Chapter 9

Geothermal Energy in Indonesia

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A. Overview of Geothermal Energy in Indonesia

Many countries have committed to decreasing fossil energy consumption and transforming their energy mix into cleaner and more sustainable energy. This means that the use of renewable energy is going to rise significantly. Indonesia has signed and joined other countries in Paris Agreement. However, some questions remain. The most common question can be the type of renewable energy suitable for Indonesia's geological and geographical conditions. Arguably, the answer to that question is geothermal energy. Geothermal is classified as renewable energy because no emissions are released during production. Geothermal energy is derived from the flow of the Earth's internal thermal energy to the surface, which includes

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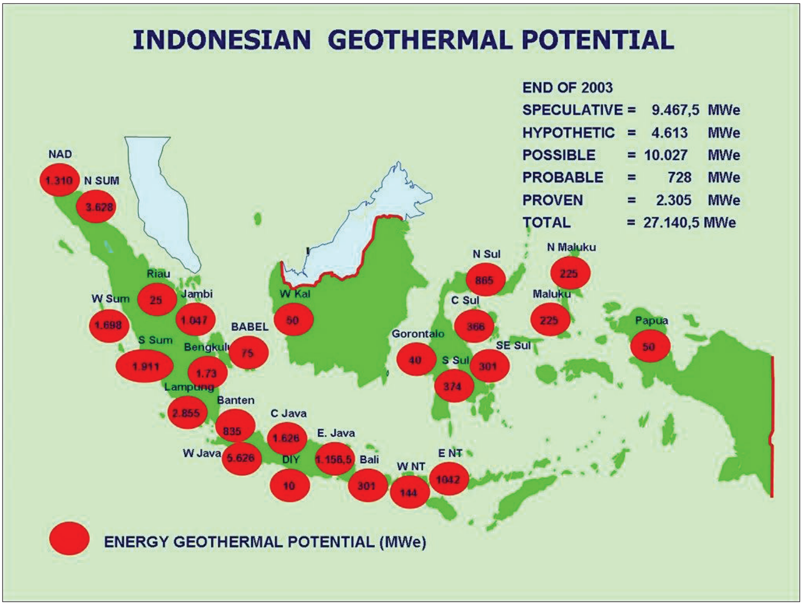
Dipayana, G. F. & Ramadhan, R. A. (2022). Geothermal energy in Indonesia. In H. Ardiansyah, & P. Ekadewi (Eds.), *Indonesia post-pandemic outlook: Strategy towards net-zero emissions by 2060 from the renewables and carbon-neutral energy perspectives* (159–180). BRIN Publishing.
DOI: 10.55981/brin.562.c9 ISBN: 978-623-7425-83-0 E-ISBN: 978-623-7425-87-8

thermal energy from the original formation of the planet and the heat-producing radioactive decay of elements in the Earth's mantle and crust (Berrizbeitia, 2014). Indonesia is located among three active tectonic plates, leading to Indonesia's strategic position as one of the wealthiest countries in geothermal energy. To produce heat below the surface, Indonesia needs to build a production well and integrate it with other infrastructures such as steam gathering facilities. Finally, the subsurface heat can be easily transferred to the surface with a fracture system.

From a geological point of view, Indonesia has 76 historically active volcanoes, making Indonesia one of the countries with the most significant number of active volcanoes (Volcano Discovery, 2022). The data also shows that the heat flow of geothermal energy in some regions of Indonesia to the surface is up to 100% greater than the average heat flow at the surface at around 120 milliwatts per square meter compared to the usual value of 60 milliwatts per square meter (Southeast Asia Research Group/SEARG, 2002). This potential provides excellent conditions for developing geothermal energy. Indonesia is listed as one of the wealthiest countries in geothermal energy. Almost 40% of geothermal resources are in Indonesia, according to mapping done by several institutions. These resources and geothermal reserves can be one solution, among others, to eliminate fossil energy as a baseload as it is estimated equal to 219 million BEO and can generate almost 27.00 GW of electricity (Suharmanto et al., 2015). The Minister of Energy and Mineral Resources of the Republic of Indonesia has published data on geothermal sites in Indonesia, with almost 80% of geothermal sites in Indonesia located in isolated active volcanic systems such as Sumatra (81 locations), Java (71 locations), Bali and Nusa Tenggara (27 locations), Maluku (15 locations), and North Sulawesi (7 locations). There are also some regions with active non-volcanic environment: Sulawesi (43 locations), Bangka Belitung (3 locations), Kalimantan (3 locations), and Papua (2 locations). The total composition of the geothermal potential of 252 locations in

Indonesia is 27,357 MW, which is consisted of 14,007 MW of resources with 13,350 MW of reserves (Wahyuningsih, 2004).

Indonesia has made a long history of developing the geothermal industry. The first main project was built and started at Kamojang, West Java, in 1983 (Radja, 1995). Pertamina and PLN, the state-owned electricity company, have constructed 140 MW of steam gathering facilities and power plants. The first private contracts were signed in 1982–1984. Afterward, several companies also signed contracts on joint operations with Pertamina for ten contract areas between 1994 and 1997. As a result of these contracts, geothermal energy generated an additional 480 MW in regions such as Salak (220 MW), Wayang Windu (110 MW), Darajat (90 MW), and Dieng (60 MW) in Java. Pertamina also developed other geothermal working areas in Indonesia at Sibayak (2 MW) in North Sumatra and Lahendong (20 MW) in North Sulawesi (Fauzi et al., 2005).



Source: Suharmanto et al. (2015)

Figure 9.1 Indonesia Geothermal Potential

Geothermal possesses many advantages compared to other fossil energy sources; an example can be found in the reliability of electric power generated from geothermal energy that can be sustained as a long base (more than 30 years). In general, the capacity factor of geothermal power plants may reach 90% per year if we look at the examples of PLTP Kamojang (93% capacity factor), Tiger Puppet (94% capacity factor), and Darajat (93% capacity factor). So, geothermal energy can be used as a baseload in electricity systems at a higher capacity than other energy sources, especially since geothermal energy is available steadily throughout the year. The productivity of geothermal resources is relatively unaffected by climate change, making it different from renewable energy sources such as wind or solar and the annual hydropower season. Another advantage of geothermal energy is that it does not require large tracts of land.

The use of geothermal energy can reduce our dependency on fossil fuels significantly. To illustrate the comparison of geothermal to other powers, 1 kWh generated electricity assumption requires 0.28 liter of fuel, or 1 MWh requires 280 liters or approximately 2 barrels.

B. Drilling

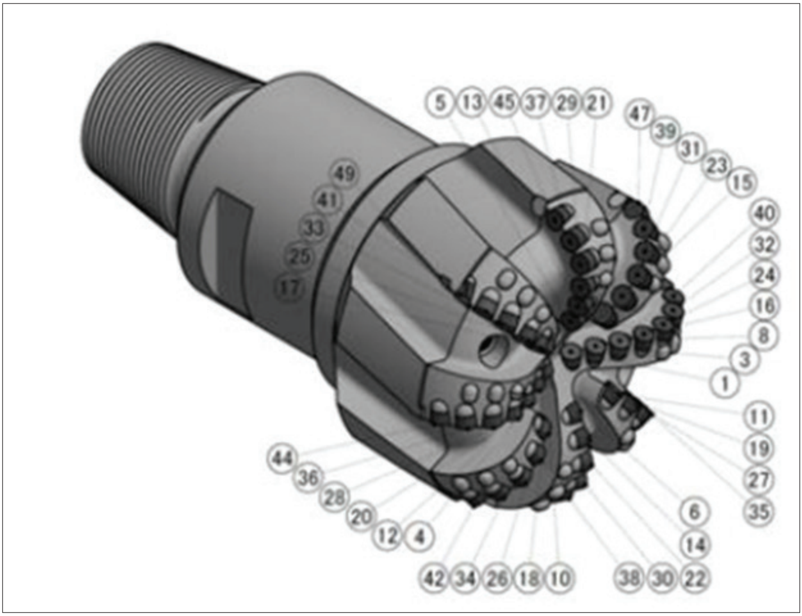
The first step in developing geothermal resources is exploration activities. This activity aims to confirm the size of reserves below the surface or in a reservoir. One of the most critical activities is exploration drilling. Many data have shown that exploration drilling costs almost 40% of the total investment in the project or capital expenditure of a company for a new high-temperature geothermal project (Kipsang, 2013). The data from historical drilling costs show that the depth of the well is the main reason and parameter explaining its overall cost. It is calculated that 56% of the investment costs of geothermal wells are linked to depth (Cedric, 2010). The data also shows that many factors must be considered during drilling operations, such as the well configuration and duration. Almost all geothermal sites are located in deep and ultra-deep wells; the deeper the target we want to reach, the more problems we may face. These problems are ultra-high temperature, high pressure, high sulfur, multiple pressure systems, poor drillability, and impurities contents, making it more difficult to reach the target and bringing more challenges to the exploration stage (Wu et al., 2020). There are a few challenges regarding drilling and completion engineering of exploration. They are (1) high-temperature instrumentation and seals; (2) Geothermal logging instruments and tools must be modified regarding the high temperature in geothermal wells; (3) Due to high temperature, thermal expansion is possible, affecting the buckling and collapse of the casing; (4) The property of drilling fluids and mud coolers. Mud coolers are one of the most important parts during drilling operations; they can prevent bad things such as high mud temperature; (5) The loss circulation of geothermal. This phenomenon happens in geothermal and oil and gas; the reason is similar due to faults associated with the zones.

There are two fundamental physical requirements for producing geothermal power from the subsurface. These are high geothermal heat flow and high permeability of the geothermal fluid for its migration to the surface (Raymond et al., 2012). The basic principles of a drilling operation in the geothermal industry are the same as oil and gas. However, there are differences in some aspects. Almost all geothermal fields consist of complex layers or hard abrasive rocks such as granites and volcanic or metamorphic rocks. However, some geothermal reservoirs consist of soft layers or rocks such as sedimentary or carbonate rocks.

Consequently, a drilling bit degrades shortly due to large loads and impacts in such severe geological conditions. A high-performance drilling bit commonly has a high drilling speed and high durability (Miyazaki et al., 2019). There is a project on geothermal drilling wells that tested two off-the-shelf polycrystalline diamond compact (PDC) bits in a geothermal drilling project in the Chocolate Mountains of Southern California. It is reported that the PDC bits exhibited higher drilling speeds and longer lifetimes than those expected with roller-cone bits (Raymond et al., 2012). Another experiment tried to evaluate the effects of the cutter geometry, material composition, and processing conditions of PDC drag cutters on the drilling efficiency, abrasion, and impact performance in hard rocks. There are many reasons to explain the failure of the drill bit to drill the geothermal formation, but the main reason is the cutters of the drill bit are challenging to face the complex abrasive rock formation. The forces on the drill bit are unevenly distributed during drilling, leading to poor working stability and abnormal vibration (Wise et al., 2005). To increase the PDC bit stability and cutter density, selecting cutter types is essential to improve the wear resistance of drill bits.

Japan Oil, Gas, and Metals National Corporation (JOGMEC)has focused on drilling techniques and established a research and development project on the PDC bit with both high drilling efficiency (speed) and long drill length (durability) in 2015 (Imaizumi et al., 2019). In the project, they studied the manufacturing technique of PDC cutters and have succeeded in developing ones with high wear resistance and impact toughness. The process of manufacturing PDC cutters has been accomplished by sintering diamond powder on a cemented carbide substrate with cobalt as a binder by applying high pressure and high temperature (HPHT) to the component**.** The cutters have been developed by using coarse diamond grains to increase impact toughness and abrasion resistance using fine diamond. They have used PDC bits with eight blades to place as many PDC cutters as possible on the bit to face hard abrasive rocks with heterogeneous geological fractures and to reduce the load (reaction force) on individual PDC cutters. It was confirmed that the reaction forces were ever-increasing outward from the bit center, but those on the adjacent cutters were almost equal.

Cost is another thing that needs to be considered by the engineer during drilling operations on geothermal wells. The associated costs in Turkey are the cheapest amongst the costs of wells in Australia, France, Germany, Iceland, Kenya, Netherlands, and the United States (Gul & Aslanoglu, 2018). There are many reasons why Turkey is listed as one of the countries with the lowest cost for drilling geothermal wells. First, they have successfully reduced the daily operating costs of rigs and third-party services since Turkey's labor costs are more affordable



Source: Imaizumi et al. (n.d.)

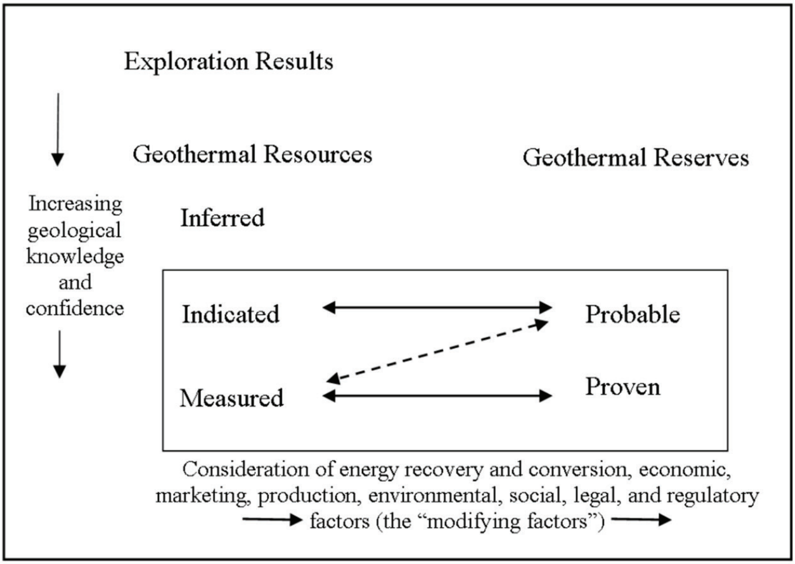
Figure 9.2 D CAD Modeling for 8-1/2” PDC bit

than other countries. Second, the most critical equipment of the wells, the casings, are chosen from the lowest cost option. Third, Turkey has more competence and experience in drilling activities, resulting in a competitive market producing better-optimized wells with shorter project lead time (Gul & Aslanoglu, 2018). From data published by Baker Huges, as of January 2017, almost 40% of total drilling rigs in the world are used in Turkey for geothermal well drilling. Turkey is also the leader in the drilling activity, with 32 of 98 drilling activities in Europe located in the country (Huges, 2017). The geothermal gradient in Turkey ranges between 8.33°C/100 m to 11.10°C/100 m in thermally active regions (Njolnbi, 2015). Therefore, Indonesia may copy Turkey’s strategy to operate geothermal wells by reducing daily drilling costs since the associated costs have affected the total project investment or capital expenditure. It also can be concluded that Turkey is currently a market leader in geothermal drilling activities, thanks to a very low-cost operating strategy.

C. Technical Data

The Australian code has been used in many countries and has gained international acceptance. This code includes three key principles: transparency, materiality, and competency. These three principles are important as a guide for determining the success of the geothermal project. Exploration practitioners in Indonesia need to adopt the Geothermal Play Fairway Analysis method. The United States Department of Energy developed this method to decrease uncertainty during geothermal exploration activities. The method evaluates a range of geological, technical, and socioeconomic factors, which are subsequently integrated to narrow a basin or regional-scale area down to smaller areas of interest for further study and prospecting (Garchar et al., 2016). There are many differences between Indonesian and Australian codes. The Australian codes explain and consider not only the technical aspects (geosciences or engineering), but also socio-economic aspects related to marketing, legal, regulatory factors, and environmental. While it may be questioned whether the Australian/ Canadian codes are applicable to Indonesia, the fact remains that they have been employed in three geothermal feasibility studies at Lumut Balai, Ulubelu, and Tompaso (Adams et al., 2011). To conclude, there are lacks in quantity and quality of data provided by the Indonesian government that needs to improve.

Indonesia needs to make a database that can be accessed by companies participating in regular tender conducted by the Government. Indonesia can also implement an open-data policy in geothermal exploration, which has been instigated in Indonesia's oil and gas industry with membership schemes for providing more accessible data and developers also can analyze not only in one basin but also regional. A further principle in the code is the demarcation of a reserve instead of the resource, considering commercial viability. A 'Geothermal Resource' is a Geothermal Play that exists in such a form, quality and quantity that there are reasonable prospects for eventual economic extraction (Williams et al., 2010). A 'Geothermal Reserve' is that portion of an Indicated or Measured Geothermal Resource which is deemed economically recoverable after considering both the Geothermal Resource parameters and Modifying Factors (Williams et al., 2010) The classification between these two terminologies' reserves and resources is important because it provides explicit understanding. The Indonesian standard codes also use resources classification called '*Cadangan Terduga*'. This word usually is meant as Contingent Reserves. However, the criteria do not include well testing and drilling wells. Reserves are used as the highest classification of petroleum and mineral exploration. For comparison, the Australian code enters well deliverability as one of the obligations to declare "reserves" and also different sources such as Joint Ore Reserves Committee Mineral code require an economic analysis such as bankable feasibility study to declare "Reserves.". The Geothermal Reporting Code recognizes three levels of Geothermal Resource (Inferred, Indicated, and Measured) based upon increasing levels of geological knowledge and confidence (Williams et al., 2010)



Source: Williams et al. (2010)

Figure 9.3 Relationship between Exploration Results, Geothermal Resources, and Geothermal Reserves

In addition, many entities have won bids with insufficient technical and financial capacity (Asian Development Bank, 2015). There are many alleged deficiencies, including a lack of technical ability of the tender committee (resulting in poor prequalification screening), tiny bid bonds, and performance bond requirements that are not imposed (Asian Development Bank, 2015). There is a requirement for posting their bid bond based on their total investment project rather than just their exploration budget for first-year and no less than US$ 10 million. The bid bond also should reflect the company's work and program funding (WP&B), and can be converted into a performance bond as evidence of exploration activities or drilling. The tender process should also follow the best international practice for more investments from domestic and multinational companies. There are no possibilities to reach the target the Government has made on geothermal without the participation of international or foreign developers and practitioners in the geothermal industry.

Some specific issues with the current version of the Indonesian standard are as follows (Asian Development Bank, 2015):

1. The Indonesian standard uses an anumerical simulation process, but there is no guidance on how that simulation can be used to determine the capacity of the resources.
2. Many investors and developers use a probabilistic approach or estimates. This method is used for determining stored heat estimation. However, in the Indonesian standard reporting code, there are no explanations regarding this method without considering this method. Indonesia is in a position by the recommendation that World Bank has given.
3. The Indonesian standard permits using the volumetric method (stored heat) and numerical simulation to estimate reserves and resources, which is appropriate. For stored heat, the 2000 revision of the standard lists preferred or defaulted single values (within broad reservoir temperature bands) for various parameters such as recovery and conversion factors at diverse resource and reserve categories and does allow the use of other values. It does not guide how those values should be selected. In contrast, for example, the Australian code lexicon provides default values.

D. Policy

1. Analysis of Geothermal Policy in Indonesia

Geothermal developments in Indonesia have fluctuated due to legal uncertainty for entrepreneurs, accompanied by an economic crisis impacted by COVID-19 and others that affect the commercial aspect, thereby increasing the risk of investing. Other factors related to geothermal power development include capital intensive, risk of security in the country, the floating Rupiah payment system, low basic electricity tariff, low public purchasing power, fiscal policy, consistent contract sanity, and strict sanctions. From these parameters, we still find things that have not been realized in the field or irregularities that often occur.

Indonesia has several policies in managing geothermal resources from 1974 to 2009 until finally, the Indonesian government in 2003 issued the first law that provided a robust legal basis for the development of geothermal energy, which is the issuance of Law Number 27 of 2003 and its derivative rules. Law Number 27 of 2003 is a regulation that regulates all geothermal exploitation activities. This law states that the flow of geothermal exploitation in Indonesia consists of five stages: a preliminary survey, exploration activities, feasibility studies, exploitation activities, and optimal geothermal utilization.

Law Number 27 of 2003 states that local governments have full authority regarding licensing and geothermal legislation. With this authority, local governments can create and provide quality human resources in geothermal processing, from technical to administrative capabilities. This authority can significantly impact local communities where their abilities are increasing. These qualified human resources aim to present accurate and detailed data and information related to the potential of geothermal energy in their area to developers who can facilitate the research process by themselves. This can affect the price quote for geothermal steam or electricity and plans for future geothermal energy projects.

The Indonesian Government has issued many policies related to geothermal energy. However, in the field, we still find some problems. Problems that usually arise are the quality of the human resources of the regional auction committee, which is not yet competent enough. There are many cases where the existing workers cannot handle this job. Resolving the problem requires an increase in the competence of human resources. This increase can be in education, training, or certification activities from related parties. The role of the Government and educational institutions is vital to creating quality human resources.

The next problem is the overlapping boundaries of the allocated geothermal working area. Most of the geothermal working areas are in conservation forests. This issue has been the subject of much debate. The Government responded to this issue by issuing PP (Government Regulation) Number 28 of 2011, which explains that geothermal is an environmental service business so that geothermal activities can be carried out in conservation forests. In implementing this regulation, it is necessary to coordinate with several parties, such as the Ministry of Energy and Mineral Resources with the Ministry of Forestry and other parties involved, so that it will not produce big questions about the placement of the geothermal working area.

Furthermore, recently there have been many permits for geothermal energy development, from the inventory of geothermal working areas to the commercial. The geothermal business licensing process takes a long time; for exploration, it takes about 2 to 3 years; for exploitation activities up to commercial, it takes 3 to 5 years. So, the total time required is about 5 to 7 years from initial inventory to operation. With this problem, to shorten the time required, regulations are needed regarding the certainty of licensing times from the relevant ministries and the Government so that many developers are interested in developing the existing geothermal potential.

Lastly is the problem of inter-sectoral coordination, which is still constrained. A more detailed and precise clarity of authority is needed between the central government, provincial governments, and local governments related to geothermal development. Articles 5, 6, and 7 of Law Number 27 of 2003 have stated the authority regulation, but it is not detailed and can cause confusion. The problem in the field is the emergence of disorder about which party is responsible for solving a problem. Therefore, more detailed and clearer derivative regulations from existing regulations are needed.

2. Geothermal Policy Analysis in the United States, New Zealand, and the Philippines

The trend of developing clean, renewable energy is hotly discussed worldwide. One of the renewable clean energies that can be produced at any time regardless of time and has excellent potential is geothermal energy. In some countries, this potential is utilized as much as possible to create clean and sustainable energy. The efforts carried out by governments in the world vary widely from financial support, technology transfer between countries, training related to geothermal processing and utilization, and geological surveys supported by the Government. The trend of geothermal development, which is constantly increasing drastically, has made countries serious about utilizing it, such as the efforts made to form policies and regulations regarding the use of geothermal energy.

Table 9.1 Top 10 Countries Developing Geothermal Capacity in 2021

Rank	Country	Installed Capacity (MW)
1	United States	3,722
2	Indonesia	2,276
3	Philippines	1,918
4	Turkey	1,710
5	New Zealand	1,037
6	Mexico	963
7	Italy	944
8	Kenya	861
9	Iceland	754
10	Japan	603

Source: Pristiandaru, D.L. (2020)

Countries in the world included in the global top 10 in developing geothermal energy and have high innovation related to geothermal processing are the United States, New Zealand, and the Philippines. In this part, we will discuss the existing policies in those three countries that can be compared with those policies in Indonesia.

a. Geothermal Policy in the United States

The United States has the most installed capacity of geothermal energy globally. The amount of installed capacity of geothermal energy is high, so the United States has a detailed policy stated in the legislation. The United States government has two of the most important laws that govern the authorization and guide the Department of Energy (DOE) in managing and conducting geothermal energy research. The two laws are the Energy Independence and Security Act of 2007 and the Geothermal Energy Research, Development, and Demonstration Act of 1976, which contain regulations for geothermal exploitation such as on mineral lands and mining, project management, loan guarantees, until the protection against environment on geothermal energy management.

In addition to these two crucial laws, other policies are applied in the United States in the management of geothermal energy, such as tax incentive policies, geothermal energy research, development policies, financial incentive policies, and geothermal energy policies regarding leasing and resource management laws.

Geothermal Energy Association (GEA), an association of US companies engaged in geothermal energy, which supports the development of geothermal energy and geothermal energy resources around the world to generate electricity from geothermal energy, issued several priority policies to support geothermal energy development in 2012.

The first policy is to provide tax incentives for a longer term to support geothermal energy development and industrial stability. The second is to facilitate the permission and construction of the transmission capacity needed to support geothermal energy development. Third, minimizing delays in geothermal energy contract permits that has been a challenge in geothermal energy development. Fourth, the policy is aimed to issue new national regulations to support the exploration, quantification, and development of geothermal energy projects. Lastly, it supports energy policies for developing geothermal energy through the clean energy base standard mechanism set by the Government. The sixth policy is to help GEA member companies to collaborate to create geothermal energy and increase their contribution to the global market.

b. Geothermal Policy in New Zealand

Geothermal utilization is proliferating in New Zealand, as evidenced by the increasing number of geothermal installed capacities in this country. With the expanding number of geothermal plants, the New Zealand government has a policy to regulate geothermal exploitation. The first policy made by the New Zealand government to control geothermal energy was The Geothermal Energy Act of 1953. Still, it was replaced through the regulation of The Resource Management Act (RMA), 1991. RMA 1991 integrated environmental management regulations into one statute for managing natural and physical resources, including air, water, land, geothermal, minerals, and coastal area resources up to 12 nautical miles. The purpose of establishing the RMA 1991 is to promote the sustainable management of natural and physical resources. RMA 1991 applies rules and governance to exercise control over resource use by delegating decisions and planning and resource management policies to the regional council until the new district council in New Zealand. RMA 1991 explains that geothermal management is further integrated into control and water permits, which are an inseparable part of development planning and regional policies within an integrated development framework. If the regional council cannot yet manage geothermal energy, the central government can assist in geothermal management (Hollroyd & Dagg, 2011). To facilitate the central government in managing geothermal resources following the scale, capacity, and designation for national energy development, the regional council that cannot yet manage geothermal resources must make plans to divide geothermal potential into five categories. It includes the geothermal can be developed, limited development, research, protection, and small geothermal systems.

Other policies governing the exploitation and management of geothermal energy in New Zealand are the Building Act (BA) 1994, which regulates building work, establishes a licensing regime for building practitioners, and sets building performance standards. The following policy is the Electricity Industry Reform Act (EIRA) 1998, which was implemented in the renewal of the New Zealand national electricity policy. The electricity supply is hoped to be managed efficiently process to provide outstanding long-term benefits for consumers (IEA, 2011). The last is Regional Policy Statements and Plans (RPSP), which is a regional council policy instrument under RMA 1991 that explains regional resource management and basic guidelines for environmental management in each region (EMSL, 2011).

c. Geothermal Policy in the Philippines

The Philippines, the third largest country that uses geothermal energy in the world, has regulated the management of renewable energy, especially geothermal energy. The first policy is the Geothermal Service Contract Law, Presidential Decree 1442, issued in 1978, regarding the control and regulation of exploration, development, and utilization of geothermal energy. The second policy is Executive Order 215, published in 1990, which effectively eliminates the NPC monopoly system and allows private sector participation in the construction, ownership, and operation of geothermal power plants. The third policy is the 2008 renewable energy law, which benefits developers, including a 7-year tax holiday, a tax-free carbon credit program, and a standard for meeting domestic electricity needs of 60%. The fourth policy is An Act to Promote the Exploration and Development of Geothermal Resources 1978 regarding incentives. The fifth policy is the Resource Management Act 1991 regarding managing resources such as land, air, and water for sustainable use.

From the Philippines' existing policies in attracting geothermal development, the Philippine government provides an example to the world, which was supporting investment in equipment capital and the entry of foreign experts, as well as sending Filipino workers abroad to learn about geothermal development. Then depreciation of capital equipment over ten years. Next is recovery from operating costs that come from government funds. Then, the service fee is up to 40% of the net result. Next is the exemption from all taxes, except individual liability income tax and the exemption from payment of duty rates and compensation tax on geothermal energy operational equipment.

d. Summary of Policy Analysis

In conclusion, the policy analysis between Indonesia has been compared to the United States, New Zealand, and the Philippines. Considering all the policies from the countries mentioned above, the first step is to improve the laws and regulations governing geothermal utilization and management so that they can provide certainty more comprehensively while not conflicting with other laws and regulations. This will make the geothermal business environment more conducive and attract investors to invest in geothermal development.

Furthermore, the Government's role must be expanded from policy discourse to a more concrete and implementable policy commitment to pique investors' interest. This solution can be done through research and development financing incentives, incentives for reducing or eliminating duties and taxes related to the pre-construction process, and incentives for installation construction.

Lastly, the requirement is clarity of authority in applying rules and governance to exercise control over geothermal utilization and management through delegation and division of power between central and regional governments, while maintaining a balance between local and national interests in allocating appropriate resources. These rules should be exist in a way that is both sustainable and environmentally.

E. Conclusions

Geothermal industry development is still facing many challenges, primarily related to the participation of international or domestic companies in investing their money and taking a risk in Indonesia's geothermal sector. The characteristic of the geothermal industry is high-risk, high capital, and high technology, which means there are no possibilities to reach the target that Indonesia's government has made without the support from international companies. There are many recommendations for encouraging the development of the geothermal industry in Indonesia:

1. Applying and implementing a new fiscal term to support the economic viability of the project called cost recovery in the upstream development of the geothermal industry. These fiscal terms also have been used in Indonesia's oil and gas industry and have proven their success in accelerating the industry development. There are many reasons for these issues because of many similarities between geothermal and oil and gas.
2. Indonesia needs to adopt or use Australia's standard reporting code to accommodate investors' interests because many international companies have used those codes and gained international recognition.
3. More investigations and studies are necessary to get proven and mature data, especially exploration drilling. Indonesia needs to conduct a Government Drilling Program; based on advice given by investors, the lack of quality and quantity data is one of the concerns and needs improvement. By presenting the Government Drilling Program or offering it through auctions or regular tender, the Government can provide more attractive and proven data. Thus, the climate of investment in Indonesia's geothermal industry will be more attractive because the Government has successfully decreased the uncertainties by providing proven, mature drilling data, which is one of the most important things.

4. Indonesia should decrease the total investment of project or capital expenditure by selecting and applying new technologies suitable for geothermal layers or lithology formations and characteristics of the geothermal reservoir. The geothermal building is known for hard rocks such as metamorphic or volcanic rocks. It means many instruments and tools need to be modified the drilling bit significantly by applying Polycrystalline Diamond Compact (PDC) bit to replace the conventional roller-cone bit. The data have proven that the PDC bit results in higher drilling speed and longer lifetimes, and it can reduce large amounts of the total investment in the geothermal project.
5. It is necessary to improve the laws and regulations related to geothermal utilization and management so that it is more comprehensive and does not overlap with other rules. The Government must also play a more active role from just policy discourse to a more concrete and implementable policy that can attract investors, as well as more clarified authority in applying rules and governance to control the utilization and management of geothermal.
6. To boost the development of the geothermal industry in Indonesia, one of the most important parts is the electricity price. By implementing the regulation called Feed-in tariff, the producers will be able to sell the electricity they generate at a cost set in advance by the government under a long-term contract; also, these policies can support the economy of geothermal power generation in the downstream industry.

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