly executed programs (in the planning or procurement process, for example) or a lack of trained staff.

Although a specific institution with lead responsibility for geothermal policy and regulation is preferred, the more important factor for the developer is the capacity of the institutional framework itself, and the harmonisation between the institutions involved.

After assessing the long-term policy infrastructure, another important factor observed by the developer is access to the resource. Issues to be addressed by the government in terms of geothermal resources are: access to geothermal resources and secure, exclusive rights to the resources.

- **Access to geothermal resources**

Questions asked by geothermal developers regarding geothermal resources are: Who legally owns the geothermal resources? How can they (the developers) access geothermal resources? Who can conduct pre-feasibility, exploration and exploitation of resources (can foreigners, for example?)? Answers to these questions are critical to the developer before she or he can proceed to develop geothermal resources, as they clarify how the developer can participate in geothermal business activities in a particular economy, as well as how to deal with third parties, later. All such information in answer to these questions, therefore, should be written with clarity and certainty in the legislation and/or regulations.

The access regime to geothermal resources at the pre-investment stage should be open to all developers on a competitive basis with reasonably simple procedures. The mechanism and procedures to access resources should be easy to access. For example, it is useful for information to be accessible through websites offered in the English language while the criteria used to evaluate or assess the applications of developers must be transparent.

In addition, since access to geothermal resources typically requires the developer to deal with many institutions that have their own administrative rules and permitting requirements, and sometimes also with many different landowners, it is helpful to the developer if the government has already identified the parties that will be involved, and assimilated the requirements that need to be fulfilled by the developer into a single procedure with consolidated guidelines.

- **Secure and exclusive rights to resources**

Other important questions the developer needs answered by the government are: If they have already invested their money in the geothermal project, how long will they have secure and exclusive rights to the resources? Are there regulations to prohibit competitors from using the same resources or to control the situation if competition is allowed?

As mentioned in Chapter 1, during the exploration and drilling phases, which might take five to seven years and during which a significant amount of money has been invested, the developer cannot generate a return on investment until a suitable power plant has been constructed and connected to the power grid. Therefore, to repay this investment and earn an adequate return, the developer expects to have secure and exclusive rights to the resource. These rights are typically ensured through issuing licences with a suitably long duration. Common licensing practice allows for 20 to 35 years of commercial production. In addition, if the geothermal resource continues to be commercially produced and used at the end of the initial licence term, the licensing rules should also consider providing for extension of the licence to the developer, with clear and transparent evaluation criteria for the decision to extend or terminate the licence.

To avoid other developers using the same resources in the same area, a situation that could lead to resource depletion and/or downgrade the capacity of the power plant or halt its operation, a developer expects that under his or her licence, there will be protection against other users of the resources. Therefore, regarding secure and exclusive rights to the resource, developers expect that the licence will be able to protect their project in a specific area with a sufficient timeframe for maintaining their business.

Obtaining the proper permits is one of the biggest challenges for geothermal developers. Permitting is a time-consuming process, which can often cause delays in projects. Therefore, the issues that need to be addressed by the government related to environmental and other development permitting are: permitting time limits, one-stop permitting and inter-agency cooperation.

- **Permitting time limits**

With many different institutions involved, and each institution having its own administrative rules with sometimes inadequate information on what is expected, developers face additional costs. These may include costs for legal fees, licence fees, documents, consultations, public hearings and so on that must be covered by the developer. (These costs have been estimated to be about 1% of the total cost of a geothermal project (KPMG, 2014) and because of the effect of delays may have much more than 1% impact on the total cost of the project (Lawless, 2015).) Perhaps more seriously, however, these procedures may delay the project, thereby adding to the time the developer must wait before beginning to recover investment in the project. The situation is exacerbated if each institution does not have reasonable time limits within which permitting decisions must be reached. In effect, the slowest institution determines the pace of the project.

Regarding the permitting process, the developer would expect the government to provide economy-wide guidelines for geothermal permitting, consolidating information on the many related licences from different institutions, into one single source of information. The guidelines should specify reasonable time limits within which permitting decisions must be reached by each institution. Such guidelines should be streamlined, with a clear list of criteria against which the application for licensing will be evaluated, to avoid overlapping and overly demanding requests from institutions, as well as cutting down on lengthy procedures. It would be very helpful and useful for geothermal developers if such national geothermal guidelines for permitting were displayed on official government websites, with English language available.

- **'One-stop permitting'**

As mentioned above, with many different institutions involved, and various legal frameworks in place, developers face a difficult and time-consuming effort to understand the licensing process as a complete picture. Even though it is helpful and useful for the developer if the government has national geothermal guidelines for permitting, to obtain various licences, the developer still needs to spend her or his time dealing with the requirements and procedures of a number of different institutions. As a result, the process is time consuming, and increases the expenses to the developer.

To provide developers with a more convenient and effective permitting process, 'one-stop permitting' could be established. Under 'one-stop permitting', all developers' applications would be received and checked for conformity with various related legislation with geothermal and other agencies' requirements. During the application check, if a document required completion by the developer, the developer would not necessarily have to go to another agency. Geothermal permitting and other related permitting would be processed, coordinated with other agencies and issued through 'one-stop permitting', with reasonable time limits for each step. In this case, the developer would not need to go to other agencies, saving time and extra expense. Moreover, the 'one-stop permitting' could also have the task of monitoring the licences.

- **Inter-agency cooperation**

With many different institutions involved in developing geothermal electricity, each with its respective administrative rules and permitting requirements based on its own legislation, potential duplication of responsibilities and authorities and sometimes policy conflicts might result, especially if there is a lack of coordination between governmental agencies and at all levels of government. If this situation cannot be solved by the government, it acts as a deterrent to investors or developers to develop geothermal electricity and/or results in a delay of the project.

Developers expect adequate coordination between governmental agencies and at all levels of government, to avoid duplication of responsibilities and authorities as well as policy conflicts. Such inter-agency coordination should not only attract more participation of investors or developers to develop geothermal electricity by easing the licensing procedures or streamlining the process of permitting and/or providing other government support, and also by solving the backlog that could occur during the development of the geothermal project (for example, in licensing, land acquisition, transmission issues and so on).

GOVERNMENT SUPPORT FOR THE GEOTHERMAL INDUSTRY

Again, one of the biggest challenges for geothermal electricity developers is not knowing the size and quality of the geothermal fluids or steam that can be extracted from underground resources before drilling activities are carried out. Moreover, the exploration and drilling phases typically require several years, during which a significant financial commitment needs to be made by the developer before the characteristics of the resource can be fully known. (The total drilling costs might be 35–40% of the total project cost.) During these phases, the developer cannot generate a return on investment. That starts only when a suitable power plant has been constructed and connected to the electrical grid. Therefore, geothermal electricity projects are high risk, and require significant expenditure to meet capital costs in the initial stages. Without support from the government to reduce this risk, it might be difficult for developers to initiate their projects. The support that is needed from the government includes providing relevant databases, R&D, human resources development (HRD) and financial incentives.

- **Database**

If a database regarding the geothermal resource potential (for example, geological, hydrological, thermal and drilling data) has been compiled by the government, the developer can use the information to pre-analyse possible geothermal reservoir locations (that is, estimate the size and quality of the geothermal fluids or steam that can be extracted from an underground resource), and then to identify further activities that need to be conducted to fill the data gaps. Thus, government databases can not only avoid duplicating activities and analyses that would otherwise need to be made by the developer, but could also lower the risk and cost to the developer in the initial stages. As information is a ‘public good’, the benefits of which can be enjoyed by many users at about the same cost as for one user, it is very appropriate for the government to assume an information provider role for the geothermal industry.

Thus, regarding databases, developers expect the government to compile and maintain relevant, high-quality databases on geothermal resource potential (for example, geological, hydrological, thermal and drilling data). This information should be made easily obtainable through official government websites, with English language available (to allow participation from abroad). Moreover, in order to complete a credible resource assessment, it is desirable to use independent verification consultants and/or to follow a standard for resource certification procedures to encourage investors or developers to develop geothermal electricity. (An International Standard for Resources Certification is still in the preparation stage (Lawless, 2014a).)

- **Research and development**

One of the key contributors to the successful development of geothermal electricity since the first use of geothermal electricity by Prince Gionori Conti between 1904 and 1905 has been R&D. As a result of R&D, the technology to develop geothermal electricity generation is continuously improving and evolving. However, even though the engineering technology for exploration and drilling have been improved significantly, the exploration and drilling phases remain an enormous challenge for developers of geothermal electricity (in terms of high risk and high capital outlay) and ultimately economics will be the limiting factor, not technology.

Regarding R&D of geothermal electricity, developers expect governments to implement policies that encourage and support the improvement of geothermal electricity by providing adequate funding for geothermal R&D on a continuous basis. Like information, R&D is a 'public good', generally viewed by economists as appropriate for government funding. The funding for R&D is necessary not only to lower the costs of existing technologies (for example, exploration sensing technology, drilling technology, reservoir technology and power plant efficiency), but also for the development of emerging technologies (for example, EGS) or future technologies (for example, submarine geothermal generation).

- **Human resources development**

As explained in Chapter 1, geothermal electricity projects create a variety of jobs throughout their lifecycles from many relevant disciplines, including for archaeologists, hydrologists, wildlife biologists, geologists, geochemists, geophysicists, GIS specialists, exploration drillers, engineers, sample analysts, consultants, management staff, rig hands, site managers, mud loggers, drilling fluids personnel and so on These jobs require many well-trained personnel in the community in which the geothermal electricity project is located, both at the economy and regional levels. Problems occur for geothermal developers when a sufficient supply of well-trained personnel is not provided by the economy where the project is located, triggering a difficult situation. If developers want to maintain a timely schedule, they might hire well-trained personnel from outside of the economy, increasing the cost of the personnel budget and the total cost of investment; or, if they want to wait until the economy can provide well-trained personnel or if they want to train their own personnel, the project may be delayed, which could also increase the total cost of the investment. In many cases, this situation may be viewed by investors or developers as a deterrent to developing geothermal electricity.

Regarding HRD, developers expect the government to establish professional training programs related to geothermal resources at universities and other institutions to provide trained geothermal personnel of sufficient quality and quantity to meet the developers' needs. Once the government commits to developing geothermal electricity within its borders, HRD should be an integral part of this plan. The professional training programs established by the government should be large enough to meet the requirements of developers on a continuing basis. Education, including professional training, is widely viewed by economists as having broad social benefits, and thus is appropriate for government funding.

- **Financial incentives**

As mentioned earlier, one of the biggest challenges for geothermal electricity developers is the exploration and drilling phase, in which the risk is high, and there are high upfront investment costs and long lead times. Since the risk at the initial stages is high, most geothermal developers have difficulty borrowing from banks. In earlier times, if half of the wells were successfully drilled, developers could obtain a bank loan to complete the project. Today, however, commercial banks often want developers to drill 100% of the wells by themselves, and perhaps invest a little more, before they will lend money to complete the project (Lawless, 2014a). The changing requirements of the banks has become an important consideration in developers' decisions to develop geothermal electricity. Multi-lateral agencies may accept lower thresholds, but will still require a substantial proportion of the drilling to be funded from equity (Lawless, 2014a).

Without financial incentives from the government in the exploration and drilling phases, developers might decide to develop geothermal electricity projects at their own risk. (With no chance of obtaining debt finance from banks, they might secure the money either through self-financing or an equity partnership with other parties.) However, all the developers' risks and costs will ultimately be reflected in the overall power price later.

The expectations of developers in this area are that the government will provide financial incentives for geothermal electricity development reflective of its environmental benefit. Environmental benefit means that both the early (that is, phases 1 to 5) and late (that is, phases 6 and 7) development stages of financial incentives should be covered. On the upstream side of the geothermal electricity project, incentives can reduce the risk and high investment costs at the initial stages by providing various schemes of subsidy and/or fiscal incentives; at the late development stage, they can construct and maintain continuity in the operation of power plants by providing various schemes of geothermal energy price incentives. For example, in Indonesia, the government established a new ceiling price mechanism in 2014 where PLN (the State-owned electricity company) must purchase geothermal power from the lowest bidder. However, the developer's cost estimates for power plant construction in the tendering process may have changed significantly—whether due to changes in market conditions for imported equipment or inflation since the project may only start operation six to eight years in the future (ADB and World Bank, 2015, p. 18). To address this issue, the government provides a policy on escalation of ceiling price only after developers have the completed the exploration and feasibility study phases (ESDM, 2014a).

ACCESS TO THE ELECTRICITY MARKET

As mentioned previously, in developing geothermal electricity projects, developers cannot generate a return on investment until a suitable power plant has been constructed and connected to the electricity grid. Therefore, the next issues that need to be considered by geothermal electricity developers are transmission network development and electricity sales contracting.

- **Transmission network**

In order to sell power from a geothermal power plant to the off-taker or buyer, access to a transmission network is key for geothermal developers or producers. As many geothermal power plants are located in remote areas near the resources, such as in the mountains, a transmission network is needed to transmit power to the load centres.

Access to a transmission network could be an issue for geothermal developers or producers, especially when the companies that develop geothermal energy are different from the company that operates the transmission network (which is usually the case). Without clear information regarding transmission connection procedures (for example, nearby transmission capacity and characteristics, standards and criteria for access, transmission fees and so on) provided by the transmission company or operator, developers would be deterred from proceeding with plans to develop geothermal electricity.

Regarding the transmission network, geothermal developers or producers expect governments to provide policies or regulations to ensure that access to the transmission network service is provided in a fair and transparent manner for all players without discriminatory treatment. To implement this goal, the government should ask the electricity regulators and transmission companies/providers to establish and make public their standard rules for transmission connections, with simple procedures and reasonable time limits for the approval of a connection and guidelines on land acquisition if this is to be done by the developer.

- **Electricity sales contracting**

Other important questions of geothermal developers or investors regard electricity sales contracting: Who can they sell their power to? How will the power be priced? How long does the Power Purchase Agreement (PPA) period last? The responses are very important to developers before they can consider whether to develop geothermal resources.

The situation regarding electricity sales contracting is very different in economies depending on their electricity market situation (that is, open/competition or not open/monopoly). In the monopoly electricity market, the geothermal producer mainly sells geothermal power to the electricity utility through PPA for some years with the price set by the government (that is, in Indonesia and some States in the United States). While in the competition electricity market, the geothermal producer may sell their geothermal power either to the electricity utility, retailer or consumer under PPA for some years at a price set based on negotiation or selling their geothermal power to the electricity wholesale at a price set by the market (that is, in New Zealand, the Philippines and some States in the United States).

By identifying potential buyers, developers can gauge the size of market penetration for their product, which can significantly influence power prices. Regarding power prices, developers and investors are always concerned that their revenue will cover the investment cost that they have made, or whether it will be less than expected due to an unreasonably set power price with a short Power Purchase Agreement (PPA) term.

Whatever the electricity market situation that is applied, geothermal developers or producers expect the government to implement policies or regulations to ensure that they can enter into long-term contracts for sales of geothermal electricity at a reasonable price and with clearly defined escalation factors.

Box 6: Geothermal developers' needs

- **Policy infrastructure**
  - Clear and certain legislation and/or regulations that are harmonised with other related regulations (legal basis);
  - A well-defined strategy for promoting geothermal electricity development, including strategies to mitigate the high risk of the developer (government strategy);
  - History of government keeping its commitment to investors (government commitment to investors); and
  - Adequate institutional capacity for policy and regulation (institutions).
- **Access to the resource**
  - Open and competitive bases for accessing geothermal resources for all players, with reasonably simple procedure (access to geothermal resources); and
  - Appropriately secure and exclusive access to the resources in which investors have made an investment (secure and preferably exclusive rights to resources).
- **Environmental and other development permitting**
  - Reasonable timeframes for permitting (permitting time limits);
  - Coordination of all aspects of permitting in one office ('one-stop permitting'); and
  - Coordination among governmental agencies at all levels (inter-agency cooperation).

- **Government support for the geothermal industry**
    - A good quality public database (database);
    - Adequate funding for R&D, provided continuously by the government (R&D);
    - Sufficient professional personnel, in quality and quantity (HRD); and
    - Financial incentives provided by the government that reflect the environmental benefits of geothermal development (financial incentives).
- **Access to the electricity market**
    - Streamlined procedures to access transmission networks without discrimination (transmission network); and
    - Long-term contracts for electricity pricing with reasonable price structures (electricity sales contracting).

Box 7: Assessing APEC economies, determining the scorecard

The scorecard described here will be used to assess the six APEC economies that have already developed geothermal electricity over the last several years: the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan. Since Chinese Taipei has not had a commercially-operated geothermal power plant, and has, instead, only had a demonstration plant and pilot plant, the scorecard does not include this economy. However, the current development of geothermal electricity in Chinese Taipei will be described separately in Box 10 as additional information.

The basic concept of the scorecard is simple. It compares developer needs or expectations (see Box 6 above) with the current government public policies on geothermal electricity in each respective economy. To make comparisons among the issues, 'a bar chart' is used, with a scale from '0 (zero)' to '5 (five)', with the following explanation:

1	**2**	**3**	**4**	**5**

- 5 bars (or green colour) indicates that the economy's public policy on geothermal electricity meets the expectations of developers in most respects.
- 4 bars (or yellow colour) indicates that the economy's public policy on geothermal electricity meets the expectations of developers in some respects.
- 0–3 bars (or red colour) indicates that the economy's public policy on geothermal electricity does not currently meet the expectations of developers; there is room for improvement.

Chapter 4
Public Policies on Geothermal Electricity Development in the APEC Region

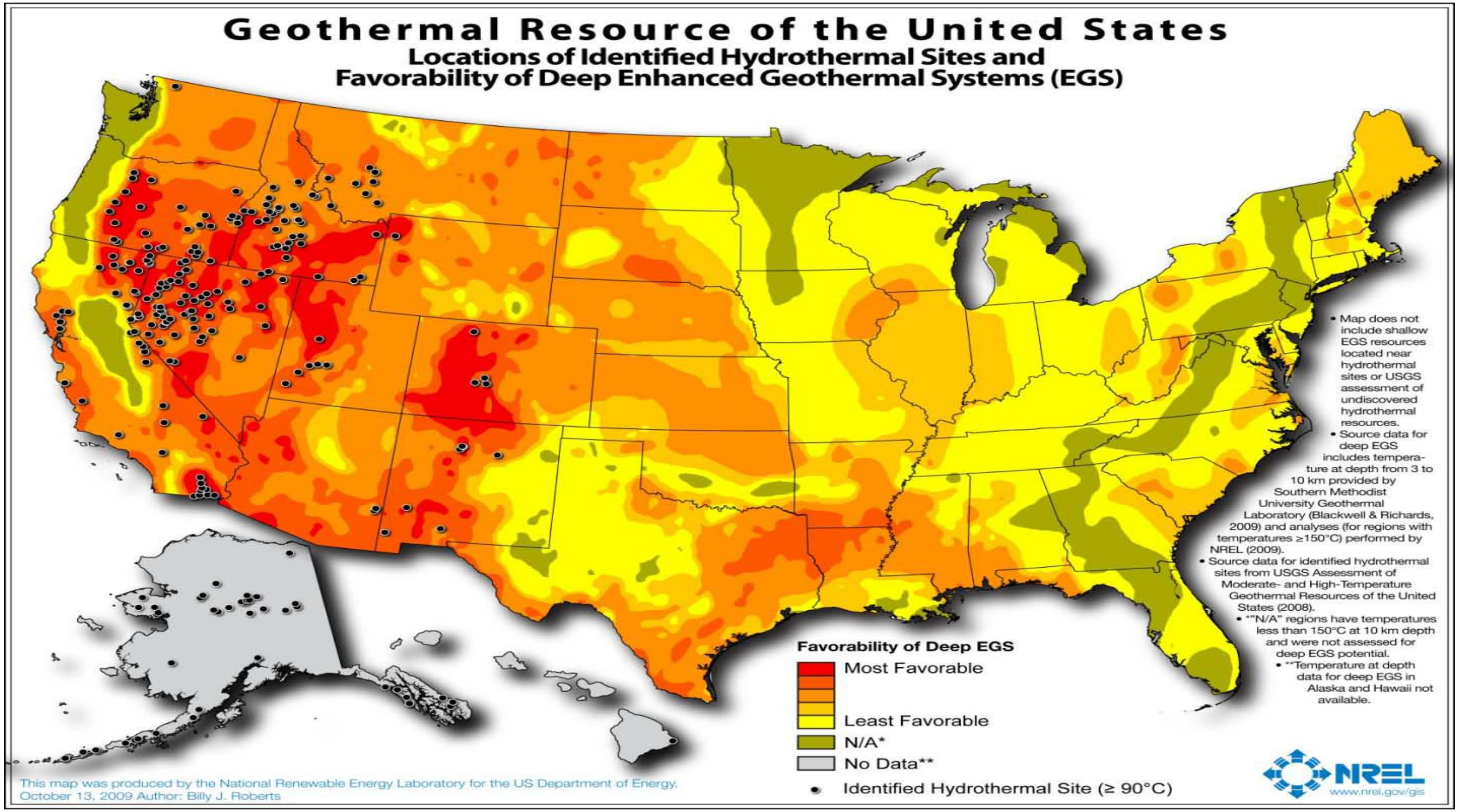
Six of APEC's 21 economies (the United States; the Philippines; Indonesia; New Zealand; Mexico; and Japan) have developed 100 to 1000 MW of geothermal electricity over many years. The experiences of these economies can assist with an assessment of the public policy behind their achievement with regard to the 15 sub-key factors. The situation in Chinese Taipei, which plans to re-start its geothermal electricity program after many years of closure, will be explained in a separate box as additional information.

THE UNITED STATES

The United States has a long history of geothermal electricity development compared to other APEC member economies, beginning with its first geothermal power plant, with a capacity of 250 KW that began operation in 1922 at The Geysers, in California. After 38 years of R&D, the first large-scale geothermal power plant was successfully operated in 1960 by Pacific Gas & Electric at The Geysers, with a capacity of 11 MW. Since most of the highest quality geothermal resources are located in the western part of the economy, most geothermal plants have been developed in the western States (California, Nevada, Utah, Hawaii, Oregon, Idaho, Alaska and Wyoming). Other western States, such as Arizona, Colorado, North Dakota, New Mexico and Texas, have plans to develop their first geothermal power plants in the near future. The eastern States, which are least favourable in terms of geothermal resources, do not yet have plans to develop geothermal electricity.

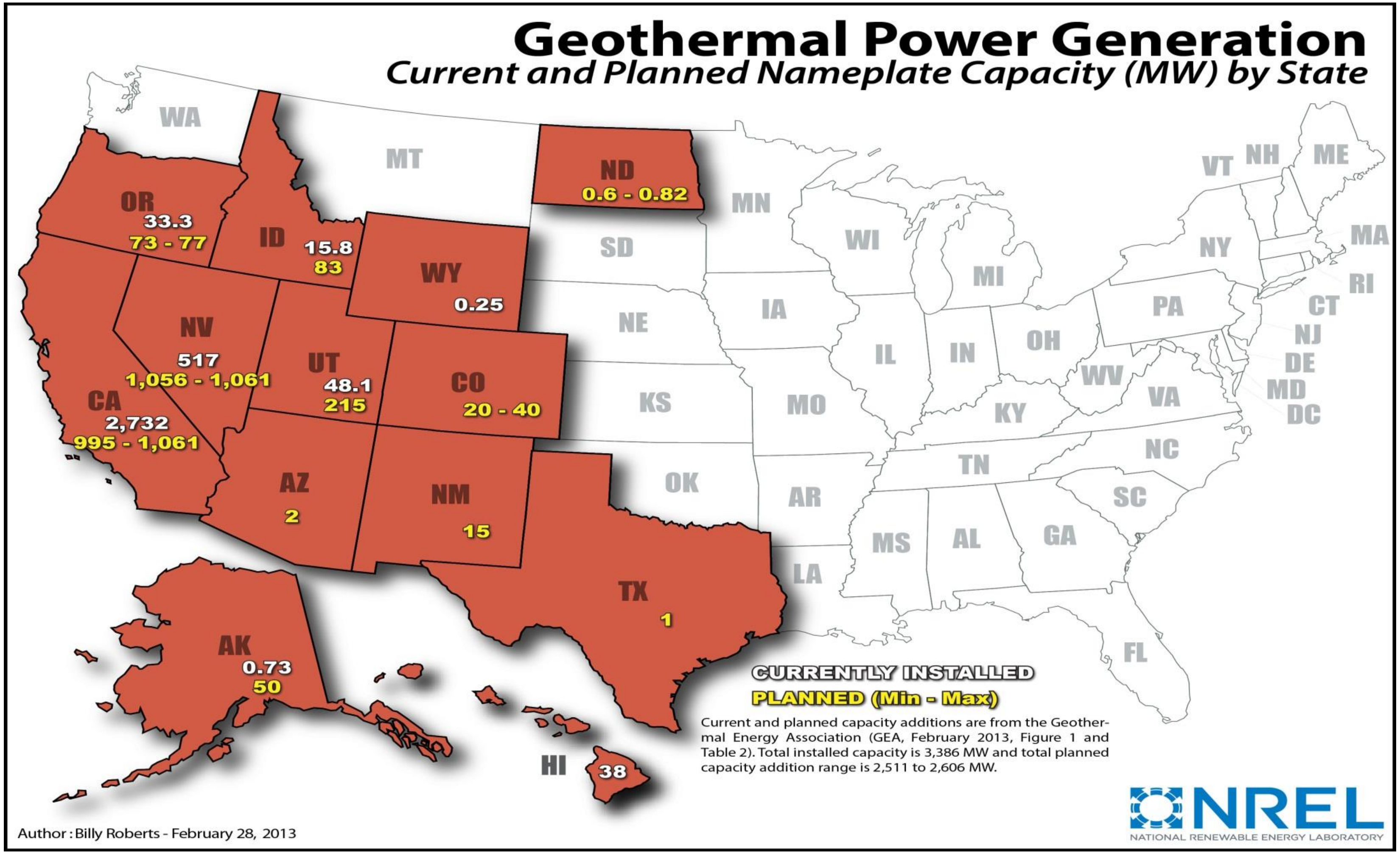
As of 2014, the US geothermal installed capacity was approximately 3525 MW, giving the economy the largest installed geothermal capacity in the world (BP, 2015). In terms of States, California is the State with the greatest geothermal installed capacity, accounting for approximately 81% of the total, followed by Nevada (15%) and Utah (1%) (GEA, 2013a, p. 7). However, in the past 10 years (2004–2014), the annual growth rate of geothermal installed capacity in the US has been low, at 2.1%.

Figure 14. Geothermal resources, United States



Source: NREL, 2011.

Figure 15. Geothermal installed and planned capacity by State, United States



Source: NREL, 2014.

Legal basis

To encourage expansion of the development of geothermal energy, the California State Government enacted the California Geothermal Resources Act in 1967 as the legal basis for developing geothermal electricity in the State. Following this, the federal government passed the Geothermal Steam Act in 1970 (amended in 1988) as the legal basis for developing geothermal electricity on federal lands. Approximately 90% of geothermal resources in the United States are located on federal lands, particularly those within eastern Oregon, western Utah and Idaho, and much of Nevada and California (Fish, 2009, chapter 1, p. 1). Other western States have followed suit over the years, enacting their own geothermal legislation.

These first two acts addressed both legal issues (for example, permitting, environmental, ownership of resource and access) and financial issues (for example, rent/lease, royalties, taxes, grants and loans). They have successfully provided a legal basis to encourage the development of geothermal electricity on public lands not only in California, but also in other States in the western US. The leasing mechanism on federal lands under the Geothermal Steam Act in 1970 has opened large areas of the western US to geothermal electricity development. As a result, over 40% (1500 MW) of US geothermal power plants are currently on public lands (BLM, 2014a).

However, these two acts did not clearly determine the ownership of geothermal resources. After court cases in which the courts decided that geothermal resources are mineral in nature and belong to the mineral estate, the federal government in 1977 and the State of California in 1981 claimed geothermal ownership wherever it held the mineral estate (Lund and Bloomquist, 2012, p. 2). However, ownership consistent with the Geothermal Steam Act of 1970 has not been adopted by all States, particularly when geothermal resources are not located on federal land, and some States have their own specific definition of geothermal resources in their acts, as shown in Table 9.

Table 9. Geothermal resources, definition by State

Definition	State
Mineral Resources	Federal, CA, HI, NM, TX and NV (if only used for heat content—classified as water otherwise)
Water Resources	AK, CO, SD, UT and WY
Sui Generis, that is, unique in itself	ID, MT (governed by groundwater law) and WA (direct-use as ground water)
Water of Mineral	OR
Heat	ND
Steam, Hot Water, Heat or Mineral	AZ

Source: Lund and Bloomquist, 2012.

Therefore, in the United States, geothermal resources are owned not only by the federal government but also by each State government, private owners and Indian tribes. Special attention is necessary if geothermal resources are located on private land, as sometimes the private landowner may not own the subsurface resource, and conflict can occur when one entity owns the surface rights while another owns the subsurface rights.

Other regulations that need to be followed by the developer include the National Environmental Policy Act (NEPA) of 1969, the Energy Security Act of 2005 (EPAct), the Energy Independence and Security Act of 2007 (EISA) and other State regulations. Both EPAct and EISA promote an increased role for geothermal energy in the US's national energy portfolio, and both provide tax incentives to encourage geothermal development, as well as funding from the US Department of Energy (DOE) to invest in research, development and demonstration (RD&D) for future EGS production.

Government strategy

The big promotion of geothermal electricity development in the US occurred in the 1970s, after the first oil crisis. To support the development of geothermal electricity, two strategies were implemented by the federal government and western States governments: (1) a program to reduce the risk to geothermal developers in the early stages by providing research data on the geology and geothermal resources to developers, cost sharing in geothermal fields and fiscal incentives; and (2) a program to increase the ability of the developer to raise capital for geothermal projects through the provision of loans, loan guarantees, grants and the Renewable Portfolio Standard (RPS) scheme.

As part of the effort to reduce the risk to geothermal developers in the early stages of development, the United States Geological Survey has conducted several geological surveys since 1975 to assess geothermal resource potential and characteristics in the US with federal government funding. Through these activities, favourable areas for discovery and development have been identified, and this information has been published through circulars that can be used by developers to evaluate the prospects of geothermal projects. In addition, under the User Coupled Confirmation Drilling Program (UCDP), which was initiated in 1980, the federal government has absorbed a portion of the risk associated with the confirmation of hydrothermal resources in the initial stages (for example, drilling and flow testing, reservoir engineering and drilling of injection wells) through cost sharing (20% if successful and 90% if not) (Lund and Bloomquist, 2012, p. 5). Moreover, some fiscal incentives are provided by the federal government, such as Investment Tax Credits (1978), which provide for deduction of intangible drilling costs and allow for percentage reservoir depletion allowances (the percentage of gross income deductible for depletion, declining from 22% in 1978 to 15% for 1984 and the years thereafter); the Public Utilities Regulatory Policy Act of 1978 (PURPA) obligated utilities to purchase the output of geothermal power plants owned by non-utility companies at their avoided cost of generation; and the Federal Production Tax Credit, providing USD 1.8 cents per kWh of tax credit for five years (recently increased to USD 2.0 cents per kWh, valid for geothermal in 2004 on a limited basis and 2005 on a full basis) (Lund and Bloomquist, 2012, pp. 3–4).

To increase the ability of the developer to raise capital for geothermal projects, the federal government provided several loan programs, such as loans for conducting feasibility studies, reservoir confirmation and construction. In addition, under the Geothermal Loan Guarantee Program, initiated in 1975, loan guarantees for up to 75% of project costs, with the federal government guaranteeing up to 100% of the amount borrowed, were also provided to developers. This program was amended in 1980, to allow for the granting of loans of up to 90% of the total aggregate project cost, provided that the applicant was an electric, housing or other cooperative or municipality. In an effort to promote the development of advanced geothermal technology and to lower costs and barriers to market entry for geothermal development, the federal government also allocated almost USD 400 million in funding as grants and/or cooperative agreements for eligible developers in 2009, under the American Recovery and Reinvestment Act (ARRA). Moreover, to assist potential geothermal developers who had little or no expertise in the geothermal field, the federal government established DOE's Technical Assistance Grant Program (Lund and Bloomquist, 2012, p. 4, p. 6). The Renewable Portfolio Standards (RPS), initiated by State governments in the 1990s, are also one of the success factors in developing geothermal electricity in the western US (for example, California). The RPS sets targets for renewable energy in the portfolio of electricity resources for a State, and obligates retail electricity suppliers to obtain a minimum amount of their electricity supply from eligible renewable sources, such as geothermal resources.

In the future, geothermal electricity will play more of a key role in efforts to provide electricity to consumers in the US, as President Barack Obama has set an ambitious goal to double renewable electricity generation by 2020, including geothermal. To realise this target, specific strategies were launched, such as a plan to issue permits for 10 GW of renewables on public lands by the end of the year 2012. This was achieved by the Department of the Interior ahead of schedule, so the President ordered permit issuance for an additional 10 GW by 2020. As the single largest consumer of energy in the US, the Department of Defense has committed to deploying 3 GW of renewable energy on military installations, including geothermal, by 2025.

Government commitment to investors

The US is one of the most stable democratic countries in the world, and was ranked seventh out of 189 economies in the World Bank's 2015 'Ease of Doing Business Rankings', and 25th of 189 economies in the subcategory 'Protecting Minority Investors'[9] (World Bank, 2015).

Regarding specific commitments to geothermal investors, the US Government has shown a reliable commitment to geothermal investors from the beginning by consistently implementing programs to reduce the risk to geothermal developers in the early stages and increasing the ability of the developer to raise capital for geothermal projects since 1970 as mentioned above.

Institutions

As mentioned earlier, the owners of geothermal resources in the US are the federal government, State governments, private owners and Indian tribes. Geothermal resources are found mostly on federal lands, where the Bureau of Land Management (BLM), an agency of the US Department of the Interior (DOI), is the lead agency dealing with geothermal development. Its role encompasses leases on federal lands, as well as reviewing and approving permits and licences that authorise developers to explore, develop and produce geothermal energy. In addition, during the approval process, the BLM works closely with local communities, States, industry and other federal agencies (for example, the US Forest Service and the US Environmental Protection Agency) to ensure the developer's proposal meets all applicable environmental laws and other regulations. After a project is approved, the BLM ensures the compliance of the developers with use authorisation requirements and regulations. Although the Bureau of Indian Affairs issues mineral leases on Indian lands, the BLM approves and supervises mineral operations on these lands. In addition, the BLM takes part in a Cabinet-level working group that is developing a coordinated federal permitting process for siting new transmission projects that would cross public, State and private lands (BLM, 2014b).

State agencies in the US are also key players in geothermal development, particularly when the geothermal resource is located on State land, private lands and when State law requires permitting by State agencies, even if the resource is located on federal land. However, since every State can classify geothermal resources in a different way, each has different agencies to regulate its geothermal resources, depending on its classification (Battocletti, et al., 2005, pp. 9–10).

Other US agencies that have key roles with regard to geothermal resource development are:

- The Department of Energy (DOE) – The Geothermal Technologies Program (GTP) has the strategic mission to support RD&D in technologies for geothermal resource extraction through scientific discovery, clean energy deployment, green job creation and environmental responsibility.

[9] *Doing Business* measures the protection of minority investors from conflicts of interest through one set of indicators and shareholders' rights in corporate governance through another and the scores are ranked. The lowest ranked economy shows the strongest legal protection of minority investors. This may increase the confidence of investors in markets, making them more likely to invest. More information: https://openknowledge.worldbank.org/bitstream/handle/10986/20483/DB15-Full-Report.pdf?sequence=1

- The United States Geological Survey (USGS) is a scientific agency within the DOI that provides impartial information on the health of the nation's ecosystems and environment, natural hazards, resources and the impact of climate and land-use changes. Within the USGS, the Energy Resources Program provides reliable and impartial scientific information on a wide range of geologically based energy resources, including geothermal resources (GTP, 2011, p. 13).
- The US Forest Service (USFS) is an agency of the US Department of Agriculture (DOA) that administers approximately 193 million acres of the nation's national forests and grasslands. The USFS works closely with the BLM on leasing decisions, including those related to geothermal energy projects. This includes providing consent to lease and serving as the lead agency for leasing availability analyses and decisions. The USFS worked with the BLM to develop Geothermal Resources Leasing Programmatic Environmental Impact Statements (PEIS) to analyse and expedite the leasing of its administered lands with high potential for geothermal resources in 11 western States, including Alaska (GTP, 2011, p. 14).
- The US Environmental Protection Agency (EPA) is responsible for protecting the nation's human health and its environment. As part of its mission, it administers federal environmental laws. Geothermal energy development is subject to these laws (GTP, 2011, p. 14).
- The Department of Defence (DOD) – The Geothermal Program Office (GPO), established in 1978, participates in geothermal development activities, in particular as an end user. The US Navy is designated as the lead agency responsible for geothermal exploration and development on military lands. The DOD GPO manages 32 million acres of land, and has helped develop geothermal energy projects for the military as an end user at a variety of locations in the western US, including those in California at the Naval Air Weapons Station China Lake, the Naval Air Facility in El Centro and the Marine Corps Air Ground Combat Center in Twentynine Palms; those in Nevada at the Naval Air Station in Fallon and the Hawthorne Army Depot in Hawthorne; and one in Arizona at the Chocolate Mountains Aerial Gunnery Range (GTP, 2011, pp. 17–18). The DOD has committed to deploying 3 GW of renewable energy, including geothermal energy, on military installations by 2025 (The White House, 2013, p. 7).

Access to geothermal resources

To access geothermal resources, it is important that developers know where the resources are located (federal lands, State lands, private lands and/or Indian lands), as the location of the resource determines what regulations apply, which agencies have jurisdiction, and what permits are required. There is no single procedural guideline for developing geothermal electricity at the federal level, although some States, such as Wyoming,[10] Utah,[11] California,[12] Hawaii,[13] Idaho,[14] Colorado[15] and Nevada[16] have such guidelines.

For geothermal resources on federal lands, the developers must have geothermal leases issued by the BLM through a competitive leasing process. Non-competitive leasing is allowed only in a few exceptional cases, wherein no competitive bid is received. After obtaining a geothermal lease, the developers must still obtain permits and licences from the BLM to explore, develop and produce geothermal energy. During the process of issuing permits and licences, the BLM requires developers to complete the necessary requirements of other parties or agencies (for example, local communities, State agencies, the USFS and the EPA). Because this process involves many different agencies and there is no federal guideline, it is difficult and time-consuming for the developers. To expedite the permitting process for renewable energy development, including geothermal energy, on the National System of Public Lands, Renewable Energy Coordination Offices were established under the BLM in 2009 (DOE, United States of America, 2014).

Regarding access to geothermal resources on State lands, developers must contact each relevant State agency directly. However, some States, such as Wyoming, Utah, California, Hawaii, Idaho, Colorado and Nevada, have procedural guidelines for developing geothermal resources. Developers should take note that if the resources are located on private lands, it is sometimes the case that the surface landowner may not own the subsurface resource, and conflict may occur when one entity owns the surface rights while another owns the subsurface rights. In this case, negotiation with the private owners of the subsurface mineral or geothermal estate needs to be carried out (Battocletti, et al., 2005, pp. 9–11, p. 21).

If the resources are located on Indian-owned lands, over which tribes have inherent authority as sovereign nations, their approval must be obtained to use or lease the resources, for example, land, water and minerals (Battocletti, et al., 2005, pp. 21–22). However, even though the Bureau of Indian Affairs issues mineral leases on Indian lands, the BLM approves and supervises mineral operations on these lands (BLM, 2014b).

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[10] Wyoming Geothermal Institutional Handbook, May 1980,

source: http://digitallib.oit.edu/cdm/ref/collection/geoheat/id/4718

[11] Utah Geothermal Institutional Handbook, 1982,

source: http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1058&context=govdocs

[12] Geothermal Permitting Guide, April 2007,

source: http://energy.ucdavis.edu/files/04-24-2013-CEC-500-2007-027-1.pdf

[13] Federal and State Approvals for Geothermal, April 2010,

source: http://energy.hawaii.gov/wp-content/uploads/2011/11/geothermal_guidebook.pdf

[14] Geothermal Permitting in Idaho, March 2012,

source:
http://geology.isu.edu/Geothermal/PermittingInfo/ID%20Geothermal%20Permitting3312012.docx

[15] Guide to Colorado Well Permits, Water Rights, and Water Administration, September 2012,

source: http://water.state.co.us/dwripub/documents/wellpermitguide.pdf

[16] Nevada Geothermal Guidance,

source
http://www.blm.gov/nv/st/en/prog/minerals/leasable_minerals/geothermal0/geothermal_guidance.html

Secure and exclusive rights to resources

Once the developer obtains geothermal leases issued by the BLM, she or he has ownership rights over approximately 51 200 acres within any one State, as a maximum limit (Fish, 2009, chapter 1, pp. 2–3). For leases issued after 8 August 2005, the lessee will be given a primary production term of up to 35 years, with possible renewal of up to an additional 55 years, if the lessee continues to produce or use the geothermal resources. For leases issued before that date, if geothermal steam is produced or used in commercial quantities within the primary term of the lease, the lessee may extend the primary term for up to an additional 40 years. If, at the end of the 40-year term, geothermal steam continues to be commercially produced and used, the lessee has a preferential right to renew the lease for a second 40-year term (Fish, 2009, chapter 1, p. 3). Furthermore, if there are conflicting claims, leases or permits involving the same land, the person who was first issued a lease or permit, or who first recorded the mining claim, shall be entitled to first consideration (BLM, 2007, p. 82). However, for the purpose of properly conserving the natural resources of any geothermal resource, especially if public interest is at stake, lessees may unite with each other, and either jointly or separately, collectively adopt and operate under a cooperative or unit plan of development or operation of resources whenever this is determined and certified by the DOI Secretary (BLM, 2007, pp. 87–88).

Geothermal leases can be suspended or cancelled at the discretion of the DOI Secretary, who may suspend leases in the interest of conservation of resources, and may terminate leases for any violation of the BLM regulations or lease terms, with notice (Vann, 2012, pp. 15–16).

Permitting time limits

As mentioned earlier, the process for accessing geothermal resources often involves many different agencies, and without the benefit of a national geothermal guideline. Although the Renewable Energy Coordination Offices were established under the BLM in 2009 to expedite the permitting process for developing renewable energy, including geothermal energy, on the National System of Public Lands, geothermal industry stakeholders have still identified the permitting process as one of the most significant barriers to geothermal power project development (Nathwani and Young, 2013, p. 3). This barrier was also identified by the Office of Energy Efficiency and Renewable Energy in a 2011 report of Blue Ribbon Panel Recommendations (OEERE, 2011, p. 9), which expressed the need for a more streamlined geothermal permitting process.

Although some States have established guidelines for geothermal permitting, such as Wyoming, Utah, California, Hawaii, Idaho, Colorado and Nevada, no document has outlined the entire permitting process (Nathwani and Young, 2013, p. 3). In 2012, the DOE initiated the Geothermal Regulatory Roadmap (GRR) to facilitate the permitting and regulatory process for geothermal development, and the GRR team collected recommendations to combat inefficiency and to reduce the length of time for the permitting process (Levine, et al., 2013, p. 3). The objectives of the GRR are to develop the permitting roadmap for geothermal power projects at the federal, State and local levels in order to gain an overview of the current process; to convene industry stakeholders, both in agencies and industry, who are involved in the permitting process to validate the process and identify potential bottlenecks and inefficiencies; and to work with all stakeholders to optimise and streamline the regulatory process to the benefit of all. This GRR project is still on-going, and the activity carried out in 2014 was to create new tools to facilitate efficient permitting of new geothermal projects and the Regulatory and Permitting Information Desktop (RAPID) Toolkit (EERE, 2014b). Beyond 2014, it is expected that agencies and Congress can change legislation and rulemaking (law or policy) to reduce the permitting time for geothermal electricity project development (Nathwani and Young, 2013, p. 3, p. 12, p. 14).

'One-stop permitting'

Currently, the US Government is studying the need to establish 'Coordinating Permit Offices' for geothermal resource development, to address the concerns of industry and agencies raised during the GRR process regarding the long and numerous NEPA processes, uncertain timeframes of the permitting process and lack of agency interaction in geothermal development. This office is expected to help facilitate coordination between developers and government agencies and set a timeline for the process (Levine, et al., 2013, p. 4).

Although not yet tested for geothermal projects, some States, such as Alaska and Hawaii, have specific coordinating permit offices. The Alaska Department of Natural Resources Office of Project Management and Permitting, established in the early 1990s, is the 'Coordinating Permit Office' for large and capital-intensive projects in all matters (no specific eligibility requirements). However, projects generally take longer when using the Coordinating Permit Office to coordinate all permitting processes since there is no specific timeframe within which decisions on permitting are reached. This office only establishes permitting timelines for projects on a case-by-case basis. The Hawaii Department of Business, Economic Development and Tourism (DBEDT), established in 2008, acts as the 'Coordinating Permit Office' for renewable energy projects (including geothermal power) and power production (projects with a capacity of 200 MW or more and projects with a capacity of 5–199 MW at the discretion of the DBEDT). The current average permitting time for solar and wind energy production is two to four years to completion. However, under the Renewable Energy Facility Siting Process (REFSP), the goal is to complete power plant permitting in one to two years (Levine, et al., 2013, pp. 5–6, p. 10, p. 18).

Inter-agency cooperation

As mentioned, in US geothermal development, the lead agency is the BLM, working closely with local communities, States, industry and other federal agencies (for example, the USFS and EPA) to ensure that everything proposed by developers meets the requirements of all regulations. In addition, the BLM takes part in a Cabinet-level working group that is developing a coordinated federal permitting process for siting new transmission projects that would cross public, State and private lands. In this case, the BLM becomes the coordinating body for developing geothermal electricity in the US. In this role, the BLM has participated in several achievements in inter-agency cooperation: interagency collaboration on geothermal resource assessment and energy development to identify 241 geothermal sites on private or accessible public lands across 13 US States (GTP, 2011, p. 19); interagency collaboration in the West-Wide Energy Corridor Programmatic Environmental Impact Statement (PEIS) to address the potential impacts associated with the designated energy transport corridors to be used for a variety of energy sources, including renewable energy (such as geothermal energy), on federal lands in 11 western States (GTP, 2011, p. 19); interagency collaboration in Geothermal Resources Leasing PEIS to facilitate the geothermal leasing process and reduce the backlog of geothermal lease applications (GTP, 2011, p. 19); interagency collaboration for further geothermal energy development (for example, identifying potential geothermal energy resources with the least disruption to the environment and the greatest impact on energy security and emissions reductions, identifying potential sources of data to populate the National Geothermal Data System for effective resource management and planning) (GTP, 2011, pp. 10–11).

In 2009, to expedite the permitting process for renewable energy on the National System of Public Lands, including electrical transmission facilities, the Renewable Energy Coordination Offices were established under the BLM. The offices will initially be located in the four States where companies have shown the greatest interest in renewable energy development (Arizona, California, Nevada and Wyoming). These offices will also be expected to improve the BLM's coordination with State agencies and other federal agencies, including the DOE and the EPA (DOE, United States of America, 2014).

Database

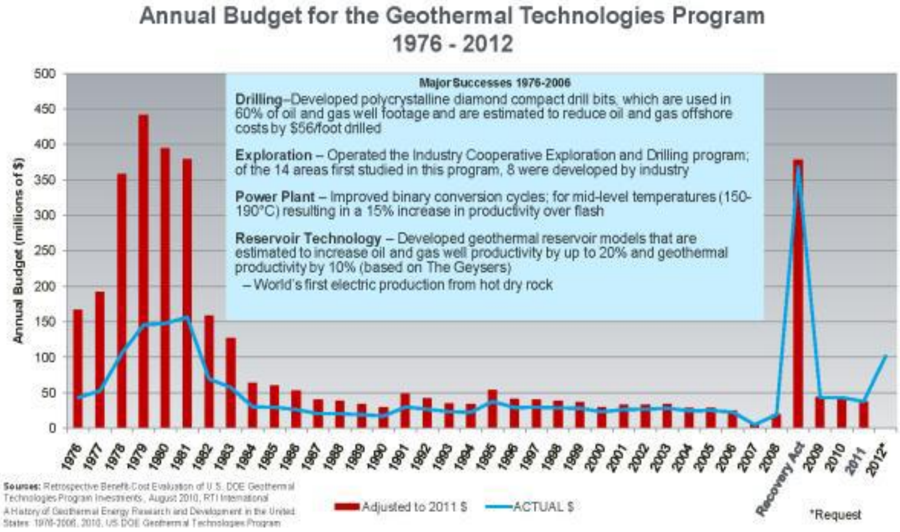
One of the success factors in developing geothermal electricity in the US is the provision of research data on the geology and geothermal resources by the federal government to developers in an effort to reduce the risk to geothermal developers in the early stages. Since 1975, the USGS has conducted several geological surveys to assess geothermal resource potential and characteristics in the US. Based on these surveys, favourable areas for discovery and development have been identified, information about which is published in circulars that can be used by developers to evaluate the prospects of geothermal projects. Besides the USGS, other agencies, such as the US National Renewable Energy Lab (NREL) and academic research centres have provided data and information regarding geothermal resources in the US. Currently, the potential resource data of EGS have already been identified.

To incorporate all geothermal data contributed by academic researchers, private sector participants and State and federal agencies (primarily the DOE) into one integrated database system, the US Geothermal Technologies Program (USGTP) has established a National Geothermal Data System (NGDS), funded by the federal government. The NGDS is a catalogue of documents and datasets that provide information about geothermal resources located primarily within the US, and can be used to determine geothermal potential, guide exploration and development, make data-driven policy decisions, minimise development risks, understand how geothermal activities affect the community and the environment and guide investments. Any metadata or dataset provided in the NGDS complies with the standards and protocols proposed by the U.S. Geoscience Information Network (USGIN) (NGDS, 2014). These data can be easily accessed, viewed and downloaded online through http://geothermaldata.org/.

Research and development

The United States has a long history of supporting research related to the development of geothermal. The DOE provides an annual budget for the Geothermal Technologies Program (GTP) to support geothermal electricity projects (RD&D). In response to the oil crises and to promote geothermal electricity development, the government increased the annual budget for geothermal R&D between 1976 and 1981, reaching USD 150 million by 1981. However, from 1982 to 1984, the funding level was gradually decreased, and then remained fairly constant at around USD 30–40 million annually. R&D funding was only increased when the ARRA program was launched by the government in 2009. Although during 1976–2012 some successes were achieved, particularly in drilling technology, exploration, improved binary power plant technology and reservoir technology, inconsistent funding levels for R&D was a factor that slowed growth in geothermal electricity development in the US (Doris, et al., 2009, p. 1).

Figure 16. USDOE-GTP funding by year



Source: Lund and Bloomquist, 2012.

To increase the budget for R&D, the DOE-GTP received additional funding under the American Recovery and Reinvestment Act (ARRA or 'Recovery Act') of 2009. The Recovery Act funding included approximately USD 350 million in geothermal energy RD&D for electricity generation, and approximately USD 50 million for the deployment of ground-source heat pumps (commonly called 'geothermal heat pumps' or GHPs) to heat and cool buildings (GTP, 2011, p. 9).

Currently, using federal funding, the Geothermal Technologies Office (GTO, 2014b) has conducted several R&D programs in geothermal energy, the goals of which are to investigate:

- Acceleration of near term hydrothermal growth by lowering risks and costs of development and exploration, lowering the levelised cost of electricity (LCOE) to USD 6 cents/kWh by 2020 and accelerating the development of 30 GWe of undiscovered hydrothermal resources; and
- Securing the future of EGS by demonstrating 5 MW of reservoir creation by 2020, and lowering LCOE to USD 6 cents/kWh by 2030.

Human resources development

As a result of the dramatic increase in US geothermal development, and in response to the shortage of trained industry professionals, especially higher-level geothermal power plant managers, geologists, resource analysts, permitting staff, drillers, engineers and geothermal heat pump installers, a number of colleges, universities and training institutions across the economy are currently introducing undergraduate, graduate and certification programs related to geothermal energy (GEA, 2011, p. 5).

As of 2011, there were 30 schools/universities with geothermal programs, courses and/or research opportunities in the United States. A few institutions, such as Southern Methodist University (SMU), have a geothermal focus within a major. Others, including Oregon Institute of Technology (OIT), Massachusetts Institute of Technology (MIT), Cornell University and the University of Nevada, Reno (UNR), offer undergraduate renewable energy-related minors that highlight geothermal. The OIT also offers an undergraduate renewable energy major. Generally, a background in physical sciences or engineering will benefit students entering the geothermal industry or pursuing more advanced degrees suited for geothermal studies. Due to the more specialized nature of graduate studies, many more opportunities in geothermal-specific education exist at the graduate level than at the undergraduate level. Stanford University and SMU offer both geothermal masters and doctorate degrees. In addition to the Stanford Geothermal Program and SMU's Geothermal Laboratory, research facilities and/or geothermal research opportunities exist at a growing number of institutions (GEA, 2011, p. 5). Moreover, there are eight geothermal technical training schools and institutions that provide training for technician and geothermal specialists, such as in well design and drilling, and training for operators (GEA, 2011, pp. 19–21). However, most funding allocated by the DOE-Geothermal Technologies Office (GTO) for HRD is still focused on supporting research facilities and research opportunities in geothermal.

Financial incentives

In addition to the US Government having a sound strategy for the development of geothermal electricity, the government at both federal and State levels provides financial incentives for geothermal developers. At the federal level, financial incentives include:

- Reduction in the royalty structure for electricity production under the Federal Steam Act of 1970;
- Loan guarantee for up to 75% of project costs, with the federal government guaranteeing up to 100% of the amount borrowed under the Geothermal Loan Guarantee Program (GLGP) in 1975 (amended in 1980 to allow for the granting of loans of up to 90% of the total aggregate project cost);
- Deduction of intangible drilling costs and allowance for percentage reservoir depletion allowances as Investment Tax Credits (ITC) in 1978;
- Requiring regulated utilities to purchase the output from renewable energies, including geothermal facilities, at their avoided cost of generation, and requiring utilities to provide transmission and backup service at a reasonable rate under the Public Utilities Regulatory Policy Act of 1979 (PURPA);
- Cost sharing for the confirmation of a hydrothermal resource in the initial stages, under the User Coupled Confirmation Drilling Program (UCDP) in 1980;
- Initial tax credits for geothermal energy development, which was implemented on a limited basis in 2004 and on a full basis in 2005, as a Federal Production Tax Credit (PTC);
- Funding to promote the development of advanced geothermal technology and to lower costs and barriers to market entry of development of geothermal under the American Recovery and Reinvestment Act (ARRA) in 2009; and
- Technical assistance for potential geothermal developers who had little or no expertise in the geothermal field, under DOE's Technical Assistance Grant Program (Lund and Bloomquist, 2012, pp. 3–7).

At the State level, financial incentives include:

- Tax incentive programs in the form of business tax credits, residential tax credits, property tax exemptions, sales tax exemptions and exemptions on public utility taxes (Lund and Bloomquist, 2012, p. 4);
- Setting targets for renewable energy in the portfolio of electricity resources for the State and requiring retail electricity suppliers to include a minimum amount of their electricity supply from eligible renewable resources such as geothermal resources, under the Renewable Portfolio Standards (RPS) regulation. The RPSs have been adopted in numerous States; they exist in 29 States and DC, and seven additional States have non-binding goals. Most RPS policies have been established through State legislation, but some were initially established

through regulatory action (New York, Arizona) or ballot initiatives (Colorado, Missouri, Washington) (Barbose, 2012).

- Other State initiatives include the marketing of Renewable Energy Credits (RECs), often referred to as ‘green tags’ or ‘green certificates’, which represent the property rights to the environmental, social and other non-power qualities of renewable electricity generation (or represent proof that renewable electricity was generated from an eligible renewable energy resource). These can be sold separately from the underlying physical electricity associated with a renewable-based generation source, and allow utilities to support renewable energy development and protect the environment when green power products are not locally available (EPA, 2014). The RECs have significantly improved the economic viability of a number of renewable generation technologies, including geothermal technologies, in several States (Lund and Bloomquist, 2012, p. 4).

Transmission network

In the United States, transmission providers are required by the Federal Energy Regulatory Commission (FERC) to offer transmission service on an open, non-discriminatory basis, pursuant to a transmission tariff that governs the terms by which such service is provided. Upon receiving a request for service, the transmission provider will evaluate the available transmission on its system and determine whether additional transmission facilities need to be constructed to accommodate the requested service. In some parts of the US, the transmission provider is a Regional Transmission Organization (RTO) or Independent System Operator (ISO) rather than the actual owner of the applicable transmission facilities (Hall, et al., 2009, chapter 7, p. 5).

To access the electric transmission grid, geothermal producers must negotiate and execute interconnection agreements and transmission service agreements, and purchase necessary ancillary services with transmission providers before the developers begin generating the first MW of power. Most transmission providers are subject to jurisdiction by FERC, and therefore transmission service and generation interconnection agreements are generally subject to regulation by FERC. Regarding procedures and agreements for the interconnection of generating facilities with the interstate transmission facilities owned, controlled or operated by the nation’s investor-owned utilities, FERC has established standards. In regions where the transmission system is owned and operated by separate entities, FERC requires that those entities sign the interconnection agreement (Hall, et al., 2009, chapter 7, p. 1, p. 3).

Recent developments have made access to the transmission grid both easier and more economical. In particular, the implementation of standardized interconnection procedures and agreements for ‘Large Generators’ (generators larger than 20 MW) and ‘Small Generators’ (generators with a capacity of 20 MW or less) will help streamline the interconnection of renewable power sources with the transmission grid (Hall, et al., 2009, chapter 7, p. 7).

Electricity sales contracting

In the United States, the buyer of geothermal power is often a utility that is required to serve its load, because the utility may be motivated by an RPS that has already been adopted in numerous States, or other regulatory policy that encourages the development of geothermal power and other forms of renewable energy. Consequently, the power purchase agreement (PPA) is entered into between the geothermal producer and electricity utility. The PPA requires the buyer to buy the output that the seller delivers. It may also require the seller to pay the buyer if the project is not built on schedule, or fails to achieve certain output levels or other performance standards. Each party will be concerned about the other’s ability to satisfy these payment obligations. If one party is not creditworthy, the other may require it to provide a guaranty, or post a letter of credit or other security to ensure that amounts due under the PPA will be paid (Holmes, et al., 2009, chapter 3, p. 1).

In a State that permits direct access or allows renewable energy to be sold at retail (for example, Connecticut, Delaware, Illinois, Massachusetts and Maryland), the buyer may be a retail buyer, such as a manufacturing facility that wishes to hold itself out as a 'green' company. Power marketers may also buy output for resale to one or more third parties. Power marketers can sometimes purchase all of a project's output (something that no other single-market player may be able to do), taking a 'merchant position', and enabling the owner to finance the plant (Holmes, et al., 2009, chapter 3, p. 1).

THE PHILIPPINES

Geothermal energy exploration in the Philippines began in the late 1950s. It was only in 1969 that definitive results from studies of geothermal resources were obtained by geoscientists from the Commission on Volcanology, who successfully lit a bulb at the base of Mt Mayon volcano, during the period of the 1970s oil crisis. Geothermal reservoirs of hot fluid are found in many parts of the Philippines, and typically remain active for many years. Tiwi and Makiling-Banahaw (Mak-ban) were the first and second geothermal power plants in commercial operation in the Philippines, both since 1979, for more than 30 years.

At the beginning of geothermal electricity development in the Philippines, to reduce the risks, the 'Old Regime' was introduced by the government, whereby the government took part in constructing power generation in a first scheme and in exploring for geothermal resources in a second scheme. The first scheme, with a timeframe of 1970–1990, was introduced when the State-owned National Power Corporation (NPC) was given responsibility for administering the exploration and development of Tiwi geothermal field. Because it needed technical expertise and financial support, the NPC entered into a contract with Philippine Geothermal, Inc. (PGI), a subsidiary of Union Oil Company of California (Unocal), to develop Tiwi (330 MW) and later on, the Mak-ban (426 MW). In Tiwi and Mak-ban geothermal fields, the NPC was the power plant operator, while PGI was the steam-field operator. PGI sold steam to the NPC, which then sold electricity through the grid system. In 1976, the government established the subsidiary company of the Philippine National Oil Company (PNOC), the PNOC Energy Development Corporation (PNOC EDC), to take over the exploration and development functions of NPC in the Tongonan and Palinpinon geothermal fields. In 1980, to support PNOC EDC activities, an exploration loan of approximately USD 36 million was provided by the World Bank. Thus, the PNOC EDC became the government's primary vehicle for implementing a national geothermal program (Dolor, 2005, pp. 2–3, p. 9). To expand the development of geothermal electricity in the Philippines and allow developers or investors to develop geothermal electricity through a Geothermal Service Contract with the Bureau of Energy Development of the Ministry of Energy (now the Department of Energy-DOE), the government issued the Geothermal Service Contract[17] under Presidential Decree 1442 (PD 1442) in 1978 as a legal basis. As a result, leading up to 1990, the Philippines had successfully developed 981 MW in total geothermal power plant capacity, and became the world's second-largest geothermal energy producer in 1984 (Ogena and Fronda, 2013).

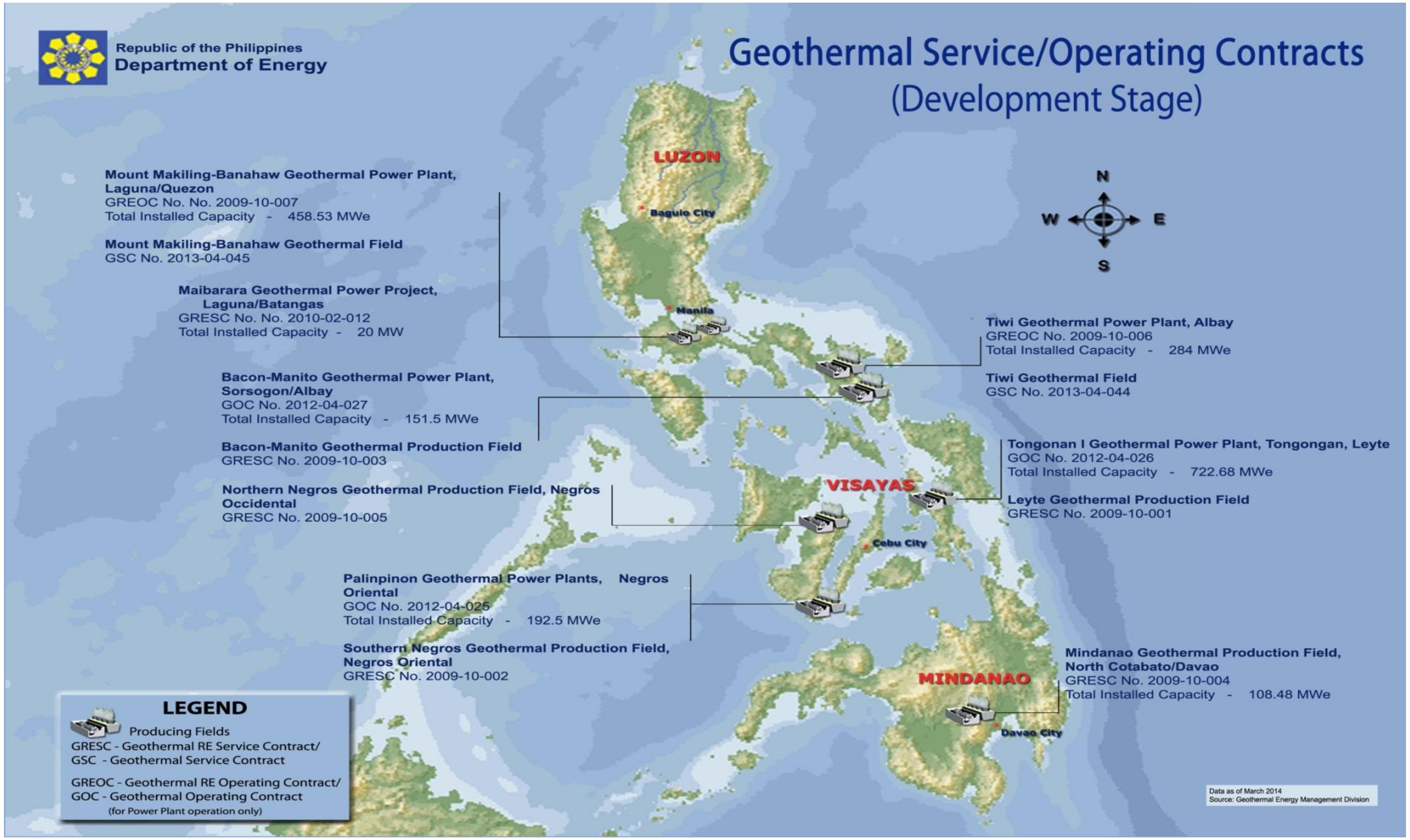
The second scheme, which lasted from 1990 to 2008, was introduced when the government allowed the participation of the private sector in the construction, ownership and operation of power plants through Build-Operate-Transfer (BOT) contracts or similar arrangements, and removed NPC's monopoly on power generation under Executive Order 215 in 1990. Under this scheme, for most projects, PNOC EDC became the resource developer or steam-field operator and private sector entities were the Power Plant Operators (for example, CalEnergy/Ormat in

[17] The Renewable Energy Service (Operating) Contract (RE Contract) is the service agreement between the government, through the DOE, and the RE Developer over a period in which the RE Developer has the exclusive right to a particular RE area for exploration and development.

Layte-Luzon; CalEnergy in Leyte-Cebu and Marubeni in Mt Apo) (Dolor, 2005, pp. 2–3). In 2001, under the Electricity Power Industry Reform Act (EPIRA), the economy's electricity supply industry was restructured, paving the way for the privatisation of the State-owned National Power Corporation (NPC). As part of the privatisation program, the PNOC EDC was also privatised and sold to Energy Development Corp (EDC)—a private Philippine entity—in 2007, when this company took over ownership of some PNOC-owned geothermal power plants. As a consequence of the privatisation program, all of the geothermal power plants in the Philippines are now owned by Independent Power Producers (IPPs). During the second scheme, 924 MW of total geothermal power plant capacity were successfully developed (Ogena and Fronda, 2013).

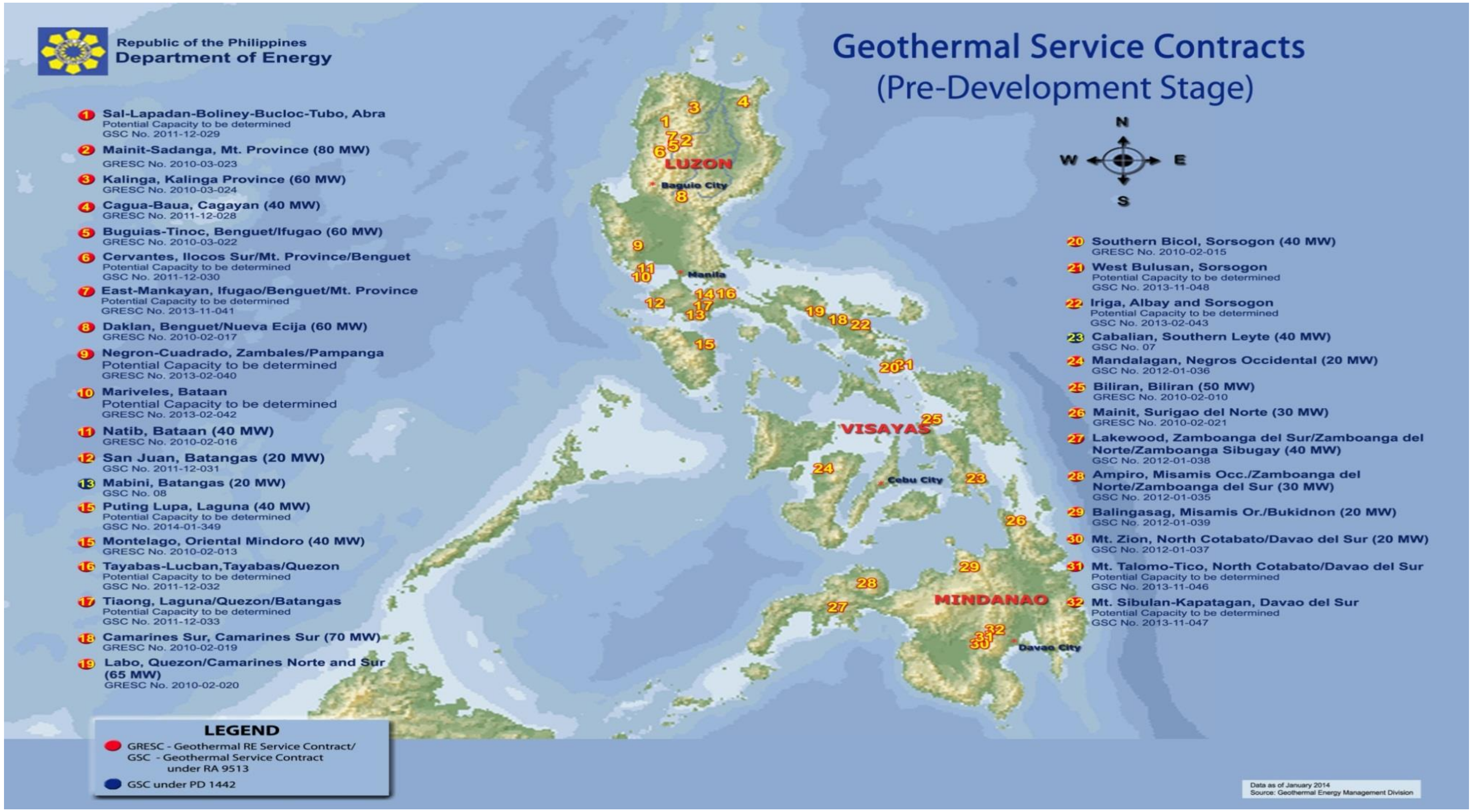
The 'New Regime' was introduced by the government when the Renewable Energy Act (Republic Act (RA) 9513) was enacted in 2008 to repeal/modify the salient features of PD 1442—the Geothermal Service Contract of 1978. Under the Renewable Energy Act, the private sector was allowed to enter into geothermal resource exploration, development and utilisation as a power plant operator only, steam-field developer only or an integrated geothermal system developer, through the award of Geothermal Renewable Energy Service Contracts (GRESCs). As of February 2014, the economy has a total installed geothermal capacity of 1868 MW, and among the major islands, Visayas has the highest installed capacity with 915 MW. Luzon has 844 MW and Mindanao 109 MW of geothermal installed capacity (Fronda, 2014).

Figure 17. Geothermal fields in operation, the Philippines



Source: Fronda, 2014.

Figure 18: Pre-development stage of geothermal, The Philippines



Source: Fronda, 2014.

Legal basis

The Renewable Energy Act (RA 9513) of 2008 is the legal basis for developing geothermal electricity in the Philippines. It repealed/modified the Geothermal Service Contract Law or Presidential Decree 1442 (PD 1442) that took effect in 1978. This Act addressed issues of legality (for example, permitting, environmental, ownership of resource and access) and/or financial aspects (for example, taxes, fees and royalties). Also under this Act, geothermal resources are considered to be mineral resources and the private sector (100% foreign-owned corporations) is allowed entry to geothermal resource exploration. Development and utilisation either as a power plant operator only, steam-field developer only or integrated geothermal system developer will be possible through awarding of Geothermal Renewable Energy Service Contracts (GRESCs). Since the implementation of this Act, a total of nine GRESCs have been signed under an Open and Competitive Selection Process (OCSP), five Geothermal RE Operating Contract/Geothermal Operating Contracts, 22 GRESCs/Geothermal Service Contracts under Direct Negotiation for frontier areas, and seven conversions of Geothermal Service Contracts under PD 1442 into GRESCs under RA 9513 (Fronda, 2014).

Since geothermal resources were defined as minerals in the Renewable Energy Act, certain provisions of the Philippine Mining Act of 1995, or RA 7942, have likewise been enforced. RA 7942 states that all mineral resources in public and private lands within the territory and exclusive economic zone of the Republic of the Philippines are owned by the State. It is the responsibility of the State to promote their rational exploration, development, use and conservation through the combined efforts of government and the private sector and to enhance national growth in a way that effectively safeguards the environment and protects the rights of affected communities. However, while ownership of geothermal resources lies with the State, the indigenous people also have ownership of resources on their land, as provided in the Indigenous Peoples Rights Act of 1997 (RA 8371). In this case, the developer must obtain certification from the National Commission on Indigenous Peoples (NCIP) indicating that the area does not overlap with any ancestral domain, or that the free and prior informed consent (FPIC) of the concerned indigenous cultural communities or indigenous peoples (ICCs/IPs) has been obtained before commencing exploitation phase activities (Penarroyo, 2010, pp. 3–4).

In addition to the regulations under these Acts (the Renewable Energy Act, the Philippine Mining Act and the Indigenous Peoples Rights Act), other important legal provisions, such as environmental laws and regulations, must be followed by geothermal developers, to avoid negative environmental impacts. For instance, development activity must be in compliance with the Philippine Environmental Impact Assessment (EIA) System, and the National Integrated Protected Areas System Act for resources located in protected areas.

Government strategy

Past strategies

With the initiation of geothermal electricity development, the Philippine Government established a risk-sharing mechanism with the private sector, to reduce the risk of geothermal electricity development in the early stages. In the first scheme, the State-owned National Power Corporation (NPC) became the power plant operator. Thus, this company had responsibility for securing funding for construction of the power plant, while the private sector entity (Philippine Geothermal, Inc., or PGI) was the steam-field operator, with responsibility for securing funding for exploration of resources. The mechanism for sharing risk resulted in successful development of geothermal electricity in Tiwi and Mak-ban in 1979. Moreover, to expand the development of geothermal electricity in the Philippines, allowing developers or investors to develop geothermal electricity through a Geothermal Service Contract with the Bureau of Energy Development of the Ministry of Energy (now the Department of Energy), the government provided fiscal incentives, under the Geothermal Service Contract Law, Presidential Decree 1442 (PD 1442) in 1978. There were other fiscal incentives, such as giving the right to use the resource for up to a 25-year production period with 18 years of possible extension, exemption from all taxes except income tax, exemption from payment of tariff duties and compensating tax on the importation of machinery and equipment and spare parts and all materials required for geothermal operation, and annual cost recovery of a maximum of 90% of gross proceeds (Fronda, 2014). As a result, leading up to 1990, the Philippines had successfully developed 981 MW of capacity in its geothermal power plants and became the world's second-largest geothermal producer in 1984 (Ogena and Fronda, 2013).

After acquiring knowledge and expertise in the exploration and development of the geothermal field (learning from the experiences of a private company in Tiwi and Mak-ban geothermal fields that obtained an exploration loan from the World Bank in 1980), it was possible for PNOC EDC to become a resource developer or steam-field operator. Once geothermal resources with manageable risks had been identified by PNOC EDC, it offered cooperation with the private sector (mostly power plant contractors) for an agreed period of time (for example, a 10-year period) to design, supply, install and commission the power plant (as a power plant operator). During the cooperation period, PNOC EDC paid for the plant through an energy conversion tariff (essentially a BOT fee) that covered operating costs, and provided for capital recovery and return on capital. At the end of the cooperation period, landownership was transferred and handed over to PNOC EDC. Furthermore, the government provided a guarantee to back up PNOC EDC in case of default on its obligations to the BOT contractor (ESMAT, 2012, p. 93). To support this scheme, the government removed NPC's monopoly on power generation and allowed the participation of the private sector in the construction, ownership and operation of power plants through BOT contracts or similar arrangements under Executive Order 215 of 1990. Later, in 2001, the electricity supply industry was restructured under the Electricity Power Industry Reform Act (EPIRA) to give more of an opportunity to the private sector to be involved in electricity production, including geothermal electricity. As a result, during the second scheme (1990–2008), 924 MW of total geothermal power plant capacity were successfully developed (Ogena and Fronda, 2013).

Current strategies

After the electricity supply industry was restructured under EPIRA in 2001, and national assets privatized (for example, NPC and PNOC EDC), a risk-sharing mechanism was no longer provided by the government in developing geothermal electricity, other than fiscal incentives under the Geothermal Service Contract Law, PD 1442. In 2008, the Renewable Energy Act was put in place to repeal/modify PD 1442. Under this new law, the government provides fiscal and non-fiscal incentives for renewable energy (RE), including geothermal energy, to reduce the risk to geothermal developers, and a financial assistance program to help developers to raise capital for geothermal projects (Penarroyo, 2010, pp. 5–6), as follows:

- Income tax holiday ('ITH') for the first seven years of commercial operation;
- Duty-free importation of RE machinery, equipment and materials;
- Special realty tax rates on equipment and machinery;
- Net operating loss carry-over ('NOLCO');
- Corporate tax rate of 10% after seven years of ITH;
- Accelerated depreciation (only if an RE project fails to receive an ITH);
- Zero percent value-added tax rate;
- Cash incentive of RE developers for missionary electrification (off-grid areas);
- Tax exemption from carbon credits;
- Tax credit for domestic capital equipment and services;

- Tax exemptions to manufacturers of RE equipment and components (incentive for RE commercialisation); and
- Financial assistance program through government financial institutions (for example, the Development Bank of the Philippines and so on).
- In addition, the minimum target of renewable energy has been set in the portfolio of electricity resources (Renewable Portfolio Standard – RPS) to which sector RPS shall be imposed on a per grid basis.[18] However, as of the time of writing, there is no further information regarding implementation of an RPS mechanism for geothermal energy.

In the future, under the National Renewable Energy Program, the government has a target to increase the geothermal installed capacity by 2030 by 75% compared to 2010. To achieve this target, some strategies have been laid down in the Roadmap for Geothermal Energy Development 2011–2030, such as the establishment of a geothermal training centre; investigating the feasibility of small-scale geothermal energy; a research study on Enhanced Geothermal Systems (EGS), including conducting a feasibility study; optimisation and improvement of geothermal power plant efficiency and energy conservation; and continued improvement of database and networking for better data access for both internal and external clients (Fronda, 2014).

Government commitment to investors

In the past (1970–2008), the Philippine Government has shown a commitment to geothermal investors. The risk-sharing mechanism established between the government and private sector has resulted in significant expansion of geothermal electricity development throughout the economy, and is a positive reference point for government commitment to investors developing geothermal electricity.

However, the government commitment to investors changed when the privatisation program for electricity supply was initiated and national assets privatized in 2001. After implementation of this program, the risk-sharing mechanism, which had been a good scheme, was no longer implemented by the government. As a result, geothermal developers could only enjoy fiscal incentives provided under PD 1442, which was later repealed/modified by the Renewable Energy Act in 2008.

Furthermore, the Renewable Energy Act of 2008 has already set the minimum target for renewable energy in the portfolio of electricity resources (Renewable Portfolio Standard – RPS) to which sector RPS shall be imposed on a per grid basis. However, as of the time of writing, there is no further information regarding implementation of the RPS mechanism for geothermal energy. Moreover, the Philippine Government also plans to develop and utilise emerging geothermal technology such as the Enhanced Geothermal System (EGS) in the near future. Without strong government support, such as in establishing an FIT scheme, the development of EGS may be derailed.

Institutions

In the Philippines, the Department of Energy (DOE) is the lead agency dealing with all aspects of energy, including geothermal energy. The DOE is mandated to prepare, integrate, coordinate, supervise and control all plans, programs, projects and activities of the government related to energy exploration, development, utilisation, distribution and conservation. The DOE is also the responsible agency for processing Geothermal Renewable Energy Service Contracts including the selection process, the awarding of contracts and the monitoring of geothermal development activities. Under the DOE, there are two agencies, the Renewable Energy

[18] Currently, three interconnected grids exist in the Philippines, namely Luzon, Visayas and Mindanao.

Management Bureau (REMB) and the National Renewable Energy Board (NREB), that help the DOE with tasks and functions dealing with all aspects of renewable energy.

In addition, Local Government Units (LGUs, or 'local government') in the Philippines are also key players in geothermal energy production, as they are in charge of the issuance of permits and licences specific to geothermal reservation areas. Finally, the National Commission on Indigenous Peoples (NCIP), a government agency, has responsibility for addressing issues regarding the concerns of the country's indigenous peoples.

Other agencies that have key roles related to geothermal development are:

- The Department of Environment and Natural Resources (DENR) is the government agency to be consulted in relation to environmental issues. It is the lead agency for implementing the Environmental Impact Statement (EIS) System and handles the review and evaluation of the environmental impact of development projects.
- The Department of Trade and Industry (DTI) and Board of Investments (BOI) are the government agencies to consult in relation to incentives for renewable energy commercialization.

Access to geothermal resources

According to the Renewable Energy Act (RA 9513), to access geothermal resources, developers need to obtain a Geothermal Renewable Energy Service Contract (GRESC) through open and competitive selection or direct negotiation (conducted for frontier areas, or if open and competitive selection fails) held by the Department of Energy (DOE). The DOE only gives a GRESC to the developer who gives the best counter proposal for each Predefined Contract Area. The GRESC then gives the developer the right to explore, develop and utilise geothermal resources in a particular geothermal area over a stated appropriate period as determined by DOE, and in turn remits to the government taxes and royalties from the net proceeds.

However, before the geothermal developers can start the exploration, development and use of geothermal resources, they must obtain permission or approval from different government agencies, both central and local, as follows:

- Developers must conduct prior and periodic consultations with the LGUs within the respective jurisdictions, as required by the Local Government Code of 1991 (Penarroyo, 2010, p. 3);
- Developers must obtain prior certification from the National Commission on Indigenous Peoples (NCIP) that the area does not overlap with any ancestral domain, or that free and prior informed consent (FPIC) has been obtained from the concerned indigenous cultural communities or indigenous peoples, as required by the Indigenous Peoples Rights Act of 1997, before the GRESC can be approved by the DOE. To obtain FPIC from indigenous cultural communities or indigenous peoples through their Council of Elders usually involves a negotiation process, which sometimes lacks clear-cut rules on how decisions will be made. This situation presents a deterrent for geothermal electricity developers (Penarroyo, 2010, pp. 3–4);
- Developers must obtain an Environmental Compliance Certificate (ECC) from the Department of Environment and Natural Resources (DENR) and/or any other concerned government agency prior to the commencement of the project. The ECC contains specific measures and conditions that the project proponent must undertake before and during the operation of a project, and in some cases, during the project's abandonment phase, to mitigate identified environmental impacts (Penarroyo, 2010, pp. 3–4). Since geothermal projects are classified as Environmentally Critical Projects, and are usually located in Environmentally Critical Areas, they are subject to the Environmental Impact Assessment System;

- If geothermal resources are located in protected areas, their exploitation or use shall be allowed only through the passage of a law by Congress, as stipulated by the National Integrated Protected Areas System (NIPAS) Act of 1992.

As identified by the DOE with the passage of laws for the preservation of the environment under the National Integrated Protected Areas System (NIPAS) Act and the empowerment of the cultural minorities under the Indigenous People's Rights Act (IPRA), environmental and socio-cultural concerns are now considered to be critical factors in geothermal resource development. There is a need for the harmonisation of the NIPAS and IPRA, as these pose problems to renewable energy investors in prospect areas that are both protected areas and ancestral lands (DOE, Republic of the Philippines, 2014a).

Secure and exclusive rights to resources

Immediately upon entering into a Geothermal Renewable Energy Service Contract (GRESC), developers are issued a DOE Certificate of Registration that also qualifies the developer for the incentives and privileges provided under the Renewable Energy Act. The contract gives the developer the exclusive right to the area. The GRESC has a term for the pre-development stage (the preliminary assessment and feasibility study, up to financial closing of a geothermal project) of two years, extendible for two years and further extendible for one year, as long as the developer has not been in default in its obligation under this contract. While the operation period of a geothermal power plant can be 25 years under the contract, and if the developer has not been in default in its obligations under this contract, the DOE may grant an additional extension of 25 years, provided further that the total term of the contract shall not exceed 50 years (DOE, Republic of the Philippines, 2014b).

Even though the developer might have a secure and exclusive right to resources, the DOE has the power to terminate the contract after due notice to the developer. Grounds for suspension or termination include non-compliance with the rules cited under the contracts. Termination will not take effect if its cause is cured on or before the effective date of the termination notice (DOE, 2014b).

Permitting time limits

As mentioned earlier, before a geothermal developer can start the exploration, development and utilisation of geothermal resources, she or he must obtain permission or approval from different government agencies, both central and local. Furthermore, there are no reasonable time limits within which permitting decisions must be reached by the agencies. For example, to obtain free and prior informed consent (FPIC), the developer must negotiate with a Council of Elders, where there is sometimes a lack of clear-cut rules on how decisions will be made. The approval and permitting process is complicated, particularly in the area of environmental and social regulations (Penarroyo, 2010, p. 4). There is no national geothermal guideline for permitting in the Philippines that assimilates all the related licensing requirements for developing geothermal from different agencies into one single source of information, specifying reasonable time limits within which permitting decisions must be reached. However, regarding environmental permitting, a new one-stop permitting process to be implemented in the near future should assist with expediting the permitting process for the Department of Environment and Natural Resources (DENR) applications and processes, including those for geothermal resources. (See the following section.)

‘**One-stop permitting’**

In the Philippines, there is no ‘one-stop permitting’ for geothermal development approval processes. Instead, in the Investment Symposium for Energy Sector in the Philippines held in Tokyo, Japan, on 16 October 2013, the Minister of the DOE, Secretary Carlos Jericho Petilla, stated that the DOE is assigning a person, tentatively called the ‘Fixer’, who will be in charge of processing all documents required by developers who wish to engage in renewable energy development activities, including geothermal energy.

For environmental permitting, however, on 9 July 2012, the Office of the President released EO No. 79, entitled 'Institutionalizing and Implementing Reforms in the Philippine Mining Sector, Providing Policies and Guidelines to Ensure Environmental Protection and Responsible Mining in the Utilization of Mineral Resources', which aims to create a one-stop permitting shop for all mining applications. The EO mandates the DENR to establish an inter-agency one-stop shop for all mining related applications and processes within six months (Torres, 2012, p. 37). Since geothermal energy is defined as a mineral in the Renewable Energy Act, the DENR's 'one-stop shopping' would also be valid for geothermal energy. However, at the time of writing, there is no further information regarding implementation of one-stop permitting.

Inter-agency cooperation

As mentioned, the DOE has identified environmental and socio-cultural concerns as critical factors in geothermal resource development. To address this challenge, the agency must harmonise the National Integrated Protected Areas System (NIPAS) Act and the Indigenous People's Rights Act (IPRA), as renewable energy investors often prospect in areas that are both protected areas and ancestral lands. In response to this situation, a joint Department of Environment and Natural Resources (DENR) – Department of Energy (DOE) Technical Working Group (TWG) was established. Among the many functions and responsibilities of the TWG, the primary function is to develop policies and guidelines on exploration, development and use of natural resources that do not conflict with policies and guidelines on conservation of natural resources especially in protected areas.

Database

One of the service contractor obligations is to provide the DOE with geological, geophysical and other information resulting from their operations. Aside from this information, the Geothermal Division of DOE's Energy Resource Development Bureau also generates exploration data by conducting geoscientific investigation on various geothermal prospects in the economy. The DOE has managed voluminous amounts of data derived from geothermal operations since the beginning of exploration in the early 1970s (Salvania, 1995, p. 241).

To store and manage the energy data and information generated and used by both the government and private sectors involved in energy exploration and development in the Philippines, the Energy Data Center of the Philippines (EDCP) was established under the DOE. Regarding geothermal data, this centre has geoscientific reports (hydrocarbon prospectivity, reconnaissance geology, biostratigraphy, micropaleontology and so on); field samples (processed and unprocessed); maps, charts and drawings (aeromagnetic, gravity, bathymetry, location and so on); and aeromagnetic tapes (DOE, Republic of the Philippines, 2014c). The public must pay fees and charges to access the data.

In the future, as part the National Renewable Energy Program and Geothermal Energy Development Roadmap, the DOE will continuously improve its database and networking for better data access by both internal and external clients (Fronda, 2014).

Research and development

Since 2000, the Philippine Government and private sector have shown good progress in providing investment in geothermal development, including geothermal R&D. From 2000 to 2004, funding for R&D including surface exploration and exploration drilling was allocated in the amount of USD 350 million, and USD 122.58 million for field development (including production drilling and surface equipment), the private share of which was 74% of the total. From 2005 to 2009, R&D funding including surface exploration and exploration drilling was increased to USD 359.33 million and USD 161.92 million for field development funding, the government share of which was 55% of the total (Ogena, et al., 2010, p. 10).

In the future, as part of the National Renewable Energy Program and Geothermal Energy Development Roadmap, R&D programs for the development of geothermal energy resources will continue, including research on the 'Enhanced Geothermal System (EGS) and Geothermal Heat Pump' (Fronda, 2014).

Human resources development

The Philippines has intensive education and training programs for developing technical geothermal skills. Universities in the geothermal resource-rich Visayas offer specialisation in geothermal engineering. Most universities in the Philippines offer geological, geodetic and mining engineering disciplines; no graduate programs in geothermal engineering, however, are offered in these universities. Statistics from 2009 show that more than 10% of geothermal engineering graduates were from various engineering courses (NGAP, 2014, p. 2). While school fees and charges in State universities are subsidized by the government, privately-owned universities on the other hand offer scholarships to deserving students. The United Nations University Geothermal Training Program (UNU-GTP) offers scholarships for advanced education, specifically in geothermal disciplines, which are often used by the government.

The economy has already acquired and educated many highly trained professionals in the field. They have developed their expertise, and provided practical solutions and innovations in geothermal technology. The number of consultants brought into geothermal operations in the Philippines is insignificant, reflecting the capability of home-grown personnel to handle most of the technical aspects of geothermal operations. Until 2009, the technical manpower directly involved in geothermal operations in the Philippines stood at 1547 (excluding the manpower count of NPC power plants). There has been, however, a trend of slightly increasing technical manpower through the years. With expected renewed interest in geothermal energy development in the short term, this trend is expected to continue over the next few years (Ogena, et al., 2010, p. 5, p. 9).

Although the number of technical personnel in the geothermal field is sufficient in quality and quantity, attention needs to be paid to the technical manpower employed by the government (only 26 professionals in 2009—see Table 10). Since the DOE is the lead agency dealing with all aspects of energy, including geothermal energy, the lack of numbers of technical manpower could slow the progress of geothermal development in the future, due to personnel having little expertise and a limited understanding of geothermal planning and development. Thus, the government's plan is to establish a geothermal training centre under the Roadmap for Geothermal Energy Development to increase the technical manpower of the government in the near future.

Table 10. Geothermal activities, allocation of professional personnel

Year	Professional Person-Years of Effort			
	Total	Government	Paid Foreign Consultants	Private Industry
2005	**1470**	1186	12	272
2006	**1486**	1186	8	292
2007	**1466**	23	8	1435
2008	**1517**	23	10	1484
2009	**1547**	26	13	1508

Note: Restricted to personnel with University degrees.

Source: Ogena, et al., 2010, p. 9.

Financial incentives

As mentioned, under the Renewable Energy Act, the government provides fiscal and non-fiscal incentives for renewable energy (RE), including geothermal energy, to reduce the risk for developers, and financial assistance programs to help them raise capital for geothermal projects (Penarroyo, 2010, pp. 5–7). The incentives offered are as follows:

- Income tax holiday (ITH)

  Granted for the first seven years of commercial operation. Longer ITH is given for new investments (the discovery and development of new RE resources is treated as new investment) but not to exceed three times the period of the initial availability of the ITH;

- Duty-free importation of RE machinery, equipment and materials

  Allowed for 10 years, duty-free importation of equipment, machinery, spare parts and materials directly, actually needed and used exclusively in the RE facilities;

- Special realty tax rates on equipment and machinery

  Not to exceed 1.5% of an RE developer's original cost, less accumulated normal depreciation or net book value;

- Net operating loss carry-over (NOLCO)

  Given for the first three years of commercial operation;

- Corporate tax rate

  10% after seven years of ITH;

- Accelerated depreciation

  Given only if the ITH is not received. If the geothermal project has already applied for accelerated depreciation, the project or its expansion is no longer eligible for an ITH. The rate used for depreciation of RE resources should not exceed twice the rate that would have been used for the annual allowance;

- Zero percent value-added tax rate

  Given for fuel sales or power generation from RE sources;

- Cash incentive of RE developers for missionary electrification

  Given for those in off-grid areas, up to 50% of the universal charge;

- Tax exemption from carbon credits

  Given for all proceeds from the sale of carbon emission credits;

- Tax credit on domestic capital equipment and services

  Given for equivalent of 100% of the value of the VAT and customs duties if purchases of machinery, equipment, materials and parts are from a domestic manufacturer;

- Tax exemptions to manufacturers of RE equipment and components (Incentive for RE commercialisation)

  Given to all manufacturers, fabricators and suppliers of locally-produced RE equipment and components for the tax and duty-free importation of components, parts and materials; the tax credit on domestic capital components, parts and materials; the income tax holiday and exemption; and the zero-rated value-added tax transactions;

- Financial assistance programs through government financial institutions (for example, the Development Bank of the Philippines and so on)

Given for the development, utilisation and commercialisation of RE projects to obtain preferential financial packages.

- In addition, setting the minimum target of renewable energy in the portfolio of electricity resources (RPS) to which sector RPS shall be imposed on a per grid basis. However, as of the time of writing, there is no further information regarding implementation of RPS mechanisms for geothermal energy.

Transmission network

The Philippine transmission network provides a high-voltage backbone system of interconnected transmission lines, sub-stations and related facilities that exist in Luzon, Visayas and Mindanao. The National Grid Corporation of the Philippines is responsible for the planning, construction and centralized operation and maintenance of high-voltage transmission facilities, including grid interconnection and ancillary services.

The basic rules, requirements, procedures and standards that govern the operation, maintenance and development of the high-voltage backbone system of an interconnected transmission line in the Philippines, was established in the 'Grid Code' by the Energy Regulatory Commission in 2001. According to the Grid Code of the Philippines, the basic rules for connection to the grid are fair and non-discriminatory for all users of the same category; and any user seeking a new connection to the grid shall secure the required Connection Agreement with the Grid Owner prior to the actual connection to the grid. As long as the proposed connection will not result in the degradation of the grid based on the Grid Impact Studies, and the user meets with all the Grid Owner's connection requirements, a Connection Agreement can be signed by the Grid Owner and the user. However, if the Grid Owner and user cannot reach agreement on the proposed connection to an existing grid connection point, the Grid Owner or user may bring the matter before the Energy Regulatory Commission for resolution (ERC, 2001, p. 47, pp. 49–51). As existing geothermal power plants are located within the economy's grid areas, interconnection to the grid is generally not a problem for geothermal developers.

Electricity sales contracting

Under the Electric Power Industry Reform Act of 2011, introducing competition in the electricity sector, geothermal developers and producers may participate in the wholesale electricity market to sell their power under prices set by the market. In addition, this Act also allows them to sell their output directly to distribution utility, supplier or contestable market (the electricity end-users who have a choice of electricity supplier) under long-term contract prices set through negotiation with the buyer.

INDONESIA

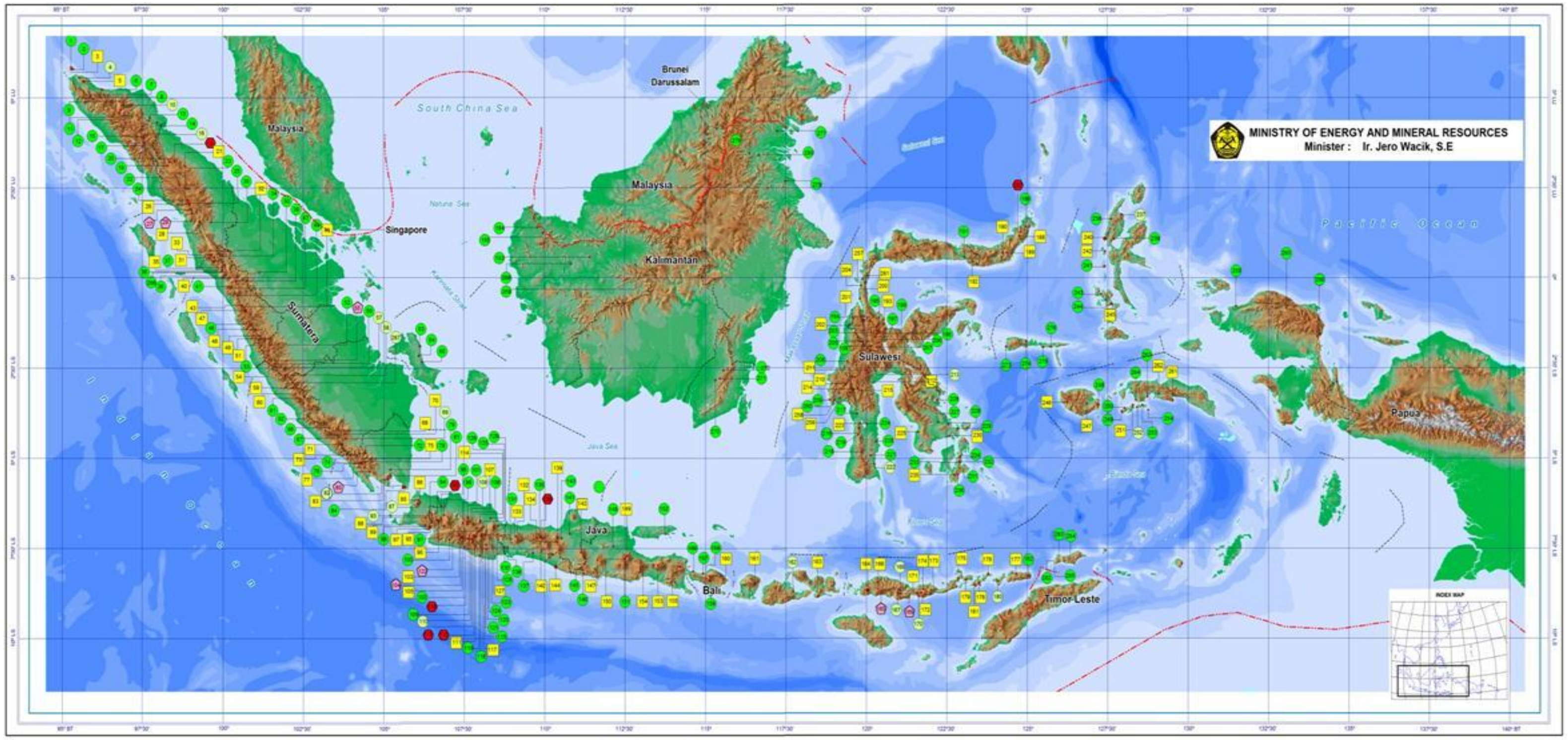
Indonesia has more than 30 years of history with geothermal electricity development, since the first geothermal power plant, in Kamojang, with a capacity of 30 MW, was successfully operated in 1983 (Sukarna, 2012). This project was owned and developed by PERTAMINA (the State-owned oil and gas company, later transferred to PERTAMINA Geothermal Energy), which at that time was selling geothermal steam to PT PLN (the State-owned electricity company) under the Steam Sales Agreement.

At first, under the 'Old Regime', the government strategy to develop geothermal electricity assigned PERTAMINA to conduct exploration and exploitation and to convert steam into energy. To expand the development of geothermal energy, the government authorised PERTAMINA with its contractor under a Joint Operation Contract (JOC) to undertake an integrated geothermal (to explore and exploit the geothermal source, and also build power plants and sell electricity to PLN and other consumers). A JOC is a contract whereby

PERTAMINA was responsible for managing the operation and the contractor was responsible for producing geothermal energy from the contract area, converting energy to electricity and delivering energy or electricity as an Independent Power Producer (IPP) (PwC, 2012, p. 156). Under this 'Old Regime', 19 Geothermal Working Areas (GWA) were identified by the government, nine of which were successfully constructed and operated with a total installed capacity of 1341 MW (DG, 2013). In 2000, the government introduced the 'New Regime' in developing geothermal electricity, wherein the government no longer enters into a JOC, but instead, issues a mining licence; this process was fully formulated into law when the Geothermal Law was enacted in 2003 (PwC, 2012, pp. 157–158). Although under the 'New Regime', no geothermal electricity projects have yet been constructed and/or operated, it has had the impact of opening large areas of Indonesia to the development of geothermal electricity through the government's identification of 39 new GWAs (DG, 2013).

Geothermal prospect areas in Indonesia are mostly concentrated in Sumatera (90 locations), Java (71 locations) and Sulawesi (65 locations) (GA, 2014). Since the electricity demand is concentrated in Java and Sumatera Islands, and an adequate infrastructure has been developed in these areas, most of the existing geothermal power plants are located on these islands. As of October 2014, Indonesia's installed geothermal power capacity had reached 1401 MW, or 5% of Indonesia's total potential (DG, 2013).

Figure 19. Distribution map and potential, geothermal area, Indonesia



Note:

- Early preliminary survey
- Preliminary survey
- Detailed survey
- Ready to develop
- Installed

Source: GA, 2012.

Table 11. Geothermal potential, Indonesia, from December 2012

<table>
<tr><th rowspan="2">LOCATION</th><th colspan="2">RESOURCES (MWe)</th><th colspan="3">RESERVE (MWe)</th></tr>
<tr><th>SPECULATIVE</th><th>HYPOTHETICAL</th><th>POSSIBLE</th><th>PROBABLE</th><th>PROVEN</th></tr>
<tr><td>Sumatera</td><td>3089</td><td>2427</td><td>6849</td><td>15</td><td>380</td></tr>
<tr><td>Java</td><td>1710</td><td>1826</td><td>3708</td><td>658</td><td>1815</td></tr>
<tr><td>Bali</td><td>70</td><td>58</td><td>1013</td><td>-</td><td>-</td></tr>
<tr><td>Nusa Tenggara</td><td>290</td><td>359</td><td>787</td><td>-</td><td>15</td></tr>
<tr><td>Kalimantan</td><td>145</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Sulawesi</td><td>1323</td><td>119</td><td>1374</td><td>150</td><td>78</td></tr>
<tr><td>Maluku</td><td>545</td><td>97</td><td>429</td><td>-</td><td>-</td></tr>
<tr><td>Papua</td><td>75</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="3">TOTAL
(299 Locations)</td><td>7472</td><td>4886</td><td>13373</td><td>823</td><td>2288</td></tr>
<tr><td colspan="2">12358</td><td colspan="3">16484</td></tr>
<tr><td colspan="5">28842</td></tr>
</table>

Source: GA, 2012.

Table 12. Installed geothermal power capacity, Indonesia, October 2014

No.	Geothermal Working Area/Location	License Holder	Developer	Power Plant	Installed Capacity
1.	Sibayak – Sinabung, North Sumatera	PT Pertamina Geothermal Energy	PT Pertamina Geothermal Energy	Sibayak	12 MW
2.	Cibeureum – Parabakti, West Java	PT Pertamina Geothermal Energy	KOB – Chevron Geothermal Salak, Ltd	Salak	377 MW
3.	Pangalengan, West Java	PT Pertamina Geothermal Energy	KOB – Star Energy Geothermal Wayang Windu, Ltd	Wayang Windu	227 MW
4.	Kamojang – Darajat, West Java	PT Pertamina Geothermal Energy	PT Pertamina Geothermal Energy	Kamojang	200 MW
5.	Kamojang – Darajat, West Java	PT Pertamina Geothermal Energy	KOB – Chevron Geothermal Indonesia, Ltd	Darajat	270 MW
6.	Dieng Plateau, Central Java	PT Geo Dipa Energi	PT Geo Dipa Energi	Dieng	60 MW
7.	Lahendong – Tompaso, North Sulawesi	PT Pertamina Geothermal Energy	PT Pertamina Geothermal Energy	Lahendong	80 MW
8.	Ulubelu, Lampung	PT Pertamina Geothermal Energy	PT Pertamina Geothermal Energy	Ulubelu	110 MW
9.	Ulumbu, NTT	PT PLN (Persero)	PT PLN (Persero)	Ulumbu	10 MW
10	Pengalengan, West Java	PT Geo Dipa Energi	PT Geo Dipa Energi	Patuha	55 MW
				TOTAL	**1,401 MW**

Source: Harahap, 2014.

Legal basis

In 2003, Geothermal Law No. 27 was enacted, changing the 'Old Regime' to the 'New Regime' in developing geothermal electricity in Indonesia. The law mainly regulates both technical aspects (for example, the role of central and local government, ownership of resources and access and permitting) and financial aspects (for example, tax, import duty, levies, production fees and bonuses), and provides that geothermal resources are owned by the State, and that developers can utilise these resources only if they have a licence for a Geothermal Working Area (GWA), which is offered by the government through competitive bidding. Even though no geothermal electricity projects have been constructed and/or operated under this law to date, it has opened large areas of Indonesia to the development of geothermal electricity by identifying 39 new GWAs. Under this law, the government (at both central and local levels) is obligated to carry out the preliminary survey and/or exploration stage, either itself or by other entities, to reduce the risk for developers in these early stages. Thus, many potential geothermal areas in Indonesia have been examined before a GWA is offered by the government.

Since geothermal development activities were considered mining activities and therefore fell under the Forestry Law, no mining activity was allowed in forest areas (protection and conservation forest); as a result, geothermal energy could not be developed if it was located in protected forest areas (which accounts for around 44% of total geothermal potential capacity). This prohibition was one of the barriers to developing geothermal electricity in Indonesia. In order to remove this restriction and allow geothermal development in protected forest areas, the government issued the New Geothermal Law of 2014 on 17 September 2014. Under the new law, geothermal development activities are not considered mining activities, as the government has changed the scheme of permitting from 'Geothermal Mining Permit' to 'Geothermal Permit'. Moreover, this new law states that geothermal energy can be developed in production, protection and conservation forests after obtaining a permit from the Ministry of Forestry under the category of permit for environmental service use. Another important point of the New Geothermal Law of 2014 is that the 'Geothermal Permit' will be issued by the Minister of Energy and Mineral Resources (MEMR), where before it was issued by the MEMR, and Governors or Regents/Mayors, in accordance with their respective jurisdictions. As the regulations under the new law are still being developed, the legal situation in Indonesia can be described as being in a state of flux, although the resulting changes can be expected to be positive for development (Lawless, 2015).

The developer must also comply with other regulations, such as the Environment Law, the Forestry Law if the resources are located in forest areas and the Electricity Law, to obtain a licence for the electricity supply business.

Government strategy

As mentioned earlier, initially, the development of geothermal electricity was carried out by PERTAMINA (under the 'Old Regime'), and a Joint Operation Contract (JOC) system was introduced to allow PERTAMINA to work with its contractors in developing geothermal electricity (PERTAMINA was responsible for managing the operation, and the contractor was responsible for producing geothermal energy from the contract area, converting energy to electricity and delivering energy or electricity, as an Independent Power Producer-IPP.). To attract the participation of the contractor, special tax treatment was introduced by the government, whereby a 34% 'all in' fixed tax rate was stipulated for contractors. This special tax rate assumed and discharged the contractors from other tax obligations, including VAT, import duty/taxes and land and building tax that would have been due under a normal tax regime. This scheme was called 'Government Share' (PwC, 2012, p. 156). Under this 'Old Regime', 19 Geothermal Working Areas (GWA) were identified by the government, nine of which were successfully constructed and operated with a total installed capacity of 1341 MW (DG, 2013).

After Geothermal Law No. 27 was enacted, the government strategy to develop geothermal electricity changed from the 'Old Regime' to the 'New Regime', in which the government no longer enters into a JOC, but instead issues a mining licence. To attract the participation of investors or developers to develop geothermal electricity in the 'New Regime', two programs have been implemented by the government: (1) a program to reduce the risk of geothermal developers in the early stages by providing them with data on the geology and geothermal resources and fiscal incentives; and (2) a program to increase the ability of developers to raise capital for geothermal projects through loans, government guarantees and attractive tariffs.

As a part of the effort to reduce the risk to geothermal developers in the early stages, the Ministry of Energy and Mineral Resources (MEMR) assigned the Geological Agency to carry out a preliminary survey of geothermal resources in Indonesia through the State budget.

Although the quality of the exploration data collected by the government is still doubted by private developers and investors, this survey has had an impact by opening large areas of Indonesia to the development of geothermal electricity through the government's identification of 39 new GWAs. In addition, fiscal incentives are provided by the government, such as fiscal incentives for income tax (either a tax holiday or an investment allowance for geothermal, only one of which may be applied for by developers); and fiscal incentives for value added tax (exemption from value added tax, exemption from import duty and exemption from withholding income tax for imports) (MoF, 2014).

To increase the ability of developers to raise capital for geothermal projects, the government provided a loan mechanism for the local government or geothermal developers that can be used to finance exploration stages through a Geothermal Fund Facility although in practice very little of this facility has been used because the terms are unattractive (Lawless, 2015). In 2013, the total amount of geothermal funding provided by the government reached IDR 3 trillion, or around USD 294 million (MoF, 2014). However, the magnitude of available geothermal funds depends largely on the allocation provided by the government in the State budget. A government guarantee is also provided to guarantee the business viability of PLN, ensuring the ability of PLN to meet its obligations to third parties in accordance with the Power Purchase Agreement (PPA) (MoF, 2014). Attractive tariffs have also been established by the government. Starting in 2011, to increase the participation of private developers or investors, the government introduced a ceiling price mechanism, whereby the tariff for geothermal energy was set at USD 9.7 cent/kWh as a ceiling price. However, because the tariff cannot cover the investment cost of developers, especially with regard to the regulation that requires PLN to purchase geothermal power from the lowest bidder (APERC, 2012, p. 81), the government introduced the Feed-in Tariff (FIT) mechanism in 2012. Under the FIT mechanism, PLN must purchase geothermal electricity at a predetermined price (ranging from approximately USD 10 cent/kWh in Sumatera to USD 18.5 cent/kWh in Maluku and Papua, depending on the location of the projects within Indonesia and the voltage connection point) (Ibid. p. 87). However, once again, since based on the existing regulation PLN must purchase geothermal power from the lowest bidder, the FIT mechanism cannot be implemented. Recently, in June 2014, the government revised the FIT mechanism back to the ceiling price. Under this new ceiling price mechanism, PLN can still purchase geothermal power from the lowest bidder, but the ceiling price is set high enough to cover the investment cost of developers (ranging from USD 11.8 cent/kWh to USD 29.6 cent/kWh, depending on the commercial operation date of the project and the region). In addition, there is an option for escalation, after the developers carry out exploration and feasibility study phases (ESDM, 2014). As no successful concessions tendering has yet been carried out since that date, it remains to be seen if this will be sufficiently attractive. A number of previous concessions have recently been relinquished by the developers (Lawless, 2015).

One of the primary efforts of the government strategy is to solve the problem regarding restriction on development of geothermal electricity in protected forest areas (protection and conservation forest) since around 44% of Indonesia's total geothermal potential capacity is located in protected forest areas. This involved revising the Geothermal Law of 2003 with the New Geothermal Law of 2014. Under the new Geothermal Law of 2014, geothermal energy can be developed in production, protection and conservation forests, as long as development meets with the requirements of the Forestry Law. Moreover, to streamline the permitting process, the geothermal permit will be issued by the Ministry of Energy and Mineral Resources (MEMR) based on the New Law, where before it was issued by the Minister of Energy and Mineral Resources, Governor and Mayor/Regent, based on the appropriate jurisdiction of the development activity.

To expand the development of geothermal electricity through the 'New Regime', the government established the Road Map of Geothermal Development 2006–2025 in 2006, whereby 9500 MW of geothermal power plant capacity are expected to be developed as a target by 2025. (The target has since been revised to 7215 MW by 2025 (ESDM, 2014b).) To implement the Road Map, the Indonesian Government launched the 10 000 MW Fast Track Program Phase 2 in 2010, in which geothermal is targeted to contribute 4925 MW of electricity by 2014 (APERC, 2013c, p. 17).

Government commitment to investors

Historically, there has been inconsistency regarding regulatory commitments of the government to investors, raising the risk rating for Indonesia and leading to a slowdown of development of power sector infrastructures, including geothermal electricity. As a consequence, most private developers and investors asked for government guarantees to secure their investment in Indonesia. Some of the inconsistencies in government regulatory commitments are as follows:

- At the outset (1971–1991), the development of geothermal electricity was carried out by PERTAMINA, and the Joint Operation Contract (JOC) system was introduced to allow PERTAMINA work with its contractors in developing geothermal electricity. During this period, private sector entities signed on to develop 12 contract areas that were mostly large-scale geothermal projects, and committed to developing and producing 3800 MW of geothermal energy. However, due to the monetary crisis that significantly impacted the Indonesian economy in mid-1997, the Independent Power Producer (IPP) model that offered a relatively high electricity price needed to be reformed (Suryantoro, et al., 2005). As a result, several private companies' investments were suspended by the government. Two geothermal developers—Karaha Bodas Company, which had been granted contractual rights to build, own and operate electricity generating facilities in West Java, and Himpurna California Energy, which had been granted contractual rights to supply PLN with electricity from a geothermal field in Java—brought this case to international arbitration in 1998. In the end, the UNCITRAL arbitral in Geneva, Switzerland awarded substantial compensation to the two geothermal developers to recover their capital investment (Ripinsky and Williams, 2008).
- In 2002, the new Electricity Law No. 20 was enacted by the Indonesian Government. This new law sought to liberalise the nation's electricity market with the intent of making it a more attractive investment opportunity for foreign companies. However, because it was held to be contrary to the Indonesian Constitution of 1945, it was annulled by the Constitutional Court of Indonesia in December 2004. This decision was a major blow to government plans to bring in greater private sector participation. In 2009, the Indonesian Parliament passed Electricity Law No. 30, and although not as ambitious as the 2002 law, it introduced changes that would allow entities other than PLN to participate in electricity supply, as well as to redefine PLN's roles and mandates (WWF-Indonesia, 2012, p. 53).

Despite the inconsistency of its commitment to investors in the past, the government has more recently shown a strong commitment to solving some issues that have slowed down the development of geothermal electricity. These include establishing the new Geothermal Law of 2014 to address the issues of protected forest areas and the permitting process, and issuing regulations on geothermal pricing, setting the ceiling price high enough to cover the investment costs of developers.

Institutions

To promote and regulate the development of geothermal energy, the Indonesian Government established a specific agency in 2005, the Directorate of Geothermal under the Directorate General of Mining, Coal and Geothermal in the Ministry of Energy and Mineral Resources (MEMR). In 2010, as a result of structural reorganisation of MEMR, this directorate has been attached to the Directorate General of New Renewable Energy and Energy Conservation in the MEMR. This agency has the functions of preparing and implementing policies in the field of geothermal resource development, preparing the standards, norms, guidelines, criteria and procedures and providing technical guidance and evaluation (APERC, 2013c, p. 11).

Although the local government's authority to issue permits related to geothermal electricity was revoked by the Geothermal Law of 2014, local government remains a key player in the development of geothermal electricity, especially with regard to building permits and land acquisition.

Other agencies that have key roles in geothermal development are:

- The Ministry of Finance, for providing incentives and government support letters/guarantees.
- The Ministry of Environment, for environmental issues.
- The Ministry of Forestry, for permitting land use in the forest areas.

(Note: Currently, the Ministry of Environment is merged with the Ministry of Forestry as the Ministry of Environment and Forestry.)

Access to geothermal resources

Before the new Geothermal Law of 2014, in order to access geothermal resources, the developer had to obtain access to a Geothermal Working Area (GWA). This access was offered to prospective developers by the Minister of Energy and Mineral Resources (MEMR) and Governors or Regents/Mayors, in accordance with their respective jurisdictions, through competitive bidding. The successful bidders were awarded a maximum GWA of 200 000 hectares for exploration, but the exploitation area was a maximum of 10 000 hectares. Requests for larger areas were subject to approval from the Minister, the Governors, and the Regents/Mayors. Once the developer had its single allowed GWA, she or he needed a geothermal mining permit to access the geothermal resources. The exploration and exploitation phases could only be carried out by the developer after a feasibility study had been conducted and the environmental impact assessment or environmental management efforts and environmental monitoring approved by the environment agency. One aspect requiring the attention of developers was that the ownership (and related rights) of a GWA does not include the rights to surface lands. Hence, the developers needed to deal with landowners through purchasing, exchanging, compensation or other acknowledgment, or if the landowners were agencies (for example, the Ministry of Forestry), they needed to obtain permits before they could use the land. Since under the Forestry Law, mining activities were prohibited in protected forest areas (protection and conservation forest), it was difficult to obtain such a permit from the Ministry of Forestry if the resources were located in these areas. This was one of the primary barriers to the development of geothermal electricity in Indonesia.

Under the new Geothermal Law of 2014, before the developer can access geothermal resources, she or he must obtain access to a Geothermal Working Area (GWA), which is offered to prospective developers by the Minister of Energy and Mineral Resources (MEMR) through competitive bidding (no longer through the Governors or Regents/Mayors, as previously). The successful bidders are awarded working areas determined by the government based on a geothermal resource potential assessment. After obtaining the GWA, the developer must obtain a geothermal permit from MEMR (no longer including the Governors or Regents/Mayors, as previously). The exploration and exploitation phases can only be carried out by the developer after acquiring an environment permit from the Ministry of Environment, a forestry permit from the Ministry of Forestry if the resources are located in a forest area, and after a feasibility study has been approved by the MEMR. The GWA does not include the rights on surface lands. In this case, the developer must deal with the landowners through purchasing, exchanging, compensation or other acknowledgment, or if the landowners are agencies (for example, the Ministry of Forestry), they must obtain a permit from that agency before they can use the land. Under this new law, geothermal development activities are not considered mining activities, and so geothermal energy can be developed in production, protection and conservation forests after this permit from the Ministry of Forestry under categorisation of permit of utilisation of environmental services. To provide information regarding the geothermal electricity development process in Indonesia, including tender mechanisms and procedures, guidelines for geothermal business activities have been established at the national level by the government.

Secure and exclusive rights to resources

Regarding the New Geothermal Law of 2014, once the developer becomes the winner in the tendering process of a Geothermal Working Area, she or he is awarded a working area determined by the government (the MEMR) based on assessment of the geothermal resource potential. Once the developer has met certain requirements (for example, resolved land rights; submitted a long-term plan for exploration and exploitation), the geothermal permit is granted by the MEMR for a maximum period of 37 years (five years for exploration, with two one-year extensions and 30 years for exploitation), and another 20 years for each approved extension. A geothermal permit can be revoked by the MEMR if the developer does not meet requirements that have been stipulated in the geothermal regulations (for example, not paying State tax revenues or non-tax State revenues), without providing any compensation.

Permitting time limits

The permitting process for developing geothermal electricity in Indonesia is one of the barriers that have been identified by investors and developers as a cause of delay in the progress of the projects and of increases in the developers' expenses. Currently, there are 56 permits and licences that need to be obtained by geothermal electricity developers, consisting of general corporate permits/licences (14), operational (15), land related (3), environment related (6), manpower related (6) and safety related (12) (Haryo, 2014).

Although the government has established guidelines for geothermal business activities at the national level, there is no one single geothermal guideline for permitting that assimilates the multiple related licensing/permitting processes of different agencies with reasonable time limits within which permitting decisions must be reached.

One positive breakthrough that has been made by the government regarding permitting is that the issuance of geothermal permits will be made by the MEMR under the new Geothermal Law of 2014 while in the previous law it was made by the MEMR, Governors or Regents/Mayors in accordance with their respective jurisdictions.

'One-stop permitting'

There is currently no specific 'one-stop permitting' for the geothermal permitting process in Indonesia, but it has recently been announced that the Investment Coordinating Board (BKPM) will be appointed to provide this service. It has yet to be seen how that works in practice.

Inter-agency cooperation

Inter-agency cooperation in developing geothermal electricity in Indonesia remains one of the obstacles observed by investors and developers. With many different institutions involved in developing geothermal electricity, each with its respective administrative rules and permitting requirement based on its own legislation making (for example), the permitting process seems uncoordinated and cumbersome, creating uncertainty in terms of its legal aspects and the lack of cross-sector coordination. Harmonization and synchronization of the regulations, particularly across ministries and agencies, should be carried out by the government to accelerate the development of geothermal electricity in Indonesia (Poernomo, et al., 2015).

As part of streamlining the coordination among agencies, particularly in licensing, and avoiding overlap duties and responsibilities between central government and local government in regulating geothermal resources, the government has revoked the power of local governments (provincial and district/municipal) to regulate geothermal resources through the new Geothermal Law of 2014. Moreover, in order to coordinate all the permitting of power generation development, including geothermal electricity into 'one-stop permitting', the BKPM has been appointed as the agency to provide this service, although it has yet to be seen how this works in practice.

Database

According to the Geothermal Law of 2003, a preliminary survey and/or exploration stage survey must be carried out by the government (at the central or local level), or assigned to other entities. To implement this, the Ministry of Energy and Mineral Resources (MEMR) assigned the Geological Agency to carry out a preliminary survey of geothermal resources in Indonesia through the State budget. As a result, nearly all preliminary and detailed investigation of geothermal resources in Indonesia is conducted by the Geological Agency. Only a small amount is carried out by third parties through assignment from the MEMR. In 2012, the agency had identified 299 locations, with a total of approximately 28 835 MW of potential geothermal resources.

However, private developers and investors continue to question the quality of the surface exploration data since the lack of geological, geophysical and geochemical (GGG) data results in low accuracy in determining the magnitude of geothermal potential in Indonesia (Poernomo, et al., 2015).

In spite of the quality of the data, the MEMR compiled a 'Profile of Indonesia's Geothermal Potential' in 2012. This book contains a summary of information on: the geosciences, the characteristic manifestations, investigation phase and amount of potential value, as well as supporting infrastructure information for each of the identified potential points (ESDM, 2012a).

Research and development

Every year, the government provides funding to the Research and Development Agency of Mineral and Energy Resources, the MEMR, to conduct R&D related to geothermal resources. However, funding levels rise and fall depending on the project proposals of the agency. Currently, the agency is focusing on developing binary cycle geothermal technology. Despite the existence of the Research and Development Agency in MEMR, some experts believe that one of the challenges for Indonesia in renewable energy development is the absence of technology and R&D support (Darma, 2013).

The government could increase the funding for R&D in geothermal science and technology paid for by geothermal developers, since the Geothermal Law of 2003 contains a requirement that developers support R&D activities in geothermal science and technology. This obligation still exists in the new Geothermal Law of 2014. Implementation of this regulation needs to be discussed with the geothermal stakeholders, however, as it will increase the burden on geothermal developers.

Human resources development

With the ambitious target to develop geothermal electricity to 9500 MW by 2025 (already revised downward to 7215 MW) and followed by the 10 000 MW Fast Track Program Phase 2, which was launched in 2010, Indonesia needs to provide sufficient numbers and quality trained geothermal personnel. Although Indonesia has 30 years of experience in development and operation with geothermal electricity generation, since the Kamojang unit 1:30 MW in 1983, some experts see Indonesia as lacking capable technical personnel (Poernomo, et al., 2015) and with a shortage of competent human resources (Darma, 2013). Sufficient public training capacity is still not being developed.

It is estimated by the MEMR that, to develop geothermal, Indonesia requires 3000 operators and 1000 engineers (ESDM, 2012b). However, in reality, the Indonesian Geothermal Association (INAGA) currently has only about 400 professional members in geothermal businesses in Indonesia from various disciplines (PwC, 2012, p. 27). Moreover, only two universities have a magister program in geothermal: Bandung Institute of Technology-ITB for a magister program in geothermal technology, established in 2008 and with fewer than 20 students every year (ITB, 2014); and Indonesia University-UI for a magister program in geothermal exploration, established in 2012 (UI, 2012).

As part of increasing the capacity of human resources in geothermal development, in 2012, the Indonesian and New Zealand governments established cooperation under the Indonesia Strategic Framework for Development 2012–2016. Under this cooperation, New Zealand committed to providing funding of up to NZD 10.5 million for a technical assistance program and capacity building for the transformational scale-up of geothermal development in Indonesia. Since 2012, 103 industry and university staff participants have received geothermal training from GNS Science and the University of Gadjah Mada (UGM) joint courses, working to build Indonesia's geothermal workforce capability (MFAT, 2015).

Financial incentives

According to the Geothermal Law of 2003, as revised by the new Geothermal Law of 2014, developers who obtain 'the geothermal permit' have rights to both fiscal and non-fiscal incentives. Some of the financial incentives provided by the government are:

- Tax Holiday, which is an exemption from corporate income tax (from five to 10 tax years) and after the period of corporate income tax exemption ends, developers are given a 50% reduction of corporate income tax due for two tax years (MoF, 2014);
- Investment Allowance for Geothermal, for which facilities are given allowances including reduced net income tax for 30% of total investment (5% a year for six years); accelerated depreciation; income tax rate of 10% or lower, based on tax treaty on dividend paid to non-resident tax payers; and compensation for losses in certain circumstances (MoF, 2014). However, the developers may only benefit from one of these two incentives, either the Tax Holiday or Investment Allowance (MoF, 2014);
- Exemption from Value Added Tax for the import of machinery and equipment, not including spare parts (MoF, 2014);
- Exemption from Import Duty for machinery, goods and materials for construction and development, as long as the machinery, goods and materials are not produced domestically, are produced domestically yet their specifications do not meet requirements or are produced domestically, but the quantity is not sufficient (MoF, 2014);
- Exemption from Withholding Income Tax for the import of machinery and equipment, not including spare parts (MoF, 2014);
- Geothermal Fund Facility, a loan facility for the exploration stage. The distribution of rupiah cash loan funds to the geothermal business licence holder and the geothermal working area holder is limited to a maximum of USD 30 million with interest rate equal to the Indonesia's State Bank (BI) rate. The Developers as Debtors are obligated to pay their debts if they face unsuccessful exploration (Beritasatu.com, 2013).
- Government guarantee of the business viability of PLN to ensure the ability of PLN to meet its obligation to the third party in accordance with Power Purchase Agreements (PPA) (MoF, 2014).
- Ceiling price mechanism, introduced in June 2014. Under this new ceiling price mechanism, PLN can still purchase geothermal power from the lowest bidder, but the ceiling price has been set high enough to cover the investment cost of the developers (ranging from USD 11.8 cent/kWh to USD 29.6 cent/kWh depending on the commercial operation date of the project and the region). There is also the option for escalation after the developers carry out the exploration and feasibility study phases (ESDM, 2014).

Transmission network

In Indonesia, the electric transmission system and grid operations are managed by PLN (the State-owned Electricity Company), and under electricity regulations, the transmission company (PLN) has the obligation to share its transmission network services with all power generation companies at established transmission network charges. Standards for connection to the transmission network have been established by the government through the 'Grid Code', even though it applies only to the Java-Madura-Bali and Sumatera systems.

The Indonesian Government also allows geothermal developers to build associated transmission lines together with their geothermal power plants. For example, under the 10 000 MW Fast Track Program Phase 2, 29 private geothermal developers will build transmission lines with a total length of 1199 km. The shortest transmission line is 5 km from the Tangkubang Perahu Geothermal Power Plant II project to the Tangkubang Perahu Geothermal Power Plant I project (150 kV), and the longest is 104 km from the Bonjol geothermal project to Payakumbuh (150 kV) (ESDM, 2013). In this case, the geothermal developers can add the cost of transmission line construction to their electricity selling price to PLN. Although this approach may solve the problems regarding lack of transmission network availability, it may increase the risks to developers, particularly when they must deal with landowners to obtain right-of-way for the transmission line.

Electricity sales contracting

Currently, all geothermal producers sell their electricity to PLN, even though under electricity regulations, geothermal producers may theoretically also sell their electricity to other parties. Since the geothermal producers prefer selling their electricity to PLN, an electricity sales contract is required.

In the past, after developers received resources confirmation and/or conducted a feasibility study, they could approach PLN to negotiate their selling price before a contract was signed by both parties; the negotiation process was time consuming. To overcome the delays of PPA signing, in 2011, the government obligated PLN to purchase electricity from geothermal developers based on price auction results, without negotiation (in that time, the ceiling price mechanism was introduced and set to USD 9.7 cent/kWh). However, because there was no standard Power Purchase Agreement (PPA) setting 'terms and conditions' after the feasibility study prior to the auction, many geothermal developers did not sign their PPA with PLN. As a result, many geothermal projects have been delayed. To overcome these delays, a standard PPA has been drafted containing 'terms and conditions', so that it can be signed within a short time. There remain some terms and conditions that have not been agreed upon by both parties, however (ESDM, 2011, pp. 184–185).

Recently, in June 2014, the government introduced the ceiling price mechanism, to replace the FIT scheme that was introduced in 2012. Under this new ceiling price mechanism, the government, through the Ministry of Energy and Mineral Resources (MEMR), requires PLN to purchase electricity from geothermal developers based on price auction results (the ceiling price has been set ranging from USD 11.8 cent/kWh to USD 29.6 cent/kWh, depending on the commercial operation date of the project and the region); within six months after PLN receives the assignment to purchase electricity from the government, the PPA must be signed by both parties. If the delay of PPA is caused by disagreement over the geothermal price, an independent body must be appointed by both parties to recalculate the geothermal price under the developer's cost. The calculation of geothermal price by the independent body will be the final price in the PPA (ESDM, 2014).

Box 8: Old and new Geothermal Laws, the differences, Indonesia

Given that around 44% of the total geothermal potential is located in protected forest areas (as protected and conservation forests), to ease restrictions on the development of geothermal electricity in these areas, the government enacted the new Geothermal Law of 2014 on 17 September 2014, demonstrating its commitment to developers.

Some of the changes under this new law related to geothermal electricity are as follows:

Table 13. Old and new Geothermal Laws, the differences, Indonesia

Issues	Old Geothermal Law of 2003	New Geothermal Law of 2014
Are geothermal activities defined as mining?	Yes, through 'Geothermal Mining Permit'	No. Changed from 'Geothermal Mining Permit' to 'Geothermal Permit'
Are activities in forest areas limited/prohibited under the Forestry Law?	Yes. Limited and/or prohibited in protected and conservation forest areas under the Forestry Law	No. Geothermal development is allowed as long as it adheres to forestry regulations. Developer should obtain 'Permit of Environmental Service Use' from the Ministry of Forestry
Which government authority issues the Geothermal Working Area (GWA)?	The Minister of Energy and Mineral Resources (MEMR) or Governors or the Regents/Mayors in accordance with their respective jurisdictions	The MEMR
Which government authority issues geothermal permit/licence?	The Minister of Energy and Mineral Resources (MEMR) or Governors or the Regents/Mayors in accordance with their respective jurisdictions	The MEMR
How large is the concession?	Maximum 200 000 hectares with a maximum area of 10 000 hectares for exploitation. A larger area is subject to approval from the MEMR or the Governors or the Regents/Mayors in accordance with their respective jurisdictions	GWA will be determined based on assessing the geothermal resource potential
What is the period of concession?	Maximum period of 35 years (three years for exploration with two extensions of up to one year per extension and 30 years for exploitation). Possible to obtain further extensions	Maximum period of 37 years (five years for exploration with two extensions of up to one year per extension and 30 years for exploitation). Possible to obtain another 20 years for exploitation each time an extension is approved

NEW ZEALAND

New Zealand also has a long history of geothermal electricity development in the APEC region, having opened its first plant, and the world's second, at Wairakei in 1958 (MBIE, 2014).

According to the New Zealand Geothermal Association (NZGA, 2014b), geothermal areas are commonly close to the edges of continental plates, and New Zealand's location on an active plate boundary (between the Indo-Australian and Pacific Plates) has resulted in the development of numerous geothermal systems and a world-class geothermal energy resource. Most of New Zealand's existing geothermal generation and future potential is located in the Taupo Volcanic Zone in the central North Island (as shown by the large orange area in Figure 20) and one small plant (28 MW) in Ngawha in Northland (shown by the smaller orange area at the northern end of the North Island) (MBIE, 2014).

New Zealand's geothermal plants are under the ownership of either Mighty River Power (266 MW) or fully private entities (443 MW) (see MBIE, Table 10, 2013). Mighty River Power is a historically State-owned enterprise, operated on a commercial basis. In May 2013, the New Zealand Government sold a 48.2% stake in Mighty River Power in an initial public offering (The Treasury, 2014). The largest fully-private owner of geothermal plants in this economy is Contact Energy (303 MW), one of New Zealand's five major generators, which is publicly-traded. The geothermal generating capacity as of December 2014 was 971 MW (BP, 2015).

Figure 20. High temperature geothermal resources, New Zealand

Source: GNS Science, 2014.

Legal basis

The question of who legally 'owns' geothermal resources in New Zealand is complicated (White, et al., 1995). New Zealand's Geothermal Energy Act of 1953 states that 'the sole right to tap, take, use and apply geothermal energy on or under the land shall vest in the Crown, whether the land has been alienated from the Crown or not'.

Although most parts of this Act were repealed under the 1991 Resource Management Act (RMA), the property access rights vested in the Crown by the 1953 Act were expressly preserved by section 354 of that Act (Boast, 1995).

In reality, New Zealand is unique, in that it does not have a mineral licensing regime for geothermal resources other than the environmental permitting process under the RMA, known as 'Resource Consent' (O'Shaugnessey, 2000). This is because the definition of geothermal resources is 'water resources' under the RMA, not mineral resources under the Crown Mineral Act 1991. Therefore, there is no bidding system to access geothermal resources, but the developers must obtain a Resource Consent for the water right (that is, the right to take steam and discharge it back into the ground) (Anderson, 2014).

However, to access geothermal resources, even for exploration purposes, before a developer can apply for a Resource Consent, she or he is required to either own the land or have the permission of the landowner (through leasing or licensing). In practice, although not in law, one might say that landowners 'own' the geothermal resources in New Zealand (mostly owned by Maori people); however, the management of water rights is still controlled by the government.

Since there is no mineral licensing regime for geothermal electricity development in New Zealand, in general, no royalties are charged for geothermal development. The one exception is Rotorua, where a royalty was used in the past as an incentive to discourage fluid withdrawals and thus promote the recovery of natural geothermal features that had been damaged by geothermal development (O'Shaugnessey, 2000).

Government strategy

In 2011, the Ministry of Economic Development produced the New Zealand Energy Strategy 2011–2016. The strategy (MED, 2011, p. 6) notes that '[t]he Government retains the target that 90% of electricity generation be from renewable sources by 2025 (in an average hydrological year) providing this does not affect security of supply'. Under this strategy, the main incentive New Zealand provides for the development of renewable energy is an Emission Trading Scheme (MED, 2011, p. 6). In general, '[t]he Government's approach is to ensure market incentives and the regulatory framework support further investment in appropriate renewable projects by removing unnecessary regulatory barriers' (MED, 2011, p. 6). Realistically, the 'target' remains aspirational since it is not backed up by any effective policy (Lawless, 2015).

Under the Emission Trading Scheme, stationary energy participants are required to procure 'New Zealand Units' (NZUs) for their emissions of CO_2 or, in some cases, CO_2-equivalent (CO_2-e). As a transition measure, the initial stage of the scheme allowed participants to procure only one emission unit for every two tonnes of CO_2 or CO_2-e emitted, and participants were allowed to procure NZUs directly from the government at a fixed price of NZD 25/unit, effectively setting a ceiling price of NZD 12.5/tonne-CO_2. These transition measures were originally scheduled to end in December 2012; however, they have now been extended indefinitely (CCINZ, 2014a).

An NZD 12.5/tonne-CO_2 price for carbon adds a very modest amount to the cost of fossil-generated electricity. It would typically add about NZD 1.1 cents/kWh to the price of coal-generated electricity and about NZD 0.5 cents/kWh to the price of gas-generated electricity.[19] This compares to a weighted-average New Zealand residential price of electricity as of November 2013 of NZD 27.57 cents (MBIE, 2013).

[19] According to the MED (2006), footnote 86, a reasonable assumption regarding emissions would be 250 kt CO_2 per PJ of coal-generated electricity and 105.6 kt CO_2 per PJ of gas-generated electricity. According to Appendix B of the same publication, there are about 278 GWh per PJ, so this would imply 0.9 kt CO_2 per GWh (0.9 t CO_2 per MWh) of coal-generated electricity or 0.38 kt CO_2 per GWh (0.38 t CO_2 per MWh) of gas-generated electricity. Multiplying these values by NZD 12.50 per t CO_2 gives a cost of NZD 11.24/MWh for coal-generated electricity and NZD 4.75 per MWh of gas-generated electricity. Dividing both figures by 1000 gives us a value of NYD 1.1 cents per kWh for coal-generated electricity and about 0.5 NZ cent per kWh of gas-generated electricity.

The Emissions Trading Scheme also applies to fugitive emissions of CO2-e from geothermal electricity generation. However, these emissions are generally small, so the charge would typically be around one-tenth of an NZD cent/kWh of geothermally-generated electricity.[20]

Aside from the Emission Trading Scheme, New Zealand does not offer any regular subsidy programs, such as Feed-in Tariffs or Renewable Portfolio Standards, for renewable electricity. However, as discussed below under 'Permitting Time Limits', New Zealand has attempted to promote the development of renewable energy, including geothermal energy, through reforms to the Resource Consent process. These reforms were designed to make the process for obtaining a Resource Consent simpler, faster and more predictable.

Government commitment to investors

New Zealand has a stable, parliamentary system of government. It ranked third of 189 economies in the World Bank's 2013 'Ease of Doing Business Rankings', and first in the subcategory 'Protecting Investors' (World Bank, 2013). It also tied for number one ranking (with Denmark) out of 177 economies in Transparency International's 2013 Corruption Perceptions Index, which ranks the public sector of 177 economies from 'very clean' to 'highly corrupt' (TINZ, 2014).

Regarding specific commitments to geothermal investors, there have historically been few commitments made, and thus there is little comment one can make on whether the government has kept these commitments. In particular, since New Zealand's electricity prices are set in a competitive market, and there is no FIT scheme, there have been no commitments as to the price geothermal developers will receive for the electricity they produce.

A geothermal investor might, however, perceive that the New Zealand Government, at least to some degree, reneged on a commitment with their decision in 2012 to amend the New Zealand Emissions Trading Scheme. These amendments extended indefinitely the transition provisions that allow participants to surrender one emissions unit for every two tonnes of emissions (the one-for-two surrender obligation), as well as meet their obligations by paying the government NZD 25 per unit (the fixed price option). Under the earlier 2009 legislation, these provisions were scheduled to expire in December 2012, which would have effectively more than doubled the price on carbon (CCINZ, 2014b).

Institutions

In New Zealand, the Ministry of Business, Innovation, and Employment (MBIE) is the lead agency dealing with all aspects of energy. The MBIE was formed in July 2012 through the merger of four separate agencies, including the Ministry of Economic Development, which was formerly the lead agency dealing with all aspects of energy. New Zealand does not have a separate Ministry of Energy.

Regional and district councils (local governments) in New Zealand are key players in geothermal resource matters, as they have primary responsibility for issuing Resource Consents. Regional councils are the highest level of local government in New Zealand, comparable to provinces in some other economies. District Councils are the next level down, roughly comparable to counties in some other economies (see Department of Internal Affairs, 2014). The Waikato Regional Council, Bay of Plenty Regional Council, and Northland Regional Council are the important regional councils for geothermal development, since high-temperature geothermal resources are known to exist only in the territory of these three councils. The Waikato Regional Council administers approximately 80% of New Zealand's geothermal resources (Mizuno, 2013, pp. 15–16).

[20] According to MED (2006), footnote 95, a NZ \$15/tonne-CO_2-e price on carbon would imply a cost of NZ \$1.28 per MWh. Dividing this figure by 1000 gives NZ \$.0128 per kWh. Multiplying this by NZ \$12.50/NZ \$15 would give us NZ \$.0107 per kWh.

Three other agencies that have key roles with regard to geothermal resources are:

- The New Zealand Electricity Authority, which oversees the conduct of the electricity market, but does not regulate electricity prices.
- The Ministry for the Environment, which is the principal advisor to the government on environmental issues.
- The Environmental Protection Authority, which, as discussed under 'Time Limits' below, may manage the Resource Consent process for projects judged to be 'of national significance'.

Access to geothermal resources

As noted earlier, to develop geothermal resources, developers need the permission of the landowner(s) and a Resource Consent. The process of obtaining permission from the landowners may, however, be challenging, and in some ways, more challenging than under a State-permitting regime. In the typical regime where the State administers the resource, the cooperation of surface landowners would be compulsory, with compensation for surface landowners set by negotiation or, if negotiations fail, in a judicial or arbitration process. In New Zealand, there is no requirement for landowners to consent to geothermal development on their land. One can argue that this is as it should be: landowners should be free to use and not use their property as they see fit. However, as a 2010 report by New Zealand's Ministry of Economic Development notes, 'this lack of certainty can be a deterrent to investors, particularly from overseas. There is no formal process of arbitration and no legislative guarantee that the explorer will be given the first right to extract the resource. In contrast, for oil and gas (covered by the Crown Minerals permitting regime), arbitration is an option for land access negotiations, although arbitration has never been required to date' (MED, 2010, p. 17).

The Resource Consent is the other major requirement that must be met by geothermal developers in New Zealand to gain access to resources. This is discussed in further detail in the section under the heading 'Permitting Time Limits'.

Secure and exclusive rights to resources

In New Zealand, geothermal concessions for exploration and exploitation are granted not by the government, but by private landowners. There is no integrated resources management, so, in principle, another developer could move in on a neighbouring property and tap into the same geothermal resource as one in which an earlier developer has already invested a substantial sum exploring or even developing, thereby diminishing the resources available to the earlier developer. In this sense, New Zealand geothermal developers do not enjoy security over their investment, although in some cases through the resource consent process the multiple developers on a field are forced to cooperate in a joint reservoir management committee.

The Ministry of Economic Development report cited above (MED, 2010, p. 17) asserts that in practice the problem is not serious, but still sees some potential obstacles for investors: 'It has been argued that geothermal explorers do not have enough certainty to explore because someone else can come in and apply for resource consent after the explorer has invested in exploration in a particular area. However, it is not clear that the lack of a legislative guarantee over the right to develop is necessarily of concern. An application for resource consent to develop a resource requires the provision of considerable information. Hence, the ability of a new party to gazump an existing explorer to develop for the same use may not be as easy as some assume or suggest, but there is considerable potential that such a situation could delay or even terminate the development of a resource, or that there could be conflict between those seeking to use the same resource for different types of development'.

Mizuno (2013, p. 25) notes that although the Waikato Regional Council has tried to introduce a 'single tapper' policy for each of the seven development systems, the New Zealand Environment Court rejected the proposal. However, the majority of landowners and access rights holders of each system are currently controlled by a single entity, thus limiting the risk of ‘multiple tappers’.

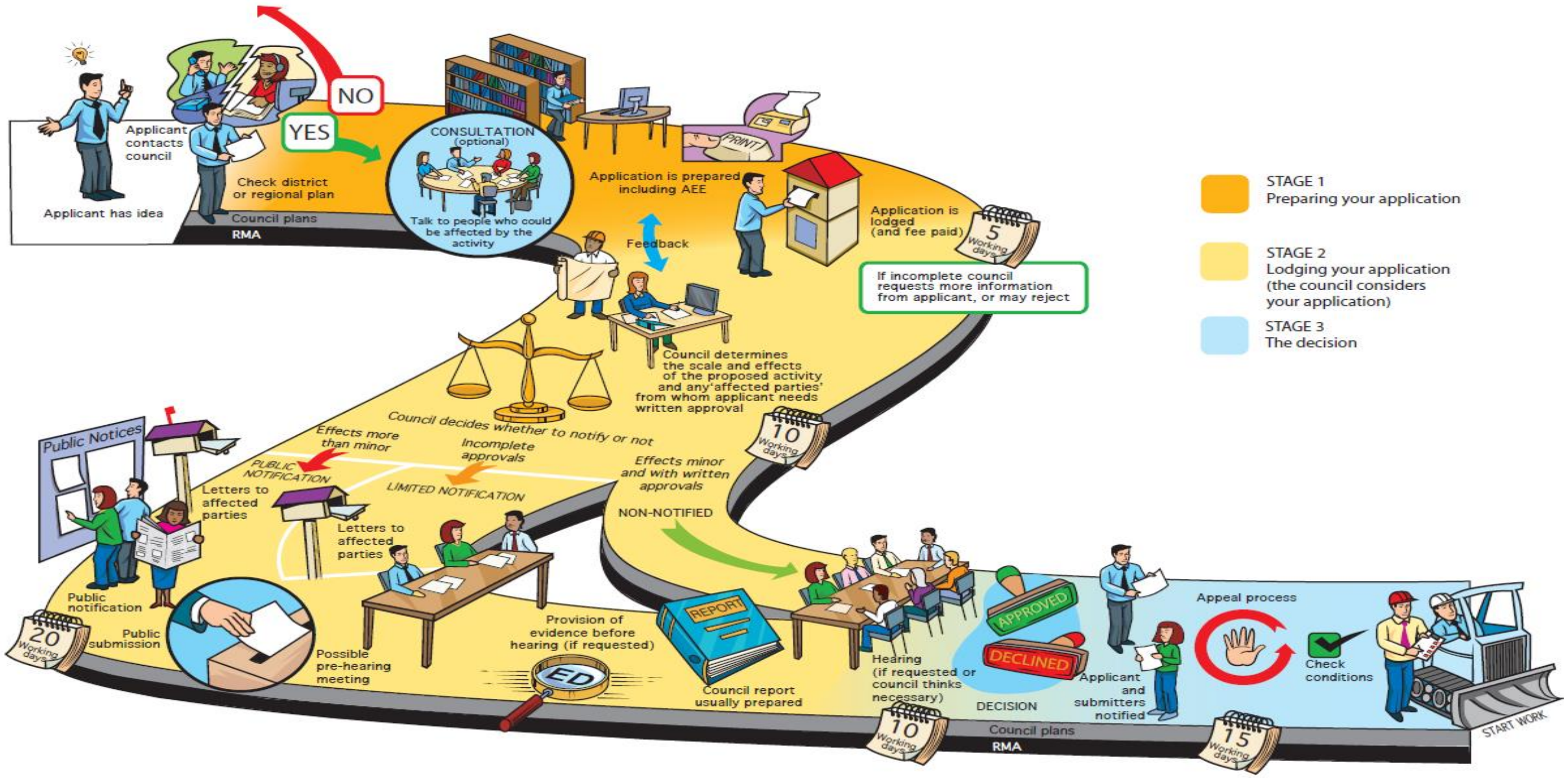
Permitting time limits

Figure 21 below graphically illustrates the basic Resource Consent application process in New Zealand. In this basic process, the applicant lodges their application with the appropriate Regional Council, who then manages all subsequent steps of the process. Due to amendments made to the Resource Management Act in 2009 and 2013, the process for a major project, such as a geothermal generation plant, could be somewhat different, and more advantageous to developers.

A major criticism of the RMA had been that decision-making was delegated to local governments, where local interests were likely to take precedence over economy-wide interests, especially for major projects. The Resource Management (Simplification and Streamlining) Amendment Act 2009 responded to this criticism by establishing an Environmental Protection Authority (EPA) to receive Resource Consent applications for proposals of ‘national significance’, and to support a specially-appointed Board of Inquiry or the Environment Court in making decisions regarding those proposals (MfE, 2009), although the Regional Council must still be consulted and involved in the process. Thus, there are now three possible alternative Resource Consent processes that a major project of national significance might take: the traditional path through the Regional Council, or (via the EPA) through an especially appointed Board of Inquiry or through the Environmental Court. The path selection is at the discretion of the Minister, with advice from the EPA and the Regional Council (see EPA, 2013a).

The details of these processes are beyond the scope of this document; however, at least for the Regional Council path and the Board of Inquiry path, there are fairly strict time limits for making a decision. A Regional Council must decide on a notified application within six months, with one clock-stop allowed to request more information (MfE, 2013b). A Board of Inquiry must decide within nine months (MfE, 2009).

Figure 21. Resource consent process, New Zealand



Source: http://www.mfe.govt.nz/rma/public/consent-apply/consent-apply.pdf

‘One-stop permitting’

New Zealand’s Resource Consent process comes very close to the model of ‘one-stop permitting’, at least for environmental permitting. The developer applies to the relevant Regional Council or the EPA for Resource Consents, which would deal both with resource allocation and with most of the serious environmental impacts of the project: air, water and land. In some cases, the developer may also need to apply for a Resource Consent with the district council or city (the next lower level of local government), regarding less serious impacts, such as noise and the location and height of buildings (MfE, 2014).

A 2013 Ministry for the Environment discussion document on ‘Improving Our Resource Management System’ (MfE, 2013a) notes that ‘when introduced in 1991, the RMA replaced more than 20 major statutes and 50 other laws related to the environment—a collection of uncoordinated approaches, with many conflicts, gaps and overlaps’. New Zealand has made a commendable effort at achieving this level of integration.

Inter-agency cooperation

New Zealand’s small population means that all units of government in New Zealand are relatively small, so government people involved with geothermal issues (and energy issues generally) tend to know each other, and have some familiarity with what is going on in other agencies. Cooperation between agencies, both formal and informal, is generally good. In particular, it should be noted that the law lays out processes by which central government (the Minister for the Environment, the EPA, Boards of Inquiry and the Environmental Court) must work with regional councils to reach decisions on resource consents for projects of national significance (EPA, 2013b).

Database

Mizuno (2013) notes that the Crown carried out drilling surveys of geothermal resources in the country, including the Taupo Volcanic Zone, during the 1970s and 1980s. The data gathered by these drilling programs have been used for regional policymaking, project planning by developers, Resource Consent applications including AEE, and monitoring.

> ‘These drilling surveys extensively covered the geophysical, geochemical, geological and ecological aspects of the Taupo Volcanic Zone in order to identify likely areas where high temperature geothermal fluid might be found. Based on the survey results, many high temperature zones were drilled to depths of approximately 1,000 m and the most promising zones were drilled to a greater extent than other areas. For areas with surface features that were considered to be nationally significant, the wells were grouted and no further drilling has been carried out.
>
> The wells drilled by the Crown have been left open in the Mokai, Rotokawa and Ngatamarki areas, which were recognized as especially high potential, and the data are for sale. In addition, negotiations between the Maori landowners of these areas and the Crown have resulted in the transfer of well rights from the Crown to Maori Trusts, which have since formed partnerships with power companies and developed geothermal power stations…. ‘(Mizuno, 2013, p. 26)

However, a 2010 report by the Ministry of Economic Development on ‘Geothermal Energy: Summary of Emerging Technologies and Barriers to Development’ notes that

> ‘Information such as drilling records and maps indicating the extent of geothermal fields, the location of geothermal resources such as geysers, hot springs and even areas of higher than normal subsurface temperatures are currently available from a range of sources, including central and local government and Crown research institutions such as GNS Sciences and the University of Auckland. However, there are inconsistencies in how this information can be accessed, and it has been argued

that it is sometimes difficult to gain access to information even when it is meant to be public. There are a range of sources of data on landownership.

Regional Councils collect data on operations on existing fields, but there are protections applied to this information to prevent other parties gaining a commercial advantage from the release of this information. For example, Environment Waikato is trying to make the information that they collect more accessible, but by contrast Environment Bay of Plenty currently treats the majority of the information they receive as commercially confidential. This reflects the current situation where Environment Bay of Plenty is regulating in an environment where there are multiple operators on a field, a situation that does not currently exist for any Environment Waikato consents (though it has in the past).

In addition to Regional Council held data, information from other sources exists, such as past Crown drilling programmes and temperature data for other drilling operations, but is kept by a variety of organisations and has a range of access requirements. This makes it difficult to get a clear overview of all of the existing data available for a particular site. This problem is greater for new market entrants who may be unfamiliar with past exploration activities in New Zealand.

Without access to the raw data on potential geothermal resources, it is not possible for subsequent analysis to take place efficiently, and be of benefit to a wide range of explorers rather than just be of relevance to one particular project, field or technology. Access provisions such as the time for which the data remains confidential, need to reflect the costs associated with obtaining and interpreting the data in the first place. It is important that the value of data on underground resources is recognised across a range of resources.... '(MED Report, 2010, pp. 14–15)

Lawless (2014b) notes that much of the data obtained from government-sponsored drilling now resides with Crown Research Institutes, who may charge high fees for access.

Research and development

The New Zealand Government has historically provided support for geothermal R&D on a modest scale. A 2012 paper by Colin Harvey and Brian White, published on the New Zealand Geothermal Association website, notes that 'the anticipated depletion of Maui [gas field] plus the recognition of the role of geothermal as a renewable, indigenous, low carbon source for electricity generation and heat led to an increase in funding since 2006. Current funding for the Crown Research Institute is close to NZ $3 million annually with some further industry support. The University of Auckland receives approximately NZ $1 million per year from Government and industry sources. These funds are applied to research in conventional systems, low temperature resources and deep geothermal exploration [but not specifically EGS]'.

Human resources development

New Zealand's major geothermal training program is the Geothermal Institute at the University of Auckland. Since 1978, more than 850 students from more than 50 economies have graduated from their programs with internationally recognized qualifications in Geothermal Energy (Geothermal Institute, 2013).

However, funding for these programs has been erratic. From 1979 to 2002, the Institute offered a year-long Geothermal Diploma course. Unfortunately, the New Zealand Government withdrew support for the program at the end of 2002, and postgraduate geothermal programs went into a hiatus from 2003 through 2006. In 2007, the Institute introduced a five-month postgraduate certificate in Geothermal Energy, with industry and University of Auckland support, which included three postgraduate lecture courses and a short (five-week) research project. Students can apply credit for these courses to other engineering degrees. In particular, the university offers a nine-month Master of Energy program, which offers students the option of specializing in geothermal energy (Newson, et al., 2010).

The New Zealand geothermal industry appears to be reasonably satisfied with the current state of geothermal education in New Zealand. The New Zealand Geothermal Association's June 2012 Position Statement notes, 'At one stage there were concerns over the availability of human resources to support the geothermal industry. There will be a growing number retiring in the next few years. However, personnel have increased in number to address the major growth in recent years, with a significant increase in "young" engineers and scientists now entering the industry. The Geothermal Institute (University of Auckland) will be a continuing source of specialist training along with other tertiary institutions' (NZGA, 2012).

Financial incentives

The New Zealand Emission Trading Scheme discussed earlier is currently the only significant financial incentive directed at supporting renewable energy in New Zealand. However, Mizuho (2013) notes that 'domestic cost comparison studies show that geothermal power is most competitive among several fossil fuels and renewable energy options on per unit of generated electricity basis. The high load factor and zero fuel costs can make the geothermal total cost per unit of electricity generated the lowest cost power generation option without financial incentives such as Feed-in Tariffs, even though capital costs per kw are expensive' (Mizuho, 2013, p. 6).

Transmission network

The electric transmission system and grid operations in New Zealand are managed by Transpower, a State-owned company, which is not affiliated with any generator. Geothermal developers appear to be satisfied with the transmission access offered by Transpower. A submission document from the New Zealand Geothermal Association (NZGA), notes: 'We have roads that give access, and a high degree of electricity grid interconnection that means that generated electricity can be readily connected' (NZGA, 2010, p. 3).

Electricity sales contracting

The electricity generation market in New Zealand is competitive, with prices set by the market. The major generation companies have electricity marketing organisations that allow them to sell their output directly to customers. Long-term contract prices for electricity are set by negotiation with the buyer. As noted earlier, there are no special pricing incentives offered for geothermal electricity.

Historically, most geothermal electricity projects in New Zealand have been developed by generation companies with their own marketing capabilities. An independent developer could contract to sell their output to a company with electricity marketing capabilities, or market their output directly to consumers. New Zealand also has a half-hourly spot market, which provides another option for selling electricity (see Electricity Authority, 2011, p. 11), but the price received would probably not be predictable enough to allow the developer to obtain financing for the project.

MEXICO

Mexico has more than 40 years of experience producing electric energy from geothermal sources. Exploration to find geothermal resources for use in electrical projects has been on-going since the 1950s, when an experimental geothermal power plant was successfully developed in Pathe, State of Hidalgo, in the central portion of Mexico in 1959 by the Federal Electricity Commission – 'Comision Federal de Electricidad' (CFE). (This plant has not been in operation since 1973, due to insufficient steam.) After that, CFE continued conducting exploration of geothermal resources at Cerro Prieto, together with the Geothermal Energy Commission – 'Comision de Energia Geotermica' (CEG), before CEG was dissolved and CFE took charge of geothermal development in 1971. As a result, CFE began operation of the first unit of 37.5 MW at Cerro Prieto I in northern Baja in 1973 (Quijano-Leon and Gutierrez-Negrin, 2003, pp. 198–199).

Mexico's geothermal resources are particularly concentrated in the central region of Mexico in La Primavera, Loz Azufres and Los Humeros fields (Aragon-Aguilar, et al., 2013, p. 24). In the initial stages of developing geothermal electricity in Mexico, CFE was given preferential rights by the Mexican Government for extraction of hot groundwater and steam for electricity generation after CEG was dissolved in 1971 (Quijano-Leon and Gutierrez-Negrin, 2003, pp. 198–199). Consequently, geothermal electricity development in Mexico is the duty of CFE (for developing, managing and operating). To raise capital for geothermal projects, the financing scheme used in Mexico is a Public-Private Partnership (PPP) scheme called 'Obra Publica Financiada' (OPF) (ESMAT, 2012, p. 91, p. 93). Under this scheme, CFE develops the steam fields where the wells were constructed and drilled by drilling companies contracted by CFE through a 100% public fund (Gutierrez-Negrin, et al., 2010, p. 4, p. 11); completes the pre-design of all the necessary components of the power plant (plant and associated transmission network); obtains necessary permits from related agencies; and then after everything is done, CFE puts the project out for public tender to private engineering procurement construction (EPC) contractors. The winning private EPC contractor finances and carries out the detailed design and construction of the project and then transfers the completed project to CFE for operation and maintenance. CFE pays the contractor the total amount of the contract after the transfer, and resorts to private or public financing institutions for long term financing to pay the EPC contractor. The risk for the private sector is limited to short-term financing over the construction and commissioning period and to guarantees for the equipment; it does not include any risk related to geothermal reservoir or drillings (ESMAT, 2012, p. 93). Up to now, CFE has successfully developed, managed and operated geothermal power plants with the net geothermal-electric capacity of 850 MW, installed in four geothermal fields: Cerro Prieto, Los Azufres, Los Humeros and Las Tres Virgenes (Flores-Armenta, 2014).

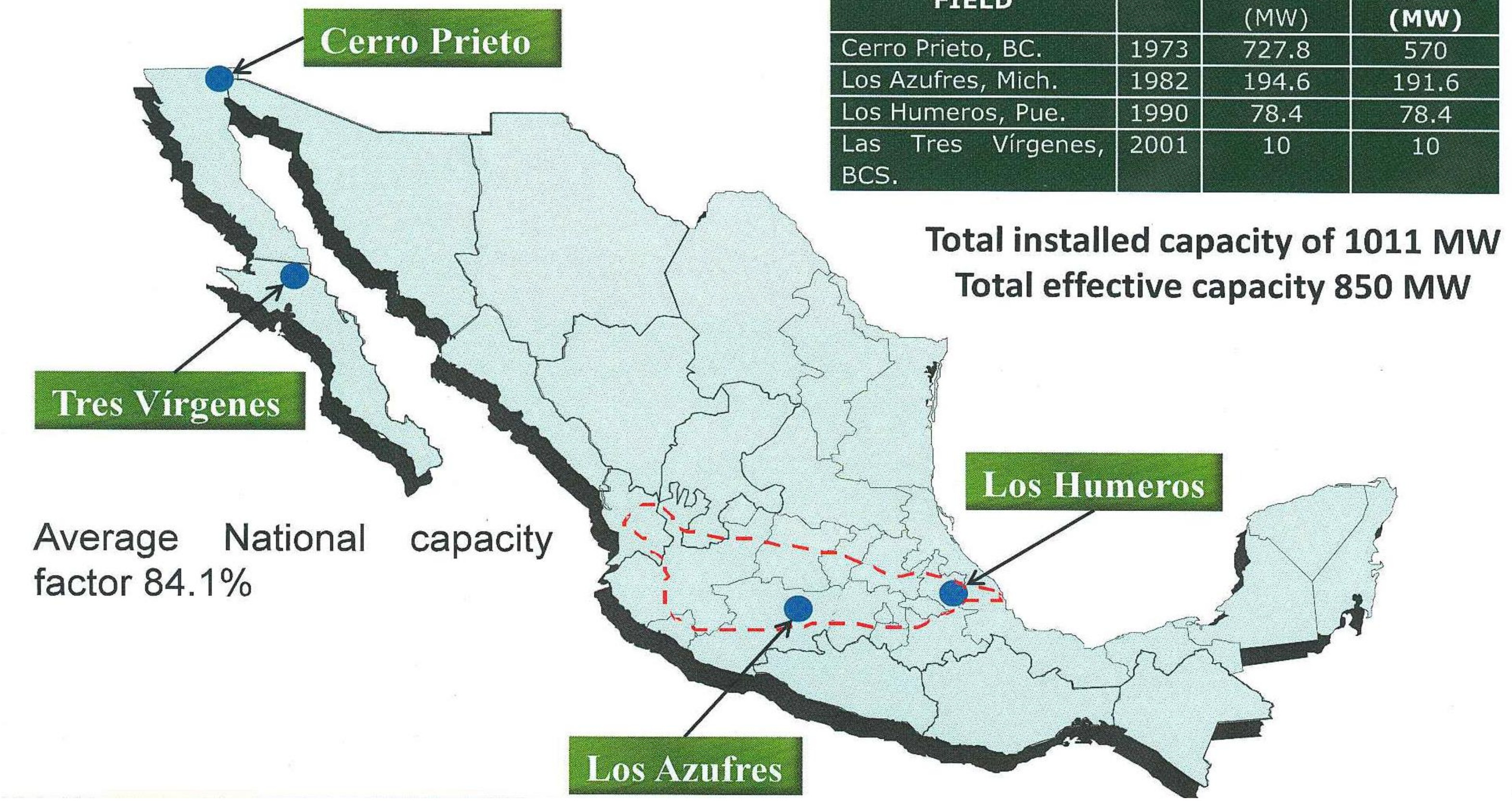
However, to enable more participation by the private sector to develop geothermal electricity, the Mexican Government enacted the Geothermal Energy Act in August 2014. Under this Act, geothermal resources can be exploited by either CFE or other enterprises/individuals after obtaining a geothermal concession from the Ministry of Energy, the 'Secretaria de Energia' (SENER), through competitive bidding. Once they have the geothermal concession and meet all the requirements stipulated in the Act and other related regulations (for example, the National Water Act and the Electricity Industry Act) the Energy Regulatory Commission, the 'Comision Reguladora de Energia' (CRE) may grant a permit to generate electricity.

Figure 22. Geothermal resources, Mexico

Source: Aragon-Aguilar, et al., 2013, p. 24.

Figure 23. Geothermal fields in operation, Mexico

GEOTHERMAL FIELD		Installed Capacity (MW)	Effective Capacity (MW)
Cerro Prieto, BC.	1973	727.8	570
Los Azufres, Mich.	1982	194.6	191.6
Los Humeros, Pue.	1990	78.4	78.4
Las Tres Vírgenes, BCS.	2001	10	10



Source: Flores-Armenta, 2014.

Legal basis

Before the government enacted the Geothermal Energy Act in August 2014, geothermal electricity development in Mexico, due to its nature, was conducted through two Acts: the Public Electricity Service Law of 1975 (as reformed on 2014) and the National Water Act of 1992 (as reformed on 2011) (SENER, 2013).

Under the Public Electricity Service Law of 1975, the public service of electricity in Mexico is provided by the Federal Electricity Commission (CFE). Since in Mexico, geothermal resources remain primarily to produce electricity, electric uses of geothermal are planned, developed and operated by CFE only (Flores-Armenta, 2012, p. 1). No independent power producers (IPPs) are allowed to enter the geothermal business except for private EPC contractors. Geothermal resources are treated as 'Hot Water' under the National Water Act, which governs the use and exploitation of underground water either as steam or liquid above 80^0C. When such aquifers may be exploited, a concession prior to geothermal production must be obtained by the National Water Commission, 'Comision Nacional del Agua' (CNA). Under this Act, since State ownership of energy assets is a historically significant characteristic of Mexico's economy, geothermal resources belong to the State (IRENA, 2013, p. 2).

To obtain a Concession of National Water for exploitation of geothermal resources, CFE must conduct a feasibility study of water availability, perform lab tests and pay fees to CNA (Nexant, 2001, p. 31, p. 35). Concessions for geothermal exploration and exploitation are granted by well, not by field or area. This results in investments not being protected during these phases (SENER, 2013). After obtaining the Concession of National Water, CFE still needs to secure several permits, such as a land use permit, environmental permit, energy regulatory permit and health and safety permit from various agencies before the municipal government can issue the construction permit, and CFE can start to construct its geothermal power plant (Nexant, 2001, p. 9, p. 11). So far, through those regulations, CFE has successfully developed, managed and operated geothermal power plants with a net geothermal-electric capacity of 850 MW in the four geothermal fields.

To establish a legal framework that regulates the recognition, exploration and exploitation of geothermal resources for generating electricity or other uses, as well as allowing participation from the private sector in the geothermal business, the Mexican Government has enacted the Geothermal Energy Act of 2014. Under this Act, geothermal resources are defined as 'Hot Water', either as liquid or vapour, with a temperature of more than 80^0 C stored naturally in a hydrothermal geothermal reservoir, which is capable of transporting energy as heat, and is not suitable for human consumption. The geothermal resources belong to the State. To exploit the resources, either CFE or enterprises/individuals should have a geothermal concession, which is granted by area valid for 30 years (with possible extension) from the Ministry of Energy, 'Secretaria de Energia' (SENER), through competitive bidding. After that, they must also obtain permits from other federal, State or municipal authorities according to their respective jurisdictions and their regulations, before they can start exploration, exploitation and use of the geothermal resources for generating electricity.

Other regulations that need to be followed by the developer include the National Water Act, the Electricity Industry Act of 2014, the General Act of Ecological Equilibrium and Environmental Protection regarding Environmental Impact Assessment and the Forest Act.

Government strategy

The past situation, before the Geothermal Energy Act of 2014 was enacted, may be summarised as follows:

- Providing preferential rights to the Federal Electricity Commission (CFE)

Since electricity is one of the public services that needs to be provided by the government, the development of the electricity sector, including power plants, must be conducted by the government in Mexico through the CFE. Thus, electric uses of geothermal are planned, developed and operated by CFE, and CFE becomes a Steam-field Developer as well as a Power Plant Operator.

- Providing continual public funding to CFE for steam-field development

As a Steam-field Developer, CFE has the responsibility to develop steam fields where wells are constructed and drilled by drilling companies contracted by CFE through 100% public funding. As a result, from 1963 to 2008, 556 geothermal wells were drilled in Mexico with a total depth of 1187.9 km. To support CFE activities to confirm the geothermal resources, the government provides 100% public funding for R&D (including surface exploration and exploration drilling) and field development (including production drilling and surface equipment) of geothermal. For instance, from 1995 to 2009, a total funding amount of USD 810.8 million was allocated by the government, with 96% of the funding used for field development and the rest used for R&D (Gutierrez-Negrin, et al., 2010, p. 4, p. 11).

- Providing CFE with a Public-Private Partnership (PPP) scheme called 'Obra Publica Financiada (OPF)' for geothermal power plant development

After necessary activities have been conducted by CFE (for example, steam field development, permits, pre-design of the power plant and transmission), the engineering, procurement and construction (EPC) of the power plant is offered to private EPC contractors under a PPP scheme through public bidding. Under this scheme, the winning private EPC contractor finances and carries out the detailed design and construction of the project, and then transfers the completed project to CFE for operation and maintenance. CFE pays the contractor the total amount of the contract after the transfer and resorts to private or public financing institutions for long term financing to pay the EPC contractor. The risk for the private sector is limited to short-term financing over the construction and commissioning period, and to guarantees for the equipment; it does not include any risk related to the geothermal reservoir or drillings (ESMAT, 2012, p. 93).

- Providing funding for Energy Transition and Sustainable Energy Use – 'Fondo Para La Transicion Energetica y el Aprovenchamiento Sustentable de la Energia' (FOTEASE)

This fund is an instrument of public policy of the Ministry of Energy (SENER); created by the Law on the Use of Renewable Energies and Financing of Transition Energy of 2008 (LAERFTE). LAERFTE aims to support the National Strategy for Energy Transition and the Sustainable Use of Energy and promote the use and development of, and investment in, renewable energy (including geothermal energy) and energy efficiency. In 2013, a total of MXN 689 million was allocated to FOTEASE by SENER; some of this funding was given to geothermal projects, such as geophysics projects for the development of pre-feasibility strategic geothermal areas of CFE (MXN 50 million) and the design and structuring of financial development of private investment in geothermal projects through the national credit corporation, 'Nacional Financiera' (NAFIN) (MXN 150 million). In 2014, the government allocated MXN 1000 million to support energy efficiency and renewable energy, including geothermal energy (SENER, 2014a).

After enactment of the Geothermal Energy Act of 2014, the changes are:

- Allowing more private sector participation in geothermal electricity development

Under the reformed energy program based on the Geothermal Energy Act of 2014, the government allows more participation by the private sector in geothermal electricity development. Under this Act, geothermal resources can be exploited not only by CFE but also by other enterprises/individuals, including private parties. The private sector may either participate in the exploration stage, by obtaining a permit from the SENER, and/or the exploitation stage, including power plant development, by winning a geothermal concession, offered by SENER through tender. Although no specific fiscal incentive is provided by the government under this Act (as exists under the Law on the Use of Renewable Energies and Financing of Transition Energy of 2008), this Act provides reasonable time limits within which permitting decisions must be reached by the federal government (the Ministry of Energy and the National Water Commission). Under this Act, the Ministry of Energy will be the agency responsible for coordinating with other departments and agencies at the federal level.

- Providing a risk mitigation and financing program for Independent Power Producers (IPPs)

With the enactment of the Geothermal Energy Act of 2014, participation by the private sector, IPPs in developing geothermal electricity in Mexico was opened up. They may either participate in the exploration stage, by obtaining permits from the SENER, and/or the exploitation stage, including power plant development, by winning a geothermal concession, which is offered by SENER through tender. However, the high risk to developers in the early stages of development of geothermal electricity remained one of the obstacles that hindered private sector participation.

To address this issue, SENER, in cooperation with Nacional Financiera (NAFIN) and the Inter-American Development Bank (IDB), conducted a risk mitigation and financing program. The program objective is to scale up investments in geothermal power generation projects by making available a range of financial mechanisms tailored to meet the specific needs of each project's stage of development. This is to include risk mitigation mechanisms at the early drilling phase (for example, providing grants to partially cover private insurance and insured loan premiums and rates), called 'Component I'; as well as various forms of financing for exploration, drilling, field development and construction phases of geothermal projects (for example, direct loans, contingent loans, subordinated loans, first loss guarantees and insured loans), called 'Component II'. A total of USD 120.1 million has been allocated for this program, for which the funding comes from IDB, channelled through NAFIN (USD 54.3 million), the Clean Technology Fund (CTF) (USD 54.3 million) and SENER (USD 11.5 million). As much as 25% of the total fund will be used to support activities under component I, 73% will be disbursed to support activities under component II, and the rest will be used to support implementation costs and technical assistance activities. The fund is expected to be disbursed under this program for a period of six years, and it is targeted to finance 300 MW of additional geothermal capacity in the long term (Paolo Bona, 2014, pp. 8–9).

Government commitment to investors

As mentioned earlier, since the government has historically given preferential rights to CFE to develop geothermal electricity in Mexico, no other utilities or private sector entities are participating in the development of geothermal electricity (either as a Steam-field Developer or as a Power Plant Operator). The participation of the private sector in geothermal electricity development has been very limited. In geothermal field development, private drilling companies may participate in the construction and drilling of wells under contract with CFE. These private drilling companies are to be paid by CFE from the public fund after successfully meeting the contract requirements. In geothermal power plant development, the government has established a Public-Private Partnership (PPP) scheme called 'Obra Publica Financiada' (OPF). Under this scheme, the government has limited the risk for the private sector to short-term financing over the construction and commissioning period, and to guarantees for the equipment; the private sector risk does not include that related to geothermal reservoirs or drilling (ESMAT, 2012, p. 93), as all the necessary activities such as steam field development, permits, pre-design of the power plant and transmission have been undertaken by CFE before the contract is offered to private EPC contractors.

As a result of the government policy to restrict the participation of the private sector, the development of geothermal electricity in Mexico has been very limited; no new geothermal power plants have been put into operation in the past 10 years. Currently, there are only four ongoing projects (Binary Tres Virgenes, Los Humeros III Phase B, Loz Azufres III Phase II and Cerritos Colorados I), with a total capacity of 76.7 MW (Flores-Armenta, 2014).

According to Paolo Bona's Independent Technical Review (2014, pp. 6–7), the main cause of the comparatively limited development of geothermal electricity in Mexico is the lack of funding (capital and financing) associated with the uncertainty and high-risk exploration investments involved in the projects. In addition to financial problems, a weak regulatory framework, specifically with regard to the exploitation and use of fields and underground water for geothermal purposes, as well as the lack of specific legal instruments for the private exploitation of geothermal resources, increases the perception of risk by investors and creates additional barriers to investment in the sector. Moreover, issues with energy tariffs, financial disadvantages against modern fossil-fuel generation, and other regulatory risks, such as rules on access to the transmission network and to the knowledge generated by CFE, are additional elements that have discouraged private investment in the Mexican geothermal industry.

Since the Mexican Government has recently committed to significant reforms in geothermal energy, investors expect the government to keep that commitment in the future.

Institutions

In Mexico, the Ministry of Energy, the 'Secretaria de Energia' (SENER) is the lead agency dealing with all aspects of energy, including geothermal energy, at the national level. In addition to having responsibility for preparing, developing and implementing the National Energy Strategy of Mexico, SENER is also authorized to implement regulations under the Law on the Use of Renewable Energies and Financing of Transition Energy of 2008, the Electricity Industry Act of 2014 (revising the Public Electricity Service Law of 1975) and the Geothermal Energy Act of 2014. Under the Geothermal Energy Act of 2014, the Ministry of Energy has functions such as regulating and promoting the exploration and exploitation of geothermal areas, issuing permits in geothermal concessions, and coordination with other departments and agencies at the federal level.

States and municipal authorities are also key players in geothermal electricity development, especially when geothermal resources are located on State or municipal lands. Geothermal developers need to obtain permits from these authorities as well (for example, permits to emit noise, vibrations and thermal energy in non-daily activities, construction permits from municipal agencies; authorisation to establish industrial facilities from State agencies (Nexant, 2001, p. 11).

Other agencies that have key roles related to geothermal resources are:

- The Ministry of the Environment and Natural Resources, 'Secretaria del Medio Ambiente y Recursos Naturales' (SEMARNAT), is the branch of the federal government that deals with environmental issues (Nexant, 2001, p. 7). There are three agencies under SEMARNAT with responsibility for environmental impact issues, natural resources and water impact issues, as well as land use issues in forested areas:
    - The Office of Environmental Impact and Risk, 'Direccion General de Impacto y Riesgo Ambiental' (DGIRA) is the agency within SEMARNAT that regulates all issues related to environmental impacts, including protection of natural areas, rational exploitation of natural resources and measures for controlling atmospheric, soil and water contamination (Nexant, 2001, p. 40);
    - The National Water Commission, 'Comision Nacional del Agua' (CNA) is a decentralized agency of SEMARNAT that regulates all issues related to water resources under federal jurisdiction, except municipal water supply, treatment and discharge networks (Nexant, 2001, p. 30). Under the Geothermal Energy Act, the Ministry of Energy must consult with the National Water Commission if there is interference between geothermal reservoirs with adjacent aquifers, before the Minister decides on whether to perform exploratory work regulated under this Act. In the case of hydrothermal geothermal reservoirs, this agency has authority to grant the water concessions to developers, based on the National Water Act;

- The State Delegations of SEMARNAT are responsible for issuing land use change permits for projects that will involve alteration of forested areas (Nexant, 2001, p. 7).

- The Energy Regulatory Commission, 'Comision Reguladora de Energia' (CRE) is a decentralized agency of SENER with technical and operational autonomy and powers to regulate the energy sector. This includes the electricity and renewable energy sectors, particularly with regard to resolving issues arising from interaction between the public and private sectors as a product of energy reform (CRE, 2014). Under the Electricity Industry Act of 2014, CRE has functions such as issuing permits for generating electricity, establishing general conditions for the provision of the transmission and distribution networks and electricity supply, and their modification; setting regulated prices for transmission and distribution networks; and issuing the Electricity Market Rules.

- The Federal Electricity Commission, 'Comisión Federal de Electricidad' (CFE) is the sole Mexican electricity utility, in charge of generating, transmitting, distributing and selling electricity. All geothermal fields and power plants are owned and operated by the federal government of Mexico through its government-owned agency CFE.

Access to geothermal resources

Before the Geothermal Energy Act of 2014, access to geothermal resources was only given to the Federal Electricity Commission (CFE). To access the resources, CFE was required to obtain a water concession from the National Water Commission. After that, CFE needed to secure the rights of land use through negotiation with the landowners (whether private, communal (ejidos) or public) for the land that would be required for the implementation of the project; if the project would cross forested land, a permit to change land use for forested lands was required from the State Delegation of SEMARNAT (Nexant, 2001, p. 26, p. 45). To drill geothermal wells, either exploration or production wells, various Official Mexican Standards, 'Norma Oficial Mexicana' (NOM) for environmental protection from various agencies would need to be met by CFE, such as from CNA (maximum limits of contaminants in discharges of wastewater), and from SEMARNAT (toxic waste abatement, vehicle noise) (Aragon-Aguilar, et al., 2013, pp. 27–29).

Under the Geothermal Energy Act of 2014, a developer (either CFE or enterprises/individuals) can use geothermal resources to generate electricity if she or he has a geothermal concession and obtains the necessary licences. A geothermal concession is offered to prospective developers by the Minister of Energy through competitive bidding. The successful bidders are awarded a geothermal concession in an area equal to 150 km^2 or less as specified in the permit. Developers should note that the rights to (or ownership of) a geothermal concession do not include the rights to surface lands. Hence, developers need to negotiate (purchasing, exchanging, compensation or other acknowledgment) with the landowners (private, communal (ejidos) or public) to use their land for projects, as mentioned under the Electricity Industry Act of 2014. If the project will cross forested land, a permit to change land use for forested lands is required from the State Delegation of SEMARNAT.

Once the developer has obtained a geothermal concession and has secured the rights of land use to access geothermal resources, she or he must obtain licences such as exploration and exploitation permits from the Ministry of Energy. However, to obtain such permits, developers must first obtain other permits from various government authorities (federal, State or municipal) in accordance with their authority and regulation, and apply Official Mexican Standards. In the case of hydrothermal hot water reservoirs, they must also obtain a water concession from CNA under the National Water Act.

Secure and exclusive rights to resources

Geothermal resources in Mexico are treated as 'Hot Water' under the National Water Act, and geothermal concessions for exploration and exploitation are granted by well and not by field or area. Hence, there is the possibility that another developer may tap the same resource, if she or he has obtained a concession from the National Water Commission, 'Comision Nacional del Agua' (CNA). This can result in investments not being protected during the exploration and exploitation stages. However, since geothermal electricity development can only be planned, developed and managed by the Federal Electricity Commission (CFE) – no other entities can acquire secure and exclusive rights to resources. Thus, one can say that CFE has had appropriately secure and exclusive rights to resources for more than 40 years, as long as it has followed all the regulations stipulated by the government, both at the federal level and State/municipality levels, but not other developers.

Based on the Geothermal Energy Act, the developer who wins the tendering process of geothermal concession is awarded a maximum 150 km^2 area by the Ministry of Energy (SENER). After meeting the requirements (for example, compliance with the Mexican Standards, payment of royalties and so on), a geothermal exploration permit will be granted by the Ministry of Energy for a maximum period of three years, extendable only once for three additional years; after that, the developer is also entitled to obtain a geothermal exploitation permit for 30 years (extendable, as long as the developer meets the requirements). However, for purposes of national security, public interest, efficiency in the use of geothermal resources and environmental protection, SENER can determine whether the geothermal resources may be used jointly or separately by different developers, when there are corresponding concessions between two different concession owners.

Geothermal concessions and other permits can be revoked by the Ministry of Energy if the developer does not meet the specific requirements of the Geothermal Energy Act (for example, does not comply with the relevant investment commitments or environmental provisions and so on), without payment or compensation.

Permitting time limits

There is no national guideline for permitting that compiles the many related licences for developing geothermal resources from various agencies into one single information source and sets reasonable time limits within which permitting decisions must be reached. However, in 2001, with support from the U.S. Agency for International Development (USAID), the Mexican Government (SEMARNAT, SENER and CFE) developed a 'Handbook on Environmental Permitting Issues – Project Development – Mexican Electric Sector'. This publication is intended to assist developers of electricity generation and transmission projects in Mexico with understanding the requirements and regulations in environmental permitting from various agencies on environmental issues. It also provides information on the time required for a permitting decision to be reached (Nexant, 2001, p. ix). This handbook also applies to geothermal power plant projects.

To provide more certainty to geothermal developers regarding permitting in geothermal electricity development, the Geothermal Energy Act of 2014 sets a reasonable period within which permitting decisions must be reached by various government agencies (for example, SENER and CNA). For example, exploration permits must be granted by the Ministry of Energy (SENER) within a period not to exceed 45 working days. The exploitation permit is to be granted by SENER within a period not to exceed 30 working days from the filing of the request. However, developers must keep in mind that permits are granted only after all the necessary documents have been fully submitted to SENER, in compliance with related regulations.

In addition, the SENERin collaboration with the Ministry of Environment and Natural Resources (SEMARNAT), the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food, the Energy Regulatory Commission, the Federal Electricity Commission (CFE), the National Water Commission (CNA) and the National Institute of Anthropology and History have proposed developing a Renewable Energy Window, 'Ventanilla de Energias Renovables' (VER). This project aims to help promote investment in renewable energy projects, including geothermal energy, by simplifying the requirements and procedures imposed upon developers. Mapping of the procedures has shown that if carried out sequentially over time, they would represent 600 days of pending time for a permit decision; the VER presents end users with a mechanism to help them identify parallel proceedings, avoiding duplication of requirements and reducing the time required to a minimum. Preliminary estimates indicate that through this effort, the government can achieve a reduction of approximately 35% in the total permit processing time. This project is funded by the World Bank through the Project Development of Large-Scale Renewable Energy (SENER, 2014b).

'One-stop permitting'

Mexico has no known 'one-stop permitting' for the geothermal permitting process.

Inter-agency cooperation

In Mexico, electric sector development, including geothermal electricity, is a collaborative effort of the federal government, through the Ministry of Energy (SENER), the Ministry of Environment and Natural Resources (SEMARNAT) and the Federal Electricity Commission (CFE). Even though inter-agency cooperation among those agencies has worked well for the success of geothermal electricity development, procedure mapping conducted by SENER (SENER, 2014b) has shown that the procedures for permitting still represent 600 days of pending time for permit decisions, because there remains duplication of requirements among agencies. If the duplication could be eliminated, along with streamlining of the procedures, the time required for permit processing could be reduced to 35% of the total processing time.

To improve inter-agency cooperation, particularly with other departments and agencies of the federal government, under the Geothermal Electricity Act of 2014, SENER has been appointed as the coordinator for solving technical issues among agencies.

Database

As discussed earlier, the Federal Electricity Commission (CFE) has historically been given preferential rights by the government to develop, manage and operate geothermal electricity in Mexico. Consequently, CFE holds the entire database regarding geothermal resources at various temperature levels in Mexico; this database cannot be easily accessed by the public. As the Geothermal Electricity Act of 2014 has issued, all geothermal data obtained by CFE should be transferred to SENER who will be responsible for the collection, protection and management of this information.

As part of the reformed energy program and implementation of the Law on the Use of Renewable Energies and Financing of Energy Transition (LAERFTE), the Ministry of Energy (SENER) used supporting funding from the Fund for the Energy Transition and Sustainable Energy Use (FOTEASE) to establish the National Renewable Energy Inventory, 'Inventario Nacional de Energias Renovables' (INER) in 2013. INER is a system of statistical and geographical information services for various renewable energy sources, including geothermal resources, which contains information on the status of major projects to generate electricity from renewable energy sources. The purpose of this system is to allow private and public actors and society in general to access reliable information on renewable resources in Mexico. Currently, a national atlas of geothermal resources is also under preparation (SENER, 2014c). More information about INER can be obtained through http://iner.energia.gob.mx/publica/version2.6/

Research and development

Mexico has a long history of supporting R&D on geothermal resources. Most geothermal research activities are focused on development and exploitation of resources for power generation with the aim of improving knowledge of the geothermal fields, and thus the ability to predict their behaviour under continued exploitation (Maya-Gonzalez and Gutierrez-Negrin, 2012, p. 3). Regarding R&D funding, SENER provides the annual budget for R&D in geothermal electricity development, including surface exploration and exploration drilling. In the period from 1995–1999, funding for R&D in the amount of approximately USD 7.41 million was disbursed by the government through public funding. In the period from 2000–2004, this increased by 57% compared to the previous period, or USD 11.61 million. In the period from 2005–2009, the R&D budget for geothermal electricity development increased to USD 15.65 million (Gutierrez-Negrin, et al., 2010, p. 11). As a result of continuing budget support from the government, CFE houses data and information for more than 1200 locations with signs of geothermal resources at various temperature levels (SENER, 2013). In the period from 2010–2014, the R&D budget increased by 313% compared to the previous period, and was disbursed by the government through public funding (95%) and private funding (5%). (Gutierrez-Negrin, et al., 2015, p. 8).

To promote the development of geothermal electricity in Mexico, through both R&D and HRD, SENER established a virtual Mexico Center for Geothermal Energy Innovation (CeMIE-Geo) in 2013. The centre involves 30 projects of various scientific institutions in the economy as the first step to promote the use of geothermal energy; these projects will be funded with nearly MXN 1 billion (USD 77 million) by SENER. The Institute of Geophysics of the National Autonomous University of Mexico (UNAM) serves as the coordinator of this virtual agency for R&D projects (Thinkgeoenergy, 2013).

Human resources development

Since the development, management and operation of geothermal electricity in Mexico have been carried out by the Federal Electricity Commission (CFE), most HRD has focused on increasing the capacity of CFE engineers (mechanical, electrical, chemical and geological engineers). In the past, CFE trained some of their engineers through the geothermal programs offered by Iceland (the United Nations University), New Zealand (the Geothermal Institute of the University of Auckland) and the Baja California University (UABC). As a result, almost 50% of Mexican geothermal personnel came from CFE in 2014 (Gutierrez-Negrin, et al., 2015, p. 8).

As mentioned earlier, to promote the development of geothermal electricity in Mexico in the areas of R&D and HRD, SENER established the virtual Mexico Center for Geothermal Energy Innovation (CeMIE-Geo) in 2013. As part of its program, three levels of training will be carried out by this virtual agency: short training courses (of approximately three weeks); graduate studies in specific areas (for example, exploration and reservoir engineering); and master's and doctoral programs. This training will be carried out in partnership with the United Nations University in Iceland, universities in New Zealand and universities in the United States. The Renewable Energy Institute of the Geophysical and Geologic Institutes of the National University (UNAM) and the Center for Scientific Research and Higher Education of Ensenada (CICESE) have been appointed as coordinators of the three levels of the training program (Thinkgeoenergy, 2013).

Table 14 Geothermal activities, allocation of professional personnel

Year	Professional Person-Years of Effort						
	Total	Government	Public Utilities	Universities	Paid Foreign Consultants	Contributed through Foreign Aid Program	Private Industry
2010	**157**	6	105	25	0	0	21
2011	**161**	7	107	24	0	0	23
2012	**165**	7	105	26	1	0	26
2013	**193**	7	105	30	1	0	50
2014	**223**	8	105	40	0	0	70

Note: Restricted to personnel with university degrees.

Source: Gutierrez-Negrin, et al., 2015, p. 8.

Financial incentives

In the past, to support the activities of Federal Electricity Commission (CFE) to develop steam fields, the government provided continuous public funding as part of the investment budget given to CFE. In cases where drilling was not successful, the expended money was considered a loss for accounting purposes. This practice changed completely when the government limited the money available to continue its support, leading to an energy reform that allowed more participation by the private sector.

As part of the energy transition program and mandate of the Law on the Use of Renewable Energies and Financing of Transition Energy of 2008 (LAERFTE), the government has allocated some funding for geothermal through the Energy Transition and Sustainable Energy Use, 'Fondo Para La Transicion Energetica y el Aprovenchamiento Sustentable de la Energia' (FOTEASE), program. FOTEASE is a public policy instrument of the Ministry of Energy, the aims of which are to support the National Strategy for Energy Transition and the Sustainable Use of Energy and to promote use, development and investment in renewable energy (including geothermal) and energy efficiency. In 2013, a total of MXN 689 million were allocated through FOTEASE, with some of this funding allocated to geothermal projects, such as: a geophysics project for the development of pre-feasibility strategic geothermal areas of CFE (MXN 50 million); and design and structuring of financial development of private investment in geothermal projects using instruments of the national credit corporation, 'Nacional Financiera' (NAFIN) (MXN 150 million). In 2014, the government allocated MXN 1000 million to support energy efficiency and renewable energy, including geothermal energy (SENER, 2014a). However, at present, some experts see no financial incentives for geothermal development in Mexico, particularly since geothermal power generation is considered to be conventional, and thus, set to compete on the same basis as fossil-fuel, conventional hydro and nuclear technologies. The lack of economic incentives provided by the government could be a primary constraint for further geothermal development (Maya-Gonzalez and Gutierrez-Negrin, 2012, p. 3).

Currently, the government is taking steps to provide geothermal financing schemes such as grants, loans and guarantees to the private sector under the risk mitigation and financing program. A total of USD 120.1 million has been allocated for this program by IDB, CTF and SENER, of which 25% of the total fund will be used to support activities under component I (risk mitigation for the early drilling phase); 73% will be disbursed to support activities under component II (financing adapted to different phases of project exploration and development); and the remainder will be used to support implementation costs and technical assistance activities. The fund will be disbursed over a six year period, and it is targeted to finance 300 MW of additional geothermal capacity in the long term (Paolo Bona, 2014, pp. 8–9).

Transmission network

Federal Electricity Commission (CFE) is the dominant player in the generation sector, controlling over three-fourths of the installed generating capacity in Mexico. CFE also holds a monopoly on electricity transmission and distribution, while the Energy Regulatory Commission (CRE) has principal regulatory oversight of the electricity sector. Since historically all of the geothermal power generation was developed by CFE (even under the PPP scheme, CFE has responsibility for the transmission network connection), there was no problem obtaining access to the transmission network.

However, since the government has introduced more participants, including the private sector, into the development process for geothermal electricity under the Geothermal Energy Act of 2014, access to the transmission network could be an issue for geothermal developers and producers. To solve this issue, under the Electricity Industry Act of 2014, CRE requires transmission providers to offer transmission service on an open, non-discriminatory basis where technically feasible, pursuant to a transmission tariff that will govern the terms by which such a service is provided. However, to obtain access to the transmission network, geothermal developers or producers need to conform to market rules and must have an interconnection agreement under the supervision of CRE. Under the Electricity Industry Act of 2014, clean energy producers (including geothermal energy) are allowed to interconnect to the transmission network without delays or surcharges.

Electricity sales contracting

Under the energy reform of the Electricity Industry Act of 2014, which was promulgated by the government to introduce competition into the electricity sector, geothermal developers and producers (that is, CFE, private generators, private co-generators, representatives of generators and private commercial participants) may participate in the wholesale electricity market to sell their power for lower than the market price. In addition, this Act allows them to sell their output directly to any generator or commercial operator, a marketer/trader or qualified consumer under long-term contract prices set by negotiation with the buyer.

Box 9: Before and after energy reform, the differences, Mexico

Geothermal electricity development in Mexico has historically been planned, developed and operated by the Federal Electricity Commission (CFE) under the Public Electricity Service Law of 1975 and the National Water Act. However, since the government has experienced a lack of funding to support CFE activities in geothermal electricity development, and in order to accelerate and expand the development of geothermal energy, energy reform was undertaken to allow more participation by the private sector in geothermal energy.

The government made basic changes for geothermal electricity development after the energy reform, effected through the Electricity Industry Act of 2014 and the Geothermal Energy Act of 2014. The changes were as follows:

Table 15. Before and after energy reform, the differences, Mexico

Issues	Before Energy Reform	After Energy Reform
Is private sector participation encouraged?	No. It is very limited and only for drilling contractors or an EPC contractor (under the Public Electricity Service Law)	Yes. Any interested party may participate either in the exploration stage and/or exploitation stage (under the Geothermal Energy Act)

Which authority offers concessions?	The National Water Commission, 'Comision Nacional del Agua' (CNA)	The Ministry of Energy, 'Secretaria de Energia' (SENER), through tender, except for hydrothermal hot water reservoirs, which require a water concession from CNA
What are the types of concessions?	Water concession by well (under the National Water Act)[a]	Geothermal concession by area (under the Geothermal Energy Act)
What is the area of the concession?	Per m^3 of water[a]	≤ 150 km^2
What is the period of the concession?	5–30 years[a]	Maximum period of 36 years (three years for exploration with one extension for three years, and 30 years for exploitation), which can be extended

a Source: SENER, 2013.

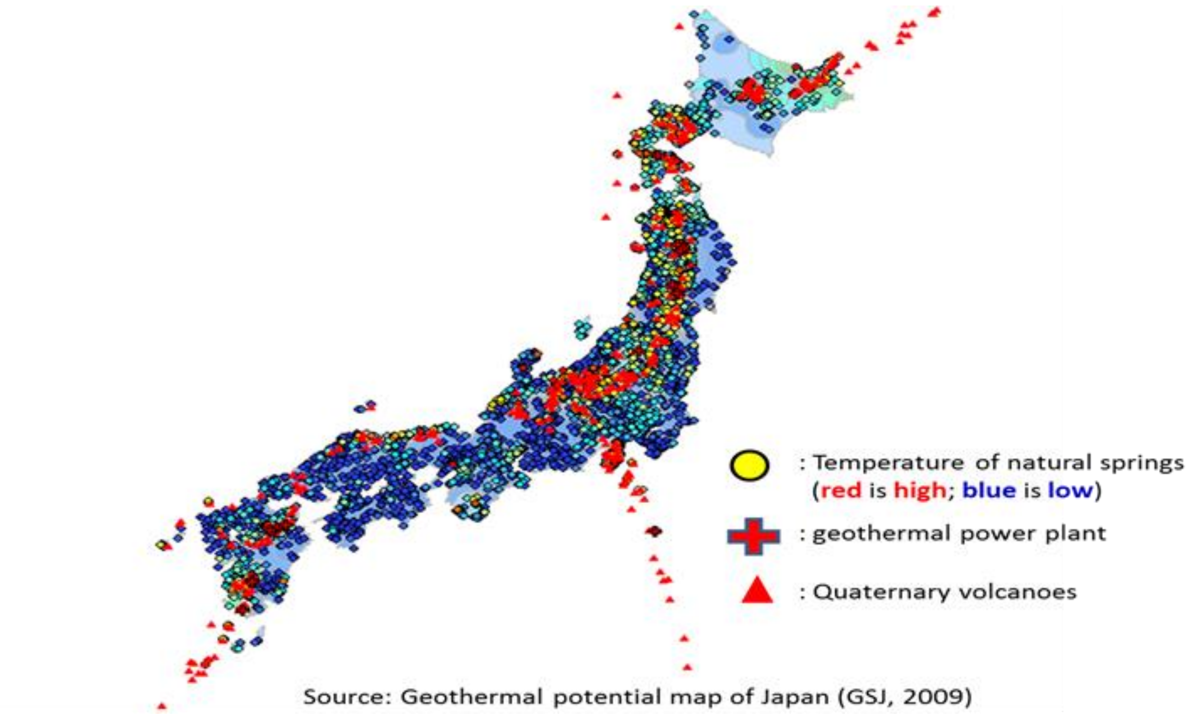
JAPAN

Japan has a long history of geothermal electricity development; it has been more than 80 years since the first experimental geothermal power generation, with a capacity of approximately 1.12 kWe, was conducted by Dr H. Tachikawa in 1925. In 1966 and 1967, the first and second geothermal power plants began operating at Matsukawa and Otake, respectively. After the first oil shock of 1973, the Sunshine project to promote new energy, including geothermal R&D, was initiated by the Ministry of International Trade and Industry (now METI), resulting in the opening of four more geothermal power plants in the 1970s, three in the 1980s and six plants and two units in the existing plants in the 1990s (GRSJ, 2014).

The main geothermal sources in Japan are located along the East Japan Volcanic Belt and the West Japan Volcanic Belt, which shows the close correlation between geothermal energy and volcanic areas (see Figure 24). However, since 80% of geothermal resources exist inside national parks (Yasukawa, 2014), where the exploitation of this resource, including geological surveys, is restricted, the huge potential of geothermal energy cannot currently be developed in Japan.

There are two styles of developing geothermal resources for energy generation in Japan. One is the 'once through' style whereby one company constructs all facilities from well to generator. The other is the steam supply style, in which a steam supplier sends steam to a plant owner, usually a utility. In the case of the once through style, the decision to begin construction of a power plant is made within the company once a feasibility study has been conducted. On the other hand, the steam supplier must explain the results of exploration to the plant owner and the two companies must conclude a basic agreement regarding power generation. As a large amount of money is required for a new plant, the plant owner gives careful consideration to the decision and usually requires a long time for discussion (Yamaguchi and Kawazoe, 2014, p. 557). Currently, geothermal electricity development is developed mostly by general electricity utilities (Tohoku EPCo; Kyusyu EPCo; Hokkaido EPCo; and Tokyo EPCo), one power plant is developed by a wholesale electric utility (J-Power) and five power plants are developed by private companies (Tohoku Hydropower & Geothermal Energy Co. Inc.; Mitsubishi Materials Corp.; Sugino Hotel Co. Ltd.; Daiwabo Kanko, Co. Ltd; and Kuju Kanko Hotel) with a total installed capacity of only 537 MW or less than 0.3% of the national total installed capacity (Nagata, 2012).

Figure 24. Geothermal potential, Japan



Source: Yasukawa, 2014.

Legal basis

There is no specific geothermal law in Japan except for the Hot Spring Act. As geothermal resources are similar to hot springs in terms of obtaining steam and hot water from the underground, developers must refer to the Hot Spring Act regarding the development of geothermal resources in Japan (that is, by drilling either exploration or production geothermal wells) (Yamaguchi and Kawazoe, 2014, p. 555). According to the Hot Spring Act, drilling in pursuit of hot springs (hot water, mineral water, steam and other gas from underground) requires the permission of the local (prefectural) governor (Kaga, 2013). The local government can grant permission to drill geothermal wells once the developers have secured the rights of land use and accepted the opinion of the Natural Environment Conservation Council in the local government (municipal and prefectural) (Yamaguchi and Kawazoe, 2014, p. 555).

Even though the ownership of geothermal resources resides with the State (because the Hot Spring Act was legislated by the central government), the development of these resources is regulated by local governments (municipal and prefectural). Since hot springs are valued by the Japanese people for their health benefits and are an important source of tourism for some areas, and since this business is protected by the Hot Spring Act, local governments (municipal and prefectural) are considerate of any influence that new geothermal wells may have on other hot springs, causing the permitting process for developing geothermal electricity to become cumbersome. This issue has become a barrier to the development of geothermal electricity in Japan.

Other regulations that should be considered by developers in developing geothermal resources are the Environmental Impact Assessment (EIA) Law, which mandates that the construction of a power generation plant with output of 10 000 kW or more requires an EIA; the Natural Park Act, the National Forest Law and the Agricultural Land Law, to obtain permits if the resources are located in those areas.

Government strategy

In order to develop geothermal electricity, the Japanese Government has, in the past, initiated several strategies to increase the utilisation of geothermal electricity in Japan, some of which have already been successful and some of which are expected to increase the development of geothermal electricity in the near future, as follows:

Past strategies

- The Sunshine Program

  After the first oil crisis impacted on Japan, the Ministry of International Trade and Industry (MITI) (now METI) initiated the Sunshine Program in 1974. The goal of the program was to find an alternative energy to oil and under the close cooperation of industry, government and academic organisations, technology development was promoted in four areas, including geothermal R&D, through government initiatives (Kimura, 2009, p. 1). To promote the development and introduction of new energy technologies, the New Energy and Industrial Technology Development Organization (NEDO) was established in 1980 as a semi-governmental organisation. Since its establishment, NEDO has been conducting a long-term and comprehensive exploration program—the Survey for Promotion of Geothermal Development—that appraises geothermal areas throughout the economy. The main objective of the NEDO surveys is to evaluate the possibility of geothermal power generation (Kawazoe and Combs, 2004, p. 61). This program resulted in four more geothermal power plants being opened in the 1970s after the first and second geothermal power plants began operating at Matsukawa and Otake in 1966 and 1967 respectively; and three power plants in the 1980s (GRSJ, 2014). In 1993, this program was terminated and, together with the Moonlight Program (which was launched to develop new energy conservation technologies), was unified into a new program called the New Sunshine Program (Kimura, 2009, p. 2).

- The New Sunshine Program

  This program was launched in 1993, and similar to the Sunshine Program focused on finding alternative energies to oil including geothermal through R&D with scope also expanded to developing new energy conservation (Kimura, 2009, p. 2). As part of the New Sunshine Program, the NEDO promoted technical developments in surveying, drilling and exploitation of geothermal resources as well as conducting long-range projects to develop unused geothermal resources (Fuchino, 2000, p. 195). Under this program, six plants and two units in the existing plants opened in the 1990s (GRSJ, 2014). In 2002, the New Sunshine Program was terminated owing to the restructuring of government ministries and agencies (Kimura, 2009, p. 2), and in 2002 and beyond, no more government geothermal R&D subsidies were allocated. The reason for this policy is because geothermal was excluded as a new energy source when Japanese politicians enacted the law concerning Special Measures to Promote the Use of New Energy in June 1997. As a result of this exclusion, budget cuts were made to geothermal R&D (JFS, 2009). Another reason is that there was no indication of an increase in geothermal generation even though a large amount of subsidy expenses had been allocated by the government, while newly developed technologies, including binary generation and hot dry rock power generation, were not put to practical use (Kimura, 2009, p. 18). On the other hand, the utilisation of nuclear, coal fired and gas turbine power plants increased significantly from 1990–2002. However, the NEDO continues to provide subsidies for geothermal surveying and exploration.

- Renewable Portfolio Standard (RPS)

  In 2002, the government established the Special Measures Law Concerning the Use of New Energy by Electric Utilities, which was known as the RPS. This law aims to increase the utilisation of renewable energy to produce electricity from five kinds of energy, namely, wind, solar, small hydropower, biomass power generation and binary geothermal. The RPS system was fully implemented in 2003; however, this system is not applicable to conventional geothermal power plants, and only binary-cycle power plants are covered by this scheme (Kawazoe and Combs, 2004, p. 62). In 2012, the RPS system was terminated when the government introduced the Feed-in Tariff.

Current strategies

- Financial support

  In order to increase the development of geothermal resources, METI provides some financial support to the private sector through NEDO (in 2012, transferred to the Japan Oil, Gas and Metals National Corporation-JOGMEC). This financial support includes funding for geological surveys that cover 50–100% of the cost of exploration well drillings; subsidies for public acceptance (PA) that cover 100% of PA activities by the private sector; government investment with an investment ratio of up to 50% of equity capital; a loan guarantee ratio of up to 80% of the loan provided by financial institutions; subsidies for R&D that cover 50–100% of the cost of R&D; and subsidies for shortening the lead time of environmental impact assessments (EIA) that cover 50% of the cost of the EIA (Kaga, 2013).

- Feed-in Tariff

  The FIT scheme began on 1 July 2012 under the Act on Purchase of Renewable Energy Sourced Electricity by Electric Utilities. Under this Act, the tariff for a geothermal power plant with a capacity of 15 MW or more was set at JPY 27.3 per kWh for 15 years and JPY 42 per kWh for 15 years for geothermal power plants with a capacity of less than 15 MW (Kaga, 2013).

These Japanese Government efforts to promote geothermal development are also already clearly emphasised in the 'Japan Revitalization Strategy – Japan is Back' which had already been decided by the Cabinet on 14 June 2013. Under this strategy, the government will increase investment in geothermal generation. They will also promote regulatory and institutional reform including streamlining the procedure for environmental impact assessments (procedures usually take three to four years; hence, they are reducing the period by half) and streamlining safety regulations to promote small geothermal generation using existing hot spring wells, and promoting the understanding of local people (Japan Revitalization Strategy, 2013, p. 101).

Government commitment to investors

Historically, government commitment to investors has been inconsistent. After the first oil crisis impacted on Japan, MITI initiated the Sunshine Program, and later the New Sunshine Program, both of which allowed the successful development of geothermal electricity in Japan. However, geothermal development started to face difficulties after it was excluded as a new energy source when Japanese politicians enacted the Law Concerning Special Measures to Promote the Use of New Energy in June 1997, which was intended to ensure energy security and tackle global warming. Under this law, new energy means oil alternative energies that are not price-competitive. Hydropower and geothermal power are excluded because of their price-competitiveness and their exclusion under this new law brought budget cuts in geothermal R&D (JFS, 2009). This was because the government saw no indication of an increase in geothermal generation even though a large amount of subsidies had been allocated while the development of new technologies, including binary generation and hot dry rock power generation, had not been put to practical use (Kimura, 2009, p. 18). On the other hand, the utilisation of nuclear, coal fired and gas turbine power plants significantly increased from 1990–2002, which has meant no more geothermal R&D subsidies were allocated by the government in 2002 and beyond. Moreover, geothermal-related generation systems, except geothermal binary power generation, were also ruled out from the category of new energy sources under the Law on Special Measures Concerning New Energy Use by Electric Utilities (known as the Japanese RPS Law), which was implemented in June 2002 (JFS, 2009). Since then, geothermal electricity has lost government support and no geothermal power plant has been constructed since 1999.

However, since the Great East Japan Earthquake and the accident at the Fukushima Dai-ichi Nuclear Power Station caused the fuel cost of thermal power generation to increase drastically and impact on Japan's economy, the government strategy on energy development has changed. Under the 'Japan Revitalization Strategy – Japan is Back', which was launched in June 2013, the government will promote the use of renewable energy sources in Japan, including geothermal resources (Japan Revitalization Strategy, 2013, p. 100). Besides financial support for geothermal development and the FIT provided by the government, under the 'Japan Revitalization Strategy', the government will also plan to increase investment in geothermal generation and will promote regulatory and institutional reform including streamlining the procedure of environmental impact assessments.

Institutions

According to Kaga (2013), two government agencies will lead the development of geothermal resources in Japan, namely:

- METI (Ministry of Economy, Trade and Industry). This agency acts as a 'Regulator' for geothermal development based on the Electricity Business Act and has a function to promote geothermal development based on policies for energy security.
- MOE (Ministry of Environment). This agency acts as a 'Regulator' for geothermal development based on the Hot Spring Act and the National Park Act, and has a function to promote geothermal development based on policies to reduce CO_2 emissions.

However, local (municipal and prefectural) governments also have an important role in developing geothermal resources in Japan since such resources are treated as hot springs and must comply with the Hot Spring Act; to drill geothermal wells, either exploration or production wells, requires the permission of the local (prefectural) governor. Moreover, the local (municipal and prefectural) government has a role in providing opinions during the environmental impact assessment activity conducted by the developers.

Several government-related agencies are also important in providing research and technical support for the development of geothermal resources in Japan (Kaga, 2013), namely:

- JOGMEC (Japan Oil, Gas and Metals National Corp.). This agency has had a role in providing a subsidy scheme for the subsurface development of geothermal energy since September 2012 and the technical development of the subsurface area of geothermal resources (such as geothermal potential surveys, recovery of geothermal output by injection of water and increasing recharge fluid) since 2013;
- NEDO (New Energy Development Organization). This agency has a role in providing technical development for power generation areas;
- AIST (National Institute of Advanced Industrial Science and Technology). This agency has a role in supporting both the scientific and technical subsurface development of geothermal resources as well as acting as an advisor to METI, and

- Universities (Kyushu University, Tohoku University and so on). The university has a role in supporting the science of the subsurface development of geothermal resources as well as acting as an advisor to the government.

Access to geothermal resources

Japan's laws and regulations have been a major deterrent to development since there are no geothermal-specific laws in Japan. To access geothermal resources, no specific regulations have been formulated regarding competition. The basis for accessing resources is generally 'first come first served'. Even so, geothermal developers have been required to go through cumbersome permission processes, particularly to access resources in national parks (Worldview, 2012, p. 11). According to Yamaguchi and Kawazoe (2014, p. 555), in the exploration and feasibility study step, well drilling is the most difficult operation for which to obtain a permit.

Under the Hot Spring Act, in order to drill either exploration or production geothermic wells, the developers must obtain permission from the local (prefectural) governor (Kaga, 2013). The local government can grant permission to drill geothermal wells once the developers have secured the rights of land use and accepted the opinion of the Natural Environment Conservation Council in the local (municipal and prefectural) government (Yamaguchi and Kawazoe, 2014, p. 555). Permission for drilling activities is given for two years from when the permission is issued with a one-time extension of two years (Okinawa, 2014).

In order to secure the rights of land use, the developers can either purchase or lease the land from landowners. The landowners can vary, for example, being either a person or company for private lands, the Ministry of Environment (MOE) for lands located in natural parks, the Ministry of Agriculture, Forestry and Fisheries (MAFF) for lands located in agricultural areas and national forest, and local (prefectural) government for lands located in quasi-natural parks and prefectural national parks. This situation can involve several acts or laws depending on where the land is located. If the land use is located in a natural park, the developers should follow the Natural Park Act and obtain permission from the MOE. A similar situation pertains if the land use is located in a national forest or on agricultural land, in which case the developers should meet the requirements of the National Forest Law or the Agricultural Land Law in order to obtain a permit from the MAFF.

After the rights of land use have been secured by the developers, the Environmental Impact Assessment (EIA) must be conducted if the output capacity of the power generation plant will be 10 000 kW or over. Based on the EIA Law, during the EIA process, three public hearings must be conducted by the developers in order to obtain opinions from the public before the Environmental Impact Statement can be finalized and she or he can proceed to the next step. The EIA procedure is time consuming and usually takes three–four years; however, the government plans to reduce this period by half.

Secure and exclusive rights to resources

As mentioned previously in 'Access to Geothermal Resources', after the rights of land use have been secured by the developers and they have an 'accepted opinion' from the local government (municipal and prefectural) and from authorizing agencies, generally the developers will have secure and exclusive rights to resources for a period and they follow and meet the regulations (the Hot Spring Act does not clearly mention the duration of rights to resources).

Even though the developers mostly enjoy secure and exclusive rights to resources, hot-spring owners could threaten the rights to resources of geothermal developers. Since hot springs are valued by the Japanese people for their health benefits and are an important source of tourism for some areas, and since this business, rather than the geothermal sector, is protected by the Hot Spring Act, local governments (municipal and prefectural) are concerned about any influence that new geothermal wells may have on other hot springs. Although it has never occurred, the local (prefectural) government might take action to protect hot-spring resources by stopping the utilisation of geothermal resources.

Permitting time limits

According to the Geothermal Energy Association (GEA, 2013b, p. 30) report, Japan has a number of regulatory and structural barriers to overcome before any surge in geothermal development is expected. It typically takes 10 or more years from the first geological surveys to build an operating plant, a long and costly lead time. In addition, there is no national geothermal guideline for permitting. Based on the Environmental Impact Assessment (EIA) Law, constructing a power generation plant with an output of 10 MW or larger requires an EIA; Japan's EIA process is especially long (it takes three–four years).

As a part of the 'Japan Revitalization Strategy – Japan is Back', the government will promote regulatory and institutional reform. A reform to streamline environmental impact assessments should reduce the time required by one-half compared to the usual procedures that take three–four years (Japan Revitalization Strategy, 2013, p. 101).

Moreover, in order to avoid delays in granting permission, MOE made a new guideline in March 2012 regarding MOE's involvement in applications to local (prefectural) governments for permission for geothermal drilling. Under this new guideline, MOE will try to provide the local (prefectural) government with information on the relationship between geothermal reservoirs and hot spring aquifers and how the local government can check the possibility of interference in those two resources based on geo-scientific information, geothermal system modelling and monitoring data on their relationship, in case the local government fears that geothermal development may deplete hot spring aquifers (Yasukawa, 2014).

'One-stop permitting'

There is currently no specific 'one-stop permitting' for the geothermal permission process in Japan.

Inter-agency cooperation

Inter-agency cooperation related to developing geothermal electricity in Japan, particularly the Environmental Impact Assessment (EIA), is complex and one of the big challenges faced by investors and developers. Although MOE is the 'Regulator' for geothermal development related to the environment, the local government (municipal and prefectural) has more power to regulate it. Mostly, a public opinion mechanism will be used by the local government to make decisions regarding permission for geothermal drilling instead of the recommendations of relevant authorities, particularly if geothermal electricity development may affect other users (hot spring industries). This process is cumbersome since three public opinion surveys should be conducted by the developer. This is time consuming and also increases the developers' project costs.

Database

In order to obtain accurate and reliable data on geothermal resources so that the risk to developers can be reduced, the Japanese Government provides two kinds of program, namely the 'Survey for Promotion of Geothermal Development' and 'The Government's Subsidy for Drilling including Geological Survey'.

According to Fuchino (2000, p. 195), the 'Survey for Promotion of Geothermal Development' was conducted in 52 areas by NEDO with a subsidy from MITI (now METI) between the beginning of the program in 1980 to the end of the fiscal year 1998. The objective of the survey was to evaluate the possibility of geothermal power generation for promising areas with potential geothermal resources throughout the economy and the program comprised three stages: A, B and C. In the fiscal year 1999, surveys took place in the following six areas:

- Survey A (three years): a survey mainly to detect and confirm the presence of underground high temperature, for areas of 100–300 km^2. Kumbetsu-dake (Hokkaido) and Kuwanosawa (Honshu) were the places in this category;
- Survey B (three years): a survey mainly to detect and confirm geothermal reservoirs, for areas of 50–70 km^2. Three areas: Musa-dake (Hokkaido), Tsujino-dake (Kyushu) and Kumaishi (Hokkaido) were surveyed;
- Survey C (four years): a survey of areas of 5–10 km^2 to estimate the amount of geothermal resources. Akinomiya (Honshu) was the location at this stage.

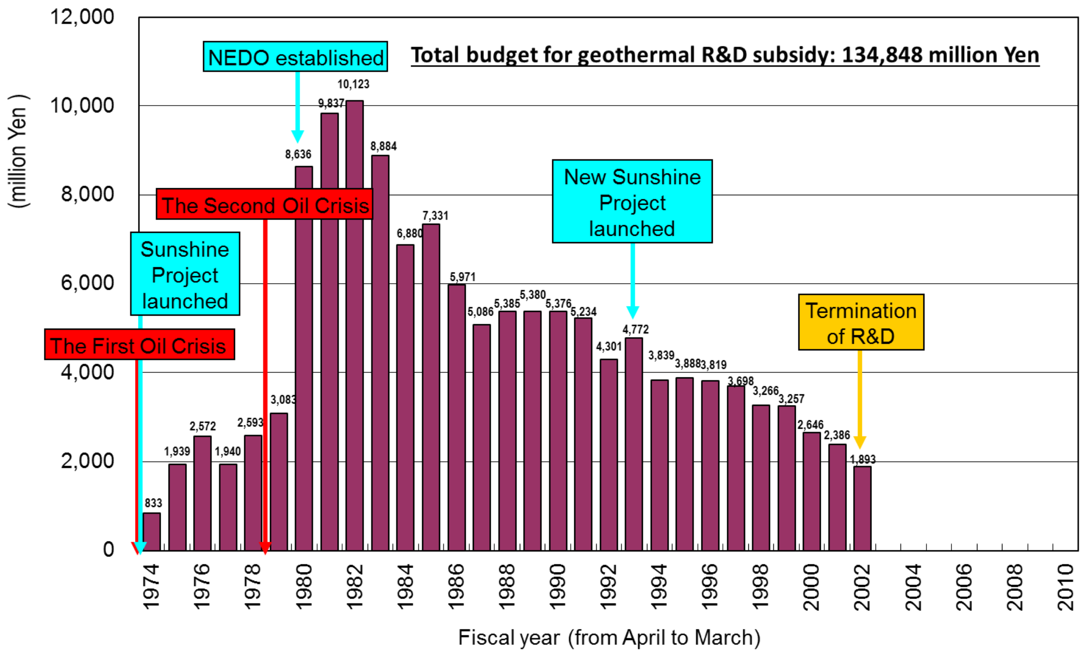
This information is available to the public through the Geological Survey of Japan, the National Institute of Advanced Industrial Science and Technology's (AIST) website https://www.gsj.jp/Map/EN/geo-resources6.html.

'The Government's Subsidy for Drilling including Geological Survey' has been offered by NEDO (in 2012, transferred to JOGMEC) to geothermal developers. This subsidy covers 50–100% of the cost of exploration well drillings. For the fiscal year 2013, the government has allocated a budget of JPY 7.5 billion through JOGMEC for geological surveys conducted by developers in 17 areas throughout the economy (Musa-Dake, Ashoro Town, Kamikawa, Toyoha, Amemasu-Dake, Toyako-Onsen, Iwakisan-Dake, Matsuo-Hachimantai, Amihari, Oyasu, Kijiyama-Shitanotai, Unazuki-Onsen, Tateyama Sanroku, Noya, Hiiji-Dake North, Ishimatsu-Nouen and Bandai Areas) (Kaga, 2013). Under this subsidy scheme, if wells are successfully drilled and used in business, the developers, as recipients of the subsidy, must return part of the subsidy. However, if the drilling of the wells fails, the developers do not need to return any part of the subsidy (JOGMEC, 2013).

Research and development

Since the first oil crisis, the Japanese Government, under the Sunshine Program and the New Sunshine Program, has conducted extensive geothermal R&D to find alternative energies to oil. During the period 1974 to 2002, the government was allocated a budget for geothermal R&D subsidies of up to JPY 134 848 million, in which the year 1982 had the highest government-allocated budget (JPY 10 123 million) (Nagata, 2012). In 2002 and beyond, no more geothermal R&D subsidies were allocated by the government. After the long absence of R&D subsidies, in the fiscal year 2013, the government tried to provide a budget for R&D subsidies once more, of up to JPY 0.95 billion with a focus on techniques for searching for fractures, reservoir management technologies and environmentally friendly and high performance power generating systems. These subsidies can be provided at a ratio of 50–100% of the total R&D cost (Kaga, 2013).

Figure 25. Geothermal R&D subsidy, past budget



Source: Nagata, 2012.

Despite the lack of R&D budget for geothermal development, however, Japan has the capability to produce geothermal equipment (turbines and generators) and this makes Japan the largest supplier of geothermal equipment in the world. Toshiba Corporation, Mitsubishi Heavy Industries, Ltd. and Fuji Electric Co., Ltd. have supplied 70% of geothermal turbines and generators worldwide (Kaga, 2013).

Human resources and development

According to Fuchino (2000, p. 198) and Kawazoe and Shirakura(2005, p. 6), the professional personnel involved in geothermal activity decreased significantly from 1518 professionals in 1995 to 1090 professionals in 2004 as shown in Table 16.

Table 16. Geothermal activities, allocation of professional personnel

Year	Professional Person-Years of Effort				
	Total	**Member of JGEA** (Individual)	**Member of JGEA** (Corporate)	**Member of GRSJ** (Individual)	**Member of GRSJ** (Corporate)
1995	**1518**	470	110	821	117
1996	**1481**	448	108	810	115
1997	**1471**	445	109	804	113
1998	**1436**	430	108	787	111
1999	**1387**	408	101	771	107
2000	**1291**	399	97	702	93
2001	**1271**	389	93	692	97
2002	**1201**	354	89	670	88
2003	**1141**	316	84	659	82
2004	**1090**	279	84	649	78

Note: JGEA: Japan Geothermal Energy Association (JGEA); GRSJ: Geothermal Research Society of Japan (GRSJ).

Source: Fuchino, 2000, p. 198; Kawazoe, et al., 2005, p. 6.

According to the International Energy Agency-Geothermal Implementing Agreement report (IEA-GIA, 2012, p. 21), the number of professional personnel employed in geothermal related jobs in Japan was approximately 500 professionals in 2010. This is likely because no geothermal power plant has been constructed since 1999 so that the professional personnel in geothermal related jobs in Japan has dropped significantly.

There are currently four universities in Japan with graduate school and/or master's and/or doctoral programs in geothermal related studies, namely Tohoku University, Kyushu University, Kyoto University and Akita University.

Financial incentives

As mentioned above, the Japanese Government currently provides several types of financial support to geothermal developers through the Japan Oil, Gas and Metals National Corporation (JOGMEC) and has introduced the FIT scheme to promote and increase the utilisation of geothermal energy in the near future.

Financial supports include (JOGMEC, 2013):

- Subsidies for geological surveys that cover 50–100% of necessary funds depending on terms and conditions to be determined by JOGMEC;
- Equity capital finance for exploration (for example, drilling of investigation well, discharge test) up to 50% of equity capital depending on terms and conditions to be determined by JOGMEC, but JOGMEC is not allowed to be the largest shareholder;
- 100% grant to potential survey for public acceptance (PA) to allow people, including hot spring owners and industries, to understand the nature of geothermal energy and accept the geothermal electricity development; and
- Loan guarantees for geothermal development (for example, drilling of production well and reinjection well, construction, start-up and commissioning of power plant) up to 80% of loan provided by financial institutions.

In order to obtain such financial supports, the developers need to contact JOGMEC and must meet JOGMEC's screening criteria including geothermal potential, regulatory approval and licensing and harmony with the local community. One aspect that developers must be aware of is that the subsidy given by JOGMEC is not a means of financial support but a risk share, meaning that if wells are successfully drilled, and used in business, the developers, as recipients of the subsidy, must return part of the subsidy. They do not need to return any part of the subsidy if they find un-economic resources after drilling (JOGMEC, 2013).

- Another government support is the FIT scheme, which was implemented on 1 July 2012. Under this scheme, if a renewable energy producer requests an electric utility to sign a contract to purchase electricity at a fixed price and for a long-term period guaranteed by the government, the electric utility is obligated to allow grid connections and accept this request. The tariff for geothermal power plants that should be paid by the utilities is JPY 27.3 per kWh for 15 years for geothermal power plants with a capacity of 15 MW or more; and JPY 42 per kWh for 15 years for geothermal power plants with a capacity of less than 15 MW (METI, 2012).
- Moreover, in the fiscal year 2013, the government also provided other financial support such as the budget for R&D subsidies of up to JPY 0.95 billion with a focus on techniques for searching for fractures, reservoir management technologies and environmentally friendly and high performance power generating systems. This subsidy can be given with a ratio of 50–100% of the total R&D cost. Also, a budget for shortening the lead time of environmental impact assessments (EIA) of up to JPY 3.37 billion has been allocated. This subsidy can be given at a ratio of up to 50% of total EIA costs to accelerate the environmental impact assessment process (Kaga, 2013).

Transmission network

As mentioned above, in order to maintain fair and transparent use of the electric power transmission and distribution system for all players, the Electric Power System Council of Japan (ESCJ) was established in 2005 as the sole private organisation to make rules and supervise operations from a neutral position since transmission and distribution networks are owned and operated by General Electricity Utilities (FEPC, 2013, p. 5). In addition, the government introduced rules of conduct, such as prohibiting discriminatory treatment. The price of using the transmission system ('wheeling tariffs') must be set in accordance with regulations established by METI and reported to it (Jones and Kim, 2013, p. 7). Moreover, under the FIT scheme, electric utilities are obliged to allow grid connections and execute contracts as required for the purchase of renewable energy, including from geothermal (METI, 2014).

Electricity sales contracting

In 2012, Japan established an FIT scheme, which obliges the General Electric Utilities to purchase electricity from almost all renewable energy producers to promote renewable energy including geothermal. Under this scheme, geothermal producers can sell their electricity at a fixed long-term price guaranteed by the government. The price for geothermal power plants with a capacity of 15 MW or more is set at JPY 27.3 per kWh for the next 15 years, and for geothermal power plants with a capacity of less than 15 MW is set at JPY 42 per kWh for the next 15 years. The tariff is set high enough to make geothermal energy profitable.

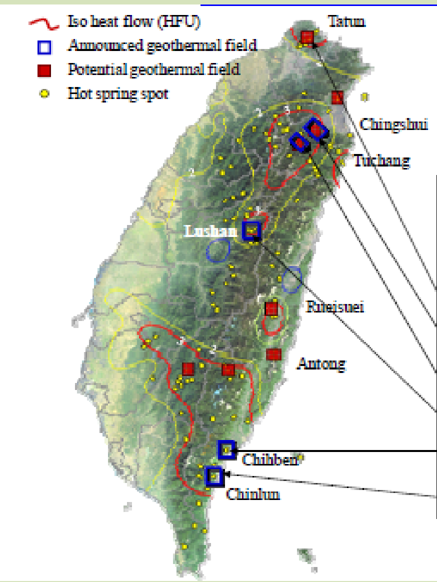
Box 10: Geothermal electricity development, Chinese Taipei

Chinese Taipei is located on a major geological fault-line along the Pacific Rim, as a consequence of which, the economy has abundant geothermal resources. Investigation of geothermal resources was conducted by the Bureau of Energy, the Ministry of Economic Affairs, in hundreds of hot spring sites during the 1970s and 1980s. As a result, a comprehensive exploration estimates that Chinese Taipei has total geothermal potential of up to 1000 MW. A report published by the Industrial Technology Research Institute (ITRI) on ‘Geothermal status and perspectives of Chinese Taipei’ (Ouyang, 2013) mentions that Chinese Taipei has six main geothermal potential sites with a total capacity of 714 MW, where Tatun site has become the major potential site with 514 MW of potential, followed by Chingshui site with 61 MW and Chinlun site with 48 MW.

The investigation of geothermal resources has resulted in the Chingshui site becoming probably the most suitable initial area for generating electricity in Chinese Taipei. A reconnaissance survey of this field was performed by the Industrial Technology Research Institute (ITRI) from 1973 to 1975. Further exploration was subsequently conducted by the Chinese Petroleum Corporation (CPC) from 1976 to 1980. Later, the first 3 MW geothermal power plant was built in this field by the National Science Council in 1981 (Tong, et al., 2008, p. 413). Nineteen wells (exploration and production) had been drilled by CPC in this site and produced a steam with a temperature of up to approximately 220℃. However, due to scaling in the water pipes and wellbores causing a decline in steam production, the power plant was decommissioned in 1993. After that, no geothermal electricity project was conducted by the government until 2006, when, under the guidance of the Bureau of Energy, ITRI again performed a series of geothermal energy research projects at Chingshui site. After almost six years of research at the Chingshui site, a 50 kW geothermal demonstration plant was built there by ITRI in 2012. By the end of 2014, it was expected that a 1 MW geothermal pilot plant could operate.

Currently, there is no energy production from geothermal energy in Chinese Taipei. As a step toward commercially developing and using geothermal energy for electricity, the Bureau of Energy (BOE) has been working closely with the local government of Yilan County where the Chingshui site is located to develop a geothermal power generation project through an ROT (Rehabilitation, Operate and Transfer) contract.

Figure 26. Geothermal resources, geographical distribution, exploitation potential, Chinese Taipei



Early (~1994) estimation for power generation potential of selected geothermal fields based on preliminary exploration data

SITE	Average temperature	Power Potential (MWe)
Tatun	245 ℃	514
Chingshui	200 ℃	61
Tuchang	170 ℃	25
Lushan	180 ℃	41
Chipen	170 ℃	25
Chinlun	160 ℃	48

Source: Ouyang, 2013.

The Chinese Taipei Government has a plan to develop geothermal electricity in the near future as mandated in the Renewable Energy Development Act, which aims to promote the utilisation of renewable energy, including geothermal; to increase the diversity of energy sources; to improve environmental quality; and to drive the economy’s sustainable development. Under this Act, the target of a geothermal installed capacity plant was set to 4 MW by 2015, 66 MW by 2020, 150 MW by 2025 and 200 MW by 2030 (Ouyang, 2013).

In order to realise this program, some public policies have been established by the government, and to ascertain how far the efforts of the government meet the expectation of geothermal developers, the following assessments have been conducted:

Legal basis

There is no geothermal specific law in Chinese Taipei, and it seems there is ambiguity in the implementation of regulations regarding geothermal electricity development in this economy, which is perhaps due to the lack of expertise of the regulators. According to the Hot Spring Act, 'geothermal heat (steam)' is classified as one of the hot spring's products and as a natural resource is owned by the State. Under this Act, developers who want to develop a hot spring must obtain the 'water right' or the 'mining right' and complete the development work before the local government (municipal and county/city) can give an operation permit for their project. The definition of the 'hot spring water right' under this Act means the right to access and use or monetarily benefit from hot spring water pursuant to the Water Act, while the 'hot spring mining right' means the right to explore or mine hot spring gas or geothermal heat (steam) pursuant to the Mining Act. Observing these two definitions, since geothermal heat (steam) is more clearly mentioned in the definition of the 'hot spring mining right', then in our understanding, everybody who wants to develop geothermal electricity should follow the requirements of the Hot Spring Act and the Mining Act. However, in practice, when the government developed a 50 kW geothermal demonstration plant and a 1 MW geothermal pilot plant at Chingshui site, the permitting process that they used was based on the Hot Spring Act and the Water Act where the procedures needing to be followed are simpler than those of the Mining Act. In this case, the government needs to decide what regulations need to be referred to by geothermal developers who want to participate in developing geothermal electricity.

The other unclear message regarding the regulations is that even though the Hot Spring Act has mentioned that in order to develop a hot spring (where geothermal heat (steam) is classified as one of the hot spring's products) the developer must obtain the 'water right' or the 'mining right'. However, neither the Water Act nor the Mining Act clearly mention geothermal a product to be regulated under those regulations. This could potentially create legal uncertainty in the development of geothermal resources.

Other regulations that need to be followed related to geothermal electricity development include the Renewable Energy Development Act, the Electricity Act, the Environmental Law, the Environmental Impact Assessment Law, the National Land Use Planning Act and the National Park Act.

Government strategy

As mentioned earlier, in order to promote the utilisation of renewable energy, increase the diversity of energy sources, improve environmental quality and drive the economy's sustainable development, the Chinese Taipei Government has a plan to develop geothermal electricity in the near future as mandated in the Renewable Energy Development Act. The target for developing geothermal electricity has been set by the government.

In order to achieve this target, the government has some strategies as follows (Ouyang, 2013):

- Short-, medium- and long-term strategies

  Most of the geothermal resources in Chinese Taipei are volcanic and are located in mountains or remote areas, making their exploitation difficult. Geothermal resources with easy access and high potential will be prioritized for development. Related to this situation, the strategies that will be implemented by the government are:

- Short-term: develop and build the economy's own key technologies for the sustainable utilisation of geothermal energy with the Chingshui Geothermal field of Yilan County as the foundation, including geothermal field exploration, power generation potential assessments, production well scale inhibition, tail-water recycling and numerical simulation techniques; help local governments advance the construction of geothermal demonstration power plants and restore the general public's confidence in geothermal power generation; provide economically attractive wholesale purchase rates to geothermal power developers pursuant to the Renewable Energy Development Act, so as to drive the growth of geothermal power generation-related industries. The targeted installed power generation capacity will be 4 MW by the end of 2015.
- Medium-term: widen the scope of geothermal power generation demonstration projects and conduct industry advocacy and technology transfer as well as expand the participation of the private sector; gradually develop the Tatun Volcanoes and other geothermal areas; the targeted installed power generation capacity will be 66 MW by the year 2020; expand the scope of surveys of deep geothermal potential areas; complete the initial assessment of Chinese Taipei's deep geothermal potential zones; develop EGS technology and expand the scope of geothermal energy extraction and utilisation to facilitate the increase of geothermal power generation capacity.
- Long-term: continue to expand the installed power generation capacity of shallow geothermal, with the total installation target of 150 MW by 2025 and 200 MW by 2030; select one to two deep geothermal potential areas for a deep geothermal power generation demonstration project implementation.

- Establish a Feed-in Tariff scheme

  Under the Renewable Energy Development Act, FIT schemes for geothermal electricity have been established where Taiwan Power Company (the State-owned electricity company) must purchase electricity from geothermal power plants. The FIT has been set not lower than the average cost for fossil fuel power generation of domestic power utilities and it is guaranteed for 20 years.

- Establish subsidies under the Renewable Energy Fund

  Under the Renewable Energy Development Act, the government has established the Renewable Energy Fund. The fund is collected through an annual fee from the power utility and institutions that install self-generation equipment that reaches a certain level of capacity as determined by the government. The fund will be used for subsidies for electricity generation from renewable energy; subsidies for renewable energy equipment; subsidies for demonstration of renewable energy and promotion of its use; and other uses of renewable energy approved by the government.

- Providing fiscal incentives

  Under the Renewable Energy Development Act, the government will exempt those developers from customs duty who import machinery, equipment, special transportation equipment, training equipment and their parts and modules as long as that machinery, equipment, parts and modules are not yet produced by domestic manufacturers and suppliers.

Government commitment to investors

As mentioned in 'Government strategy', government efforts that provide clear short- to long-term strategies to develop geothermal electricity combined with providing the FIT scheme, subsidies and fiscal incentives have shown the government's strong commitment to investors. However, there is ambiguity surrounding the implementation of regulations regarding geothermal electricity development, either through the Water Act or the Mining Act; and under these acts, it is not clearly mentioned whether geothermal will become one of the products to be regulated or not. This may potentially result in later uncertainty in the development of geothermal resources.

Institutions

In Chinese Taipei, the Ministry of Economic Affairs has become the lead agency in developing geothermal electricity since to utilise these resources, developers need to obtain either the 'water right' from the Water Resources Agency if the water source flows through two or more counties/cities or municipalities or the 'mining right' from the Department of Mines where both of these agencies are under the Ministry of Economic Affairs. In addition, through the Bureau of Energy, which is also under the Ministry of Economic Affairs, other regulations that are related to geothermal electricity development, such as energy policies, electricity prices and electricity permits, will be regulated by this Ministry.

The local government (municipal and county/city) is also a key player in geothermal development based on the Hot Spring Act since the hot spring development permit and the operation permit of the geothermal power plant facility will be issued by the local government in accordance with their respective jurisdictions. In addition, under the Water Act, the local government is also the issuing authority of the 'water right' if the water source is located on their land.

Other agencies that play key roles in geothermal development are:

- The Ministry of Interior, which formulates the National Land Use Planning Act and the National Park Act, and oversees the conduct of land use;
- The Environmental Protection Administration, which is responsible for the planning permission of all energy developments such as reviewing the environmental impact assessment (EIA), and
- The National Science Council (now known as the Ministry of Science and Technology), which is responsible for the promotion of science and technology development and surveys of R&D activities.

Access to geothermal resources

Since the regulation remains ambiguous regarding whether developers should follow the Water Act or the Mining Act, both of these mechanisms to access geothermal resources are presented in this section.

To access geothermal resources, based on the Hot Spring Act, the developer should have a 'hot spring development permit', which is issued by the local government (municipal and county/city). The permit will be given after the developer secures the right to use the land from the landowner (be they public, private or indigenous people), provides a plan of development and use of resources that is not in conflict with the local government's hot spring administration plan and shows that the resource is not located in an area of hot spring outcrop. Next, the developer needs to obtain either the 'water right' or 'mining right', which is rather confusing as no clear authority exists as to which should be acquired.

- If 'water right'. Under the Water Act, developers who want to acquire the 'water right' should submit their application to the municipal or county/city government where the water source is located. If the water source flows through two or more counties (cities) or provinces (municipalities), the application must be submitted to the Water Resources Agency, the Ministry of Economic Affairs (MOEA). The authority-in-charge will review the document and conduct a survey as well as make an announcement to the public to elicit their comments before the 'water right' is given. If it is necessary to conduct well drilling, the developer needs to obtain a permit from the local government (municipal or county/city) where the resource is located.

- If ‘mining right’. Under the Mining Act, developers who want to acquire the ‘mining right’ should submit their application to the Department of Mining (MOEA). The authority-in-charge will review and check the document against requirements such as securing the right to use the land, environmental protection, soil and water conservation, mine safety measures and mining hazard prevention before the ‘mining right’ is given. Once the ‘mining right’ is obtained, the developer can conduct exploration or mining of the resources.

After obtaining the ‘water right’ or ‘mining right’, and completing the development work, the developer still needs to obtain an operation permit from the local government for her/his project according to the Hot Spring Act.

To access geothermal resources in Chinese Taipei, no specific regulations mention competition, and there is no restriction on who can explore for the geothermal resources. The basis for accessing geothermal resources is ‘first come first served’.

Secure and exclusive rights to resources

After the developer has met all the requirements, the ‘water right’ is given by the local government (municipal and county/city) or the Water Resources Agency, MOEA, for the certain period, which is decided by the authority-in-charge and which can be extended. However, since concessions for geothermal exploration and exploitation are granted by well, and not by field or area, this has caused insecurity and nonexclusive rights to resources.

A different situation can be seen for the ‘mining right’. Under this ‘right’, concessions for geothermal exploration and exploitation are granted by area. The horizontal surface area of a mineral concession will be given as a minimum of 2 hectares to a maximum of 250 hectares, while for a mine concession it can be up to 500 hectares. The duration of a ‘mining right’ is up to 20 years with another 20 years per extension if it is approved by the authority-in-charge. Even though the developer might have a secure and exclusive right to resources under the ‘mining right’, the Department of Mining (MOEA) has the power to revoke the ‘mining right’ if the developer does not comply with the regulations.

Permitting time limits

As with other economies, in order to develop geothermal electricity in Chinese Taipei, besides obtaining permits from those agencies already mentioned above, developers still also need to obtain permits or consents from other governing agencies such as the Land Administration Agency for resources located on public land, the Environmental Protection Administration for the environment, the Bureau of Energy for the electricity permit, the Bureau of Forestry for resources located in forest areas, where each government agency has its own oversight and administration of regulation. The permitting process from those agencies usually takes time. No guidance for geothermal electricity permission currently exists.

‘One-stop permitting’

There is no ‘one-stop permitting’ with regard to the geothermal permitting process.

Inter-agency cooperation

Chinese Taipei is currently at the demonstration phase and there is no specific regulation for the development and management of geothermal electricity. Currently, the Hot Spring Act and the Water Act or the Mining Act are the basic regulations to be referred to by developers if they are interested in developing geothermal electricity. Under the Hot Spring Act, most of the power to regulate hot spring development including geothermal energy is given to the local government (municipal and county/city). Currently, the understanding and expertise of the local government officials on geothermal energy are limited, so assistance and support from the central government agencies are very much needed, such as setting forth the procedures and criteria (guidelines) for issuing permits that can be used by the local government.

Database

As mentioned previously, the investigation of geothermal resources in Chinese Taipei was conducted by the Bureau of Energy, the Ministry of Economic Affairs, in hundreds of hot spring sites during the 1970s and 1980s. As a result, a comprehensive exploration estimates that Chinese Taipei has a total geothermal potential of up to 1000 MW which, with the current report published by the Industrial Technology Research Institute (ITRI) on the 'Geothermal Status and Perspectives of Chinese Taipei' (Ouyang, 2013), has been revised to 714 MW. Based on the preliminary surveys, geothermal resources at Tatun volcanic area were found to be acidic and the quality not especially good for geothermal electricity, making large-scale utilisation dependent on further technological advancement. Not all geothermal energy can be tapped as some sites are located in national parks where drilling is prohibited.

Some general information data such as geological data are available at the Central Geological Survey website http://www.moeacgs.gov.tw/english/twgeol/twgeol_introduction.jsp, while the details of the geothermal data are still kept confidential.

Research and development

Regarding R&D in geothermal electricity, two government agencies, the Bureau of Energy and the National Science Council (now known as the Ministry of Science and Technology) have committed to continuing R&D activities. Some R&D activities have been conducted by the Bureau of Energy such as:

- Launching the Chingshui geothermal power generation promotion project in 2006 and evaluating the multipurpose utilisation of geothermal power generation technology application in 2007;
- Conducting a feasibility study of deep geothermal power generation technology including an enhanced geothermal system in 2010;
- Building a 50 kW geothermal demonstration plant in 2012, and
- Currently, the BOE is working with Yilan County to develop a geothermal power generation project through an ROT (Rehabilitation, Operate and Transfer) contract. The first phase of this project to install a 1 MW geothermal pilot plant was expected to be operational by the end of 2014.

In addition to the Chingshui geothermal area, the Bureau of Energy has also conducted a supplementary survey project to re-evaluate the geothermal potential of Tatun volcanic geothermal area since 2013. Measurements, including an airborne magnetic survey, as well as magnetotelluric and microseismic monitoring methods, have been implemented in Tatun Mountain and the acquired data are now being processed.

On the other hand, the National Science Council (now known as the Ministry of Science and Technology), which is responsible for the surveys of economy-wide national R&D activities, performed the 'National Science and Technology Program – Energy in 2008'. The objectives of this program are to (1) increase energy independence, (2) reduce greenhouse gas emissions, and (3) create an energy technology research plan with the goal of establishing an energy industry. Geothermal power has been incorporated into the major development planning, mainly focusing on advanced enhanced geothermal system technology development.

Moreover, in order to create capability and capacity for Chinese Taipei's geothermal industry to support the government's plan to develop geothermal electricity in the future, the Ministry of Economic Affairs and the State Government of Idaho signed a memorandum of understanding (MOU) on industrial cooperation in green energy, especially in geothermal power generation in April 2013. Under this MOU, some of Chinese Taipei's industries (for example, its Industrial Development Bureau; ITRI; the National Taipei University of Technology; Kavalan Qing Shui (Geothermal Power) Co., Ltd.; CPC Corporation, Chinese Taipei, YFY Inc.; Tang Eng Iron Works Co., Ltd.; Aerospace Industrial Development Corporation; Sinotech Engineering Consultants, Ltd.; and TECO Electric & Machinery Co. Ltd) will work with Idaho's industries (for example, Idaho's Department of Commerce; Idaho National Laboratory; Centre for Advanced Energy Studies (CAES); U.S. Geothermal Inc.; and Power Engineers Inc.) to develop modules and related systems for geothermal power generation. The alliance also aims to expand into the geothermal market in Southeast Asia estimated to top USD 45 billion a year (Taiwan News, 2014).

Human resources and development

No geothermal power plant is currently operating commercially in Chinese Taipei. The economy has only had a 50 kW geothermal demonstration plant and by the end of 2014, it is expected that a 1 MW geothermal pilot plant will be operational. With this situation and condition, most professional personnel in the economy are in the field of research led by the ITRI and in the field of drilling led by the Chinese Petroleum Corporation (CPC) and some oil companies. No university currently offers graduate school and/or master's and/or doctoral programs in geothermal studies. Thus, we can say, the quantity of professional personnel in the geothermal field is currently insufficient.

In part to create capability and capacity in Chinese Taipei's geothermal industry, the MOU between the Ministry of Economic Affairs and the State Government of Idaho was signed in April 2013 to develop modules and related systems for geothermal power generation. This cooperation can also create professional personnel in geothermal development for this economy in the near future.

Financial incentives

As mentioned in 'Government strategy', in order to promote the development of geothermal electricity, the Chinese Taipei Government has provided some financial incentives for geothermal developers as follows:

- Establish a Feed-in Tariff scheme

  Under the Renewable Energy Development Act, FIT schemes for geothermal electricity have been established where Taiwan Power Company (the State-owned electricity company) must purchase electricity from geothermal power plants. The FIT has been set not lower than the average cost for fossil fuel power generation of domestic power utilities and this is guaranteed for 20 years. The current FIT for geothermal energy is TWD 4.9315 per kWh (Liu, 2015). A panel consisting of relevant ministries, scholars and experts will determine the price paid to new projects every year based on criteria including the average installation cost, operating life, operation and maintenance cost and annual electricity generation.

- Establish subsidies under the Renewable Energy Fund

  As part of the government subsidy program, in order to encourage people to use geothermal energy, the Ministry of Economic Affairs has provided subsidies for the geothermal demonstration program since January 2013. Under this program, the government will provide subsidies of up to 50% of exploration costs or not exceeding TWD 50 million to the geothermal developer (BOE, 2013). However, the installed capacity of a geothermal power plant project must be higher than 500 kW. Since there is no obligation from the developer to pay back this money to the government, an assessment of the project will be carefully conducted by the government before the subsidy is given.

- Providing fiscal incentives

  Under the Renewable Energy Development Act, the government will exempt from customs duty developers who import machinery, equipment, special transportation equipment, training equipment and their parts and modules as long as that machinery, equipment, parts and modules are not yet produced by domestic manufacturers and suppliers.

Transmission network

According to the Renewable Energy Development Act, the transmission operator company must provide grid integration and cannot refuse the request of geothermal electricity producers or developers who seek access to the transmission system. However, this Act also mentions that for assessing the transmission system, the power lines connecting the geothermal power generation equipment and the transmission systems (grid) must be constructed, installed and maintained by the geothermal electricity producer or developer after obtaining an approval of connection from the transmission operator, which is Taiwan Power Company. However, it is a challenge for the geothermal electricity producer or developer to construct the power lines from her/his facility to the transmission system, since she or he must secure the right to use land from the landowner of any person (public, private or indigenous people), which can be time consuming. In addition, she or he needs to negotiate with the Taiwan Power Company regarding the cost of transmission construction, which is not covered by the FIT scheme.

Electricity sales contracting

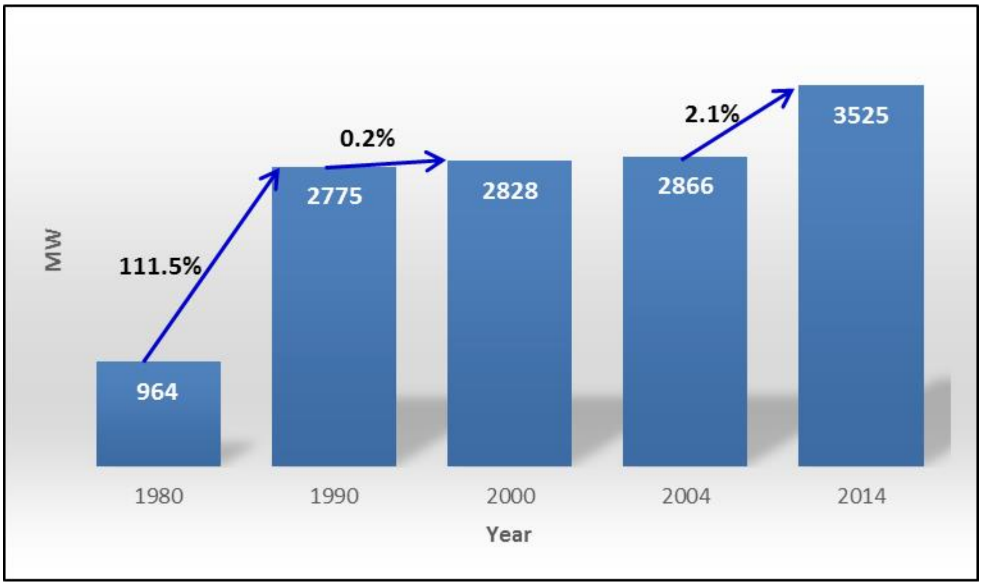
The Chinese Taipei Government has established the FIT scheme, which obliges the Taiwan Power Company to purchase electricity from almost all renewable energy producers to promote renewable energy including from geothermal. Under this scheme, geothermal producers can sell their electricity at a fixed long-term price guaranteed by the government for up to 20 years through contract. The tariff is set high enough to make geothermal energy profitable. The current FIT for geothermal energy is TWD 4.9315 per kWh. However, the geothermal electricity producer or developer still needs to negotiate with the Taiwan Power Company for the cost of transmission construction since construction of the transmission cost is not covered by the FIT scheme.

CHAPTER 5
ASSESSMENT OF POLICY SUCCESS FACTORS FOR GEOTHERMAL ELECTRICITY DEVELOPMENT

This chapter examines the policy successes and remaining barriers to geothermal electricity development in the past 10 years with regard to the 15 sub-key factors explained in the previous chapter.

THE UNITED STATES

Figure 27. Geothermal electricity development, progress, United States



Note: Figures represent cumulative installed geothermal electricity capacity.

Source: Analysis based on data from BP (2015).

Compared to other APEC member economies, the US has a long history of geothermal electricity development. This began with the setting up of the US's first geothermal power plant at The Geysers in California in 1922, with a capacity of 250 kW in operation. After 38 years of R&D activities, the first large-scale geothermal power plant was set up in 1960, with a capacity of 11 MW, by the Pacific Gas & Electric Company at The Geysers. However, serious promotion of geothermal electricity started in the US only in the 1970s, after the impact of the first was felt by the US.

In response to the oil crisis and to promote the development of geothermal electricity, in 1981, the government increased the annual budget for geothermal energy R&D to USD 150 million. Moreover, in an effort to further promote development in geothermal electricity in response to the oil crisis, two strategies were implemented by the federal government and the western States governments: (1) A program to reduce the risk faced by geothermal developers in the early stages by providing research data on the geology and geothermal resources available to them, cost sharing and the provision of fiscal incentives; and (2) A program to increase the ability of the developers to raise capital for geothermal projects through the provision of loans, loan guarantees, grants and the implementation of the RPS scheme. As a result, from 1980 to 1990, the installed geothermal electricity capacity averaged at a growth rate of 111.5% per year—the highest ever.

However, from 1990 to 2014, the growth rate of geothermal electricity capacity in the United States slowed and only increased at an average of 2.1% between 2004 and 2014. This was due to a decreasing annual budget for R&D in geothermal energy from the government (except in 2009, when the ARRA program was introduced); a backlog of geothermal lease applications at the Bureau of Land and Management (BLM) (as of 1 January 2005, there were 194 pending lease applications: 130 on BLM public lands and 64 on the National Forest Service (NFS) lands (BLM, 2007, p. I-6)); increasing utilisation of coal power plants starting in 1990; and an increase in the utilisation of gas turbine power plants as a result of the shale gas revolution that began in 2006.

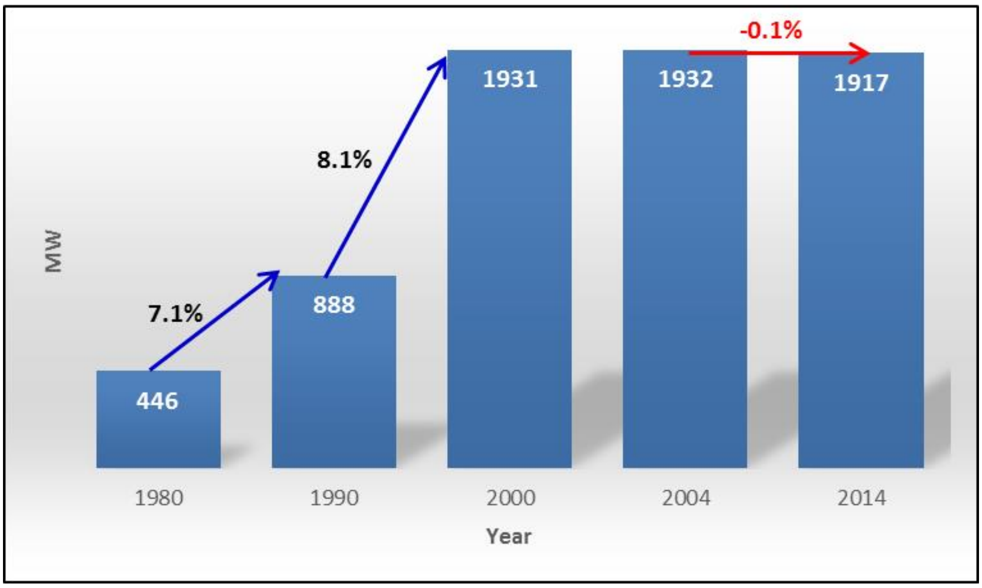
Despite the historical fluctuations in the development of geothermal electricity in the past, as of 2014, the US's installed geothermal capacity had reached approximately 3525 MW, making it the leading economy in installed geothermal capacity in the world. The success was not only due to the mechanisms mentioned in the legal basis but also due to the establishment of a conducive environment for wide private sector participation, particularly in providing a good government strategy through two programs and adequate funding for R&D.

Table 17. Matrix policy scorecard, United States

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Policy and Regulation						
- Legal Basis	Federal level: the Geothermal Steam Act of 1970; California State: the California Geothermal Resources Act of 1967; definition: mostly mineral resources since geothermal resources are found mostly on Federal lands. The ownership of resources resides with the Federal government, State government, individuals, and Indian Tribes. The developer still needs to consider other regulations such as the Environmental Policy Act and the Energy Security Act.					
- Strategy	The economy has two programmes, namely (1) reduce the risk in the early stages such as providing data, cost sharing in geothermal fields, and fiscal incentives; and (2) increase the ability of the developer to raise capital for a project, such as providing loans, loan guarantee, grants, and RPS. The government has set a target to double renewable electricity generation by 2020.					
- Government Commitment to Investors	The US government has shown a reliable commitment to geothermal investors from the beginning, with the Federal Steam Act and instituting two programs (reducing the risk of geothermal developers in the early stages and increasing the ability of the developer to raise capital for geothermal projects) in the 1970s.					
- Institutions	Other US agencies that have key roles with regard to geothermal resource development are such as the Bureau of Indian Affairs, the US Forest Service (USFS), and the US Environmental Protection Agency (EPA).					
Resource Access						
- Access to Geothermal Resources	The developer must have geothermal leases issued by the BLM through the competitive leasing process if the resource is located in the federal lands. Regarding access to geothermal resources on State lands, the developer must contact each relevant State agency. The developer still needs to obtain permits and licenses from other parties or agencies such as local communities, State agencies, the US Forest Service, the US Environmental Protection Agency, and the Bureau of Indian Affairs if the resources are located on Indian-owned land. No single procedure guideline for developing geothermal.					
- Secure and Exclusive Rights to Resources	Concession is by area, maximum 51,200 acres. The geothermal lease will be given for up to 35 years and might be renewed for up to 55 years. The person first issued a lease or permit shall be entitled to first consideration. Geothermal leases can be suspended or cancelled if the developer does not meet regulations.					

Key Factors	Assessment	Achievements 1	2	3	4	5
Environmental and Other Development Permission						
- Permission Time Limits	Though the Renewable Energy Coordination Offices were established under the BLM in 2009 to expedite the permitting process for developing renewable energy, including geothermal energy, on the National System of Public Lands, geothermal industry stakeholders have still identified the permitting process as one of the most significant barriers to geothermal power project development. No document has the entire permitting process outlined. In 2012, DOE initiated the Geothermal Regulatory Roadmap (GRR) to facilitate the permitting and regulatory process for geothermal development. The GRR project is still on-going.					
- 'One-Stop Permitting'	Currently, the US government is studying the need to establish 'Coordinating Permit Offices' for geothermal resource development, to facilitate approvals between developers and government agencies and set a timeline for the process					
- Inter-Agency Cooperation	The BLM has become the coordinating body for developing geothermal electricity in the US and will work closely with local communities, the State, and other Federal agencies (e.g. the USFS and EPA) to ensure that everything proposed by developers meets the requirements of all regulations, as well as the coordinating body for permitting process for siting new transmission projects that would cross public, state and private lands. In order to expedite the permitting process for renewable energy on the National System of Public Lands, including electrical transmission facilities, the Renewable Energy Coordination Offices under the BLM were established in 2009 in four states (Arizona, California, Nevada, and Wyoming).					
Government Support for Geothermal Industry						
- Database	A database has been provided by the Federal government through the US Geological Survey since 1975. A National Geothermal Data System (NGDS) has been established by the federal government to incorporate all geothermal data. The data can be used to determine geothermal potential, guide exploration and development, make data-driven policy decisions, minimise development risks, and understand how geothermal activities affect the community and the environment and guide investments. The data can be easily accessed, viewed, and downloaded online by the public.					
- Research and Development	The economy has a long history of supporting R&D in the geothermal field. The Department of Energy (DOE) provides annual budget for the Geothermal Technologies Program (GTP) to support geothermal electricity projects (research, development and demonstration). Approximately USD 350 million has been allocated for geothermal R&D and demonstration under the American Recovery and Reinvestment Act (ARRA) of 2009. EGS is one R&D and demonstration activity.					
- Human Resources and Development	There are 30 schools/universities with geothermal programmes, courses, and/or research in the US (e.g. Southern Methodist University (SMU), the Oregon Institute of Technology (OIT), Massachusetts Institute of Technology (MIT), Cornell University and University of Nevada, Reno (UNR)) and eight geothermal technical training schools and institutions that provide training for technicians and specialists.					
- Financial Incentives	Some financial incentives are provided at a Federal level, such as reducing the royalty, loan guarantee, cost sharing in the initial stages, and initial tax credit, and at State level, such as tax incentive and RPS.					
Electricity Market Access						
- Transmission Network	Transmission providers are required by the Federal Energy Regulatory Commission (FERC) to offer transmission service on an open, non-discriminatory basis pursuant to a transmission tariff. Geothermal producers must negotiate and execute an interconnection agreement with transmission providers before the developers begin generating the first MW of power. There is standardization for interconnection procedures and agreements for large and small generators.					
- Electricity Sales Contracting	The geothermal producers can sell their electricity to the utilities under the RPS scheme through long-term contracts. In states (e.g. Connecticut, Delaware, Illinois, Massachusetts, Maryland), where competition on the retail side has been introduced, geothermal producers may sell their power directly to retail consumers.					

Figure 28. Geothermal electricity development, progress, the Philippines



Note: Figures refer to cumulative installed geothermal electricity capacity.

Source: Analysis based on data from BP (2015).

The development of geothermal energy in the Philippines began in the late 1950s, when exploration activities were carried out by the Commission on Volcanology. Definitive geothermal resources were found at the Mt Mayon volcano in 1969. Following this, the government's efforts to locate more geothermal resources intensified, particularly when the oil crisis took place in 1970.

In response to the oil crisis and to promote geothermal electricity development, the government actively created a risk-sharing mechanism—private participation in partnership with the government in order to reduce risks at the early development stage. From 1970 to 1990, the institutions in this risk-sharing partnership were the government (through the State-owned National Power Corporation-NPC), which constructed a geothermal power plant due to a lack of knowledge and expertise in exploration and development, and the private sector (through the Philippine Geothermal, Inc.-PGI), which became the steam-field operator. This risk-sharing mechanism resulted in the successful development of geothermal electricity in Tiwi and Mak-ban in 1979. As a result of the implementation of this mechanism and allowing developers or investors to develop geothermal electricity through a Geothermal Service Contract, from 1980 to 1990, the average rate of growth for installed geothermal electricity capacity was 7.1% per year, making the Philippines the world's second-largest geothermal energy producer in 1984.

Between 1990 and 2000, the growth rate of geothermal electricity capacity in the Philippines increased at an average rate of 8.1% per year—the highest ever. The main factor for this successful increase in the rate of geothermal electricity development in this period was that risks to private developers were eliminated or reduced by the government. This was achieved by revising the risk-sharing mechanism; the government (through the Philippine National Oil Company, Energy Development Corporation – PNOC EDC) became a resource developer/steam-field operator, while the private sector became a power plant operator under the BOT contract scheme. Furthermore, the government provided a guarantee to back the

PNOC EDC in case of defaults in payments to the BOT contractor. This business model in the Philippines is a good example of geothermal electricity development measures recommended by experts.

However, the business model for developing geothermal electricity changed when the government introduced a privatisation program in the electricity supply industry. This was done because the government was experiencing financial difficulties in maintaining and expanding the development of the electricity sector, including that of geothermal electricity, after the privatisation of national assets in 2001. After the implementation of the privatisation program, the risk-sharing mechanism—which was a good scheme—was discontinued by the government and the fiscal incentives were revised when the Renewable Energy Act of 2008 was established. As a result of these steps, the growth of geothermal electricity capacity in the Philippines decreased between 2004 and 2014. Since geothermal energy is already developed (43% of the total potential has been developed), environmental and socio-cultural concerns are now critical factors in the development of geothermal resources; this is another factor that has led to the slowdown in geothermal electricity development.

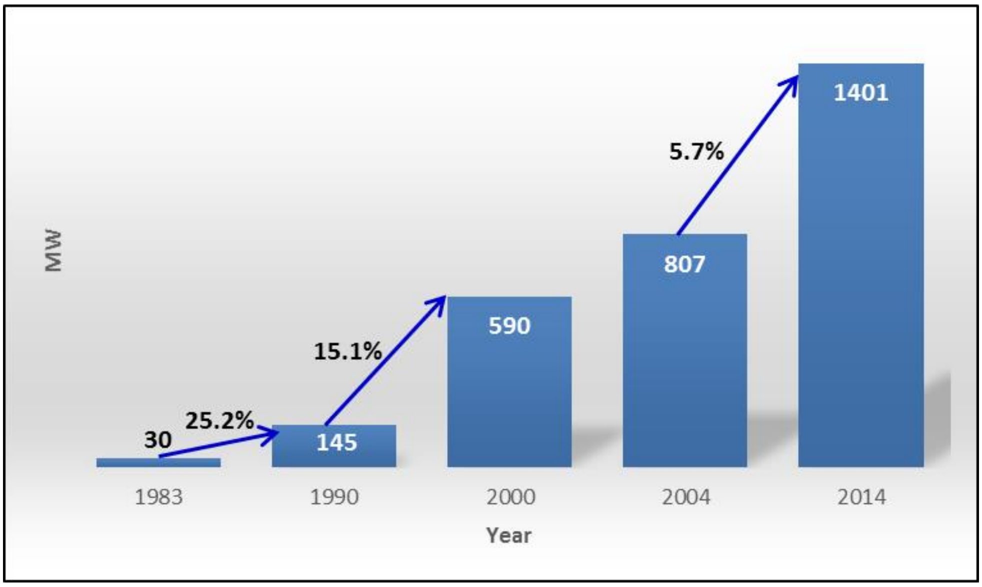
Despite the fluctuation in the development of geothermal electricity in the past, as of 2014, the Philippines' installed geothermal capacity had reached approximately 1917 MW, making it the economy with the second-largest installed geothermal energy capacity in the world. So far, the success has been possible not only due to the mechanism mentioned in the legal basis, but also due to the government introduction of a risk-sharing mechanism during the period 1980–2000, while the creation of a more conducive environment for wide private sector participation has been significantly achieved in some factors.

Table 18. Matrix policy scorecard, the Philippines

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Policy and Regulation						
- Legal Basis	The Renewable Energy Act of 2008 modifies the Geothermal Service Contract Law of 1978 governing geothermal development. Under the Act, geothermal is treated as a mineral resource meaning, 100% foreign-owned corporation can enter into geothermal resource exploration, development and utilization. The resources are owned by the State but the indigenous people also have ownership of certain geothermal resources. The developer still needs to consider other regulations such as the Indigenous Peoples' Rights Act, and the Environmental Laws.					
- Strategy	Under the Renewable Energy Act of 2008, the government provides fiscal and non-fiscal incentives to reduce risk, such as income tax holiday, duty free importation, lower corporate tax rate, zero per cent value-added tax rate, in addition to the financial assistance programme through government financial institutions. RPS is also provided in the law, but not yet implemented. Under the National Renewable Energy Program, the government has a target to increase the geothermal installed capacity by 75% by 2030 compared to 2010.					
- Government Commitment to Investors	In the past (1970—2008), the government has shown a good commitment to geothermal investors by providing a risk sharing mechanism. The government commitment changed slightly when they introduced a privatization program in power sector, where the risk sharing mechanism was changed to fiscal incentives under the Renewable Energy Act of 2008. RPS is to be applied to geothermal but there is no progress regarding the implementation of this scheme.					
- Institutions	The lead agency is the Department of Energy (DOE); the local government units and the National Commission on Indigenous Peoples are also key players.					
Resource Access						
- Access to Geothermal Resources	The developers need to obtain a Geothermal Renewable Energy Service Contract through an open and competitive selection process or by direct negotiation. Besides that, the developers must obtain permission or approval from various agencies, both central and local. Dealing with the indigenous people is one issue which needs clear-cut rules on how decisions are made. The DOE has identified a need for the National Integrated Protected Areas System (NIPAS) and the Indigenous Peoples' Rights Act (IPRA) to be harmonized since they pose a problem to investors.					
- Secure and Exclusive Rights to Resources	Concession is by area. The geothermal contract will be given for up to 25 years and it might be further renewed for up to 25 years. A geothermal contract can be suspended, cancelled, or terminated if the developer does not meet regulations.					

Key Factors	Assessment	Achievements 1	2	3	4	5
Environmental and Other Development Permission						
- Permission Time Limits	Obtaining permission or approval from various government agencies both central and local has no reasonable time limits. As mostly experienced by economies, environmental and socio-cultural concerns are considered by DOE to be critical factors in geothermal development.					
- 'One-Stop Permitting'	No 'One Stop Permitting' for the overall geothermal development approval processes. For environmental permission process, however, on 9 July 2012, the Office of the President released EO entitled 'Institutionalizing and Implementing Reforms in the Philippine Mining Sector, Providing Policies and Guidelines to Ensure Environmental Protection and Responsible Mining in the Utilization of Mineral Resources', which aims to create a one-stop shop for all mining applications. The EO mandates the DENR to establish an inter-agency one-stop shop for all mining related applications and processes within six months. Since geothermal energy was defined as minerals in the Renewable Energy Act, a one-stop shop will also apply to geothermal energy.					
- Inter-Agency Cooperation	To provide policies and guidelines so that exploration, development, and utilization of natural resources do not conflict with policies, guidelines, and conservation of natural resources, especially in protected areas, a Technical Working Group between the DOE and the Department of Environment and Natural Resources was established in 2012.					
Government Support for Geothermal Industry						
- Database	A database has been provided by the DOE since the 1970s. The Energy Data Center of the Philippines (EDCP) has been established by the DOE to store and manage energy data and information used in the exploration and development of geothermal resources. To access the data, the public must pay fees and charges. The DOE is continuously improving its database and computer networking for better data access by both internal and external clients.					
- Research and Development	Since 2000, the Philippines Government and private sector have shown good progress in geothermal research and development by providing funding for research and development (R&D) including surface exploration and exploration drilling. Adequate funding is always has been provided by the government. In the future, as part of the National Renewable Energy Program and Geothermal Energy Development Roadmap, the research and development programmes for the development of geothermal energy resources will continue, including research or study on 'Enhanced Geothermal Systems (EGS) and Geothermal Heat Pumps.					
- Human Resources and Development	The economy has adequate numbers of highly trained professionals in the field. The number of foreign consultants brought into geothermal operations in the Philippines is insignificant, reflecting the capability of home-grown personnel to handle most of the technical aspects of geothermal operations. In 2009, the technical manpower directly involved in geothermal operations in the Philippines was at 1,547 (excluding the manpower count of the National Power Corporation (NPC) power plants)					
- Financial Incentives	The government provides fiscal and non-fiscal incentives to reduce the risk, such as income tax holiday, duty free importation, lower corporate tax rate, zero per cent value-added tax rate, and a financial assistance programme through government financial institutions. RPS has been provided for in the law but not yet implemented.					
Electricity Market Access						
- Transmission Network	The basic rules for connection to the grid are fair and non-discriminatory for all users of the same category; and any user seeking a new connection to the grid shall secure the required connection agreement with the grid owner prior to the actual connection to the grid. The basic rules, requirements, procedures, and standards that govern the operation, maintenance, and development of the high voltage backbone system of the interconnected transmission lines in the Philippines, were established in the 'Grid Code' by the Energy Regulatory Commission in 2001.					
- Electricity Sales Contracting	Under the Electric Power Industry Reform Act of 2011, introducing competition in the electricity sector, geothermal developers and producers may participate in the wholesale electricity market for selling their power under prices set by the market. In addition, this Act also allows them to sell their output directly to distribution utility, supplier or contestable market (the electricity end-users who have a choice of a supplier of electricity) under long-term contract prices set by negotiation with the buyer.					

Figure 29. Geothermal electricity development, progress, Indonesia



Note: Figures refer to cumulative installed geothermal electricity capacity.

Source: Analysis based on data from BP (2015).

The first geothermal power plant in Indonesia was the Kamojang Unit 1 at Kamojang, West Java Province, with a capacity of 30 MW; the plant began successfully operating in 1983. The project was owned and developed by PERTAMINA (the State-owned oil and gas company; it has now been transferred to PERTAMINA Geothermal Energy). As a steam-field developer, PERTAMINA sold geothermal electricity to PT PLN (the State-owned electricity company) under the Steam Sales Agreement, or, as it is also known, the Energy Sales Contract (ESC).

The development of geothermal electricity in Indonesia was begun by PERTAMINA ('old regime'). To allow PERTAMINA to work with its contractors to develop geothermal electricity, the government introduced the Joint Operation Contract (JOC) system. Under this system, PERTAMINA was responsible for managing the operations and the contractor was responsible for producing geothermal energy from the contract area, converting the energy to electricity and delivering the energy or electricity as an independent power producer (IPP). In order to minimise the risk to contractors, the government established a risk-sharing mechanism for contractors—34% of the risk would be the 'government's share'—by implementing a special tax change. As a result of this scheme, from 1983 to 1990, the average growth rate of installed geothermal electricity capacity in Indonesia was 25.2% per year—the highest growth ever.

From 1990 to 2000, even though the average annual growth of geothermal electricity capacity increased at the rate of 15.1%, the growth rate was low compared to the period 1983–1990. This is because several private geothermal projects queued for development were suspended by the government because of the financial crisis that heavily impacted the Indonesian economy in mid-1997. Only a few projects that were already at the construction stage continued to be developed during this period.

In 2000, the JOC model was changed into a Mining License by the government; the formal implementation of this new scheme began after the government successfully enacted Geothermal Law No. 27 in 2003 ('New Regime'). Even though the government introduced two programs—namely (1) the program to reduce the risk to geothermal developers; and (2) the program to increase the ability of the developers to raise capital, to attract participation from investors or developers—none of the geothermal electricity projects have yet been started and/or operated under the 'New Regime'. Under the New Regime, 39 Geothermal Working Areas in Indonesia were identified and made available for development by the government. However, progress on projects undertaken by private developers slowed down because of numerous issues that the government had to address. While the growth rate of geothermal electricity capacity from 2004 to 2014 increased, this was mostly because some geothermal projects that were started between 1990 and 2000 finally began operating successfully.

Despite the fluctuating development in geothermal electricity in the past, as of 2014, Indonesia's installed geothermal capacity was approximately 1401 MW, making it the economy with the third-largest installed geothermal capacity in the world. This success stemmed largely from government efforts to continuously improve several factors in order to create an environment conducive to wide private sector participation.

Table 19. Matrix policy scorecard, Indonesia

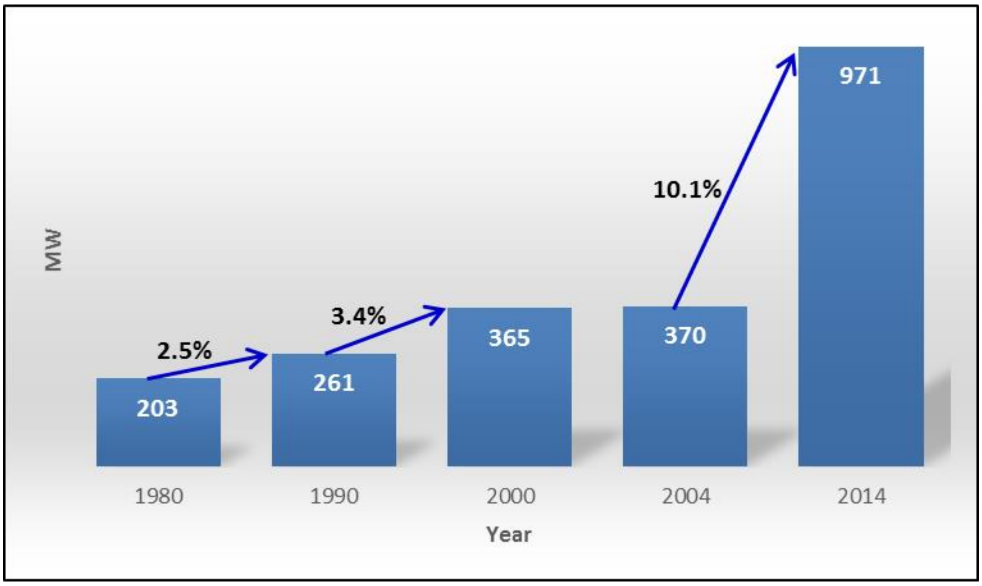
Key Factors	Assessment	Achievements				
		1	2	3	4	5
Policy and Regulation						
- Legal Basis	The New Geothermal Law of 2014 has been issued on 17 September 2014. The resources are owned by the State. Under the new law, geothermal development activities are not considered as mining activities, as the government changed the scheme of permitting from 'Geothermal Mining Permit' to 'Geothermal Permit'. As the regulations under the new law are still being developed, the legal situation in Indonesia can be described as being in a state of flux, though the resulting changes can be expected to be positive for development (Lawless, 2015). The developer still needs to consider other regulations such as the Forestry Law, the Environment Law, and the Electricity Law.					
- Strategy	Reduce the risk in the early stages such as providing data on geothermal resources, fiscal incentives (tax holiday, value added tax); increase the ability of the developer to raise capital for geothermal projects such as providing loans for financing the exploration stage; government guarantee of business viability of State Owned Electricity Company (PLN); set attractive tariff for geothermal electricity through ceiling price mechanism; reduce restrictions on development of geothermal electricity in protected forest areas. The economy has a target to develop 7,215 MW by 2025 under the Road Map of Geothermal Development 2006-2025.					
- Government Commitment to Investors	There have been historical inconsistencies in commitments by the government to investors. These have caused the country risk rating for Indonesia to become high, slowing down the development of power sector infrastructure, including geothermal electricity. These have included the Karaha Bodas Company and the Himpurna California Energy cases, as well as annulment of a new Electricity Law No. 20 by the Constitutional Court of Indonesia in December 2004. However, the government has also already shown a strong commitment to solve some issues that slow down the development of geothermal electricity by establishing the new Geothermal Law of 2014 to address the issues on protected forest areas and the permission process, and issuing a regulation on geothermal pricing whereby the ceiling price is set high enough to cover the investment cost of the developer.					
- Institutions	The lead agency to promote and regulate the development of geothermal energy is the Directorate of Geothermal under the Directorate General of New, Renewable Energy and Energy Conservation, the Ministry of Energy and Mineral Resources (MEMR). However, local government also remains a key player in the development of geothermal electricity, especially with regard to building permits and land acquisition. Other agencies that have key roles with regard to geothermal resource development are such as the Ministry of Finance, the Ministry of Environment, and the Ministry of Forestry.					

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Resource Access						
- Access to Geothermal Resources	The developers need to obtain a Geothermal Working Area through competitive bidding from the authority-in-charge (now the Ministry of Energy and Mineral Resources based on the New Geothermal Law). In addition, the developers must obtain permission or approval from various other agencies, both central and local. The Geothermal Working Area does not include rights on surface lands. It has historically difficult to obtain a permit from the Ministry of Forestry if the resources are located in forestry areas, although reforms in the by the new Geothermal Law address this problem.					
- Secure and Exclusive Rights to Resources	Concession is by area. The geothermal permit will be given for up to 37 years (5 years for exploration, with two one-year extensions and 30 years for exploitation) with a further 20 year extensions possible. A geothermal contract can be suspended, cancelled, or terminated if the developer does not meet regulations.					
Environmental and Other Development Permission						
- Permission Time Limits	The permission process for developing geothermal electricity in Indonesia is one of the barriers that have been identified by investors and developers, since it causes delay in the progress of projects and increases the expenses of the developers. No geothermal guideline for permission incorporates the many related licensing/permission requirements from different agencies into one single information document with reasonable time limits within which permission decisions must be reached. One positive breakthrough that has been made by the government regarding permission is that the issuance of geothermal permits will be made by the MEMR under the new Geothermal Law of 2014 while in the previous law it was made by the MEMR, Governors or Regents/Mayors in accordance with their respective jurisdiction					
- 'One-Stop Permitting'	No specific 'One-Stop Permitting' for the geothermal permission process in Indonesia, but it has recently been announced the Investment Coordinating Board (BKPM) will be appointed to provide this service. It has yet to be seen how that works in practice.					
- Inter-Agency Cooperation	With many different institutions involved in developing geothermal electricity, each having its respective administrative rules and permitting requirement based on its own legislation making (for example) permitting process seems uncoordinated well and cumbersome making uncertainty in legal aspects and the lack of cross-sector coordination. The government has revoked the power of local governments to regulate geothermal resources and appointed the BKPM as agency to coordinate all permits.					
Government Support for Geothermal Industry						
- Database	Regarding the data, however, private developers and investors continue to question the quality of the surface exploration data since lack of geological, geophysical and geochemical (GGG) data causing the low accuracy in determining the magnitude of geothermal potential in Indonesia. In 2012, the MEMR launched a book of 'the Profile of Indonesia's Geothermal Potential'.					
- Research and Development	Every year, the government provides funding to the Research and Development Agency of Mineral and Energy Resources, within the MEMR to conduct research and development on geothermal energy. However, the amount of funding fluctuates depending on the project proposals of the agency. Some experts believe that one of the challenges for Indonesia in renewable energy development is the absence of adequate technology and research and development support.					
- Human Resources and Development	It is estimated by MEMR, that in order to develop geothermal energy, Indonesia needs 3000 operators and 1000 engineers. However, in reality, currently the Indonesian Geothermal Association (INAGA) has only approximately 400 professional personnel in the geothermal business in Indonesia from various disciplines (PwC, 2012); and only two universities have magister programmes in geothermal-related disciplines. Some experts see Indonesia as lacking in capable technical personnel and having a shortage of competent human resources. They still do not see sufficient public training capacity being developed.					
- Financial Incentives	Tax Holiday; Investment Allowance; Exemption of Value Added Tax for import of machinery and equipment; Exemption of Import Duty for machinery, goods, and materials; Exemption of Withholding Income Tax for import of machinery and equipment; Loan facility for exploration stage through Geothermal Fund Facility; Government guarantee for business viability of PLN; and attractive pricing for geothermal (ceiling price mechanism).					

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Electricity Market Access						
- Transmission Network	Under electricity regulation, the transmission company (PLN) has an obligation to share its transmission network services with all power generation companies through the transmission network charges. A standard for connection to the transmission network has been established by the government through the 'Grid Code'.					
- Electricity Sales Contracting	In the past, the developer needs to negotiate their selling price with PLN before a contract can be signed by both parties; and the negotiation process mechanism is time consuming. In June 2014, the government introduced the ceiling price mechanism. Under this new ceiling price mechanism, the government requires PLN to purchase electricity from geothermal developers based on price auction results and within six months after PLN receives the assignment to purchase electricity from the government, the PPA must be signed by both parties.					

NEW ZEALAND

Figure 30. Geothermal electricity development, progress, New Zealand



Note: Figures refer to cumulative installed geothermal electricity capacity.

Source: Analysis based on data from BP (2015).

New Zealand has a long history of geothermal electricity development, having opened its first plant—and the world's second—at Wairakei in 1958. Geothermal power plants in New Zealand are under the ownership of either Mighty River Power—which was a State-owned enterprise, before the government partially sold its stake through an initial public offering—or fully private entities.

In the case of geothermal electricity development in New Zealand, the government successfully developed geothermal electricity without having to provide any financial incentives other than a relatively low price of carbon to investors and developers. The government strategy for developing geothermal electricity is to ensure market incentives and the regulatory framework support further investments in appropriate renewable energy projects by removing unnecessary regulatory barriers. As a result, the growth rate of geothermal electricity capacity in New Zealand has been increasing; the highest growth was between 2004 and 2014, at an average growth rate of 10.1% per year. As of 2014, New Zealand’s installed geothermal capacity was 971 MW, making it the fourth-largest economy by installed geothermal capacity in the APEC region.

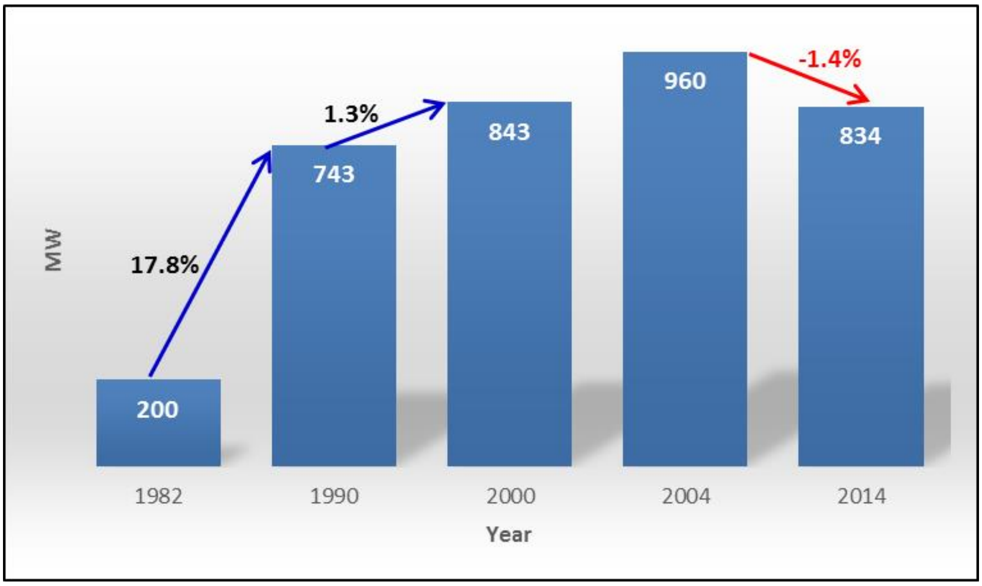
Table 20. Matrix policy scorecard, New Zealand

Key Factors	Assessment	Achievements (1–5)
Policy and Regulation		
- Legal Basis	The Resources Management Act of 1991. Geothermal is treated as a water resource. The resources are owned by the State but in practice landowners own the geothermal resources, mostly the Maori people. However, the management of water rights is still controlled by the government. The developer still needs to consider other regulations such as the Mining Act, the Indigenous Peoples' Rights Act, and the Environmental Laws.	4
- Strategy	The government offers no financial incentives. In general, the government’s approach is to ensure market incentives and the regulatory framework supports further investment in appropriate renewable projects by removing unnecessary regulatory barriers. The government retains the target that 90 per cent of electricity generation be from renewable sources by 2025.	4
- Government Commitment to Investors	New Zealand’s electricity prices are set in a competitive market, and there is no feed-in-tariff scheme. There have been no commitments as to the price geothermal developers will receive for the electricity they produce. A geothermal investor might, however, perceive that the New Zealand government at least to some degree reneged on a commitment, with their decision in 2012 to amend the New Zealand Emissions Trading Scheme.	4
- Institutions	In New Zealand, the Ministry of Business, Innovation, and Employment (MBIE) is the lead agency dealing with all aspects of energy. Regional and district councils (local governments) in New Zealand are key players in geothermal development as they have primary responsibility for issuing Resource	5
Resource Access		
- Access to Geothermal Resources	The developer should obtain the resource consent and permission from the landowners. The process of obtaining permission from landowners may, however, be a challenging one, in some ways more challenging than under a State-ownership regime. In New Zealand, there is no requirement for the landowners to consent to geothermal development on their land. One can argue that this is as it should be—landowners should be free to use and not use their property as they see fit. However, as a 2010 report by New Zealand’s Ministry of Economic Development notes, 'This lack of certainty can be a deterrent to investors, particularly from overseas'. There is no formal process of arbitration and no legislative guarantee that the explorer will be given the first right to extract the resource.	4
- Secure and Exclusive Rights to Resources	'Concessions for geothermal exploration and exploitation are granted not by field or area but depend on how the developer can negotiate with the owners of the land whose resources they will be developing. There is no integrated resource management, as a consequence of which another developer could move in on a neighbouring property and tap into the same geothermal resource as one that an earlier developer had already invested a substantial sum exploring or even developing, thus diminishing the resources available to the	4
Environmental and Other Development Permission		
- Permission Time Limits	There are three possible alternative resource consent processes that a major project of national significance might take to a decision: the traditional path through the Regional Council, through an especially appointed Board of Inquiry, or through the Environmental Court. A Regional Council is supposed to decide on a notified application within six months, with one clock-stop allowed to request more information. A Board of Inquiry is supposed to decide within nine months.	5
- 'One-Stop Permitting'	New Zealand’s resource consent process comes very close to the model of 'One-Stop Permitting', at least for environmental permission. The developer applies to the relevant Regional Council or to the Environmental Protection Authority for resource consents, who manage the process for dealing with the serious environmental impacts of the project: air, water, and land.	5
- Inter-Agency Cooperation	Cooperation between agencies, both formal and informal, is generally good. In particular, it should be noted that the law lays out processes by which central government (the Minister for the Environment, the EPA, Boards of Inquiry, and the Environmental Court) must work with regional councils to reach decisions on resource consents for projects of national significance.	5

Key Factors	Assessment	Achievements 1 2 3 4 5
Government Support for Geothermal Industry		
- Database	A reasonably good database exists, but is kept by a variety of organizations and has a range of access requirements. Much of the data obtained from government-sponsored drilling now resides with Crown Research Institutes, who may charge high fees for access.	
- Research and Development	New Zealand has provided funding for geothermal research, but only on a modest scale.	
- Human Resources and Development	New Zealand has good tertiary-level programmes at the Geothermal Institute of the University of Auckland. The New Zealand geothermal industry appears to be reasonably satisfied with the current state of geothermal education in New Zealand.	
- Financial Incentives	Other than a relatively low price on carbon imposed by the New Zealand Emissions Trading Scheme, New Zealand has no financial incentives to support renewable energy generally or geothermal electricity in particular.	
Electricity Market Access		
- Transmission Network	Transpower, the State-owned transmission company, acts as a neutral provider of transmission to all generators. Transmission access in the regions of New Zealand with geothermal resources is generally good.	
- Electricity Sales Contracting	Electricity prices in New Zealand are set competitively, with geothermal developers free to negotiate sales contracts with potential buyers without government regulation.	

MEXICO

Figure 31. Geothermal electricity development, progress, Mexico



Note: Figures refer to cumulative installed geothermal electricity capacity.

Source: Analysis based on data from BP (2015).

When Mexico began developing geothermal electricity, the government gave preferential rights to CFE, the State-owned electric utility, to develop it. Because of this, there are neither other utilities nor private firms developing geothermal electricity in Mexico. The private sector has had limited involvement in geothermal electricity development as drilling contractors or as engineering procurement construction (EPC) contractors under a Public-Private Partnership (PPP). The government has historically allocated a budget to CFE for development, management and operations every year.

Between 1982 and 1990, geothermal electricity capacity increased at an average rate of 17.8% per year. During this time, the government was providing significant funds to CFE for investments. Between 1990 and 2000, however, even though the geothermal electricity capacity increased, the growth rate was lower compared to that between 1982 and 1990. One reason for this declining growth rate was that the government limited its financial support to the activities of CFE.

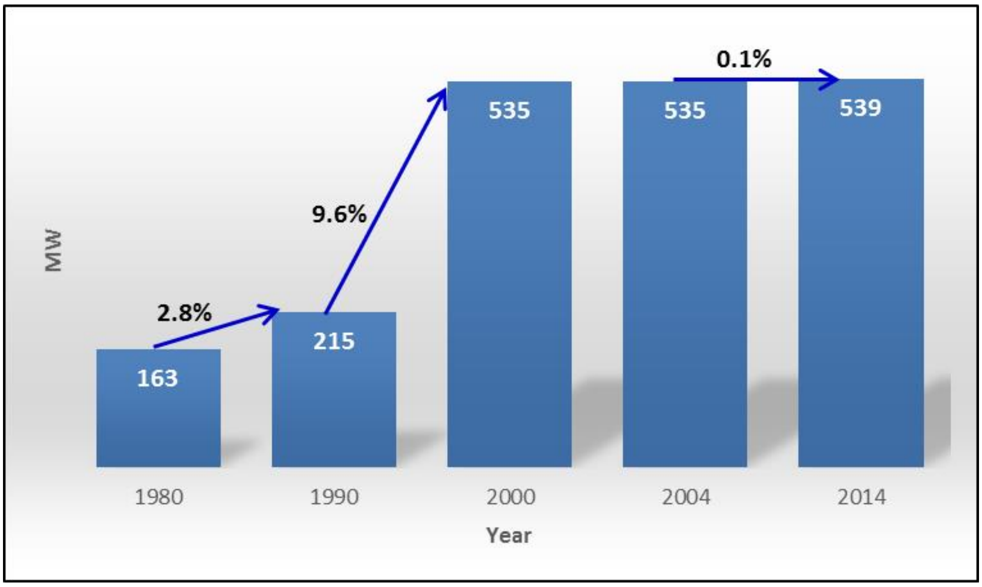
Despite the fluctuating development in geothermal electricity, as of 2014, Mexico's installed geothermal capacity was 834 MW, making it the fifth largest economy in installed geothermal capacity in the APEC region. So far, the success of geothermal electricity development was due to the government provision of significant funds to the Federal Electricity Commission (CFE) for developing, managing and operating geothermal electricity during the period 1982–2000. Adequate funding for R&D was also provided by the government. Recently, the Mexican Government has instituted significant reforms in geothermal energy by allowing wide private sector participation.

Table 21. Matrix policy scorecard, Mexico

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Policy and Regulation						
- Legal Basis	The Mexican government has enacted the Geothermal Energy Act of 2014. Under this Act, geothermal resources are defined as 'Hot Water'. The geothermal resources belong to the State. The resources can be only exploited after the developers have a geothermal concession. Developers still need to consider other regulations, such as the Public Electricity Service Law, the Forest Act, and the General Act of Ecological Equilibrium and Environmental Protection regarding Environmental Impact Assessment					
- Strategy	The Mexican government has recently committed to significant reforms in geothermal energy by allowing more private sectors participation under the Geothermal Energy Act of 2014. As part of reducing high risk to developers in the development of geothermal electricity, the government provides risk mitigation and financing program for Independent Power Producers (IPPs) by making available a range of financial mechanisms tailored to meet the specific needs for each project's stage of development.					
- Government Commitment to Investors	In the past before the Geothermal Energy Act of 2014 has been enacted, the participation of the private sector in geothermal electricity development has been very limited (only in the construction and drilling of wells under contract with the Federal Electricity Commission (CFE)). Since the Mexican government has recently committed to significant reforms in geothermal energy, keeping the government commitment in the future is expected by investors.					
- Institutions	The lead agency dealing with all aspects of energy, including geothermal energy is the Ministry of Energy (SENER). State or municipal authorities are also key players in geothermal electricity development, especially when geothermal resources are located on State or municipal lands. Other agencies that have key roles with regard to geothermal resource development are such as the Energy Regulatory Commission (CRE); the Ministry of the environment and Natural Resources (SEMARNAT); and the National Water Commission (CNA).					
Resources Access						
- Access to Geothermal Resources	Under the new Geothermal Energy Act, developers (either CFE or enterprises/individuals) can use geothermal resources for generating electricity after she or he has a geothermal concession from SENER through competitive bidding. The developers must also obtain the necessary licenses from various other agencies (federal, state or municipal). Since the rights (or the ownership) of a geothermal concession do not include the rights on surface lands. Hence, developers need to negotiate with the landowners (private, communal (ejidos) or public) to use their land for projects.					
- Secure and Exclusive Rights to Resources	Concession is by area, maximum 150 km2 area. The geothermal exploitation permit will be given for up to 30 years and it might be further renewed. For purposes of national security, public interest, efficiency in the use of geothermal resources and environmental protection, SENER can determine whether the geothermal resources may be used jointly or separately by different developers, when there are corresponding concessions between two different concession owners. A geothermal concession and permit can be suspended, cancelled, or terminated if the developer does not meet regulations.					

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Environmental and Other Development Permitting						
- Permission Time Limits	A reasonable period within which permitting decisions must be reached by various government agencies (e.g. SENER and CNA) has been set in the Geothermal Energy Act of 2014. However, that permits are granted only after all the necessary documents have been fully submitted to SENER, in compliance with related regulations. A Renewable Energy Window (VER) is currently underway by the government to help promote investment in renewable energy projects, including geothermal energy, by simplifying the requirements and procedures imposed upon developers.					
- 'One-Stop Permitting'	Mexico has no known 'One-Stop Permitting' for the geothermal permitting process.					
- Inter-Agency Cooperation	Even though inter-agency cooperation among agencies has worked well for the success of geothermal electricity development, procedure mapping conducted by SENER has shown that the procedures for permitting still represent 600 days of pending time for permit decisions, because there remains duplication of requirements among agencies. Under the new Geothermal Electricity Act, SENER has been appointed as the coordinator for solving technical issues among agencies in Mexico.					
Government Support fro Geothermal Industry						
- Database	CFE holds the entire database regarding geothermal resources at various temperature levels in Mexico. This database cannot be easily accessed by the public. As the Geothermal Electricity Act of 2014 has been issued, all the geothermal data obtained by CFE should be transferred to SENER who will be responsible for the collection, protection and management of this information. Currently, the National Renewable Energy Inventory (INER), a system of statistical and geographical information services for various renewable energy sources, including geothermal resources and national atlas of geothermal resources are under preparation by the government.					
- Research and Development (R&D)	Mexico has a long history of support for R&D in geothermal resource development. Most geothermal research activities are focused on development and exploitation of resources for power generation with the aim to improve knowledge of the fields and thus the ability to predict their behaviour under continued exploitation. Adequate funding has been provided by the Government. The Government established the Mexico Center for Geothermal Energy Innovation (CeMIE-Geo) in 2013 to promote the development of geothermal electricity in Mexico, through both R&D and human resources development (HRD).					
- Human Resources and Development (HRD)	In 2014, technical manpower directly involved in geothermal operations in Mexico currently was 223 personnel. There are several agencies and universities that could provide professionals in geothermal subject areas. Under the Mexico Center for Geothermal Energy Innovation (CeMIE-Geo), three levels of training (short training courses, graduates studies in specific areas, and master's and doctoral programs) are carried out in partnership with the United Nations University in Iceland, universities in New Zealand, and universities in the United States.					
- Financial Incentives	In the past, little financial incentives for geothermal development in Mexico. Currently, the government is taking steps to provide geothermal financing schemes such as grants, loans and guarantees to the private sector under the risk mitigation and financing program. A total of USD 120.1 million has been allocated for this program by the Inter-American Development Bank (IDB), the Clean Technology Fund (CTF) and SENER to support risk mitigation for the early drilling phase, financing adapted to different phases of project exploration and development, and technical assistance activities. The fund will be disbursed over a period six years, and it is targeted to finance 300 MW of additional geothermal capacity in the long term.					
Electricity Market Access						
- Transmission Network	Under the Electricity Industry Act of 2014, CRE requires transmission providers to offer transmission service on an open, non-discriminatory basis where technically feasible, pursuant to a transmission tariff that will govern the terms by which such service is provided. Clean energy producers (including geothermal energy) are allowed to interconnect to the transmission network without delays or surcharges. However, to obtain access to the transmission network, geothermal developers or producers need to conform to market rules and must have an interconnection agreement under the supervision of CRE.					
- Electricity Sales Contracting	Under the energy reform of the Electricity Industry Act of 2014, which was promulgated by the Government to introduce competition in the electricity sector, geothermal developers and producers (i.e. CFE, private generators, private co-generators, representatives of generators, and private commercial participants) may participate in the wholesale electricity market for selling their power under prices set by the market. In addition, this Act also allows them to sell their output directly to any generator or commercial operator, a marketer/trader or qualified consumer under long-term contract prices set by negotiation with the buyer.					

Figure 32. Geothermal electricity development, progress, Japan



Note: Figures refer to cumulative installed geothermal electricity capacity.

Source: Analysis based on data from BP (2015).

After the first experimental geothermal energy power plant, with a capacity of 1.12 kW, was successfully set up in 1925, the first commercial geothermal power plant began operating at Matsukawa in 1966. In response to the oil crisis and to promote geothermal electricity development, the government increased the annual budget for R&D in geothermal energy, reaching JPY 10 123 million in 1982. Using this budget, the government, through the New Energy and Industrial Technology Development Organization (NEDO), conducted a long-term and comprehensive exploration program—the Survey for Promotion of Geothermal Development—at promising geothermal areas throughout the country. As a result of this program, between 1980 and 1990, installed geothermal electricity capacity growth averaged at 2.8% per year.

Between 1990 and 2000, the growth rate of geothermal electricity capacity in Japan peaked, with an average growth rate of 9.6% per year. One of the reasons for the increased capacity during this period was that, on the one hand, the country's knowledge and experience in geothermal electricity development had been diligently accumulated (technical developments in survey, drilling and the exploitation of geothermal resources). On the other hand, the government budget continued to provide geothermal R&D subsidies, even though the amount was lower as compared to the budgets allocated between 1980 and 1990.

Between 2004 and 2014, the installed capacity of geothermal electricity in Japan increased slightly after the first binary system of geothermal in Hatchobaru with a capacity of 2 MW came into operation in 2006. Less geothermal electricity was developed in Japan, perhaps because geothermal was excluded as a new energy source under the Law Concerning Special Measures for Promotion of New Energy Use in June 1997, resulting in budget cuts for geothermal R&D. From 1990 to 2002, the utilisation of nuclear, coal fired and gas turbine power plants significantly increased, which led to the government discontinuing subsidies for geothermal R&D from 2002 onwards. Geothermal-related generation systems, except geothermal binary power generation, were also removed from the list of new energy sources under the Act on Special Measures Concerning New Energy Use by Operators of Electric Utilities (known as the Japanese RPS Act), which was implemented in June 2002. Since then, geothermal electricity has lost the government's support.

As of 2014, Japan's installed geothermal capacity was 539 MW, making it the sixth largest economy by installed geothermal capacity in the APEC region. This success has primarily been due to the government provision of significant funding for R&D during the period 1974–2000 in response to the oil crisis and to promote geothermal electricity development.

Table 22. Matrix policy scorecard, Japan

Key Factors	Assessment	Achievements				
		1	2	3	4	5
Policy and Regulation						
- Legal Basis	Geothermal development is governed by the Hot Spring Act. Geothermal is defined as a hot spring. Even though the ownership of geothermal resources resides with the state, the development of these resources is regulated by local government (municipal and prefectural). Exploring and exploitation this resource require the permission of the local (prefectural) governor. The developer still needs to consider other regulations such as the Environmental Impact Assessment (EIA) Law, the Natural Park Act, and the National Forest Law.					
- Strategy	the government provides some support such as subsidies for geological surveys; equity capital finance for exploration; 100% grant to potential surveys for public acceptance; liability guarantees for geothermal development; and a Feed-In Tariff (FIT) scheme. Under Japan's New Energy Mix, the share of geothermal electricity in the total electricity generation is expected to be 1.0-1.1% of total electricity generation in 2030.					
- Government Commitment to Investors	There were historically inconsistent commitments by the government to investors, such as no more geothermal R&D subsidies being allocated after 2002 and geothermal was not eligible to apply to the RPS scheme except for geothermal binary power generation.					
- Institutions	Two government agencies lead the development of geothermal resources in Japan, namely METI (Ministry of Economy, Trade and Industry) and MOE (Ministry of Environment). Local (municipal and prefectural) governments also play an important role in developing geothermal resources in Japan since they are treated as hot springs and must comply with the Hot Spring Act. Other agencies that have key roles with regard to geothermal resource development are such as Japan Oil, Gas and Metals National Corp (JOGMEC); New Energy Development Organization (NEDO); National Institute of Advanced Industrial Science and Technology (AIST); and universities (e.g. Kyushu University, Tohoku University).					
Resource Access						
- Access to Geothermal Resources	The basis used to access resources is 'first come first served'. Even so, geothermal developers have been required to go through cumbersome permission processes, particularly to access resources in national parks. Welling-drilling in the process of exploration and feasibility studies is the most difficult operation for which to obtain a permit. The procedure of EIA is time consuming and usually takes 3-4 years.					
- Secure and Exclusive Rights to Resources	Concessions for geothermal exploration and exploitation are granted by well, and not by field or area. This results in investments not being protected during these phases. Hot-spring owners or industries could be threatening the secure and exclusive rights to resources for geothermal developers. Since the hot springs are valued by the Japanese people in terms of health benefits and are an important source of tourism for some areas and this business is protected by the Hot Spring Act rather than geothermal, local governments (municipal and prefectural) take care of any influence of new geothermal wells on other hot springs.					

Key Factors	Assessment	Achievements 1	2	3	4	5
Environmental and Other Development Permission						
- PermissionTime Limits	It takes 10 or more years from the first geological surveys to build an operating plant, a significantly long and costly lead time. There is also no national geothermal guideline for obtaining permits. Based on the Environmental Impact Assessment (EIA) Law, constructing a power generation plant with output of 10 MW or higher requires an EIA; Japan's EIA process is especially long (it takes 3-4 years).	■	■	■		
- 'One-Stop Permitting'	There is currently no specific 'One-Stop Permitting' for the geothermal permission process in Japan.					
- Inter-Agency Cooperation	Inter-agency cooperation related developing geothermal electricity in Japan, particularly the Environmental Impact Assessment (EIA) is complex and one of the big challenges seen by the investors and developers. Mostly public opinion mechanism will be used by the local government to take decision on its permission for geothermal drilling instead of the recommendation from relevant authorities, particularly if geothermal electricity development may affect other user (hot spring industries).	■	■	■	■	
Government Support for Geothermal Industry						
- Database	The government has conducted the 'Survey for Promotion of Geothermal Development' since 1980 to evaluate the possibility of geothermal power generation for promising areas with potential geothermal resources throughout the economy. This information is available to the public through AIST's website.	■	■	■	■	■
- Research and Development	The Japanese Government under the Sunshine Program and the New Sunshine Program has conducted intensive geothermal R&D in order to find an alternative energy to oil. During the period 1974 to 2002, the government had been allocated a budget for geothermal R&D subsidies of up to 134 848 million Yen, in which the year 1982 had the highest allocated government budget (10 123 million Yen). In 2002 and beyond, there was no more geothermal R&D subsidy allocated by the government. After this long absence of the R&D subsidy, in the fiscal year 2013, the government again tried to provide a budget for an R&D subsidy of up to 0.95 billion Yen with a focus on techniques for searching for fractures, reservoir management technologies, and environmentally-friendly and high performance power generating systems.	■	■	■	■	■
- Human Resources and Development	In 2010, there were approximately 500 professional personnel employed in geothermal related jobs in Japan. It was because no geothermal power plants have been constructed since 1999, so that the professional personnel in the geothermal industry in Japan has significantly reduced. Currently, there are four universities in Japan with graduate school offering master's degree and/or doctoral programmes in geothermal energy, namely Tohoku University, Kyushu University, Kyoto University, and Akita University.	■	■	■	■	
- Financial Incentives	The government provides some financial support such as subsidies for drilling including geological surveys, that cover 50-100% of the cost of exploration well drillings; subsidies for public acceptance (PA) that cover 100% of PA activities by the private sectors; government investment with an investment ratio of up to 50% of equity capital; liability guarantees with loan guarantee ratio of up to 80% of loan provided by financial institutions; subsidies for research and development that cover 50-100% of the cost of R&D; and subsidies for shortening the lead time of environmental impact assessments (EIA) that cover 50% of the cost of an EIA; and a Feed-In Tariff (FIT) scheme.	■	■	■	■	■
Electricity Market Access						
- Transmission Network	Transmission and distribution networks in Japan are owned and operated by General Electricity Utilities. To maintain fair and transparent use of the electric power transmission and distribution system for all players, the Electric Power System Council of Japan (ESCJ) was established in 2005 as the sole private organization to make rules and supervise operations from a neutral position. In addition, the government introduced rules of conduct, such as prohibiting discriminatory treatment. The price of using the transmission system ('wheeling tariffs') must be set in accordance with regulations established by METI and reported to it. Moreover, under the FIT scheme, electric utilities are obliged to allow grid connections and execute contracts as required for the purchase of renewable energy including from geothermal.	■	■	■	■	
- Electricity Sales Contracting	In 2012, Japan established a FIT scheme, which obliges the General Electric Utilities to purchase electricity from almost all renewable energy producers to promote renewable energy including geothermal up to 15 years. The tariff is set high enough to make geothermal energy profitable.	■	■	■	■	■

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. APEC member economies have a huge opportunity to develop their untapped potential reserves of geothermal energy for electricity in the near future, which will not only help to address the region's energy security challenges but also to achieve the APEC goal of doubling the share of renewables in the energy mix, including power generation, from 2010 levels by the year 2030.
2. Policies such as policy infrastructure, access to resources, environmental and other development permitting, government support for the geothermal industry and access to electricity markets were proven to be effective in the development of geothermal electricity for the economies.
3. The policy success factors analysed in this study are those factors that need to be implemented by a member economy to accelerate plans for geothermal electricity production or by a member economy that has plans to develop geothermal electricity for the first time.

RECOMMENDATIONS

- **The United States**
  - Obtaining permitting for geothermal electricity development in the United States is very challenging, since geothermal resources are found on four types of land (federal, State, private and Indian country) and each State has adopted a different approach to determine ownership of geothermal resources. Each agency has its own administrative rules and permitting requirements, and sometimes, two or more agencies have overlapping jurisdictions. The plan to establish 'Coordinating Permit Offices' that facilitate approvals between the developers and government agencies in a timely manner needs to be realized soon.
  - The government initiative to carry out the 'Geothermal Regulatory Roadmaps' project to improve the permitting process at the federal, State and local level has our strong support.
- **The Philippines**
  - The government should pursue the implementation of RPS since this scheme was mandated in the Renewable Energy Act in 2008.
  - In addition, to support the government plan to develop and utilise EGS in the near future, the government may also consider applying the FIT scheme for EGS.
  - While investors have expressed interest in geothermal development, the biggest problem they will encounter is the time required for the conclusion of the permitting

process. Although the DOE has stated that 'one-stop permitting' may not be possible at this point in time, in order to unburden the investors, it provides investors with personnel to assist them in complying with requirements. As recommending the establishment of one-stop permitting may be unrealistic, we would only like to recommend that DOE continue its extensive coordination and cooperation with the institutions and agencies concerned to establish a strong relationship between all agencies.

- **Indonesia**
  - In order to accelerate the development of geothermal electricity in Indonesia, the efforts of the government to address some issues by establishing the new Geothermal Law of 2014 are highly appreciated. Although the power of local government to regulate indirect use of geothermal resources has been revoked, but the local government has maintained the responsibility to regulate direct use of geothermal resources, then harmonising regulations and authorities in terms of prioritising utilization of resources should be regulated.
  - In addition, in order to complete a credible resource assessment of geothermal, it is recommended that the government could consider using independent verification consultants and/or to follow standards for resource certification procedures that have been applied in some economies/countries until an International Standard for Resources Certification is established.
- **New Zealand**
  - New Zealand needs to offer investors and developers financial incentives for geothermal electricity generation (and renewable energy development in general) that fully reflect its environmental benefits relative to fossil-fuel energy. Such incentives are especially critical if New Zealand is to meet its target of producing 90% of its electricity from renewable sources by 2025. Currently, the only incentive offered for renewable energy is the low price on carbon imposed by the New Zealand Emissions Trading Scheme, which does not fully reflect the environmental costs of fossil fuels. If increasing the carbon price is not feasible, we recommend that New Zealand adopt some kind of 'negative tax' or 'top-up' scheme, where renewable energy developers would receive compensation in addition to the market price to promote the development of renewable electricity such as geothermal.
  - New Zealand should also consider reforms to make access to geothermal data easier and more consistent.
- **Mexico**
  - The Mexican Government has recently committed to significant reforms in geothermal energy. These reforms will positively change the government's approach to developing geothermal electricity, and should be implemented in a full-spirited manner. Since the government already has much to implement, we will not provide further recommendations. We do however hope that the government will keep its commitments to investors in the future.
- **Japan**
  - As mentioned earlier, 80% of Japan's geothermal resources exist inside national parks. Without the reformation of regulations that restrict the development of geothermal power plants within national parks (similar to the approach taken by the Indonesian Government), a large part of geothermal potential that is stored in Japanese land cannot be used for the prosperity of the Japanese people. As part of the government's commitment to investors, a win-win solution is required—one that does not harm the environment.

REFERENCES

ADB (Asian Development Bank) and World Bank (2015). *Unlocking Indonesia's Geothermal Potential*, http://www.adb.org/sites/default/files/publication/157824/unlocking-indonesias-geothermal-potential.pdf

Anderson T (2014). *Policy and Regulation of Geothermal Development in New Zealand*, presented at Indonesia International Geothermal Convention and Exhibition (IIGCE) 2014, Jakarta, Indonesia, 5 June 2014

APEC (Asia-Pacific Economic Cooperation) (2014a). *The APEC Leaders' Growth Strategy,* http://www.apec.org/Meeting-Papers/Leaders-Declarations/2010/2010_aelm/growth-strategy.aspx

— (2014b). *2010 APEC Energy Ministerial Meeting. Fukui Declaration-Low Carbon Paths to Energy Security: Cooperative Energy Solutions for a Sustainable APEC*, http://www.apec.org/Meeting-Papers/Ministerial-Statements/Energy/2010_energy.aspx

— (2014c). *2011 Leaders' Declaration. The Honolulu Declaration-Toward a Seamless Regional Economy*, http://www.apec.org/meeting-papers/leaders-declarations/2011/2011_aelm.aspx

— (2014d). *Annex B – Strengthening APEC Energy Security*, http://apec.org/Meeting-Papers/Leaders-Declarations/2012/2012_aelm/2012_aelm_annexB.aspx

— (2014e). *2013 Leaders' Declaration. Bali Declaration-Resilient Asia-Pacific, Engine of Global Growth,* http://apec.org/Meeting-Papers/Leaders-Declarations/2013/2013_aelm.aspx

— (2014f). *2014 Leaders' Declaration. The 22nd APEC Economic Leaders' Declaration – Beijing Agenda for an Integrated, Innovative and Interconnected Asia – Pacific,* http://www.apec.org/Meeting-Papers/Leaders-Declarations/2014/2014_aelm.aspx

APERC (Asian Pacific Energy Research Centre) (2012). *APEC Energy Overview 2011,* http://aperc.ieej.or.jp/file/2012/12/28/Overview2011.pdf

— (2013a). *APEC Energy Overview 2012,* http://aperc.ieej.or.jp/file/2013/6/28/APEC_Energy_Overview_2012.pdf

— (2013b). *APEC Energy Demand and Supply Outlook,* 5th edition, http://aperc.ieej.or.jp/publications/reports/outlook.php

— (2013c). *Final Report Peer Review on Low Carbon Energy Policies in Indonesia,* http://aperc.ieej.or.jp/file/2014/3/6/Final_Report_of_PRLCE_for_Indonesia.pdf

Aragon-Aguilar A, Izquierdo-Montalvo G and Arellano-Gomez V (2013). Security regulations in Mexican renewable energies: case of geothermal projects. *Smart Grid & Renewable Energy, Scientific Research*: 21–31, http://dx.doi.org/10.4236/sgre.2013.46A003

Arvizu D, Bruckner T, Chum H, Edenhofer O, Estefen S, Faaij A, Fischedick M, Hansen G, Hiriart G, Hohmeyer O, Hollands KGT, Huckerby J, Kadner S, Killingtveit Å, Kumar A, Lewis A, Lucon O, Matschoss P, Maurice L, Mirza M, Mitchell C, Moomaw W, Moreira J, Nilsson LJ, Nyboer J, Pichs-Madruga R, Sathaye J, Sawin J, Schaeffer R, Schei T, Schlömer S, Seyboth K, Sims R, Sinden G, Sokona Y, von Stechow C, Steckel J, Verbruggen A, Wiser R, Yamba F and Zwickel T (2011). Technical summary. In *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation.* O Edenhofer, R Pichs-Madruga, Y Sokona, K Seyboth, P Matschoss, S Kadner, T Zwickel, P Eickemeier, GHansen, S Schlömer and C von Stechow (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, https://www.ipcc.ch/pdf/special-reports/srren/SRREN_FD_SPM_final.pdf

Barbose G (2012). *Renewables Portfolio Standards in the United States: A Status Update*, National Summit on RPS, Washington DC, 3 December 2012, http://www.cleanenergystates.org/assets/2012-Files/RPS/RPS-SummitDec2012Barbose.pdf

Battocletti L, Lawrence B and Associates, Inc. (2005). *An Introduction to Geothermal Permitting*, http://www.geothermal-biz.com/Docs/Intro_to_geo_permitting.pdf

Beritasatu.com (2013). *Siapkan Rp 10,541 T, PIP Bidik Investasi Ramah Lingkungan dan Panas Bumi*, http://www.beritasatu.com/industri-perdagangan/102347-siapkan-rp10541-t-pip-bidik-investasi-ramah-lingkungan-dan-panas-bumi.html

BLM (Bureau of Land Management) (2007). *Mineral Leasing Act of 1920 as Amended*, re-transcribed 8 September 2007, http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/legislation.Par.23212.File.dat/mla_1920_amendments1.pdf

— (2014a). *Geothermal Energy*, http://www.blm.gov/wo/st/en/prog/energy/geothermal.html

— (2014b). *New Energy for America*, http://www.blm.gov/wo/st/en/prog/energy.html

Boast RP (1995). Geothermal resources in New Zealand: a legal history. *Canterbury Law Review* 6, http://www.austlii.edu.au//nz/journals/CanterLawRw/1995/1.pdf

BOE (Bureau of Energy) (2013). *Incentives for Geothermal Demonstration Power Systems*, http://web3.moeaboe.gov.tw/ECW/populace/Law/Content.aspx?menu_id=2028

Bona P (Paolo Bona Geothermal Consultant) (2014). *Mexico: Geothermal Financing and Risk Transfer Facility – Proposal for Operation Development*, Independent Technical Review, Report prepared for Inter-American Development Bank, Climate Change and Sustainability Division, Washington, USA, 25 February 2014, https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/IDB_GeothRiskMitigationFacility_RevisionPB_FinalVersion_250214.pdf

BP (2015). *Statistical Review of World Energy June 2015*, https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-full-report.pdf

CCINZ (Climate Change Information New Zealand) (2014a). *Energy's Obligations: Reporting Emissions and Surrendering NZUs*, http://www.climatechange.govt.nz/emissions-trading-scheme/participating/energy/obligations/

— (2014b). *Legislative Changes to the New Zealand Emissions Trading Scheme (NZ ETS)*, http://www.climatechange.govt.nz/emissions-trading-scheme/ets-amendments/

CRE (Comision Reguladora De Energia) (2014). *Historical Development*, http://www.cre.gob.mx/articulo.aspx?id=10

Darma S (2013). Indonesia Renewable Energy Society. *Potential and Challenges in the Indonesian Renewable Energy Development,* presented at APEC Peer Review on Low Carbon Energy Policy (PRLCE), Jakarta, Indonesia, 13 May 2013

Department of Internal Affairs (2014). *About Local Government in New Zealand*, http://www.localcouncils.govt.nz/lgip.nsf/wpg_URL/About-Local-Government-Index?OpenDocument

DG (Directorate of Geothermal) (2013). *Development of Geothermal in Indonesia,* presented at In-house Training on Geothermal, Japan, 28 October 2013

DOE (Department of Energy, United States of America) (2014). *Bureau of Land Management to Established Renewable Energy Offices*, http://www1.eere.energy.gov/solar/sunshot/news_detail.html?news_id=12195

DOE (Department of Energy, Republic of the Philippines) (2014a). *Geothermal*, https://www.doe.gov.ph/renewable-energy-res/geothermal

— (2014b). *Geothermal Renewable Energy (RE) Service Contract*, https://www.doe.gov.ph/microsites/pecr/Geothermal/Model%20Contract.pdf

— (2014c). *Energy Data Center of the Philippines*, http://www2.doe.gov.ph/EDCP/edcp.htm

Dolor FM (2005). *Phases of Geothermal Development in the Philippines*, paper to be presented at Workshop for Decision Makers on Geothermal Projects and Management, organized by UNU-GTP and KengGen, Naivasha, Kenya, 14–18 November 2005, http://www.os.is/gogn/flytja/JHS-Skjol/Kenya%202005/05DolorPhasesDevelPhilippines.pdf

Doris E, Kreycik C and Young K (2009). *Policy Overview and Options for Maximizing the Role of Policy in Geothermal Electricity Development*, Technical Report NREL/TP-6A2-46653, September 2009, http://www.nrel.gov/docs/fy10osti/46653.pdf

EERE (U.S. Office of Energy Efficiency & Renewable Energy) (2014a). *Electricity Generation*, http://energy.gov/eere/geothermal/electricity-generation

— (2014b). *Regulatory and Permitting Information Desktop Toolkit*, http://www.nrel.gov/docs/fy14osti/61183.pdf

EIA (U.S. Energy Information Administration) (2014). *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014*, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

Electricity Authority (2011). *Electricity in New Zealand*, www.ea.govt.nz/dmsdocument/12292

EPA (Environmental Protection Authority) (2013a). *Fact Sheet: Applying to the EPA for a Proposal of National Significance*, http://www.epa.govt.nz/Publications/EPA_Fact_Sheet_Applying_to_the_EPA_for_a_proposal_of_national_significance.pdf

— (2013b). *Fact Sheet: The Roles of Council in Proposals of National Significance,* http://www.epa.govt.nz/Publications/EPA_Fact_Sheet_The_roles_of_council_in_proposals_of_national_significance.pdf

EPA (The United States Environmental Protection Agency) (2014). *Renewable Energy Certificates (RECs)*, http://www.epa.gov/greenpower/gpmarket/rec.htm

ERC (Energy Regulatory Commission) (2001). *Philippine Grid Code*, http://www2.doe.gov.ph/Downloads/Final_Grid_Code.pdf

ESDM (Ministry of Energy and Mineral Resources, Republic of Indonesia) (2011). *Peluang Investasi Sektor ESDM*, http://prokum.esdm.go.id/Publikasi/Buku%20Investasi%20ESDM%20Indonesia%20FINAL-1.pdf

— (2012a). *Profil Potensi Panas Bumi Indonesia*, http://www.esdm.go.id/cari/2012%20geothermal.html

— (2012b). *Kembangkan Panas Bumi, Indonesia Memerlukan 3000 Operator Terlatih dan 1000 Orang Tenaga Ahli*, http://www.esdm.go.id/berita/panas-bumi/45-panasbumi/5780-kembangkan-panas-bumi-indonesia-memerlukan-3000-operator-terlatih-dan-1000-orang-tenaga-ahli.html

— (2013). *Decision of Minister of Energy and Mineral Resources No. 21 year 2013*, http://prokum.esdm.go.id/permen/2013/Permen%20ESDM%2021%202013.pdf

— (2014a). *The Ministerial Regulation No. 17 year 2014*, http://prokum.esdm.go.id/permen/2014/Permen%20ESDM%2017%202014.pdf

— (2014b). Indonesia Energy Outlook 2014. http://www.esdm.go.id/publikasi/indonesia-energy-outlook.html

ESMAT (Energy Sector Management Assistance Program) (2012). *Geothermal Handbook: Planning and Financing Power Generation,* Technical Report 002/12, June 2012, http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/FINAL_Geothermal%20Handbook_TR002-12_Reduced.pdf

FEPC (The Federation of Electric Power Companies of Japan) (2013). *Electricity Review Japan 2013,* http://www.fepc.or.jp/library/pamphlet/pdf/2013ERJ_full.pdf

Fish JR (2009). *Chapter One the Law of Lava, Just Starting Out: Leasing, Siting, and Permitting Geothermal Projects*, Lava Law Legal Issues in Geothermal Energy Development, 2009, http://www.stoel.com/webfiles/LawofLava.pdf

Flores-Armenta MC (2012). *Geothermal Activity and Development in Mexico – Keeping the Production Going*, presented at Short Course on Geothermal Development and Geothermal Wells, organized by UNU-GTP and LaGeo, Santa Tecla, El Salvador, 11–17 March 2012, http://www.os.is/gogn/unu-gtp-sc/UNU-GTP-SC-14-05.pdf

— (2014). *Barriers and Opportunities for Geothermal Development in Mexico*, presented at APERC Annual Conference 2014 and Workshop, Tokyo, Japan, 27 March 2014

Fronda AD (2014). *Barriers and Opportunities for Geothermal Development in the Philippines*, presented at APERC Annual Conference 2014 and Workshop, Tokyo, Japan, 27 March 2014.

Fuchino H (2000). Japan Geothermal Energy Association. *Status of Geothermal Power Generation in Japan,* Proceedings of the World Geothermal Congress 2000, Kyushu – Tohoku, Japan, 28 May–10 June 2000, http://www.geothermal-energy.org/pdf/IGAstandard/WGC/2000/R0871.PDF

GA (Geological Agency) (2012). *Geothermal Area Distribution Map and its Potential in Indonesia,*

— (2014). *Neraca Panas Bumi 2012,* http://psdg.bgl.esdm.go.id/index.php?option=com_content&view=article&id=1027&Itemid=642

GEA (Geothermal Energy Association) (2011). *Geothermal Education and Training Guide*, http://geo-energy.org/reports/2011GEAGeothermalEducationandTrainingGuide.pdf

— (2013a). *2013 Annual US Geothermal Power Production and Development Report*, http://geo-energy.org/pdf/reports/2013AnnualUSGeothermalPowerProductionandDevelopmentReport_Final.pdf

— (2013b). *2013 Geothermal Power: International Market Overview*, http://geo-energy.org/events/2013%20International%20Report%20Final.pdf

Geodynamics (Geodynamics Limited) (2014). *Innamincka (EGS) Project*, http://www.geodynamics.com.au/Our-Projects/Innamincka-Deeps.aspx

GRSJ (The Geothermal Research Society of Japan) (2014). *Geothermal Energy*, http://grsj.gr.jp/en/all.pdf

GTO (Geothermal Technologies Office) (2014a). *What is an Enhanced Geothermal System (EGS)?,* http://energy.gov/sites/prod/files/2014/02/f7/egs_factsheet.pdf

— (2014b). *Why It Matters*, https://www1.eere.energy.gov/geothermal/about.html

GTP (Geothermal Technologies Program) (2011). *Federal Interagency Geothermal Activities*, working draft, updated June 2011, http://www1.eere.energy.gov/geothermal/pdfs/ngap.pdf

Geothermal Institute (2013). http://www.engineering.auckland.ac.nz/en.html

Goldstein B, Hiriart G, Bertani R, Bromley C, Gutierrez-Negrin L, Huenges E, Muraoka H, Ragnarsson A, Tester J and Zui V (2011). Geothermal energy. In *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation.* O Edenhofer, R Pichs-Madruga, Y Sokona, K Seyboth, P Matschoss, S Kadner, T Zwickel, P Eickemeier, G Hansen, S

Schlomer and C von Stechow (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, http://srren.ipcc-wg3.de/report/IPCC_SRREN_Ch04.pdf

Gutierrez-Negrin LCA, Maya-Gonzalez R and Quijano-Leon JL (2010). *Current Status of Geothermics in Mexico*, Proceedings World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010, http://217.174.128.43/web_data/iga_db/Mexico.pdf

— (2015). *Present Situation and Perspective of Geothermal in Mexico*, Proceedings World Geothermal Congress 2015, Melbourne, Australia, 19–25 April 2015, https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/01002.pdf

Hall SC, Wood M and Martin JH (2009). *Chapter Seven the Law of Lava, Delivering the Goods: Regulatory and Transmission-Related Issues*, Lava Law Legal Issues in Geothermal Energy Development, 2009, http://www.stoel.com/webfiles/LawofLava.pdf

Harahap RC (2014). *Geothermal in Indonesia*, International Geothermal Conference: Geothermal Energy and Technology Development for the Last 10 years and the Next 10 years, Tokyo, Japan, 14 October 2014

Haraldsson IG (2012). *Legal and Regulatory Framework – Barrier or Motivation for Geothermal Development?*, presented at Short Course on Geothermal Development and Geothermal Wells, UNU-GTP and LaGeo, Santa Tecla, El Salvador, 11–17 March 2012, http://www.os.is/gogn/unu-gtp-sc/UNU-GTP-SC-14-17.pdf

Harvey C and White B (2012). *A Country Update of New Zealand Geothermal: Leading the World in Generation Growth Since 2005*, New Zealand Geothermal Association, 2012, http://www.nzgeothermal.org.nz/Publications/Industry_papers/A-Country-Update-of-NewZealand-2012.pdf

Haryo T (2014). *Overlooked Challenges in Indonesian Geothermal Development,* presented at Indonesia International Geothermal Convention and Exhibition (IIGCE) 2014, Jakarta, Indonesia, 5 June 2014

Holmes WH, Jones KE and Martin JH (2009). *Chapter Three the Law of Lava, Signing Up: Power Purchase Agreements and Environmental Attributes*, Lava Law Legal Issues in Geothermal Energy Development, 2009, http://www.stoel.com/webfiles/LawofLava.pdf

IRENA (International Renewable Energy Agency) (2013). *Promoting the Enabling Environment for Geothermal Development in the Andean Countries: Legal and Regulatory Frameworks: A Summary and Way Forward,* workshop report, November 2013, http://www.irena.org/documentdownloads/events/2013/november/olade/summary.pdf

ITB (Bandung Institute of Technology) (2014). *Magister Program in Geothermal Technology,* http://geothermal.itb.ac.id/students-0

IEA (International Energy Agency) (2011). *Technology Roadmap – Geothermal Heat and Power*, http://www.iea.org/publications/freepublications/publication/Geothermal_Roadmap.pdf

— (2012). *Geothermal Energy, Annual Report 2010.* International Energy Agency Implementing Agreement for Cooperation in Geothermal Research & Technology, 2012, http://www.iea.org/files/ann_rep_sec/geo2010.pdf

IEA-GIA (International Energy Agency-Geothermal Implementing Agreement) (2012). *Trends in Geothermal Applications, Survey Report on Geothermal Utilization and Development in IEA-GIA Member Countries in 2010, Annex X: Data Collection and Information, 2012*, http://iea-gia.org/wp-content/uploads/2012/08/GIA_TrendsGeotermalApplications-2010_Vs2_1-Ganz-29Aug121.pdf

IGA (International Geothermal Association) (2013). *Geothermal Exploration Best Practices: A Guide to Resource Data Collection, Analysis, and Presentation for Geothermal Projects*, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/06/06/000445729_20130606150939/Rendered/PDF/782280WP0IFC0I0Box0377330B00PUBLIC0.pdf

Japan Revitalization Strategy (2013). *Japan Revitalization Strategy – Japan is Back*, http://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/en_saikou_jpn_hon.pdf

JFS (Japan For Sustainability) (2009). *Current Status and Future Prospects of Geothermal Energy Use in Japan*, JFS Newsletter No. 88, 2009, http://www.japanfs.org/en/news/archives/news_id029640.html

JOGMEC (Japan Oil, Gas and Metals National Corporation) (2013). *Geothermal Energy Developments in JOGMEC*, presented at In-House Training on Geothermal, Tokyo, 31 October 2013.

Jones RS and Kim M (2013). *Restructuring the Electricity Sector and Promoting Green Growth in Japan*, OECD Economics Department Working Papers, No. 1069, OECD Publishing, http://www.oecd-ilibrary.org/docserver/download/5k43nxrhfjtd.pdf?expires=1393914200&id=id&accname=guest&checksum=833B630EE86B4CD2E26964B3BDA8D800

Kaga Y (2013). Ministry of Economy, Trade and Industry. *Overview of Policy on Geothermal Development*, presented at In-House Training on Geothermal, Tokyo, 28 October 2013.

Kawazoe S and Combs J (2004). *Geothermal Japan, History and Status of Geothermal Power Development and Production*, GRC Bulletin, 2004, http://u16259443.onlinehome-server.com/PDFs/Articles/GeoJapan.pdf,

Seiki Kawazoe and Noriyuki Shirakura (2005). *Geothermal Power Generation and Direct Use in Japan*, Proceedings World Geothermal Congress, Antalya, Turkey, 24-29 April 2005, p.6,

Kimura O (2009). Central Research Institute of Electric Power Industry. *The National Program for Development of Energy Technologies*, http://criepi.denken.or.jp/en/serc/research_re/download/09007dp.pdf

KPMG (2014). *World Geothermal Market & Outlook – An Insight into KPMG's Report on the International Geothermal Energy Sector*, https://www.kpmg.com/IS/is/utgefidefni/greinar-og-utgefid/Documents/KPMG_WorldGeothermalMarketandOutlook_oct2010.pdf

Lawless JV (2002). *New Zealand's Geothermal Resource Revisited*, New Zealand Geothermal Association Annual Seminar, Taupo, New Zealand

Lawless J (2014a). Interview with the Author, 28 March 2014

— (2014b). *Business Models for Successful Geothermal Electricity Development*, presented at APERC Annual Conference 2014, 27 March 2014

— (2015). Interview with the Author, 27 April 2015

Levine A, Young KR and Witherbee K (2013). *Coordinating Permit Offices and the Development of Utility-Scale Geothermal Energy*, 2013 Geothermal Resources Council Annual Meeting, Las Vegas, Nevada, 1 October 2013, http://www.nrel.gov/docs/fy14osti/60276.pdf

Liu C-H (2015). Interview with the Author, 4 May 2015

Lund JW (2007). *Characteristic, Development and Utilization of Geothermal Resources*, GHC Bulletin, 2007, http://geoheat.oit.edu/pdf/tp126.pdf

Lund JW and Bloomquist RG (2012). *Development of Geothermal Policy in the United States: What Works and What Doesn't Work*, GHC Bulletin, 2012, http://geoheat.oit.edu/bulletin/bull30-4/art1.pdf

Matek B (2014). *The Manageable Risks of Conventional Hydrothermal Geothermal Power System: A Factbook on Geothermal Power's Risks and Methods to Mitigate Them*, Geothermal Energy Association, 2014, http://geo-energy.org/reports/Geothermal%20Risks_Publication_2_4_2014.pdf

Matek B and Schmidt B (2013). *The Values of Geothermal Energy: A Discussion of the Benefits Geothermal Power Provides to the Future U.S. Power System*, Geothermal Resources Council and Geothermal Energy Association, 2013, http://www.geothermal.org/PDFs/Values_of_Geothermal_Energy.pdf

Maya-Gonzalez R and Gutierrez-Negrin LCA (2012). *Mexico Country Report 2012*, IEA Geothermal Implementing Agreement, http://iea-gia.org/wp-content/uploads/2013/10/2012-Mexico-Country-Report-IEA-GIA-iwth-cover-Photo-16Oct13-pdf.pdf

MBIE (Ministry of Business, Innovation and Employment) (2013). *Energy in New Zealand 2013,* http://www.med.govt.nz/sectors-industries/energy/energy-modelling/publications/energy-in-new-zealand-2013

— (2014). *Background of Geothermal Energy in New Zealand*, http://www.med.govt.nz/sectors-industries/natural-resources/geothermal/background-of-geothermal-energy-in-new-zealand

MED (Ministry of Economic Development) (2010). *Geothermal Energy: Summary of Emerging Technologies and Barriers to Development*, http://www.med.govt.nz/sectors-industries/natural-resources/pdf-docs-library/geothermal/geothermalbarriersupdate1-pdf

— (2011). *New Zealand Energy Strategy 2011-2016,* http://www.med.govt.nz/sectors-industries/energy/pdf-docs-library/energy-strategies/nz-energy-strategy-lr.pdf

METI (The Ministry of Economic, Trade and Industry) (2012), *Feed-in-Tariff Scheme in Japan*, http://www.meti.go.jp/english/policy/energy_environment/renewable/pdf/summary201207.pdf

— (2014). *Geothermal Power Generation*, http://www.meti.go.jp/english/policy/energy_environment/renewable/ref1012.html

MfE (Ministry for the Environment) (2009). *Overview of the Resource Management (Simplifying and Streamlining) Amendment Act 2009*, www.mfe.govt.nz/rma/central/amendments/resource-management-simplify-and-streamline-amendment-bill-2009/overview-rma-2009.html

— (2013a). *Improving Our Resource Management System, February 2013,* http://www.mfe.govt.nz/publications/rma/improving-our-resource-management-system-discussion-document.pdf

— (2013b). *Resource Management Act->Fact Sheet: 6 Month Processing of Notified Consent Applications*, http://www.mfe.govt.nz/publications/rma/rma-amendment-act-factsheets-2013/factsheet-3.pdf

— (2014). *Applying for a Resource Consent*, http://www.mfe.govt.nz/publications/rma/everyday/consent-apply/index.html

MFAT (Ministry for Foreign Affairs and Trade) (2015). *New Zealand Aid Program - Indonesia*, https://www.aid.govt.nz/where-we-work/asia/indonesia

Mizuno E (2013). Geothermal power development in New Zealand - lessons for Japan, *Japan Renewable Energy Foundation Research Report*, *2013*, http://jref.or.jp/en/activities/reports_20120914.php

MoE (Ministry of the Environment) (2014). *Environmental Impact Assessment in Japan*, https://www.env.go.jp/en/policy/assess/pamph.pdf

MoF (Ministry of Finance, Republic of Indonesia) (2014). *Innovative Fiscal Policies to Create Energy Resilience – Focusing on Geothermal*, presented at Indonesia International Geothermal Convention and Exhibition (IIGCE) 2014, Jakarta, Indonesia, 4 June 2014

Nakagawa M (2014). *Opportunities for Geothermal Development Created by New Technologies*, Presented at APERC Annual Conference 2014, 27 March 2014

Nathwani J and Young K (2013). *Geothermal Regulatory Roadmap*, Geothermal Technologies Office 2013 Peer Review, 22 April 2013, http://www1.eere.energy.gov/geothermal/pdfs/grr_peer2013.pdf

Newson JA, O'Sullivan MJ and Zarrouk SJ (2010). *Postgraduate Geothermal Training in New Zealand*, Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010, http://www.geothermal-energy.org/pdf/IGAstandard/WGC/2010/0904.pdf

Nexant, Inc. (2001). *Handbook on Environmental Permitting Issues – Project Development – Mexican Electric Sector*, USAID, 2001, http://pdf.usaid.gov/pdf_docs/Pnacq577.pdf

NGAP (National Geothermal Association of the Philippines) (2014). *Geothermal Energy*, https://drive.google.com/viewerng/viewer?a=v&pid=sites&srcid=bmdhcGhpbC5vcmd8d3d3fGd4OjJjZjRmZTc4YzFiYTk2YjE

NGDS (A National Geothermal Data System) (2014). *About NGDS and Who Contributes Data to NGDS?,* http://geothermaldata.org/ngds/about

NREL (National Renewable Energy Laboratory) (2011). *Policymakers' Guidebook for Geothermal Electricity Generation*, http://www.nrel.gov/docs/fy11osti/49476.pdf

NZGA (New Zealand Geothermal Association) (2010). Submission on the MED Paper on Geothermal Energy and Barriers, 21 April 2010, http://www.nzgeothermal.org.nz/Publications/Submission-on-MED-Geothermal-Paper-100421.pdf

— (2012). *Geothermal Energy: New Zealand's Most Reliable Sustainable Energy Resource,* http://www.nzgeothermal.org.nz/Publications/Submissions/2012-NZGA-Position-Statement-draft6.pdf

— (2014a). *Regulatory Environment*, http://www.nzgeothermal.org.nz/regulatory_environment.html

— (2014b). *Geothermal Systems*, http://www.nzgeothermal.org.nz/geo_systems.html.

OEERE (Office of Energy Efficiency and Renewable Energy) (2011). *Geothermal Technologies Program, Blue Ribbon Panel Recommendations*, http://www1.eere.energy.gov/geothermal/pdfs/brp_draft_report_june_17_2011.pdf

Ogena MS and Fronda A (2013). *Prolonged Geothermal Generation and Opportunity in the Philippines*, Geothermal Resources Council 2013 Annual Meeting, Las Vegas, Nevada, 30 September 2013

Ogena MS, Sta Maria RB, Stark MA, Oca RAV, Reyes AN, Fronda AD and Bayon FEB (2010). *Philippine Country Update: 2005-2010 Geothermal Energy Development*, Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010, http://217.174.128.43/web_data/iga_db/Philippine.pdf

Okinawa (Okinawa Prefecture) (2014). *Hot Spring Act,* http://www.pref.okinawa.jp/site/kankyo/shizenryokuka/koen/documents/8_riyou.pdf

O'Shaughnessy, Brett W., "Use of Economic Instruments in Management of Rotorua Geothermal Field, New Zealand", *Geothermics*, volume 29, 2000, pp. 539-555

Ouyang S (2013). *Geothermal Status and Prospectus of Chinese Taipei,* http://www.egnret.ewg.apec.org/workshops/GeothermalEnergy/05.Ouyang_Chines e%20Taipei%20Geothermal%20Status%20and%20Perspectives_20130625_final_sv_M.pdf

Penarroyo FS (2010). *Renewable Energy Act of 2008: Legal and Fiscal Implications to Philippine Geothermal Exploration and Development*, World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010, http://www.geothermal-energy.org/pdf/IGAstandard/WGC/2010/0305.pdf

Poernomo A, Satar S, Effendi P, Kusuma A, Azimudin T and Sudarwo S (2015). An overview of Indonesia geothermal development – current status and its challenges. *Proceedings of the World Geothermal Congress 2015*, Melbourne, Australia, 19-25 April 2015, https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/08025.pdf

PwC (PricewaterhouseCoopers Indonesia) (2012). *Oil and Gas in Indonesia, Investment and Taxation Guide,* 5th edition updated for GR 79/2010 and its implementing regulation*,* http://www.pwc.com/id/en/publications/assets/oil-and-gas-guide_2012.pdf

Quijano-Leon JL and Gutierrez-Negrin LCA (2003). *Mexican Geothermal Development: An Unfinished Journey – 30 Years of Geothermal-Electric Generation in Mexico,* GRC Bulletin*,* 2003, http://www.geothermal.org/PDFs/Articles/30yearsmexico.pdf, pp. 198-199

Ripinsky S and Williams K (2008). *Case Note Karaha Bodas and Himpurna Arbitrations,* http://www.biicl.org/files/3931_2000_himpurna_and_karaha_bodas_arbitrations.pdf

Salvania NV (1995). *Development of a Geothermal Database and Resource Assessment of MT. Natib Geothermal Prospect, Philippines*, Geothermal Training Programme, UNU, Orkustofnun, Iceland, 1995, http://www.os.is/gogn/unu-gtp-report/UNU-GTP-1995-10.pdf

SENER (Secretaria De Energia) (2013). *Initiative for the Development of Geothermal Energy in Mexico,* http://www.energia.gob.mx/res/0/Geothermal_01.pdf

— (2014a). *Fund for the Transition Energy and Sustainable Use of Energy (FOTEASE),* http://www.sener.gob.mx/portal/Default.aspx?id=2930

— (2014b). *Window of Renewable Energy (VER),* http://www.sener.gob.mx/portal/Default.aspx?id=2931

— (2014c). *National Inventory of Renewable Energy (INER),* http://www.sener.gob.mx/portal/Default.aspx?id=2923

Sukarna D (2012). Secretary of Directorate General of New Renewable Energy and Energy Conservation. *Development of Geothermal Policies, Potential Resources and Implementation Target,* presented at Indo EBTKE Conference and Exhibition, Jakarta, Indonesia, 18 July 2012, http://energy-indonesia.com/03dge/07.pdf

Suryantoro S, Dwipa S, Arianti R and Darma S (2005). *Geothermal Deregulation and Energy Policy in Indonesia*, Proceedings of the World Geothermal Congress 2005, Antalya, Turkey, 24-29 April 2005, http://www.geothermalenergy.org/pdf/IGAstandard/WGC/2005/0310.pdf

Taiwan News (2014). *Taiwan, U.S. Sign MOU on Green Energy Collaboration*, http://www.taiwannews.com.tw/etn/news_content.php?id=2204797

The Treasury (2014). *Mighty River Power Initial Public Offering*, http://www.treasury.govt.nz/publications/abouttreasury/annualreport/12-13/096.htm

The White House (2013). *The President's Climate Action Plan, Executive Office of the President*, http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

Thinkgeoenergy (2013). Mexico creates center for geothermal energy innovation (CeMIE-Geo), *Think Geoenergy*, 5 December 2013, http://thinkgeoenergy.com/archives/17380

TINZ (Transparency International New Zealand) (2014). *Corruption Perceptions Index*, http://www.transparency.org.nz/Corruption-Perceptions-Index

Tong L-T, Ouyang S, Guo T-R, Lee C-R, Hu K-H, Lee C-L and Wang C-J (2008). Insight into the geothermal structure in Chungshui, Ilan, Taiwan. *Terr. Atmos. Ocean. Sci.* 19(4):413–424, http://tao.cgu.org.tw/pdf/v194p413.pdf

Torres Q (2012). *Primer on the Philippine Minerals Industry*, http://www.bakermckenzie.com/files/Publication/d7097b64-8763-4e60-99df-528114387eb9/Presentation/PublicationAttachment/43680602-296e-4252-9693-54a47f5bf1c9/bk_manila_primermineralsindustry_2012.pdf

Toshiaki Nagata (2012). International Affairs Office, Energy Conservation and Renewable Energy Department, Agency for Natural Resources and Energy. *Overview of Policy on Geothermal Energy*, presented at World Geothermal Energy Summit, Manila, 12-13 December 2012

UI (Indonesia University) (2012). *Master Program in Geothermal Exploration – Brochure* 2012

Vann A (2012). *Energy Projects on Federal Lands: Leasing and Authorization, Congressional Research Service*, http://www.fas.org/sgp/crs/misc/R40806.pdf

White B, Grant M and Lumb T (1995). *New Zealand Geothermal Resource Ownership—Cultural and Hstorical Perspective*, presented at the World Geothermal Congress, 1995, http://www.geothermal-energy.org/pdf/IGAstandard/WGC/1995/1-white.pdf

World Bank, 2013. "Doing Business—Rankings" web page, http://www.doingbusiness.org/rankings

—(2015). *Doing Business—Rankings*, https://openknowledge.worldbank.org/bitstream/handle/10986/20483/DB15-Full-Report.pdf?sequence=1

Worldview (2012). *Geothermal Opportunities in Japan,* Worldview Report, 2012, http://www.nzgeothermal.org.nz/Publications/Industry_papers/Geothermal-Opportunities-in-Japan.pdf

WWF-Indonesia (World Wide Fund) (2012). *Igniting the Ring of Fire: A Vision for Developing Indonesia's Geothermal Power,* Report, 2012, http://awsassets.wwf.or.id/downloads/geothermal_report.pdf

Yamaguchi F and Kawazoe S (2014). Japan Geothermal Energy Association. *Process of Geothermal Energy Development in Japan*, http://www.geothermal-energy.org/pdf/IGAstandard/WGC/1995/1-yamaguchi2.pdf

Yanagisawa N (2011). *Geothermal Development Status in Japan*, Geothermal Research Symposium, Colorado School of Mines, 23–24 May 2011, http://www.pir.sa.gov.au/__data/assets/pdf_file/0007/156580/Yanagisawa-CSM-revised2.pdf

Yasukawa K (2014). National Institute of Advanced Industrial Science and Technology, Japan. *Geothermal Development Activities in Japan after the Big Earthquake in 2011*, http://www.geothermalconference.is/files/fyrirlestrar/130315_Iceland%20-%20Dr.%20Kasumi%20Yasukawa%20-%20updated.pdf