Powering Malaysia's Future with Geothermal Inspiration from Southeast Asia

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ABSTRACT

Geothermal energy is a highly advantageous renewable energy source for countries on the Pacific Ring of Fire, including Malaysia. From 2008 to 2009, the Minerals and Geoscience Department discovered a promising geothermal well in Apas Kiri, Tawau, Sabah, which could potentially provide a significant renewable energy source for the country. However, Malaysia faces several challenges in adopting geothermal energy, including regulatory constraints, technical difficulties, and economic factors. This paper aims to explore these obstacles and discuss the importance of renewable energy in Malaysia's energy mix. To gain a comprehensive insight into the challenges preventing Malaysia from fully embracing geothermal energy, it is helpful to examine the experiences of countries such as the Philippines and Indonesia, which have already established geothermal wells. By comparing these nations' approaches and strategies, we can identify potential barriers to geothermal energy development in Malaysia and explore the reasons for such obstacles. Such a comparative analysis can provide valuable insights and inform policy decisions promoting sustainable energy development in Malaysia.

Keywords: geothermal energy, regulatory constraints, technical difficulties, economic factors.

INTRODUCTION

The global energy landscape is undergoing a paradigm shift driven by the pressing need to address climate change. In this context, clean and sustainable sources like geothermal energy have become crucial alternatives to traditional fossil fuels. Geothermal energy is harnessed by drilling deep wells into Earth's geothermal reservoirs, extracting hot water or steam, transferring heat to a secondary fluid through a heat exchanger, and using the vaporised secondary fluid to drive turbines connected to electricity generators. Then, the cooled secondary fluid is re-injected into the reservoir to complete the cycle (Department of Energy, 2024). Geothermal energy boasts immense potential as a reliable baseload renewable resource, offering consistent power generation independent of weather conditions (United Nations, 2024).

Malaysia's potential to expand geothermal energy is vast and immense. It can be seen by identifying multiple hot springs throughout Peninsular Malaysia. Hot springs are found in areas with active hydrothermal systems, indicating potential for geothermal energy exploitation (Geological Society of Malaysia, 2024). Hot springs have been successfully used to generate geothermal energy in various nations, including Iceland, Italy, Japan, New Zealand, the Philippines, Turkey, and the United States. These resources were initially used for direct heating but are now increasingly used to generate power. Figure 1.0 below shows the hot springs locations around Peninsular Malaysia that could be identified as potential for geothermal exploration.

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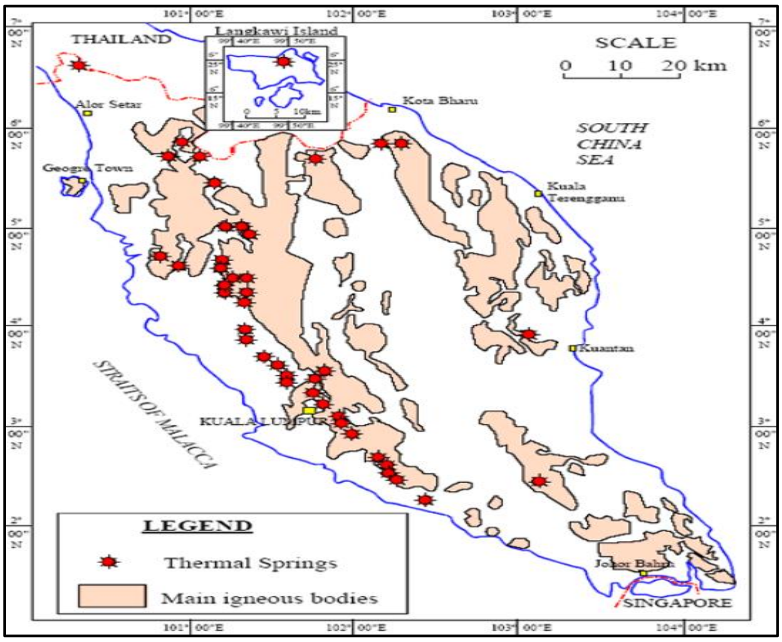

Figure 1.0: Hot spring locations in the Peninsula Malaysia (Sum et al., 2010)

In recent decades, Malaysia's energy landscape has undergone significant transformation. Traditionally reliant on fossil fuels, the country has diversified its energy sources to include renewable alternatives such as hydropower and solar energy. Malaysia's abundant natural resources offer significant potential for sustainable and clean energy production, mainly through geothermal sources (Le et al., 2022). In alignment with global climate change mitigation efforts, the Malaysian government has pledged to enhance its reliance on carbon-neutral energy. Recently, they elevated the national renewable energy target from 20% to 31% by 2025. This commitment reflects a proactive step toward a greener and more environmentally conscious future. In 2016, Malaysia is actively exploring adopting geothermal energy, focusing on the states of Sabah and Sarawak due to their substantial energy potential (Richter, 2016). Despite its inherent advantages, geothermal energy adoption in Malaysia remains considerably lower compared to neighbouring Southeast Asian nations like Indonesia and the Philippines (Mesina, 2017).

Exploration and development of geothermal energy resources in Indonesia can be difficult and time-consuming. The country's vast archipelago and complex geology make it challenging to find and exploit geothermal resources, resulting in high exploration costs and unclear returns on investment. In Indonesia, geothermal exploration and exploitation activities are regulated by Law No. 21 of 2014 concerning Geothermal Energy and Government Regulation No. 7 of 2017 concerning Indirect Utilization of Geothermal Energy (Law 21/2014, 2014) New Geothermal Law. It includes a spectrum of regulatory instructions, from licence registration to the administrative and financial sanction conferred upon defaulting parties.

To effectively navigate the energy transition, the Philippines must enhance the utilisation of geothermal energy sources, particularly in addressing pollution and environmental concerns. The country has established two key legal frameworks to regulate water resources: The Philippine Clean Water Act of 2004 (Republic Act 9275) and the Water Code of the Philippines (Presidential Decree 1076) (Republic Act No. 9275, 2004). These laws aim to safeguard water resources from pollution and ensure their availability for various purposes, including power generation in geothermal plants. By leveraging these laws, the Philippines can effectively protect water resources and promote the sustainable development of geothermal energy.

Although Malaysia had not yet developed a significant geothermal energy infrastructure and primarily relies on natural gas, coal and hydroelectricity for its energy needs, the government enacted the Renewable Energy Act 2011 that provides the legal basis for promoting renewable energy sources, including feed-in tariffs and other incentives for renewable energy projects. The Renewable Energy Act is intended to encourage the development of several renewable energy sources, such as solar, wind, biomass, and biogas, even if geothermal energy is not explicitly listed in the act. If geothermal energy projects are developed in Malaysia, the regulatory framework will likely be modified or enlarged to facilitate these projects.

Despite its potential as a sustainable energy source, geothermal energy adoption faces significant challenges in Malaysia, particularly when compared to neighbouring countries like Indonesia and the Philippines. This study aims to identify and analyse the key obstacles hindering the widespread adoption of geothermal energy in Malaysia, drawing insights from comparative analysis with Indonesia and the Philippines. Their efforts to ensure that the benefits of this sustainable energy source are fairly distributed among all communities while protecting future generations' rights and opportunities are the key comparison points for Malaysia. Therefore, this research aims to comprehensively analyse the unfeasibility of expanding geothermal energy in Malaysia. By examining the regulatory constraints, technical difficulties, and economic and social challenges associated with this energy source, potential investors and stakeholders can make informed decisions about the future of geothermal energy in Malaysia.

RESEARCH METHODOLOGY

The doctrinal method is employed in the study to analyse regulatory, technical, and economic challenges of impending geothermal energy adoption in Malaysia with a comparative lens in Indonesia and the Philippines. This methodology critically examines existing laws, policies, and frameworks governing renewable energy, specifically those relating to geothermal projects. This method identifies gaps and inconsistencies hindering geothermal development by scrutinising statutory provisions, judicial interpretations and regulatory practices in Malaysia, Indonesia and the Philippines. It analytically compares Malaysia's regulatory constraints, such as the absence of geothermal laws, with the comprehensive legal framework in the Philippines and Indonesia. It highlights lessons Malaysia can draw to advance its geothermal energy opportunities.

FINDINGS AND DISCUSSION

Regulatory Constraints

While geothermal energy is the most efficient renewable energy source, it still leaves a scar on the environment and society. A systematic regulatory framework ensures effective management of these issues, establishing standards and procedures for mitigating these impacts and ensuring that geothermal projects adhere to environmental laws and regulations, safety standards and protocols, land sovereignty, and societal acceptance.

Indonesia

In Indonesia, geothermal exploration and exploitation activities are regulated by Law No. 21 of 2014 Concerning Geothermal Energy and Government Regulation No. 7 of 2017 concerning Indirect Utilisation of Geothermal Energy.

In the region where geothermal activity is operated, companies are required by Article 65 of Law No. 21 of 2014 to notify of any dangers, pollution, or environmental devastation. This is because, compared to projects in other nations with comparable capacity, geothermal energy projects in Indonesia typically require longer access roads. There are roughly twice as many roads constructed there, around 10 km for every 100 MW capacity, compared to only 5 km elsewhere, significantly negatively influencing forests and wildlife (Meijaard et al., 2019). Forests are indirectly impacted by road-facilitated hunting, illegal logging, fire use, and other detrimental activities (Profor, 2024).

Furthermore, Article 48 mentions that the Direct Use License holder can conduct Geothermal business for direct use in a specific location and is obligated to control environmental pollution, which includes prevention and mitigation of environmental pollution and recovery of ecological functions. If the companies fail to comply, they are subjected to administrative sanctions (Article 50(1) of Law 21/2014). The aim is to guarantee compensation for the companies responsible for the damage and those living near the affected area. The administrative sanctions referred to in section (1) are a written warning, temporary suspension of all geothermal business activities for Direct Use and revocation of the Direct Use License.

Philippines

It is undeniable that regulations play a crucial role, particularly in exploiting natural resources. Sustainable development is intricately woven into various laws and regulations governing geothermal energy utilisation in the Philippines. One notable legislation is the Philippine Renewable Energy Act of 2008 (Republic Act No. 9513), Which advocates for the sustainable development and utilisation of renewable energy sources, including geothermal energy. Concerning environmental conservation, this law underscores the significance of safeguarding the environment while utilising geothermal energy. It mandates conducting environmental impact assessments (EIAs) for geothermal projects to identify potential environmental impacts and recommend mitigation measures to reduce adverse effects on ecosystems, water resources, and air quality.

With its geothermal plantations, the Philippines is steadily reducing pollution and the adverse effects it has on the environment. For instance, the Water Code of the Philippines (Presidential Decree No. 1076) and the Philippine Clean Water Act of 2004 (Republic Act No. 9275) govern the quantity and quality of groundwater resources used in upstream and downstream processes. These regulations guarantee the availability of water resources for diverse purposes, such as power generation in geothermal plants, and safeguard them against pollution. It also serves to provide justice for the people living in the area by providing safe water consumption.

Moreover, the encroachment of ancestral domains is one of the issues that claws to the root of society. For instance, the geothermal power plant at the Manobo-Apao Descendants Ancestral Domain of Mount Apo (MADADMA) is run by the government-owned company Philippine National Oil Corporation (PNOC) (Alano, 2008). The residents of the land have objected to their involvement in the land. One of the ways that the Philippines oversees this is by establishing a National Commission on Indigenous People that issues permits in areas within their land claims since the construction of geothermal power facilities necessitates a sizable quantity of land.

Malaysia

Malaysia has not yet established remarkable regulatory frameworks dedicated to producing geothermal energy. The establishment of the Renewable Energy Act 2011 does not focus on geothermal energy, as no apparent provision discusses it. Even though the country has substantial geothermal resources, Malaysia only emphasises alternative renewable energy sources, such as solar, wind, and hydroelectric electricity. However, the lack of standards specifically for geothermal energy poses a significant regulatory barrier to the growth of this renewable energy industry.

Malaysia needs more explicit regulations on who bears the cost of potential environmental damage from geothermal projects, compared to Indonesia and the Philippines, which might have a more transparent system. This country should learn from its mistake in managing the geothermal plant in Sabah. Sabah's failed geothermal plant created scars in the heart of the forest reserve where the plant should be built (Gomez, 2024). Roads were cut and constructed to the very pinnacle of the primary forest habitat, with arterial roads built every several hundred metres to support a peripheral but lucrative logging operation.

Without clear legislative guidance, investors and developers face uncertainties regarding licensing, land rights, environmental impact assessments, and project financing for geothermal ventures. Despite its abundant resources, Malaysia's lack of specific laws renders it unsuitable for developing geothermal energy, suggesting that pursuing such endeavours should be reconsidered.

Technical Difficulties

Given that geothermal systems generally rely on lake or groundwater aquifers. Cooling they are critical to cooling. This application saves 90–95 per cent of the cooling energy required for district cooling systems. Gardermoen Airport, for example, uses one of Norway's largest groundwater reservoirs for district heating and cooling while also serving as a heat sink (Kumar, 2022). During the chilling phase, groundwater pre-cools the chilled water, providing a cooling capability of 3 MW, and after that, a 6 MW refrigeration and heat pump plant is used for post-cooling. While geothermal energy is considered environmentally friendly, there are some minor environmental concerns to address, such as the production of greenhouse gases like ammonia, carbon dioxide, hydrogen sulphide, and methane. However, far less gas is released than when fossil fuels are used.

To reduce the risks associated with geothermal drilling, exploration, and operation, measures can be taken to prevent accidents, manage hazardous materials and wastewater, regulate emissions, control pollution, and mitigate geological hazards like earthquakes. Conducting comprehensive environmental impact assessments (EIAs) before starting geothermal projects can help identify potential risks to ecosystems, water resources, biodiversity, and air quality. This allows for the development of effective mitigation strategies to minimise negative impacts.

Indonesia

According to geothermal entrepreneurs, the increase in installed capacity for geothermal power plants (PLTP) in Indonesia remains sluggish, with only 40 MW added annually (Ibp, 2023).

The Geothermal Association aims to increase geothermal power plant capacity to 3,355 MW by 2030, requiring an additional 450 MW per year. The installed capacity is 2,378 MW, with an annual growth rate of around 40 MW. This falls short of the potential capacity of approximately 24,000 MW. One challenge in geothermal energy development is the difference between electricity prices and economic viability, which may deter investors.

Large companies are encouraged to establish geothermal power plant projects through various incentives and facilitations provided by the Ministry of Energy and Mineral Resources (ESDM). ESDM has provided various facilitations to entice large corporations to develop such projects; Director Harris Yahya stated that these efforts include reducing exploration risks and providing financing mechanisms.

However, in the opinion of Fabby Tumiwa, Executive Director of the Institute for Essential Service Reform (IESR), these incentives are ineffective at attracting capital to the geothermal sector. He emphasised that business owners still view geothermal investment as high-risk. Fabby criticised the current incentives for geothermal development, stating they have not effectively reduced risks and attracted investment despite the initial goal of 7,000 MW by 2025.

Philippines

Geothermal energy must be made appealing to developers and investors through advancements in exploration technologies, techniques, and approaches. Because of resource management concerns and climate change, several technological limitations raise operating and maintenance costs for current and future geothermal projects. These discourage present operators and developers from pursuing future expansion and development plans (Department of Energy, Philippines, 2017). The Philippines' geothermal fields face the following technical resource management difficulties:

(1) acid fluids causing well and line corrosion damage,

Geothermal power production faces challenges due to system problems that result in increased labour, components, and effectiveness costs. The primary cause of material corrosion in geothermal systems is the corrosive properties of the geothermal fluid, which are impacted by temperature, pressure, and flow rate. Dissolved gases like CO2 and H2S and dissolved solids like chloride ions are the primary corrosive agents in geothermal fluids. Some systems may also have HCl gas present, which can lead to significant corrosion issues if condensation and reboiling occur (Khan et al., 2021).

(2) mineral scaling (calcite, silica, etc.) (National Power Corporation, Republic of the Philippines. (1989)),

Scales are thick layers of primarily inorganic materials formed due to excessive mineral concentrations in water. They impede heat transfer, making heat exchangers less efficient. Scale formation is influenced by water temperature, acidity or alkalinity, and the ingredients in the cooling water. Standard scales include calcium carbonate, calcium sulphate, calcium phosphate, silica, and magnesium silicate.

(3) impacts from severe weather, such as recurrent super typhoons, which cause landslides and damage to buildings and power plants (Department of Energy, Philippines. (2017).

Typhoon Haiyan caused over 6,000 deaths and more than US$15 billion in damages. The country's leading electricity distributor, Energy Department Corporation (EDC), stated that the tropical storm fell on more than 560 transmission towers (Albay, 2024). The typhoon caused significant damage to Tongonan's cooling towers and operational structures.

This led the EDC to focus on resilience projects to prepare their plants for future natural disasters. In response to the catastrophe in Leyte, EDC provided potable water, meals, and power to hospitals and city halls. They restored operations at the geothermal power plant within a month, preventing blackouts in Leyte and Cebu provinces during the holiday season. The Tongonan-1 geothermal power plant was upgraded to increase capacity to 123 MW and improve disaster resilience through modernisation efforts such as real-time monitoring and automation technologies.

In 2014, EDC started planning for the long-term rehabilitation of the Tongonan-1 plant to prolong its lifespan by 40 years. The upgrades involved installing new turbines, generator rotors, transformers, pumps, and cooling tower panels made of fibre-reinforced plastic for better performance and reliability until 2040.

Malaysia

Meanwhile, TNB has found four significant geothermal power generation sites in Peninsular Malaysia that have the potential to generate more than 2 MW of electricity. By 2016, these projects, which are being conducted in conjunction with Generation Asset Development (GAD) and TNB Research Sdn Bhd, should be completely operational (Richter, 2015).

Sabah's Apas Kiri Geothermal Field has the potential to generate clean and reliable electricity locally (Daily Express, 2024). Exploration data shows a usable geothermal resource of 14 km with a temperature of 200 ºC and a capacity of 85 MW. Tawau Green Energy Sdn Bhd drilled two deep exploration wells into Mount Maria, bringing hot water up from 2km underground. However, in August 2018, Seda cancelled development approval due to slow progress. Hannah Yeo stated that the 37-megawatt generation incentive quota from the project would be transferred to other viable renewable projects, particularly biomass and hydro (Bernama, 2018).

In a supplemental question about whether the government will save the project after spending RM35 million from the Private Public Partnership Unit, Yeo stated that there are currently plans for the project. The government plans to regularly investigate the technology and feasibility of geothermal projects due to their potential higher costs than new energy sources. She stated that the project will be implemented when it makes business sense, but it will also be biddable through an open tender.

However, if Malaysia were to install geothermal plants, Malaysia must consider the numerous technical challenges and environmental concerns that ultimately led to their abandonment. Additionally, the lack of transparency and corruption in the bidding process for renewable energy projects can hinder fair competition and result in the inefficient use of public funds. While geothermal projects may have higher initial costs, they often have lower operational costs in the long term, making them a viable investment for the government.

Economic Factors

Geothermal energy offers an adequate replacement for fossil fuels, providing a dependable and eco-friendly power source with little effect on the environment. The energy landscape might be entirely changed by utilising the rich geothermal resources in nations like the Philippines. However, economic challenges must be addressed, including expenditures, regulation, infrastructure, market dynamics, and social considerations to sustain geothermal resource exploitation successfully. This highlights the need for Malaysia to balance geothermal development with robust economic safeguards, potentially a more significant concern than Indonesia and the Philippines, which already have established geothermal industries.

Indonesia

By 2035, the government intends for the installed capacity of geothermal power plants to reach 9,300 megawatts (Briefing, 2024). However, despite the revolutionary energy that geothermal energy offers, there are still obstacles and challenges due to financial considerations. First of all, geothermal energy is seen as a risky business. Significant upfront expenditures are associated with surveying and drilling to develop geothermal energy in Indonesia, and there is a high risk that a corporation may spend much money on exploration and not locate any viable sources. Consequently, it is difficult for private companies to secure loans from private banks to build geothermal power plants. With funds from agencies such as the World Bank and the Asian Development Bank, the Indonesian government can help reduce this risk by partially bearing the cost of exploration and incentivising local and private investors. Successful geothermal investments could foster more interest from the private sector and create a market for geothermal power in Indonesia.

Market and regulatory barriers are among the challenges in developing geothermal energy in Indonesia. One of Indonesia's many obstacles to geothermal energy development involves how the energy source fits into the legislative and commercial framework. In Indonesia, geothermal energy remains substantially more costly than coal and is widely available nationwide. Approximately 60% of Indonesia's electricity is produced using coal, and the government still subsidises the country's energy production. Although part of the energy balance is gradually declining, coal is far from being phased out as a significant energy source with new facilities under development. It is challenging for producers of geothermal energy to compete with the cost of coal energy in the absence of laws requiring the usage of renewable energy. Geothermal energy has competitors besides coal. Innovations in technology have made renewable energy sources like solar and wind power more competitive and affordable. However, the cost-effectiveness of producing geothermal energy has not remained high, particularly in Indonesia. Only 2% of Indonesia's potential for geothermal, solar, wind, hydro, and biomass energy sources are utilised. If innovation in geothermal energy does not progress, the Indonesian government may prioritise wind and solar energy instead.

In Indonesia, price undoubtedly becomes an essential factor in developing geothermal energy. Ministerial Regulation No. 12/2017, which governs the use of renewable energy sources to provide power, was released by the government through the Ministry of Energy and Mineral Resources. The feed-in tariff procedure is replaced with a regulated ceiling price mechanism in the Ministerial Regulation. The maximum tariff amount in PLN has been established using the ceiling pricing method. The set price per unit produced is what PLN must pay under the FIT mechanism. Adjustments are fundamental since they cause investors to exercise greater caution when making decisions. Aside from that, the capital needed to develop geothermal power plants is more significant than that expected to construct power plants using fossil fuels (coal, oil, and gas). On the other hand, compared to fossil fuel facilities, geothermal power plants have had lower maintenance and operating costs.

The costs associated with the environment will also be taken into consideration. Most geothermal resources in Indonesia are found in or close to forested areas, where the proposed geothermal power plants would be situated (Energy for Growth Hub, 2023). Even though geothermal energy may not be environmentally destructive in and of itself, constructing a plant's infrastructure, such as roads, may negatively affect the freshwater supply, endangered wildlife, and cultural and religious values. When assessing the viability of a project, it is crucial to consider these possible costs, particularly when contrasting them with other feasible forms of energy. Although geothermal energy production typically does not emit greenhouse gases, excavation can release gases trapped beneath the Earth's surface. Developing and improving infrastructure requires large-scale civil work, including mobilising heavy equipment and extensive soil displacement. These activities can negatively impact the community by causing soil contamination in water flow lines, dirty roads, and dust. Additionally, the community may be concerned about losing their primary source of income and may view the project as having low benefits due to a lack of sustainable job opportunities. Drilling infrastructure also necessitates mass land clearing and deforestation to prepare access roads, well pads, and basecamp areas.

This situation could raise community concerns about the potential entry of wild animals into villages and the endangerment of the ecosystem. Large-scale civil work involving heavy equipment mobilisation and significant soil displacement is necessary to develop and improve infrastructure. Social issues may also arise, as the construction workforce will not be exclusively hired from the local community. This could lead to a perception among locals that foreign workers are replacing them and changing the social values of the area. Differences in social interaction, stratification, and other matters may further contribute to negative perceptions of the project owner among the local population (Fadhillah et al., 2023).

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Philippines

The energy crisis of the early 1970s spurred the Philippines' geothermal resource development. The geothermal power business expanded from 0 to 981 MWe between 1976 and 1983 (ERIA 2017). However, until Republic Act 6957, also known as the Build-Operate-Transfer Law (BOT Law), was passed in the 1990s and made it possible for the private sector to invest in infrastructure, the expansion of the geothermal power industry mainly remained stagnant. The law guarantees both sufficient earnings and cost recovery. The BOT Law's enactment allowed for the addition of 924 MWe of geothermal power capacity to the Philippine grid system between 1996 and 2000. This has become one of the challenges in the economic sector. Challenges in developing geothermal energy for the regulatory framework for geothermal development in the Philippines can be complex and bureaucratic as it may lead to delays in project approvals and implementation. Streamlining the permitting process and providing clear guidelines for developers could help expedite project development.

A remarkable feature of the Philippines in its energy supply structure is that geothermal is utilised in the world's second-largest quantity after the United States. Some amounts of natural gas and coal are produced among indigenous sources (World Geothermal Assessment. 2005). However, deposits of these Indigenous energies are limited, and it is challenging to expect their production to keep pace with the increasing demand for Indigenous energy. As the energy demand is concentrated in transportation and power generation, imported coal and oil are bound to supply a significant portion of the incremental energy demand. In addition, since regional markets are divided into separate parts in this archipelago country, there are certain constraints for large-scale utilisation of geothermal energy. Due to its high upfront risk and high initial cost, geothermal energy has not yet reached its full potential in the Philippines. The power market, grid transmission, ambiguous legal and regulatory frameworks and a dearth of private sector funding are further obstacles. Intricate laws and processes govern land-use rights. This complicates access to projects, including renewable energy as well.

Besides that, one of the corporations in the Philippines involved with geothermal development is aware that forced relocation may result in adverse economic, social and environmental effects. Resettlement plans are becoming a crucial component of project design as a result. It is because the resettlement costs after geothermal development projects have to make the area easier to access; b) shielding locals from the health risks posed by plant emissions; c) helping impacted families restore their previous standard of living; and d) facilitating the development of an independent and fruitful resettlement community. The Japan Bank for International Cooperation and the World Bank's guidelines were followed in the lack of local guidelines. The Philippines' remote location of several geothermal resources presents difficulties for developing infrastructure, including transmission lines, highways, and grid connectivity. It could also be one of the challenges as it can be costly and lengthy to build the infrastructure required to transfer electricity from geothermal sites to urban areas.

Malaysia

Malaysia may take the economic measurement by adapting and comparing Philippine and Indonesian geothermal development factors. In contrast, geothermal energy costs money to develop the infrastructure and technologies needed for geothermal energy research, drilling, and power production. Malaysia might not have invested enough in these sectors because of conflicting priorities or a lack of urgency. Furthermore, a barrier to the growth of geothermal energy could be the lack of explicit policies or incentives. Governments frequently play a critical role in this process by enacting laws, rules, and incentives that encourage the development of renewable energy sources. The factors of changes in land usage, disturbance of natural habitats, and possible disputes with nearby communities are just a few of the environmental and social effects that geothermal projects may have. Due to concerns about these effects, decision-makers may prefer alternative energy sources with lower environmental and social risks. Ignorance in looking through these factors may cause more expenditure in covering the damages.

Analysis

As a developing country, Malaysia should focus on expanding energy, which has been proven successful. This is because Malaysia has abundant resources for other forms of renewable energy, such as solar, hydro, and biomass. These alternatives are less risky, have proven track records, and are already being integrated into

Malaysia's energy mix. Prioritising these less contentious and more readily deployable renewable energy sources could be a more pragmatic approach, ensuring steady progress towards renewable energy targets without the uncertainties associated with geothermal energy.

As we can see, systematic regulatory frameworks are critical for addressing geothermal energy projects' environmental and societal implications. Malaysia cannot venture more into geothermal energy unless regulatory constraints are considered. For example, Indonesia and the Philippines have strong laws to ensure long-term development. Indonesian legislation requires steps to mitigate environmental risks posed by substantial infrastructure. At the same time, the Philippines incorporates sustainable development into its framework, which mandates Environmental Impact Assessments (EIAs) to reduce ecological damage and conserve water resources. Malaysia can learn from Indonesia and the Philippines to establish more explicit guidelines and foster a conducive environment for geothermal development, ensuring sustainability and societal acceptance.

Additionally, the lack of investment in the geothermal sector makes it technologically tricky to sustain a high-budget plant system. It is challenging due to the many aspects that must be considered while constructing a geothermal site. For instance, Indonesia struggles to attract investors since many do not think geothermal energy offers them more advantages. The Philippines also faces challenges in deploying geothermal acid fluids, which lead to mineral scaling, landslides, and damage to surface structures and power plants due to frequent super typhoons and other extreme weather events. These examples underscore the complex technological and environmental hurdles Malaysia must proactively anticipate and address. Consequently, the economic strategy of a country plays a significant role in manoeuvring the plans of its energy sector. Without a comprehensive and committed approach, Malaysia risks lagging in the geothermal energy sector, missing out on a crucial opportunity to diversify its energy portfolio and enhance its energy security.

However, the government's readability to execute the vision is one huge aspect that needs to be adequately examined. Political and regulatory obstacles could still exist despite initiatives to guarantee impartial and transparent procedures. However, the success of geothermal projects could still be threatened by corruption and ineffective bureaucracy. Long-term political stability is essential; otherwise, the geothermal projects risk collapsing and wasting time and money.

CONCLUSION

In conclusion, despite the enormous potential for geothermal energy as a sustainable power source, various nations have varied economic, regulatory, and environmental obstacles. When the Philippines faces infrastructural and bureaucratic challenges, and Indonesia faces high costs and market competitiveness, Malaysia needs to take lessons from these countries to overcome its obstacles to geothermal development.

Malaysia's approach to implementing geothermal energy reveals several critical shortcomings. Despite identifying a promising site in Sabah, the government has delayed the project until it becomes commercially viable, signalling a lack of immediate commitment to geothermal development. This hesitancy and the absence of robust policies and incentives reflect an unpreparedness to embrace geothermal energy fully. Malaysia's strategy appears to lack the urgency and proactive investment seen in countries with more advanced geothermal sectors, risking the potential benefits of this renewable resource. This shows that the Malaysian government is not ready to implement geothermal energy.

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