A HOLISTIC OVERVIEW: INDONESIA'S GEOTHERMAL ENERGY ENCOURAGES GEOTHERMAL POWER PLANT INVESTMENT IN SUPPORT OF NATIONAL DEFENSE

TINJAUAN HOLISTIK: ENERGI PANAS BUMI INDONESIA MENDORONG INVESTASI PEMBANGKIT LISTRIK PANAS BUMI UNTUK MENDUKUNG PERTAHANAN NASIONAL

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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. 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, the lack of bids in PLN's most recent procurement from 2021 requires more than the maximum electricity tariff. 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 to support national defense. The method used is descriptive qualitative, which relies on literature studies that discuss appropriate issues. The National Energy Management Blueprint 2006-2025 presents the survey results. 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 percent 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: Geothermal Power Plant, geothermal, investment, renewable energy, regulatory

Abstrak- Cincin Api Pasifik melintasi wilayah Indonesia secara fisik, dan aktivitas vulkanik serta tektonik yang intens di Indonesia telah menghasilkan sumber daya panas bumi yang melimpah, diperkirakan mencapai 23,46 GW, tersebar di 357 lokasi. Untuk mendorong dekarbonisasi pasokan listrik Indonesia dan pengembangan energi panas bumi, pemerintah Indonesia menerbitkan Peraturan Presiden No. 112/2022 tentang Percepatan Pengembangan Energi Baru dan Terbarukan untuk Penyediaan Tenaga Listrik pada tahun 2022. Untuk memberikan insentif kepada PLTP agar berinvestasi, kekurangan penawaran dalam pengadaan terbaru PLN sejak 2021 membutuhkan tarif listrik yang melebihi batas maksimum. Penelitian ini bertujuan untuk menilai investasi panas bumi di Indonesia serta mengurangi ketergantungan pada bahan bakar fosil, yang rentan terhadap fluktuasi harga dan pasokan. PLTP memastikan pasokan energi yang konsisten untuk kebutuhan nasional guna mendukung pertahanan negara. Metode yang digunakan adalah deskriptif kualitatif dengan menggunakan studi literatur yang membahas isu-isu terkait. Cetak Biru Pengelolaan Energi Nasional 2006-2025 memaparkan hasil survei. Pemerintah Indonesia menargetkan energi panas bumi untuk berkontribusi sekitar 5% dari bauran energi nasional atau sekitar 7,32 GW pada tahun 2025. Namun, realisasi kapasitas terpasang pembangkit listrik panas bumi hingga tahun 2023 baru mencapai 2,38 GW, atau 32,52 persen dari kapasitas yang direncanakan. Melalui Kementerian Energi dan Sumber Daya Mineral, pemerintah perlu menaikkan harga pembelian listrik dari IPP PLTP guna menciptakan iklim investasi yang kondusif dan mendorong pertumbuhan industri panas bumi.

Kata kunci: Pembangkit Listrik Tenaga Panas Bumi, panas bumi, investasi, energi terbarukan, regulasi

Introduction

Geothermal energy, a clean and renewable energy source, has been used since ancient times in various parts of the world. This energy can be utilized for various purposes and methods depending on the variety of resources and technologies available. 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. The transformation in the energy sector is essential, as most greenhouse gas emissions come from this sector. As researchers, policymakers, and environmentally conscious individuals, your role is crucial in this transition.

Renewable energy sources, including clean and environmentally friendly geothermal energy, play a vital role in this process. Issues related to the efficient utilization of geothermal energy are devoted to the Special Edition of Energy under the title Geothermal Systems. Using renewable energy sources presents several benefits, including varying fuel blends, decreasing air and environmental pollution, actively promoting sustainable economic growth, and resolving the energy accessibility issue (Nezhnikova et al., 2018).

As an environmentally friendly and renewable resource, geothermal energy plays a crucial role in reducing carbon emissions in Indonesia's energy sector, especially in the power sector. It is imperative to recognize and integrate geothermal power generation into the electricity infrastructure for several reasons. First, geothermal can serve as a baseline resource with a remarkably high capacity, reaching 90-95%, and has a minimal environmental impact, making it a sustainable replacement for coal in the electricity supply (Spada et al., 2021).

From an economic standpoint, geothermal energy stands out as a viable competitor to other fossil energy sources, such as oil and gas, especially when high quality resources are utilized efficiently (Khankishiyev et al., 2024; Kushnir & Loewer, 2020).

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 entirely removed and externality costs are applied (RPS, 2023). Geothermal energy, being produced domestically, can significantly reduce dependence on fuel imports, improve energy security, and be free from the risk of fossil fuel price fluctuations and supply uncertainties. 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 et al., 2018). Geothermal energy's efficiency is a testament to its viability and potential, making it an impressive and convincing option for our energy needs (Tester et al., 2021).

Indonesia, a country along the Pacific Ring of Fire, is known for its high tectonic and volcanic activity, which has led to the discovery of abundant geothermal resources. These resources, with a potential capacity of 23,46 GW, are spread across 357 locations, as reported by Humas EBTKE in 2022.

By 2021, Indonesia's geothermal reserves were estimated at 12,4 GW, with significant distributions in key regions such as Sumatra, Java, Nusa Tenggara, Kalimantan, Papua, and Sulawesi, as shown in Table 1. These reserves, categorized into probable (9.547 MW), suspected (1.770 MW), and proven (3.104,5 MW), with the latter primarily concentrated in Java and Sumatra, as per Moraga et al. in 2022, provide a comprehensive view of Indonesia's geothermal potential (Moraga et al., 2022).

Table 1. Distribution of Indonesia's Potential Geothermal Reserves

Island	Number of Points	Potential (MW)				
		Resource		Reserve		
		Speculative	Hypothetical	Possible	Probable	Proven
Sumatera	101	2.276	1.551	3.294	976	1.120
Jawa	75	1.259	1.191	3403	377	1.820
Bali & Nusa Tenggara	40	295	169	996	231	42,5
Kalimantan	14	151	18	6	0	0
Sulawesi	91	1.365	343	1.063	180	120
Maluku	33	560	91	485	6	2
Papua	3	75	0	0	0	0
Total	357	5.981				

Source: Kementerian ESDM, 2022

With such high potential, geothermal energy is one of the primary 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 efforts and 43,20 percent with crucial 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 shown in Figure 1, the growth in the installed capacity of geothermal power plants (GPPs) in Indonesia from 2011 to 2022 has been a key driver of the increase in the Generation Mix Contribution. The capacity, which was initially around 1.200 MW in 2011, experienced a slight decline in 2013 and 2014 but increased significantly from 2015 to reach more than 2.000 MW in 2022. The Generation Mix Contribution, shown in orange, fluctuated between 2011 and 2015, with a decline from 3% to below 2,6%. However, this contribution increased gradually after 2015, reaching around 3,5% in 2022, in sync with the growth in installed capacity (Ministry of Energy and Mineral Resources Republic Indonesia, 2022).

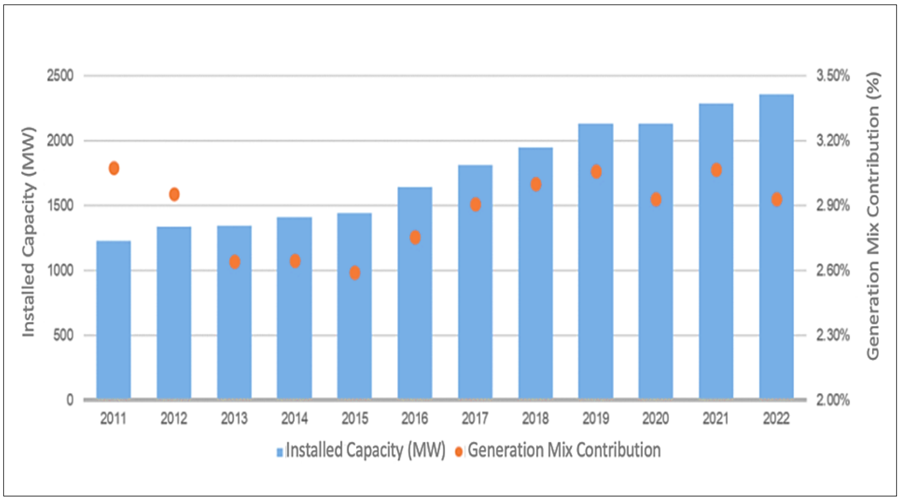

Figure 1. Installed GPPs Capacity and Energy Mix Contribution
Source: Ministry of Energy and Mineral Resources Republic Indonesia, 2022

The meticulously prepared long-term plans for geothermal energy development, crafted by various government agencies, present us with a formidable challenge. These plans set forth incredibly ambitious targets that when compared to our current achievements, highlight the urgent need for our mission in geothermal energy development.

Figure 2 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 Indonesia, 2021).

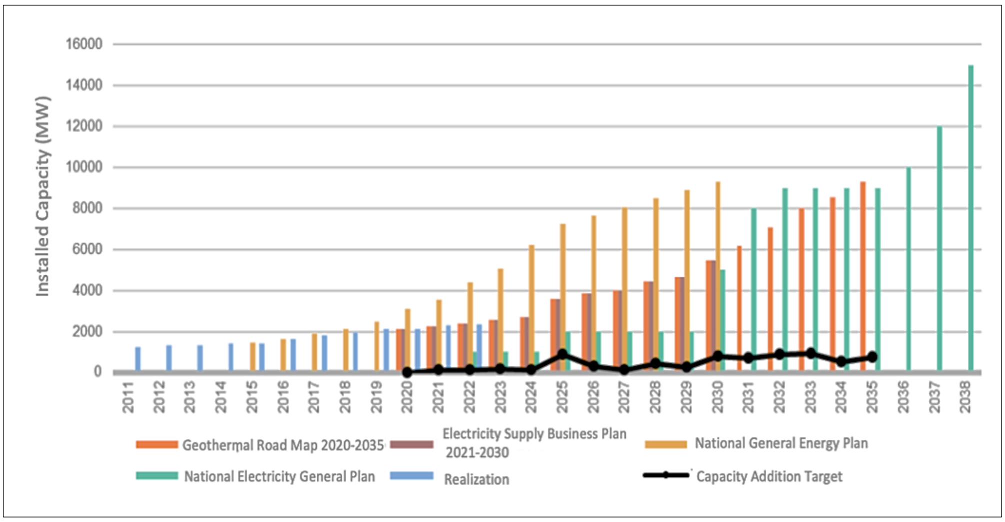

Figure 2. Comparison of Target and Realization of GPPs Installed Capacity
Source: Ministry of Energy and Mineral Resources Republic Indonesia, 2022

Figure 2 illustrates the promising trajectory of geothermal energy targets post-2025, underscoring its potential as a pivotal element of Indonesia's energy landscape. This aligns with the nation's aspirations for sustainability and carbon emission reduction. The gap between projected and actual targets signals potential hurdles in policy execution, investment, technology deployment, or other areas, but it also underscores the vast potential for growth and development in the geothermal sector.

The establishment of geothermal power plants (GPPs) in Indonesia is not without its challenges. PLN grapples with a complex issue of setting competitive electricity prices, as it must navigate the delicate balance between the demand for affordable electricity and the necessity to procure power at lower costs. Simultaneously, GPP developers are confronted with a series of regulatory, technical, and financial obstacles, all of which influence the prices they can propose to PLN.

Geothermal projects are not short-term endeavors. They span a broad horizon, encompassing the exploration, exploitation, and utilization phases, which can extend up to forty years. This long-term commitment is a key factor in the attractiveness of geothermal projects to investors, including those with a politically exposed Profile.

In 2022, the Government of Indonesia issued Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply. This initiative is of utmost importance as it aims to encourage decarbonization in Indonesia's electricity system and promote 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.

The challenges to geothermal investment extend beyond pricing issues. It's important to understand that several regulatory barriers need to be addressed. Despite improvements in procurement schemes for geothermal projects, they have yet to significantly encourage investment, mainly due to uncertainties in the procurement process, such as negotiating power purchase agreements (Barich et al., 2022).

A comprehensive approach that considers regulatory, financial, technical, and environmental factors is necessary to navigate the complexities of geothermal power projects. This understanding of the complexities of geothermal power projects will equip us to tackle the obstacles, from uncertain electricity purchase prices to complicated licensing processes, with a multifaceted solution.

Barich et al. (2022) emphasize the importance of formulating policy recommendations as a proactive approach to improving the investment climate and accelerating the development of geothermal energy in Indonesia. This study, with its comprehensive review, not only provides a nuanced understanding of the challenges and opportunities but also equips the audience with actionable solutions to drive the growth of this vital sector. It also has the potential to catalyze sustainable energy development and contribute to Indonesia's energy and environmental security goals, ensuring that the audience feels informed and knowledgeable.

Methods

This study employs a thorough descriptive analysis and literature study approach, utilizing sources from scientific journals, books, and relevant government reports (Moleong, 2007). We assess the authorship and validity of sources based on the type of reference by observing how frequently the work appears in other literature, ensuring the reliability of our findings.

The focus is on a comprehensive evaluation of Indonesia's geothermal investment, to assess Indonesia's geothermal investment and reduce dependence on fossil fuels. This shift can lead to a more stable energy supply, less vulnerability to price and supply fluctuations, and a more sustainable future.

Results 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, a crucial stage, commences with the WKP auction, the issuance of the Geothermal License by the Directorate of Geothermal, and the signing of the Pre-Transaction Agreement (PTA). The development phase then progresses through project exploration until the Power Purchase Agreement (PPA) is reached.

Furthermore, the development phase encompasses the creation of the GPPs, field development activities (exploitation), and the issuance of the Electricity Supply Business Licence for Public Interest (IUPTLU) (Enel Green Power, 2021). The operation phase, the final stage of GPP project development, is a period of significant responsibility for the developer. It involves the implementation of operation and maintenance activities, demonstrating the developer's commitment to the project's ongoing success.

GPPs Investment in Support of National Defense

Using geothermal energy to construct a thermal power plant (PLTP) can significantly contribute to national energy security and support national defense. PLTP provides a stable and sustainable energy source and reduces Indonesia's dependence on imports of fossil fuels (Fatahillah et al., 2022; Widrian et al., 2022).

Maintaining a reliable energy supply is essential, especially for military and strategic installations requiring uninterrupted electricity (Widrian et al., 2022). Using 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 can survive supply disruptions and attacks on energy infrastructure (Al Hakim, 2020; Nurrohim, 2012).

Geothermal Energy Utilization

In Indonesia, efforts to exploit geothermal energy as a fuel source for power plants began thirty-five years ago. Growth is still slow, averaging only seven percent annually between 2016 and 2021. This figure reflects the challenges faced in developing renewable energy in Indonesia, primarily related to investment, unsupportive policies, and inadequate infrastructure (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. A significant investment is still needed to generate geothermal electricity with an additional installed capacity of 5 GW in approximately four years (Gehringer & Loksha, 2012).

Investment can only be made in stages. Ideally, it should be encouraged gradually to achieve the contribution target. Utilizing geothermal as a clean energy transition has a rationality that aligns with the government's goals in its commitment to provide clean and environmentally friendly energy (Wachowicz-Pyzik et al., 2017).

The development and realization of local energy independence also depend on the use of geothermal energy because it is an energy source that cannot be distributed, and more dependable than fossil fuels because 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 coal, natural gas, oil, and diesel emissions, 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), 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 (Dewi et al., 2022).

The Business as Usual (BaU) scenario projects Indonesia's electricity demand to reach 2.214 TWh, the Sustainable Development (SD) scenario 1.918 TWh, and the Low Carbon (LC) scenario 1.626 TWh by 2050, representing an almost nine-fold increase from the 2018 electricity demand of 254,6 TWh (Allahvirdizadeh, 2020).

Identification of Barriers to Geothermal Investments

The Indonesian Government estimates that by 2025, geothermal energy will 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). However, in 2023, the installed geothermal capacity only came to 2,38 GW or 32,52% of the installed capacity initially anticipated.

Over the previous seven years, Indonesia has added less than 1 GW of GPP capacity. This is consistent with the fact that developers have yet to find geothermal working area auctions sufficiently alluring over the past few years. Between 2017 and 2019, the Government auctioned 14 geothermal working zones, but no one participated. The Government held no geothermal working area auctions in 2020 or 2021 (Soltani et al., 2021).

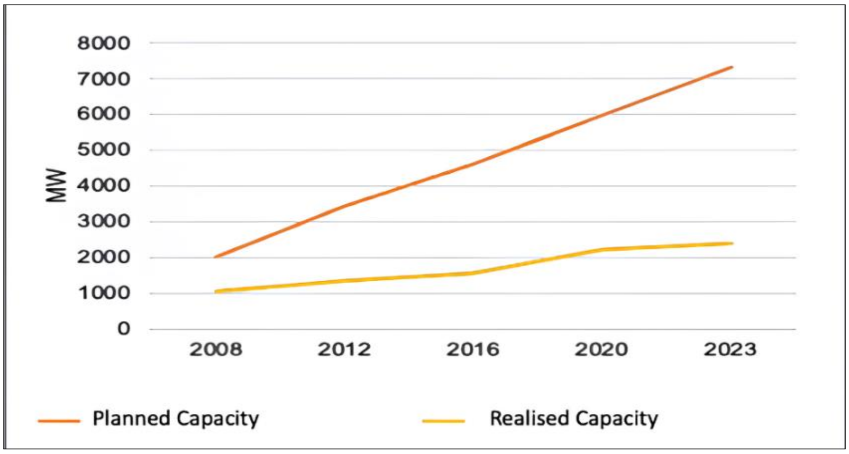

Figure 3 GPPs Capacity Planned in the National Energy Management Blueprint 2006-2025 and Realized Installed Capacity
Source: Kementerian Energi dan Sumber Daya Mineral, 2005

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 several 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. This section will discuss the various hazards that geothermal developers may face and their impact on the long-term profitability of investing in this field.

Exploration and Resource Risk in Geothermal Development

The exploratory stage, while posing significant risks, also holds the potential for substantial success, setting geothermal development apart from other renewable energy projects like wind, solar, hydro, and biomass. This risk stems from capital expenditures and the potential for substantial project failure. In Indonesia, approximately 50% of geothermal wells succeed during exploration. However, additional drilling could increase this rate to about 59% (Stringfellow & Dobson, 2021). It's important to acknowledge these challenges and proceed with caution and thorough planning.

Exploration not only poses immediate hazards, such as the risk that drilling will not yield geothermal resources for economic purposes, but also long-term risks. These include the potential for resource depletion, which could render 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).

Preliminary surveys such as geology, geochemistry, and geophysics, typically conducted at the surface, often yield indirect and sparse data. This lack of comprehensive information makes it challenging for developers and investors to make informed decisions, particularly when considering the high capital expenditures of exploration drilling. This underscores the need for further research and investment in this area.

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 encounter reserves that do not meet expectations, forcing them to drill additional exploration wells, significantly impacting the project's financial viability.

Financial Risks and Funding Sources for Geothermal Projects: From Exploration to the Operational Stage

The ability of a company to generate sufficient cash flow to meet financial obligations, such as paying interest or repaying debt, closely correlates with financial barriers (Abidin et al., 2020). Projects with relatively high levels of debt financing carry a higher level of financial risk and a higher likelihood of project cash flows being unable to meet financial obligations.

Figure 4 illustrates 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 project's bankability increases. This not only reinforces the project's financial sustainability but also broadens the financing options, enabling access to a more diverse range of commercial funds (ESMAP, 2012). This increasing access to diverse funding sources should instill confidence in the project's financial sustainability.

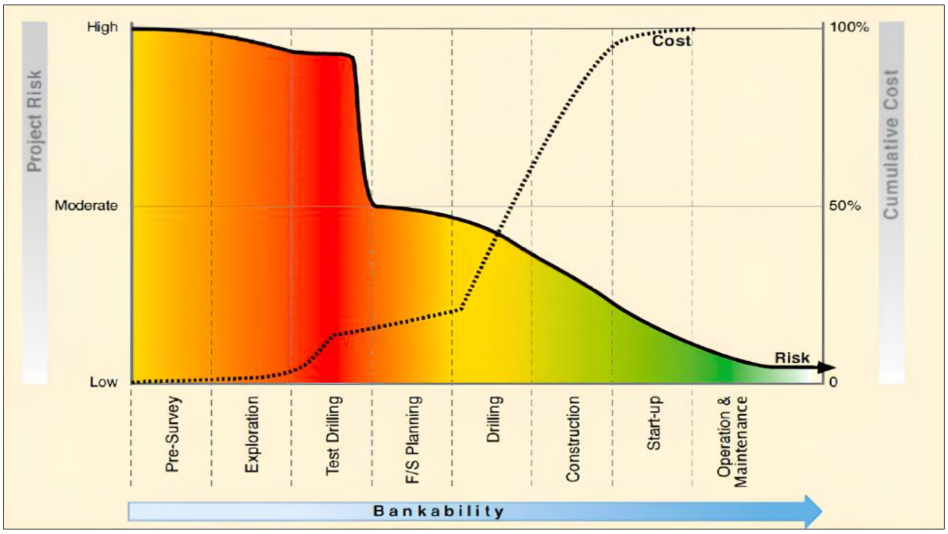

Figure 4. Cost and Risk Profile of Geothermal Projects at Various Stages of Development
Source: ESMAP, 2012

Before investing, a geothermal investor generally expects the availability of commercial geothermal reserves, attractive geothermal energy prices, guaranteed payment by the buyer, and strict adherence to the Long-Term Energy Sales Contract (Yudha et al., 2022). The geothermal project will be feasible and bankable if several factors are met. Feasible means the project is viable, while bankable means that the project will quickly obtain loans from banks or other managers.

An attractive thermal energy price can generate a long-term rate of return from the risks faced. Profitability indicators known as Internal Rate Return (IRR) measure the rate of return on investment. Meanwhile, from the investor's point of view, the Discounted Cash Flow Rate of Return (DCF-ROR) method must be used. 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. Project risk also influences the price of geothermal energy. 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. The price of geothermal energy follows the rule of "high risk, high return," which means that a project's risk is high, and investors will demand a high IRR.

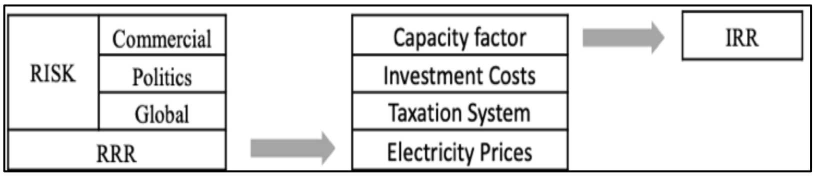

Figure 5. Key Factors Affecting Geothermal Project IRR
Source: ESMAP, 2012

The IRR of geothermal projects is determined by key factors such as the production period, capacity factor, investment cost, taxation system, and electricity price. The company sets the IRR based on risk-free and project risk premiums. As the project risk increases, the Required Rate of Return (RRR) set by the company also rises. To ensure project feasibility, the geothermal electricity price is set at a level that guarantees the IRR is greater than or equal to the RRR. Given the high risk associated with geothermal projects, particularly in the upstream sector, foreign investors typically set the RRR at no less than 16%.

Geothermal Project Regulation and Governance: Electricity Purchase Agreement Risk

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 signing the power purchase agreements (PPAs).

Regulation 37/2018 of the Minister of Energy and Mineral Resources requires PLN to submit three items to the Minister of ESDM: (i) a proposed power purchase price for approval, (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 occur after the exploration stage, indicating that the pre-transaction price is not binding. This situation poses risks for developers, who must incur the costs of exploration and preparation of feasibility studies in advance. In contrast, before enacting Minister of Energy and Mineral Resources Regulation 37/2018, developers signed PPAs before the exploration stage, ensuring certainty on the power purchase price (Fahmi et al., 2022).

The PPA negotiation process, which often takes 2-3 years before reaching an agreement, is a result of the complex nature of geothermal projects. This complexity, which includes technical, regulatory, and financial aspects, makes it difficult for financing institutions that require cash flow guarantees. This scheme also poses challenges for entrepreneurs, as exploration requires high costs expected to be handled by financing institutions. In addition, developers also have difficulties 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 utilizing local resources and capabilities. As stipulated in Article 94 of Government Regulation No. 7/2017, Geothermal License holders must 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 unavailable in the local market. This makes it difficult for developers to meet the Domestic Content Level (DCL) standards set. It's crucial to note that the development of the domestic industry is key to meeting these standards. Based on an assessment conducted by one developer, the capacity of the domestic industry to provide GPP's 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. However, by implementing more desirable support such as the exemption of PBB obligations, 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, we can create a more hopeful future for the geothermal industry.

Conclusion, Recommendations, and Limitations

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. These challenges include regulatory hurdles such as complex permitting processes and land use issues, as well as financial constraints like high upfront costs and long payback periods, and a less favorable investment climate due to perceived risks and uncertainties.

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 not only threatens Indonesia's broader energy transition goals by delaying the shift towards more sustainable sources, but also limits the diversification of the national energy mix. This could lead to overreliance on traditional energy sources, making the energy sector more vulnerable to price fluctuations and supply disruptions.

Following on the result, there are several recommendations for follow up. The Indonesian Government, along with the energy industry professionals and policymakers, should play a crucial role in strengthening 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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