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Indonesia's Geothermal Development Compare to World Top Geothermal Producers

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ABSTRACT

The installed capacity of geothermal power plant in Indonesia has reached 2,133 MWe and become the second to the USA in the world. Government of Indonesia through RUEN (Rencana Umum Energi Nasional) set target for 7,214 MWe geothermal plant installed capacity in 2025 to ensure that Indonesia's energy mix will be more independent from the volatile fossil fuel price. With the current rate, it will be a challenge for geothermal stakeholders to achieve this target. If looked back to the first installed capacity in 1983, the rate of development is very slow. If it is compared to the developed country, such as Turkey and Kenya, the rate is still low. Turkey in particular installs around 1,000 MWe in 10 years. This paper reviewed the energy mix and market of the top 5 geothermal countries, their typical geothermal system, current development strategy, and their roadmaps for development. The challenges for each country geothermal energy development was also discussed. Kenya and Turkey geothermal energy development are also discussed even though they are not in the top 5. To conclude, this study discussed what other countries do differently with Indonesia regarding the policy or technology, and what can Indonesia learns from them in order to accelerate and increase the geothermal energy portion in its energy mix.

1. INTRODUCTION

The geological setting of Indonesia makes Indonesia has the largest geothermal Indonesia. Badan Geologi (2019) stated that total geothermal potential in Indonesia is 25.39 GW (Figure 1). But unfortunately, if we compare to the other geothermal producers in the world, the utilization is only 7.6% of its potential (Figure 2). 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

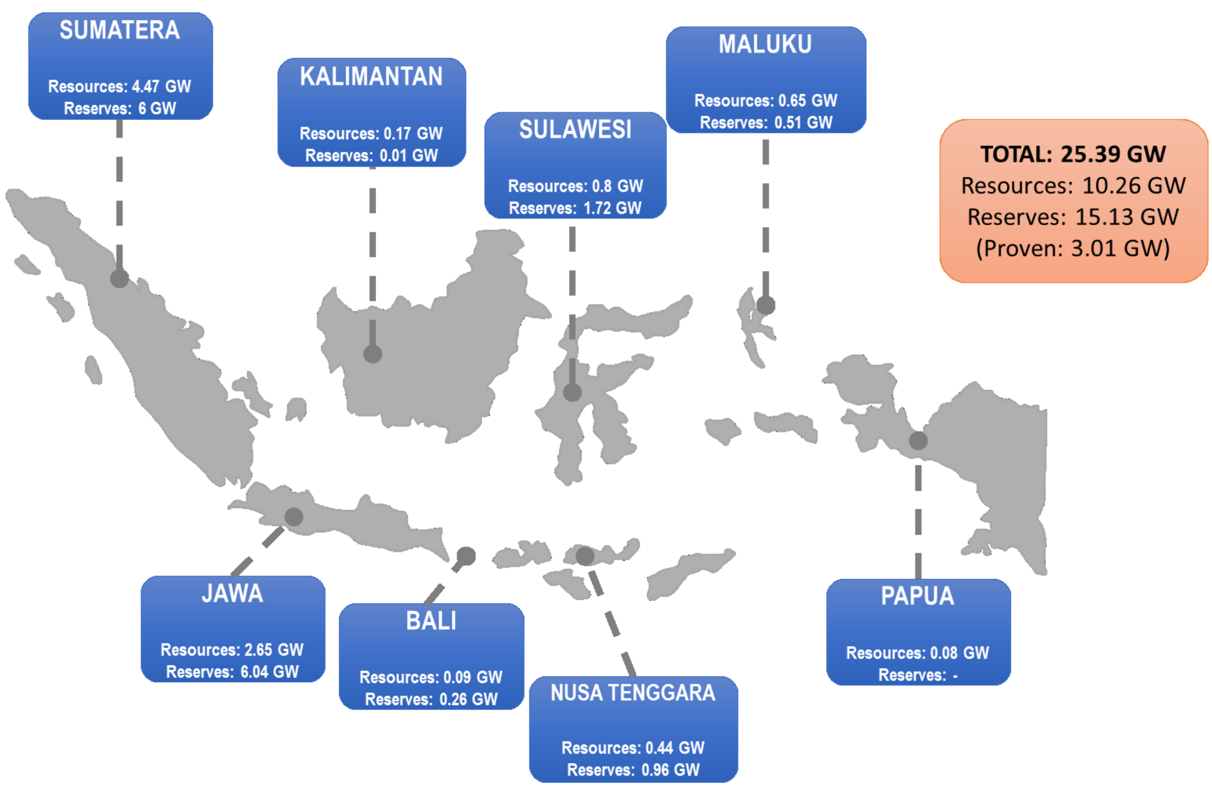

Figure 1 Geothermal Potential of Indonesia (Badan Geologi in Primana, 2019)

in 1983. 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. And in 2019, Indonesia successfully added its capacity to 2,133 MW, making it the second largest installed geothermal capacity in the world with five years rate since first installation was 6 MW/ year. And currently the rate of geothermal installed capacity is 56 MW/year. (Figure 3). This success stemmed largely from government efforts to continuously improve several factors in order to create an environment conducive to wide private sector participation. But it needs more comprehensive study to meet Indonesia's geothermal future target in 2025, that is 7,200 MW installed capacity.

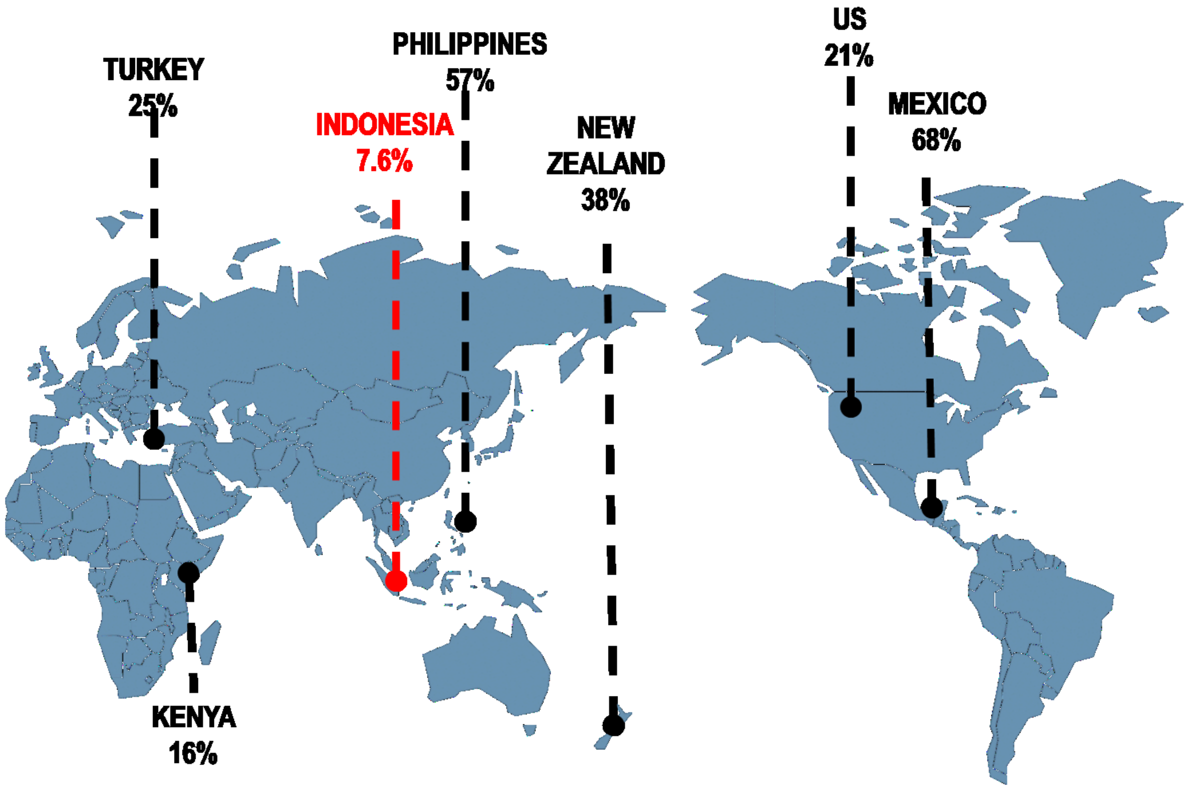

Figure 2 The Utilization of Geothermal in The World

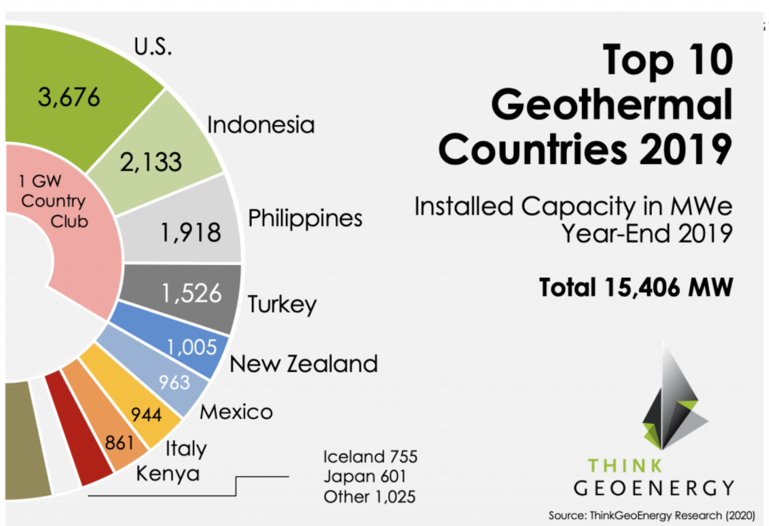

Figure 3 Installed Capacity of Geothermal Countries (ThinkGeoEnergy Research, 2020)

This study will identify the factors that effect the rate of geothermal in top geothermal producers in the world. So, it can be a recommendation for better geothermal future in Indonesia. We must know first, in simplified load curves of electricity (Figure 4), geothermal is a base load energy, and cannot be compared directly with other energy, such as coal or fuel.

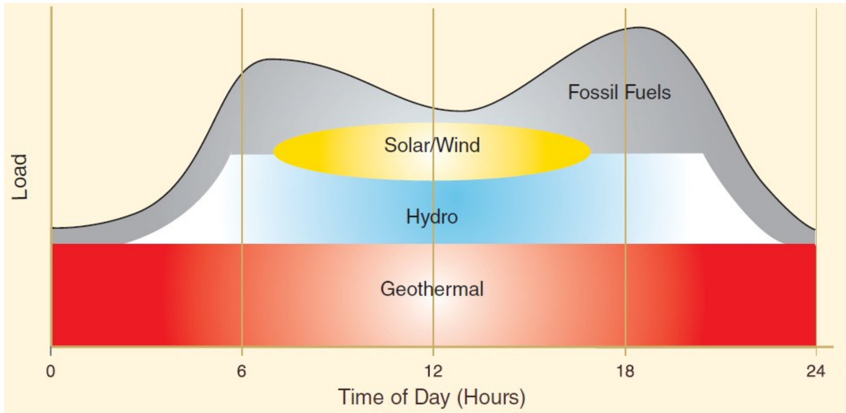

Figure 4 Simplified Load Curve with Typical Fuel Sources (Gehringer and Lokhsa, 2012)

2. IDENTIFYING THE NEEDS OF GEOTHERMAL STAKEHOLDERS IN INDONESIA

Figure 5 shows the key elements of successful energy development (ESMAP, 2013). Information, institutions, policies, and finance take control directly to the outcome of geothermal development project or program. The stakeholders of geothermal could be government, investors, and the social community. From an investor's point of view, the strength of each factors works to increase the expected return or reduce risk. From the government's standpoint, these factors may determine the level of investment in the geothermal energy or, indeed, whether or not such investments will happen at all. From the social community's perspective, geothermal will open a lot of job opportunity or impact to economic growth in the prospect area.

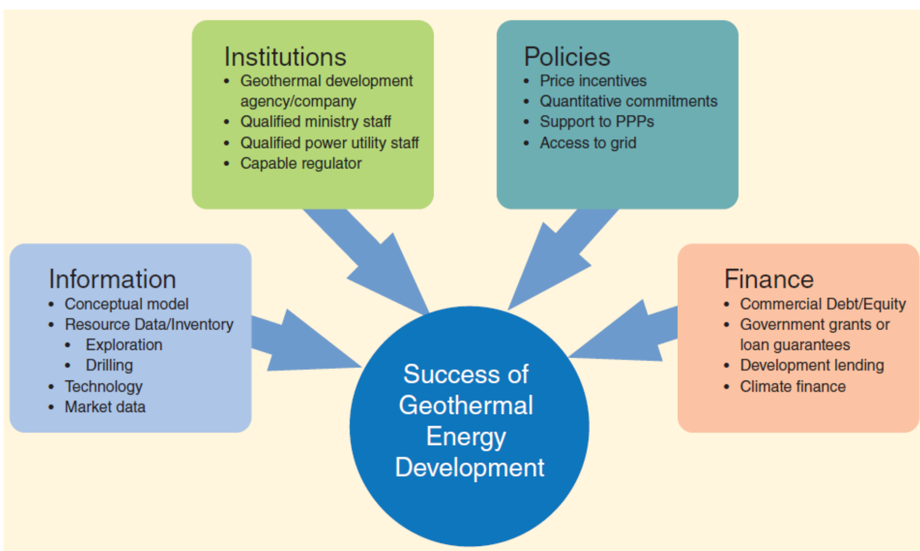

Figure 5 Key Elements of Successful Geothermal Energy Development

This study was started from reviewing literature and workshop/ seminar so the needs of geothermal stakeholders could be identified. The ESMAP key elements of successful energy development will be the base of the base key factors and sub key factors. Then these factors be identified for each country to find the success factors and barriers to meet the goal of this study (Figure 6).

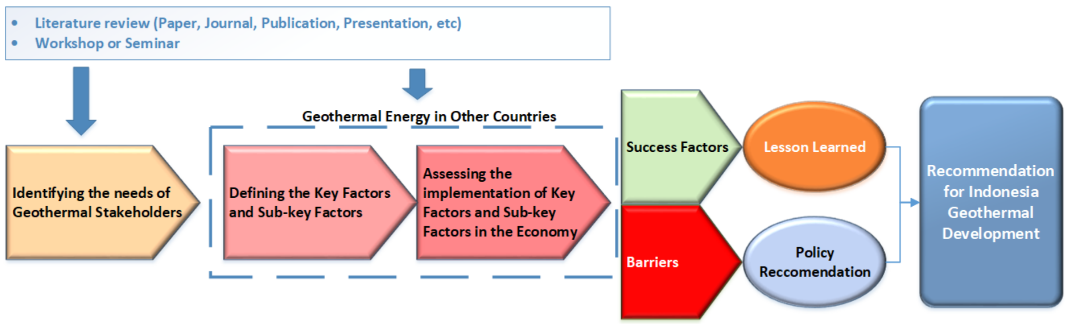

Figure 6 Methodology of study

3. COMPARISON ON OTHER TOP GEOTHERMAL PRODUCERS

To compare several aspects in geothermal development in various countries, the following aspects are reviewed and summarized:

1. Basic situation, including typical geological setting, geothermal system, development history, and current installed geothermal capacity (Table 1).
2. Energy mix and electricity market (Table 1),
3. Information (Table 2),
4. Institutions (Table 2),
5. Policies (Table 2),
6. Finance (Table 2), and
7. Technical (Table 2).

Table 1. Comparison table summary for several geothermal producer countries.

Comparison Items	Indonesia	US	New Zealand	Philippines	Turkey	Kenya	Mexico
Basic Situation							
Typical Geological Setting	Active Margin	Active Extensive Margin/Transform	Active Margin	Active Margin	Active Margin	Active Extensive Margin	Transform Plate Boundaries
Typical Geothermal System	High-relief Terrain	Fault Controlled System	Low-relief Terrain	High Terrain	Low Medium Enthalpy	Low- High Enthalpy	Fault Controlled
Development History	Since 1983	Since 1960	Since 1958	Since 1986	Since 1984	Since 1981	Since 1973
Energy Mix and Electricity Market							
Installed Capacity (2018)	2113 MW	3676 MW	1005 MW	1918 MW	1526 MW	861 MW	963 MW
5 Years Rate Since 1st Geothermal Plant Installation	6 MW/year	4 MW/year	38 MW/year	109 MW/year	3 MW/year	9 MW/year	15 MW/year
Installation Rate per Year	56 MW/year	62 MW/year	17 MW/year	46 MW/year	63.2 MW/year	30.2 MW/year	20.7 MW/year
Electricity Price	7.36	4.2	6.6	19	13.2	8.5	2.07
Electricity Market Type	Single Buyer	Free Market	Free Market	Free Market	Free Market	Free Market	Single Buyer
Geothermal Percentage in Energy Mix	4%	0.48%	17%	10%	0.40%	47%	1.60%

3.1 Basic Situation

3.1.1 United States

United States is located on active extensive margin (most of it is transform) geological setting with fault controlled geothermal system. The first utilization of geothermal energy in US was started from 1960 (Yellowstone). The 5 years rate since its first installation was only 4 MW/year, but now the mean installation rate is 62 MW/year. And currently, US is the largest installed capacity in the world (3676 MW, 2020).

3.1.2 New Zealand

New Zealand is located on active margin geological setting with low terrain geothermal system. The first utilization of geothermal energy in New Zealand was started from 1958. The 5 years rate since its first installation was very rapid (38 MW/year), but now the mean installation rate is only 17 MW/year. And currently, New Zealand geothermal installed capacity is 1,005 MW (2020).

3.1.3 Philippines

Philippines is located on active margin (most of it is subduction) geological setting with high terrain geothermal system. The first utilization of geothermal energy in Philippines was started from 1986. The 5 years rate since its first installation was 109 MW/year, but now the mean installation rate is 46 MW/year. And currently, Philippines is the third largest installed capacity in the world (1,918 MW, 2020).

3.1.4 Mexico

Mexico is located on active extensive margin (most of it is transform) geological setting with fault controlled geothermal system. The first utilization of geothermal energy in Mexico was started from 1973. The 5 years rate since its first installation was 15 MW/year, but now the mean installation rate is 20.7 MW/year. And currently, US is the largest installed capacity in the world (963 MW, 2020).

3.1.5 Turkey

Turkey is located on active margin geological setting with low – medium enthalpy geothermal system. The first utilization of geothermal energy in Turkey was started from 1984. The 5 years rate since its first installation was only 3 MW/year, but now the mean installation rate is 63.2 MW/year. And currently, Turkey installed capacity is 1,526 MW (2020).

3.1.6 Kenya

Kenya is located on active extensive margin (most of it is extensive rift) geological setting with low – high enthalpy geothermal system. The first utilization of geothermal energy in US was started from 1981 (Olkaria). The 5 years rate since its first installation was only 9 MW/year, but now the mean installation rate is 30.2 MW/year. And currently, Kenya installed capacity is 861 MW (2020).

3.2 Energy Mix and Electricity Market

From the data in Figure 7 and Figure 8 could be seen that energy price did not have big impact to the energy mix percentage and installed capacity rate in other top geothermal producers.

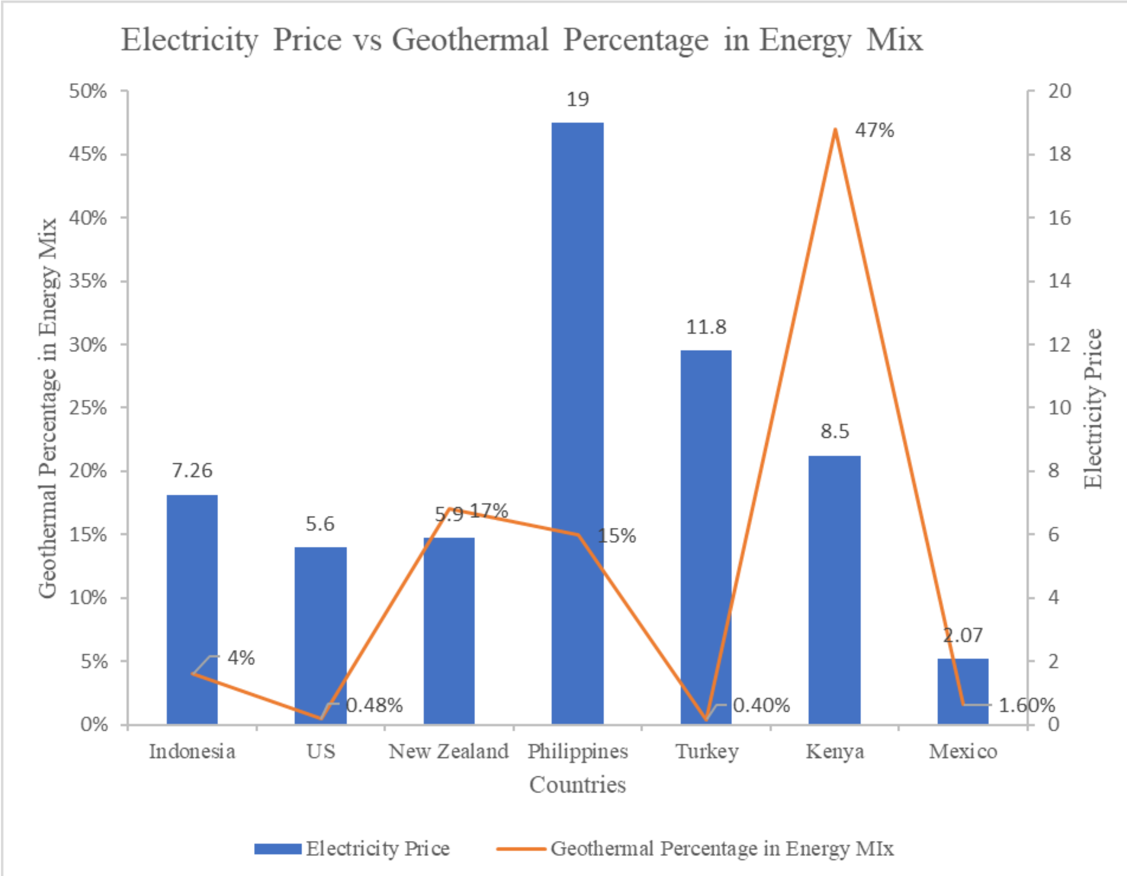

Figure 7 Electricity Price vs Geothermal Percentage in Energy Mix

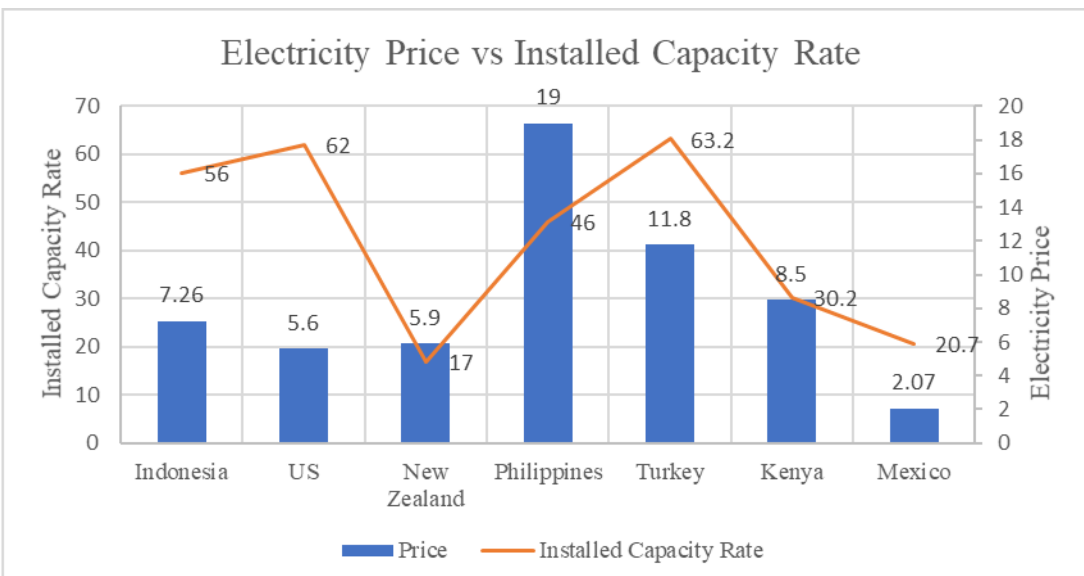

Figure 8 Electricity Price vs Installed Capacity Rate

3.3 Information Access

Information is the first key element that supports the development of a geothermal project or program. The country government has an important role to play in making geothermal resource information available to potential developers and investors (ESMAP, 2013). The government should keep public records on such geothermal attributes as geoscience data (surface geological features, fractures, etc.) and deep drilling data (temperature, pressure, faults, permeability). A reliable conceptual model of the entire underlying geothermal system (or, at a minimum, the field or reservoir under development) has to be built by the government. Information on groundwater resources is also essential, since groundwater should not be contaminated with geothermal reservoir fluids and is a potential source of cooling water for the power plants, drillings, among other uses.

3.4 Institutions

Most of countries which have geothermal energy have geothermal institution. But only a few are serious into it. A clear institutional framework for geothermal policy and regulation in a country is highly favored by developers and investor. It is getting more complicated as in some countries, geothermal resources are located in national parks / conservational forest and/or cultural land, thus any activity will require permit from various institution (e.g. central government, local government, environmental agency, land agency, electricity regulator, etc.). If each of these institutions have their own administrative rules and permitting requirement that overlap with other institutions, or worse, contradict with others, this will deter the investors or developers. However, APEC report stated that a dedicated institution for geothermal development is not enough, as the more important parameters is the ability and capacity of the institutional framework itself to coordinate other stakeholders and institutions.

3.5 Policies

The existence of supportive policies for attracting private investors. This is especially true if the country decides to move beyond a project-by-project approach to one that creates the right environment for investments in a scaled-up, nationwide effort to deploy geothermal power.

3.6 Finance

It was a tricky thing. Through this item we could see how serious of governments towards the renewable energy. Scaling up geothermal power development requires active participation by both the public and private sector. Reliance solely on commercial capital for geothermal development is rarely viable even in developed country markets. In developing countries, where the challenges involved in attracting private capital to geothermal projects are often greater, the commitment of the public sector—including the country government, international donors, and financial institutions—is an essential element of success in mobilizing capital.

3.7 Technical

The last thing to consider for the comparation item of geothermal development is technical aspects. Those technical issue including the preparation and readiness of a country in the procurement of transmission network grid, manufacturing and using of local products for the power plants, etc.

4. ASSESSING THE INFORMATION, INSTITUTIONS, POLICIES, AND FINANCE ASPECTS

For easier evaluation of the information, institutions, policies, and finance aspects, a scorecard method (Figure 9) based on developer expectations and needs are compared with current government policies for geothermal development for each countries (APERC 2015, Gehringer and Loksha 2012). Scale 3 (green) indicates that the current policy meets the expectations of developers in most respects, scale 2 (yellow) indicates that the current policy meets developers' expectations in some respects, while scale 1 (red) indicates that there are a lot of improvements has to be made in current policy to meet investor and developer expectations. **Error! Reference source not found.** summarizes the policy evaluation result of the several geothermal producer countries policy.

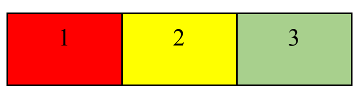

Figure 9. Scorecard bar chart to evaluate current government policies with developer needs.

From the Table 2, it can be seen that Indonesia is performed relatively well in terms of some of information, policies, finance, and technical aspects, although it is still far from all stakeholders' expectations. However, Indonesia really lacking in aiding investors or developers to obtain permits, time-wise and also procedure-wise. Indonesia is still failed to provide well-organized of geothermal database. From the institution's aspects, the research and development, and human resources development are still lacked. Government is still limited to gain the human capital in geothermal industry. Those can be seen by the lack of numbers of geothermal specialist in Indonesia who have license or capability to work in geothermal industries. Those are the areas that really needs improvement, and according to the result, countries that perform well on those five areas are Turkey and New Zealand. It has to be noted, though, that after GoI established new Geothermal Law in 2014, the permitting and resource consent application are much easier compared to before the law was established.

Table 2 Geothermal electricity development, assessment policy success factors

Comparation Item	Indonesia	US	New Zealand	Phillipines	Turkey	Kenya	Mexico
Informations							
Database	[red]	[green]	[green]	[green]	[yellow]	[red]	[yellow]
Access to Geothermal Resources	[yellow]	[yellow]	[yellow]	[yellow]	[yellow]	[green]	[yellow]
Secure and Exclusive Rights to Resources	[green]	[green]	[yellow]	[green]	[green]	[red]	[yellow]
Institutions							
R & D	[red]	[green]	[green]	[green]	[yellow]	[yellow]	[green]
Institutions	[yellow]	[green]	[green]	[green]	[yellow]	[yellow]	[yellow]
HRD	[red]	[green]	[green]	[yellow]	[yellow]	[red]	[yellow]
Policies							
Legal Basis	[yellow]	[yellow]	[yellow]	[yellow]	[green]	[yellow]	[yellow]
The Government Strategy	[yellow]	[green]	[yellow]	[yellow]	[green]	[yellow]	[yellow]
The Government Commitment to Investors	[yellow]	[green]	[yellow]	[yellow]	[green]	[yellow]	[yellow]
Permitting Time Limits	[red]	[red]	[green]	[red]	[yellow]	[red]	[red]
One-Stop Permitting	[red]	[red]	[green]	[red]	[yellow]	[red]	[red]
Inter-Agency Coorperation	[yellow]	[yellow]	[green]	[yellow]	[yellow]	[green]	[yellow]
Finance							
Financial Incentives	[yellow]	[green]	[red]	[yellow]	[green]	[red]	[yellow]
Technical							
Transmission Network	[yellow]	[green]	[green]	[green]	[green]	[red]	[yellow]
Electricity Sales Contracting	[yellow]	[green]	[green]	[green]	[green]	[yellow]	[yellow]

4.1 New Zealand's Approach

4.1.1 New Zealand's Information Access

The information access has been carried out well by the government of New Zealand. Regional Councils collect all of data and information about geothermal from the first geothermal drilling to the latest update of each geothermal field, from the various source, both the companies or other institutions.

4.1.2 New Zealand's Institutions

To support the research and development, NZ government and industry annually give funding for the Crown Research Institute and The University of Auckland to research in conventional systems, low temperature resources and deep geothermal exploration [but not specifically EGS] (APERC, 2015). And to support the human resources development, through the Auckland University, since 1978, the government of New Zealand has established the geothermal training program and become one of the well-known geothermal institute around the world.

4.1.3 New Zealand's Permitting Time Limits

Every resource usage and management in New Zealand is regulated by Resource Management Act (RMA) 1991. The RMA 1991 replaced more than 20 major statues and 50 other laws related to the environment that overlaps with each other (New Zealand Parliamentary Counsel Office 2017, APERC 2015). With RMA 1991, the resource consent for geothermal power plant application (mostly considered as a major national project) might take three possible paths (EPA 2013):

- through Regional Council (conventional);
- through Environmental Protection Authority (EPA);
- or through Environmental Court.

Those three permitting pathways have definite timeline; with permitting through Regional Council will take maximum of 6 months for a final decision, and EPA or Environmental Court is supposed to decide in 9 months.

4.1.4 New Zealand's One-stop Permitting

As discussed previously, the RMA 1991 is very close to the concept of one-stop permitting, as developers will only need to apply to related Regional Council for every consent regarding the use of natural resources, including its potential impact to the environment.

4.2 Turkey’s Approach

4.2.1 Turkey’s Information Access

The exploration of geothermal energy started in early 1962 by the General Directorate of Mineral Research and Exploration (MTA). It has been reported that 95% of the geothermal fields that have been discovered by MTA. MTA collects all of data and information about geothermal from the first geothermal drilling to the latest update of each geothermal field, from the various source, both the companies or other institutions.

4.2.2 Turkey’s Institutions

The research and development in in Turkey are held by the government through the Turkish Mineral Research and Exploration Institute since 1960s. And to support the human resources development, there are 5 universities in Turkey that have geothermal majoring (as per 2018), and support the locals to take the scholarship in geothermal majoring.

4.2.3 Turkey’s Permitting Time Limits

The Ministry of Energy and Natural Resources (MENR) has the lead responsibility for formulating and implementing energy policies and programmes, in co-ordination with its attached, related and affiliated institutions and other public and private entities, on the basis of the five-year strategic plan for 2015-19. public companies remain under the ownership of the Ministry of Finance and the direct authority of MENR is one of them the Turkish Electricity Transmission Company TEİAŞ (International Energy Agency (IEA), 2016). The permit takes around 5-7 years for new power lines and new wind power projects, including a two-year construction period. After the decision to build a new transmission line was taken, two studies were launched simultaneously by TEİAŞ. One concerns the way the transmission line project is designed, route specifications on the map, suitability of the area, tower design, etc. The other is the beginning of the takeover process. The construction of the 380-kV 100 km interconnection line will be an example to describe the length of the process for new power lines:

- The takeover and approval of the EIA report is around two and a half years.
- The construction of the track takes up to two years.
- A tender process for determining which companies will sign a Connection Agreement and fulfill the construction for at least four months.
- Construction of the track around 2 years.

A good step forward is a "pre-licensing" mechanism introduced under the Electricity Market Law to speed up regulatory approval. The pre-licensed regime by EMRA has facilitated rapid retrieval by investors.

4.2.4 Turkey’s One-stop Permitting

The Ministry of Energy and Natural Resources (MENR) in Turkey has the primary responsibility for formulating and implementing energy policies and programs, coordinating with related, related and affiliated institutions and other public and private entities, based on five years strategic plan for 2015-19. MENR's Directorate General of Energy Affairs is responsible for the legal framework for energy markets and reform programs.

4.2.5 Other Policies and Regulation in Turkey

Besides the permitting time limits and one-stop permitting, Turkey’s government also issued geothermal law and regulations (MENR No: 5685/ 2007), and feed in tariff policies. Another law was passed in 2010, Law No: 6094, Date of Acceptance: 29/12/2010, Official Gazette Publishing Date: 08/01/2011, No: 27809, which issued tariff subsidies as well as purchasing guarantees for electricity generation via renewable energy resources: “The government announced a 10.5 ¢/kWh subsidized tariff and 10 year purchasing guarantee from the date the plants are commissioned for power generation via geothermal resources until 2020″ (Aksoy, 2010). There is also additional local product support suitable for geothermal energy equipment manufactured in Turkey, which is also valid for 10 years: steam or gas turbine 1.3 ¢/kWh, generator and power electronics 0.7 ¢/kWh, steam injector or vacuum compressor 0.7 ¢/kWh. Thus, total of the subsided tariff to 13.2 ¢/kWh. The purchasing guarantee and tariff subsidies have certainly improved project financing for local and foreign investors interested in geothermal energy development in Turkey (Melikoglu 2017).

5. CONCLUSIONS

If only from the installed capacity, Indonesia is the second rank under USA and Philippines despite the fact that Indonesia is one of the countries with largest geothermal energy potential. But the acceleration of geothermal government should be learnt from Turkey and New Zealand. Several keys aspects that had been compared in this study are electricity market, information access, institutions, policies, finance, and technical aspects. Those key aspects are then assessed whether the current policies are in-line with investors or developers need. Indonesia is severely lacking in terms of duration and complexity of obtaining permit for geothermal utilization as shown by studies from the Word Bank and APEC. New Zealand with its RMA 1991 stated that simplify that resource consent and permitting application can be further studied and adopted if GoI wants to attract foreign investors to invest in geothermal project in Indonesia. 6. Turkey’s government strategies and policies are promising to be adopted, as they are capable of increasing geothermal capacity for around 1,000 MWe in 10 years 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 harmonizing regulations and authorities in terms of prioritizing utilization of resources should be regulated. However, when viewed from the total potential, Indonesia ranks last. We still have plenty rooms for improvements.

This study recommends following:

1. Government should consider to build a good database (subsurface and drilling) 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 to create credible resource assessment.
2. Even though geothermal and coal are base load power generator, but currently in Indonesia, geothermal could not compete with coal from the tariff, except the government is committed to the renewable energy to give financial incentive for cleaner energy or add more carbon tax for fossil fuel generator

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