A HOLISTIC OVERVIEW: INDONESIA'S GEOTHERMAL ENERGY ENCOURAGES GEOTHERMAL POWER PLANTS (GPPS) INVESTMENT IN SUPPORT OF NATIONAL DEFENSE

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Abstract- *The Pacific Ring of Fire passes across Indonesia physically, and the country's intense volcanic and tectonic activity has produced a wealth of geothermal resources that could reach 23.46 GW, distributed over 357 sites. In order to promote the decarbonization of Indonesia's electricity supply and the advancement of geothermal energy, the Indonesian government issued Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply in 2022. To incentivize GPPs to invest, more than the maximum electricity tariff is required—the lack of bids in PLN's most recent procurement from 2021. Investing in geothermal projects has some regulatory obstacles in addition to cost concerns. This study aims to assess geothermal investment in Indonesia and reduce reliance on fossil fuels, which are susceptible to price and supply volatility. GPPs ensure a consistent energy supply for national needs, including military and vital infrastructure to support national defense. The method used is descriptive qualitative, which relies on literature studies that discuss appropriate issues. The survey results presented through the National Energy Management Blueprint 2006-2025, the Government of Indonesia plans geothermal energy to contribute about 5% of the national energy mix or about 7,32 GW in 2025. However, the realization of installed geothermal power plant capacity in 2023 only reached 2,38 GW, or 32,52 perent of the planned capacity to be installed. Through the Ministry of Energy and Mineral Resources, the government needs to increase the purchase price of electricity from IPP GPPs to create a good investment climate and continue to grow the geothermal industry.*

Keywords: *GPPs, geothermal, investment, renewable energy, regulatory*

Introduction

Geothermal energy, as a clean and renewable energy source, has been used since ancient times in various parts of the world. Depending on the variety of resources and technologies available, this energy can be utilized for various purposes and by different methods. This variety and specification in utilization results in different classifications in geologic and geothermal engineering systems based on geographic location formation process, dominant heat transfer mechanism or resource availability. The world is currently experiencing the need for an energy transition. The current utilization of fossil fuels is causing environmental damage, resulting in the depletion of natural resources and, in many areas, significant environmental degradation due to the emission of large pollutants into the atmosphere. Transformation in the energy sector is important, as most greenhouse gas emissions come from this sector. Renewable energy sources including clean and environmentally friendly geothermal energy, play a key role in the transformation process. Issues related to the efficient utilization of geothermal energy are devoted to the Special Edition of Energy under the title Geothermal Systems. The utilization of renewable energy sources presents several benefits, including the ability to vary fuel blends, decrease air and environmental pollution, actively promote sustainable economic growth, and resolve the energy accessibility issue (Nezhnikova et al., 2018).

Geothermal energy is an environmentally friendly and renewable resource that has an important role to play in reducing carbon emissions in Indonesia's energy sector, especially in the power sector. There are several reasons why it is important to recognize and integrate geothermal power generation into the electricity infrastructure. First, geothermal can serve as a baseline resource with very high capacity, reaching 90-95%, and has minimal environmental impact, so it can replace coal in electricity supply in a sustainable manner (Spada et al., 2021). Furthermore, from an economic perspective, geothermal can compete with other fossil energy sources such as oil and gas, especially when high quality resources can be utilized easily. In fact, with more aggressive measures to support the decarbonization of the electricity system, the cost of generating electricity from geothermal can be more competitive than coal if the coal benchmark price is fully removed and externality costs are applied (RPS, 2023). Third, because it can be produced domestically, geothermal can reduce dependence on fuel imports improve energy security, and is free from the risk of fossil fuel price fluctuations and supply uncertainties. Finally, in terms of total electricity system costs, geothermal is more competitive than other energy sources, driven by technological advances such as binary cycles in geothermal plants that allow flexible operation and efficient integration with other renewable energy sources such as solar and wind farms, as well as thermal energy storage to create hybrid power plants that have high availability and efficiency(McTigue, 2018). Although it requires a large initial investment, geothermal is essentially an economical option as a baseload energy source due to its relatively low operating costs (Tester et al., 2021).

Geographically located along the Pacific Ring of Fire with high tectonic and volcanic activity, Indonesia has abundant geothermal resources with the potential to reach 23.46 GW spread across 357 locations (Humas EBTKE, 2022). In 2021, the potential geothermal reserves in Indonesia amounted to 12.4 GW spread across Sumatra, Java, Nusa Tenggara, Kalimantan, Papua, and Sulawesi, as shown in **Table** 1 These potential

reserves are divided into probable (9,547 MW), suspected (1,770 MW), and proven (3,104.5 MW). Proven reserves are concentrated in Java and Sumatra (Moraga et al., 2022).

Island	Number of Points	Potential (MW)				
		Resource		Reserve		
		Speculative	Hypothetical	Possible	Probable	Proven
Sumatera	101	2276	1551	3294	976	1120
Jawa	75	1259	1191	3403	377	1820
Bali & Nusa Tenggara	40	295	169	996	231	42,5
Kalimantan	14	151	18	6	0	0
Sulawesi	91	1365	343	1063	180	120
Maluku	33	560	91	485	6	2
Papua	3	75	0	0	0	0
Total	357	5981	3363	9247	1770	3104,5
		23465,5				

Table 1 Distribution of Indonesia's Potential Geothermal Reserves
Source: (Kementerian ESDM, 2022)

With such high potential, geothermal energy is one of the main keys for Indonesia to honor the Paris Agreement and carry out long-term commitments to reduce carbon emissions. Indonesia targets to reduce carbon emissions by 31.89 percent with its own efforts and 43.20 percent with international assistance by 2030. In line with this target, the Government of Indonesia targets a renewable energy mix of 23 percent by 2025, with Geothermal Power Plants targeted to contribute to around 7 percent of the total installed power generation capacity. Furthermore, in the net zero scenario developed by MEMR, the GoI targets a total installed geothermal capacity of 18 GW by 2060. As illustrated in **Table 1** there are currently 16 operating and exploited geothermal fields with a total installed capacity of 2.35 GW and a contribution to the energy generation mix of 2.9 percent (Kementerian Energi dan Sumber Daya Mineral, 2022).

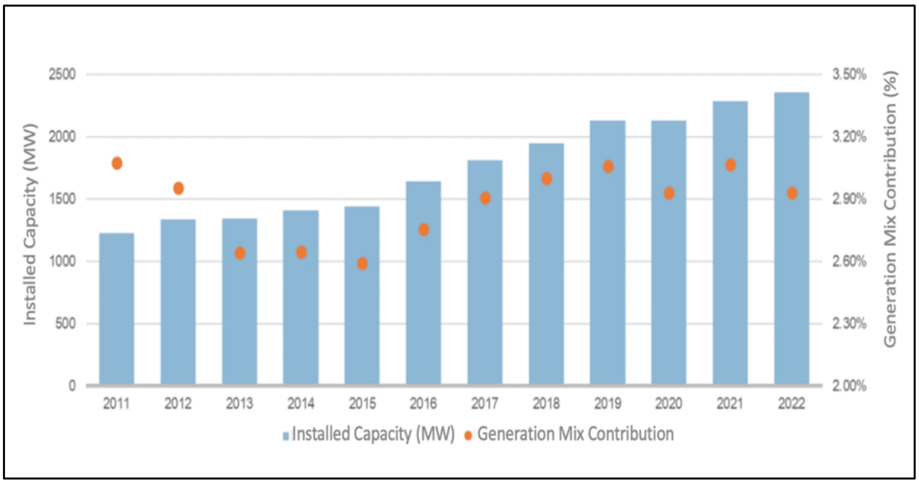

Figure 1 Installed GPPs Capacity and Energy Mix Contribution
Source: (Kementerian ESDM, 2022)

Long-term plans for geothermal energy development prepared by various government agencies have very ambitious targets, especially when compared to current achievements. Your sentences can be refined for clarity as follows:

Figure 1 shows the comparison between the installed capacity target of geothermal power plants in various planning documents such as the Geothermal Development Road Map of MEMR, Electricity Supply Business Plan of National Electricity Company 2021-2030, National Electricity General Plan, and National General Energy Plan with the actual installed capacity. Based on the geothermal development target in the General National Energy Plan, for example, which reaches 7.2 GW by 2025 and 9.3 GW by 2030, a huge effort is needed to develop 4.84 GW of geothermal projects in the first three years and 6.94 GW in the first five years from 2022 to achieve the target. However, based on historical data, increasing the installed capacity of geothermal power plants to three to four times the current level within a few years is something that Indonesia has never done before (Ministry of Energy and Mineral Resources Republic of Indonesia, 2021).

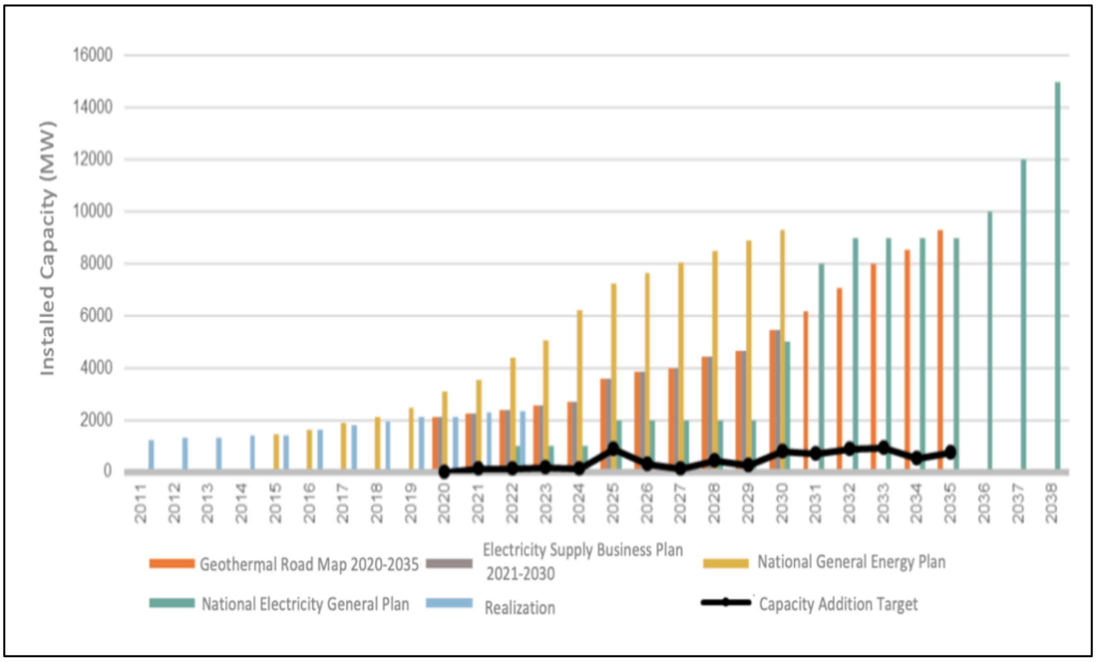

Figure 2 Comparison of Target and Realization of GPPs Installed Capacity
Source: (Kementerian ESDM, 2022)

Figure 2 shows the increasing trend in targets after 2025, indicating a strong push towards geothermal energy as a key component of Indonesia's energy mix, aligning with national goals for sustainability and reducing carbon emissions. There is a significant discrepancy between planned targets and actual realizations, reflecting potential challenges in policy implementation, investment, technology deployment, or other barriers.

The complexity of developing geothermal power plants in Indonesia is a significant challenge. From a demand perspective, PLN faces a dilemma in setting attractive electricity prices. This is due to the pressure on PLN to provide electricity at affordable prices, which creates a need to obtain electricity from producers at lower prices. On the other hand, GPPs developers face a number of regulatory, technical and financial challenges. All of these challenges impact the price offered to the electricity buyer, PLN (Bošnjaković et al., 2019). Geothermal projects have a very horizon, starting from the exploration, exploitation, and utilization phases, which can be up to forty years in total.

The exploration phase, is a project's returns and attractiveness to PEP investors.

In 2022, the Government of Indonesia issued Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply with the aim of encouraging decarbonization in Indonesia's electricity system as well as promoting the development of geothermal energy. However, the electricity tariffs set are not lucrative enough to attract geothermal investment, as seen by the lack of participants in the last procurement conducted by PLN in 2021(Pavlakovič et al., 2021). In addition to pricing issues, investments in geothermal projects also face a number of regulatory hurdles, where despite advancements in procurement schemes for geothermal, they have not been able to significantly encourage investments, especially in terms of uncertainties in the procurement process, such as the negotiation of power purchase prices (Barich et al., 2022). This research (Barich et al., 2022) aims to uncover and address the multifaceted challenges hindering geothermal energy development in Indonesia. By delving into regulatory, financial, technical, and environmental factors, tackling the complex landscape of geothermal power plant projects. From uncertain electricity purchase prices to intricate licensing processes poised to shed light on the array of obstacles.

In addition, the emphasis on the formulation of policy recommendations demonstrates a proactive approach to improving the investment climate and encouraging the rapid expansion of geothermal energy in Indonesia. Through a comprehensive review, it aims to provide not only a nuanced understanding of the challenges and opportunities, but also actionable solutions to drive the growth of this vital sector. In addition, it has the potential to catalyze sustainable energy development and contribute to Indonesia's energy and environmental security goals.

Methods

Using qualitative techniques by generating data in the form of words or descriptions, this study relies on library or literature studies, where works published between 2010 and 2024 are collected using electronic databases. This approach combines library observations with qualitative methods, utilizing various sources as research data. The study also uses comparable or related research to support its objectives, which are to comprehensively evaluate geothermal investments in Indonesia and reduce dependence on fossil fuels that are vulnerable to price fluctuations and global supply disruptions (Purwanto, 2012).

Result and Discussion

The investment in a geothermal power plant project is divided into four stages: pre-development, development, construction, and operation. The pre-development phase of the project begins with the WKP auction, the Directorate of Geothermal issuing the Geothermal Licence, and the Pre-Transaction Agreement (PTA) is being signed. Project exploration is carried out from the development phase up till the Power Purchase Agreement (PPA). In addition, the development phase includes the creation of the GPPs (Enel Green Power, 2021), field development activities (exploitation), and the issue of the Electricity Supply Business Licence for Public Interest (IUPTLU). The operation phase, which involves the developer implementing operation and maintenance, is the final stage of GPPs project development.

GPPs Investment in Support of National Defense

The use of geothermal energy through the construction of the bUMI Thermal Power Plant (PLTP) can make a significant contribution to national energy security to support national defense. PLTP provides a stable and sustainable energy source and reduces Indonesia's dependence on imports (Fatahillah et al., 2022; Widrian et al., 2022). fossil fuels. This is important to maintain a reliable energy supply, especially for military needs and strategic installations that require uninterrupted electricity (Widrian et al., 2022) . By utilizing local energy resources, Indonesia can reduce its vulnerability to price fluctuations and fossil fuel supply disruptions affected by changing geopolitical dynamics. In addition, the country is able to survive supply disruptions and attacks on energy infrastructure (Nurrohim, 2012; Ridlo, 2020).

Geothermal Energy Utilization

In Indonesia, efforts to exploit geothermal energy as a fuel source for power plants began thirty-five years ago. Its growth, however, is very sluggish, averaging only 7 (seven) percent year between 2016 and 2021. based on information from the Directorate General of Energy Conservation and New and Renewable Energy, (IEA, 2019) from 28.5 GW of potential geothermal energy resources in Indonesia, the utilization of geothermal fluid until 2021 has only reached 2.29 GW or 30.6 percent of the geothermal contribution as targeted in the National Energy General Plan, which is 7.2 GW of 45.2 GW of New Renewable Energy to be achieved by 2025. This means that a large investment is still needed to generate geothermal electricity with an additional installed capacity of 5 GW in approximately 4 years (Loksha, 2002). Of course, the investment cannot be done all at once. Ideally, it should be encouraged gradually so that the contribution target can be achieved. Utilizing geothermal as a clean energy transition has a rationality that is in line with the government's goals in its commitment to provide clean and environmentally friendly energy (Wachowicz-Pyzik et al., 2015).

The development and realisation of local energy independence also depend on the use of geothermal energy because it is an energy source that cannot be distributed, is more dependable than fossil fuels due to the fact that GPPs can operate for up to 30 years without the need for fuel, does not depend on the season or be intermittent, and has the highest availability factor level of 90–95 percent. Additionally, compared to emissions from coal, natural gas, oil, and diesel, CO_2 emissions are far lower at only 75 g/kg.

The government has demonstrated its commitment through Presidential Regulation No. 14/2017 on Accelerating the Development of Electricity Infrastructure and Presidential Regulation No. 56/2018 on Accelerating the Implementation of National Strategic Projects. The commitment is based on data from the International Energy Agency (IEA) (Dewi et al., 2022) which states that by 2030 the world's electricity demand is expected to increase by 1.6 percent per year in developed countries and 65 percent per year in developing countries starting in 2020, including Indonesia with a share of 36 percent of total energy use in Southeast Asia. Electricity demand in Indonesia is projected to reach 2,214 TWh under the Business as Usual (BaU) scenario, 1,918 TWh under the Sustainable Development (SD) scenario, and 1,626 under the Low Carbon (RK) scenario by 2050, an increase of almost nine times from the 2018 electricity demand of 254.6 TWh (Allahvirdizadeh, 2020).

Identification of Barriers to Geothermal Invests

The Indonesian government estimates that by 2025, geothermal energy would account for around 5.2% of the country's total energy mix, or 7.32 GW, according to the National Energy Management Blueprint 2006–2025 (Sharmin et al., 2023). But in 2023, actual installed geothermal capacity only came to 2.38 GW or 32.52% of the installed capacity that was originally anticipated. Over the previous seven years, Indonesia has added less than 1 GW of GPPs capacity. This is consistent with the fact that over the past few years, developers have not found geothermal working area auctions to be sufficiently alluring to participate in. Fourteen geothermal working zones were put up for auction between 2017 and 2019, but not a single person participated. The government held no geothermal working area auctions in 2020 or 2021 (Soltani et al., 2021).

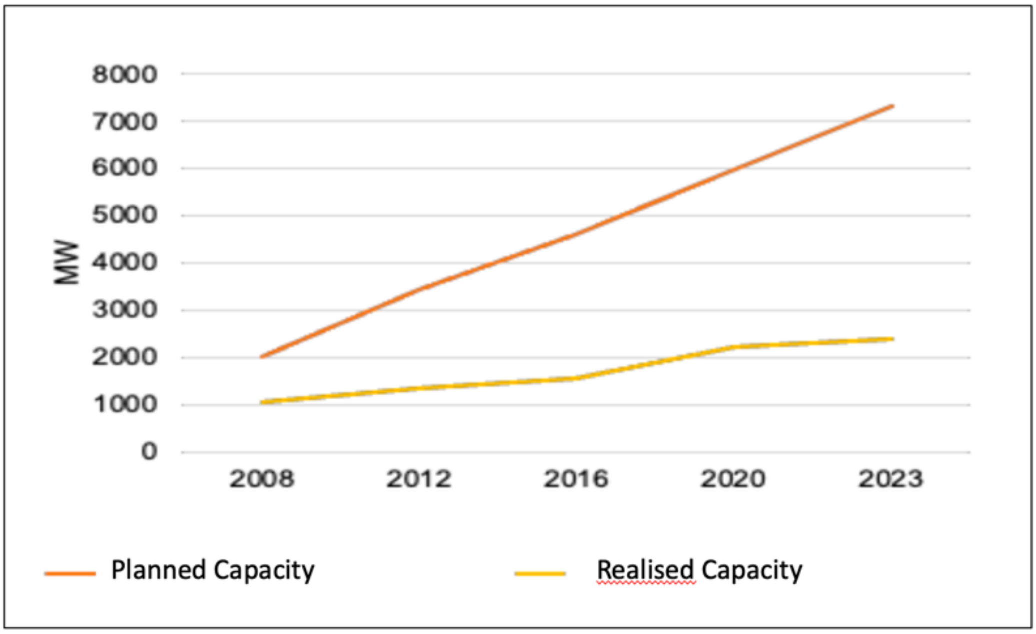

Figure 3 GPPs Capacity Planned in the National Energy Management Blueprint 2006-2025 and Realized Installed Capacity
Source: (Kementerian Energi dan Sumber Daya Mineral, 2005)

In order to meet the goals, the government must create an investment-friendly environment by enacting laws and policies that correctly account for the unique risks and features of the geothermal industry. The geothermal industry entails a number of dangers, which can arise at any point during the exploration and operation phases (Qurrahman et al., 2021). These hazards include issues with finances, resources, governance, and regulations. The several hazards that geothermal developers may encounter and how they affect the long-term viability of investment in this field will be covered in this section.

Resource Barriers

The most significant risk and what sets geothermal development apart from other renewable energy projects like wind, solar, hydro, and biomass is the exploratory stage. This risk has a direct correlation with capital expenses and the likelihood of a major collapse. In Indonesia, the success rate of geothermal wells during their discovery phase is roughly 50%; if more wells are dug, this percentage might rise to roughly 59% (Stringfellow & Dobson, 2021).

There are immediate hazards associated with exploration, including as the possibility that drilling won't yield geothermal resources that can be used for economic purposes. Long-term risks also exist, such as the possibility of resource depletion, which could make the project economically unprofitable. The unknown nature of the resources beneath the surface presents one of the biggest obstacles throughout the exploration phase (McClean & Pedersen, 2023). Indirect and sparse data are frequently obtained from preliminary surveys like geology, geochemistry, and geophysics, which are typically carried out at the surface. Because of this, it is challenging for developers and investors to decide what to invest in, particularly when considering the high capital expenditures of exploration drilling based on incomplete knowledge.

Another crucial factor arising from exploration risk is the probability of finding geothermal proven reserves that are less than satisfactory or even do not reach economic viability. In many cases, developers are faced with a situation where the discovered reserves fall short of expectations, forcing them to drill additional exploration wells, with major financial implications for the project (McClean & Pedersen, 2023).

Financial Barriers

Financial risk is closely related to the capability of a company to generate sufficient cash flow to meet financial obligations,(Abidin et al., 2020) such as paying interest or repaying debt. Projects with relatively high levels of debt financing carry greater financial risk along with a greater likelihood of project cash flows being unable to meet financial obligations.

Figure 4 shows the risk profile of a geothermal project and its relationship with bankability. In the early stages, which include preliminary surveys and exploration, project risks tend to be very high, at around 90-95%. Therefore, the ideal main funding sources at this stage include government funding, grants, and private equity funds (Karayel et al., 2022). At the next stage, which is exploration drilling involving infrastructure development and well testing, risks range from moderate to high (50-90%). At this stage, the main funding should ideally come from private equity (Nasruddin et al., 2016). As the project phase progresses, especially as it approaches commissioning and operations, the bankability of the project increases. This broadens the financing options, enabling access to more diverse sources of commercial funds (ESMAP, 2012).

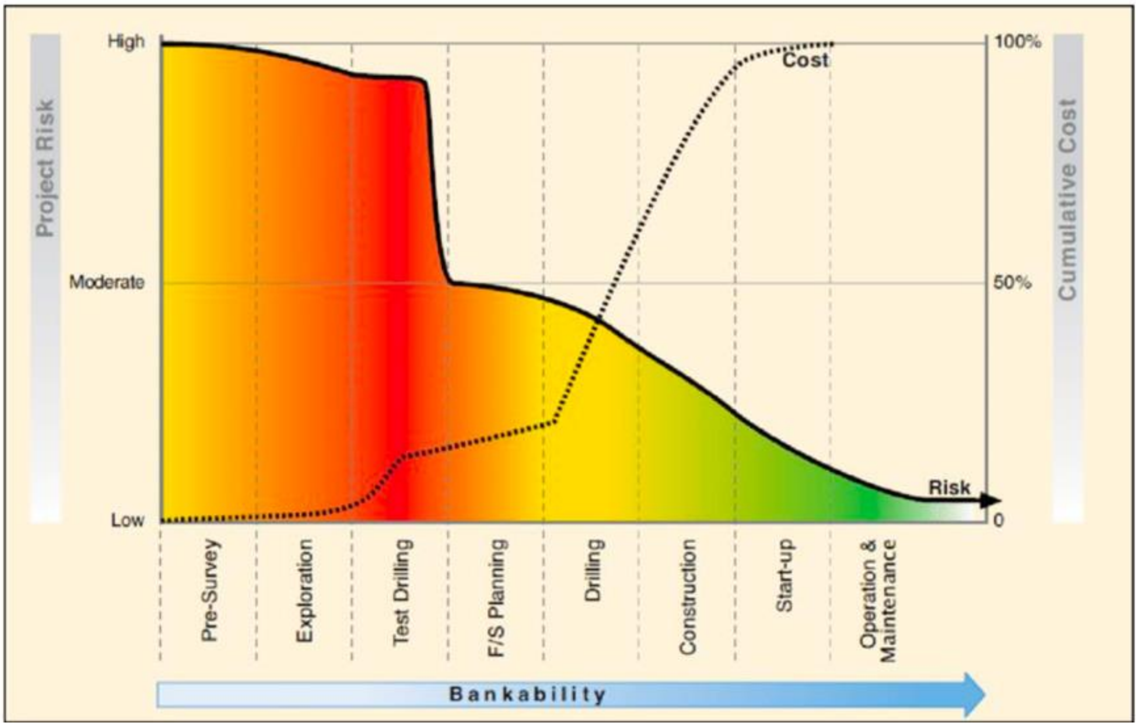

Figure 4 Cost and Risk Profile of Geothermal Projects at Various Stages of Development
Source: (World Bank, 2012)

Before making an investment, a geothermal investor generally expects the availability of commercial geothermal reserves, attractive geothermal energy prices, guaranteed payment by the buyer and adherence to the Long-Term Energy Sales Contract (Yudha et al., 2022). If several factors have been met, the geothermal project will be feasible and bankable. Feasible means that the project is feasible, while bankable means that the project will easily obtain loans from banks or other managers.

An attractive thermal energy price is a price that can generate a long-term rate of return in accordance with the risks faced. The rate of return on an investment is measured through profitability indicators called Internal Rate Return (IRR). Meanwhile, from the investor's point of view, it must use the Discounted Cash Flow Rate of Return (DCF-ROR) method. Thus, the price of geothermal energy is site specific, which is highly dependent on the characteristics of the geothermal reservoir, the location of the geothermal area, the difficulty factors above and below the surface and the success of geothermal well drilling. The price of geothermal energy is also influenced by project risk. Project risk on the upstream side (geothermal field recovery) is higher than on the downstream side (geothermal power plant development), because the upstream side faces scope of project risk and investment cost overrun risk. Basically, the price of geothermal energy follows the rule of "high risk high return", which means that the risk of a project is high and investors will demand a high IRR.

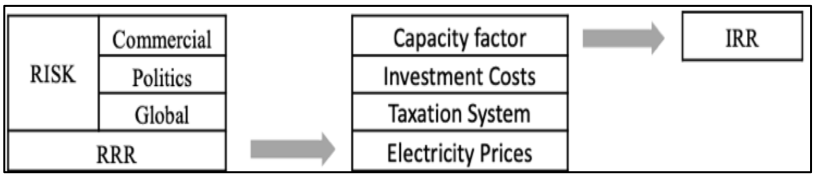

Figure 5 Key Factors Affecting Geothermal Project IRR
Source: (ESMAP, 2012)

Key factors (production period, capacity factor, investment cost, taxation system and electricity price) will affect the IRR of geothermal projects, while the IRR is set by the company based on the risk-free gate and project risk premium. The higher the risk of a project, the higher the Required Rate of Return (RRR) set by the company and the geothermal electricity price set to make the project feasible, because the IRR must ≥ RRR. The risk of geothermal projects (especially the upstream sector) is high, so foreign investors set the RRR at no less than 16%.

Regulatory Barriers

Several risks and obstacles in the context of regulation and governance faced by geothermal developers in carrying out their projects can be identified, namely:

1. The power purchase price will only become binding after the signing of the Power Purchase Agreement (PPAs).

Minister of Energy and Mineral Resources Regulation 37/2018 requires PLN to submit to the Minister of ESDM: (i) a proposed power purchase price to be approved by the Minister of Ministry of Energy and Mineral Resources, (ii) a model power purchase agreement (PPAs), and (iii) a pre-transaction agreement for the auction. However, according to the developers, negotiations with PLN on the power purchase price only take place after the exploration stage, indicating that the pre-transaction price is not binding. This situation carries risks for developers who have to incur the costs of exploration and preparation of feasibility studies in advance. In contrast, in the past, before Minister of Energy and Mineral Resources Regulation 37/2018 was enacted, PPAs were signed before the exploration stage, providing certainty on the power purchase price (Fahmi et al., 2022). The PPA negotiation process also often takes 2-3 years before reaching an agreement, which makes it difficult for financing institutions that require cash flow guarantees from Geothermal projects. This scheme makes it difficult for entrepreneurs to move because exploration requires large costs that are expected to be handled by financing institutions. In addition, developers also have difficulty in determining the budget because they only have indicative prices that are not fixed as a reference.

2. Difficulty in fulfilling the obligation of Domestic Content Level (DCL)

Geothermal Permit holders are faced with a series of regulations that encourage the utilization of local resources and capabilities. As stipulated in Article 94 of Government Regulation No. 7/2017, Geothermal License holders are required to prioritize the use of domestic goods, services, technology, and engineering and design capabilities. The obligation of Domestic Content Level for Geothermal Power Plants (PPAs) is also reinforced through Minister of Industry Regulation 54/2012(Shelare et al., 2023). This provision poses a risk to developers, as many components of geothermal power plants are not available in the local market. This makes it difficult for developers to meet the Domestic Content Level (DCL) standards set. Based on an assessment conducted by one developer, the capacity of the domestic industry to provide GPPs components has only reached 24% of the 33% proportion specified.

3. Mismatch of government incentives

The government has provided several facilities to developers to support geothermal development efforts. However, according to developers, in practice, the provision of these facilities and incentives is often not fully appropriate or effective in supporting the sustainability of the geothermal development business. One example of the incompatibility of incentives felt by developers is Law No. 36/2008 which provides taxpayers who make investments in certain business fields and / or certain regions with tax facilities in the form of loss compensation for a maximum of 10 years. In fact, at that time, companies usually have not reached the break-even point, so the incentives cannot be utilized. According to several developers, examples of support that are more desirable are the exemption of PBB obligations such as in oil and gas exploitation, reduction of VAT, Income Tax, waivers of exploration costs, Borrow-to-Use Permits for Forest Areas, as well as the return of facilities for opening access to locations by the government that were previously implemented.

Conclusion, Recommendations, and Limitation

The survey results from the National Energy Management Blueprint 2006-2025 highlight that the Government of Indonesia planned for geothermal energy to contribute approximately 5% of the national energy mix, or around 7.32 GW by 2025. However, as of 2023, the installed capacity of geothermal power plants (GPPs) only reached 2.38 GW, which is merely 32.52% of the targeted capacity. This gap between targets and realization underscores the significant challenges in scaling up geothermal energy development in Indonesia, such as regulatory hurdles, financial constraints, and a less favorable investment climate.

Despite the abundant geothermal potential, the underachievement reveals that more strategic actions are needed to boost geothermal capacity and align with the national energy targets. The low realization rate threatens Indonesia's broader energy transition goals and limits the diversification of the national energy mix towards more sustainable sources.

Following on the result, there are several recommendations for follow up. The Indonesian Government should astengthen policies and regulations that support the development of geothermal energy. Consistent and clear policies will provide certainty for investors and encourage them to invest in geothermal projects. In, addition it is also necessary to provide attractive incentives for investors, such as tax deductions, subsidies, to increase the attractiveness of investment in the geothermal sector.

The main limitation is the need for primary sources or related academic articles. Data and information on geothermal potential in some areas may be incomplete or inaccurate, which could affect project planning and development.

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