P-ISSN: 2964-0121
E-ISSN: 2963-3699
Homepage: https://return.publikasikupublisher.com/index.php/return

GEOTHERMAL ENERGY POTENTIAL IN SUPPORTING NATIONAL DEFENSE AND ECONOMIC SUSTAINABILITY IN DEVELOPING COUNTRIES

Inez Koerniawati [1] , Lukman Yudho Prakoso[2], Rheviany HS Putri[3], Nur Khotimah[4]
Indonesian Defense University, Indonesia[1,2,3,4]
inez.koerniawatii@gmail.com [1], lukman.prakoso@gmail.com[2], rheviany_h@yahoo.com[3] , nurkhot50@gmail.com[4]

PAPER INFO
Received: 02-02-2023
Revised: 10-02-2023
Approved: 26-02-2023

ABSTRACT
In recent decades, geothermal energy has become increasingly important as an alternative energy source that can support national energy security and economic sustainability in developing countries. This article discusses the potential of geothermal resources and their implications for national defense and economic sustainability in developing countries. The author presents an overview of the potential of geothermal energy in developing countries and then discusses its implications for national defense and economic sustainability. This article also discusses the challenges and opportunities faced by developing countries in harnessing the potential of geothermal energy to strengthen energy security and support economic growth. The method used in this research is literature analysis and case studies. Data was collected from sources such as official government reports, academic studies, and scientific journal articles. The results of the study show that geothermal energy has great potential in supporting national defense and economic sustainability in developing countries. However, there are still many challenges to be overcome in developing the geothermal energy industry, including difficulties in identifying geothermal resource potential and building the necessary infrastructure to harness it. Nevertheless, this article shows that geothermal energy can be a promising solution for developing countries to strengthen energy security and support sustainable economic growth.

Keywords: Geothermal Energy; Economic Sustainability; National Defense; National Energy Security; Industry Development

INTRODUCTION

Geothermal energy is an alternative energy source that can be utilized to support national energy security and economic sustainability in developing countries. Developing countries have a vast potential for geothermal energy, but its utilization is still limited. According to the International Energy Agency (IEA), the global potential for geothermal energy reached 70,000 Megawatts (MW) in 2019 (Canton, 2021). This article discusses the potential of geothermal energy in supporting national defense and economic sustainability in developing countries.

Geothermal energy has several advantages compared to other energy sources. First, it is renewable and can naturally replenish itself, making it a reliable long-term energy source. Second, it is clean energy and does not produce greenhouse gas emissions or hazardous waste (Marpaung et al., 2020). Third, geothermal energy has significant potential, especially in countries with high geological activity.

In terms of national defense, geothermal energy can be utilized in military facilities and securing strategic infrastructure. For example, in the United States, several military bases have used geothermal energy to supply their energy needs (Ceres, 2016). Moreover, geothermal energy can also serve as an alternative to fossil fuels in military vehicles.

Meanwhile, in terms of economic sustainability, geothermal energy can support the reduction of dependence on imported energy resources, the development of the energy industry, and the development of remote areas. However, the utilization of geothermal energy in developing

is still limited due to several factors, such as technological and financial limitations, unclear regulations, and social and environmental issues (Ito & Ruiz, 2017).

To increase the utilization of geothermal energy in developing countries, efforts are needed to improve technology and finance, provide clear regulations, and manage the environment sustainably. With more optimal utilization of geothermal energy, developing countries can effectively and sustainably support their national energy security and economic sustainability (Indonesia, 2016).

RESEARCH METHOD

The research method used in this article is literature study and descriptive analysis. A literature study was conducted by searching and collecting data from reliable sources such as scientific journals, books, and government reports related to geothermal resources' potential, the national defense industry, and economic sustainability in developing countries. The data was then analyzed descriptively to provide a clear picture of the potential of geothermal resources and their implications for national defense and economic sustainability.

RESULTS AND DISCUSSION

Geothermal Energy Potential In Developing Countries

The purpose of geothermal energy potential in developing countries is to strengthen energy security and support economic growth by using available natural resources sustainably. In addition, geothermal energy development can also reduce greenhouse gas emissions and accelerate the transition to clean energy. Furthermore, geothermal energy potential can be utilized to strengthen the national defense sector by providing reliable and independent sources of energy.

Geothermal energy potential in developing countries varies depending on geological and topographical factors. Several countries that have significant geothermal energy potential are presented in the following Table 1.

Table 1. The Countries that have significant geothermal energy potential

United States	Indonesia	Philippines	Turkey	New Zealand
• The capacity of geothermal power plants in the United States reached 3,965 MW in 2020. • The state of California is the main center for geothermal energy development in the United States with a capacity of over 2,600 MW	• The capacity of geothermal power plants in Indonesia reached 2,134 MW in 2020. • Indonesia has a large number of geothermal resources with a potential of up to 29,000 MW, the largest in the world located on the island of Java and Sumatra	• The capacity of geothermal power plants in the Philippines reached 1,868 MW in 2020. • The Philippines has a potential geothermal resource of up to 4,900 MW.	• The capacity of geothermal power plants in Turkey reached 1,646 MW in 2020. • Turkey has a potential geothermal resource of up to 2,000 MW.	• The capacity of geothermal power plants in New Zealand reached 1,026 MW in 2020. • New Zealand has a potential geothermal resource of up to 3,500 MW.

Source: International Renewable Energy Agency (IRENA) The data is processed.

Next, a graph will be presented showing the countries that produce the most electricity using geothermal energy.

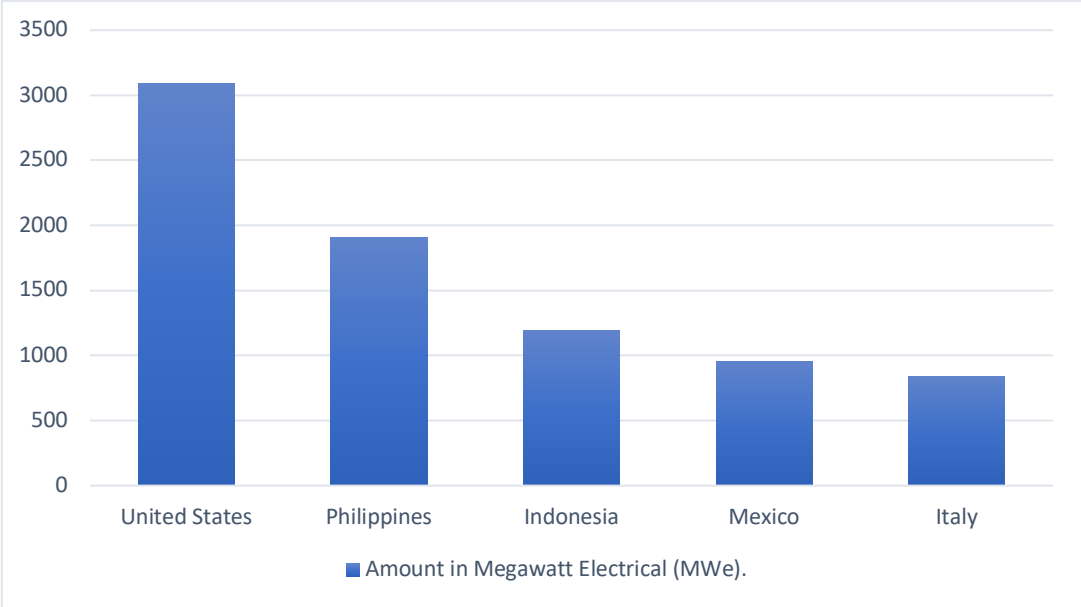

Figure 1. Geothermal Energy in Several Countries

Source: International Geothermal Association

From the graph, it can be seen that the United States is the highest user of geothermal energy in the world due to its large and widely distributed geothermal resource potential in several regions such as California, Nevada, and Oregon. In addition, the US government has provided support and incentives for the development of geothermal energy through various policies and programs such as the Production Tax Credit (PTC) and Investment Tax Credit (ITC) (Kebijakan Energi Nasional, 2014).

Benefits Of Geothermal Energy For National Defense

Geothermal energy can play an important role in strengthening national energy resilience and securing strategic infrastructure in several developing countries. Some developing countries, such as the Philippines and Kenya, have utilized geothermal energy to meet national energy needs and strengthen national defense infrastructure (Merem et al., 2019).

In the Philippines, geothermal energy has been utilized since the 1970s and is now the second-largest source of energy after fossil fuels. In addition, geothermal energy is also used in some military facilities and strategic infrastructure security in the Philippines. This is done to ensure a stable and secure energy supply for national defense purposes.

Meanwhile, in Kenya, the use of geothermal energy has also increased since the 1980s and is now the third-largest primary energy source after hydro and fossil fuels. In addition, the use of geothermal energy is integrated with national defense needs and strategic infrastructure security in Kenya, such as its use in military facilities and communication networks.

The use of geothermal energy to strengthen national energy resilience and secure strategic infrastructure in several developing countries can help reduce dependence on fossil fuels that are vulnerable to price and supply fluctuations. In addition, the use of geothermal energy can also help meet national energy needs sustainably and in an environmentally friendly way. Some examples of potential uses of geothermal energy in the defense industry sector are:

1. The use of geothermal energy for air conditioning in military buildings and command centers. This can reduce energy consumption from conventional AC, reduce costs, and extend the lifespan of AC equipment (Darwish & Al-Dabbagh, 2020).
2. Utilization of geothermal energy in the production of firearms. One example is the use of geothermal heat energy in the tempering process of steel, which is required in the production of firearms (Kehinde et al., 2018).

3. The use of geothermal energy in the production of explosives. An example is the utilization of geothermal steam to dry explosives, thereby reducing the need for fossil fuels and reducing carbon dioxide emissions (Hill, 2019).

Related to the energy needs to support the national defense sector in several countries aimed at ensuring the continuity of military operations and national defense as well as supporting military mobility and logistics. Some examples of countries that have high energy needs for their national defense sector include the United States, the United Kingdom, and Japan, with the following data:

1. According to a study conducted by the US Department of Defense, energy consumption for military purposes in the country accounts for around 3% of the total national energy consumption (Hartkopf, 2012).
2. A study by Jones and Jenkins (2018) showed that the national defense sector in the UK consumes around 14 terawatt-hours of energy each year, with the majority used for military operations and transportation (Andrews & Nwapi, 2018).
3. According to the annual report of the Japanese Ministry of Defense, total energy consumption for military purposes in the country increased by 6% in 2020 (Japanese Ministry of Defense, 2021).

In Indonesia itself, according to the Ministry of Defense report in 2020, around 5-10% of the national defense budget is used to finance the operational facilities of national defense, including energy and fuel procurement. The energy needs to run national defense facilities, such as military bases and training facilities, including energy for lighting, heating, cooling, water treatment, and so on. In addition, the energy needs for military operations can also include the need to operate military vehicles, aircraft, and naval ships. However, specific data on energy needs for the national defense sector is difficult to obtain due to national security reasons.

The Benefits Of Geothermal Energy For Economic Sustainability

The utilization of geothermal energy in developing countries can provide significant benefits in supporting economic sustainability, especially in reducing dependence on imported energy resources. By utilizing abundant geothermal resources, countries can produce energy independently and reduce the cost of importing fossil fuels. In addition, the development of geothermal energy industries can also have positive impacts on job creation and local economic growth.

An example of a developing country that has developed geothermal energy potential to support economic sustainability is the Philippines. According to the Philippine Department of Energy, geothermal energy is the country's second-largest energy resource after coal, with a potential capacity of over 4,000 megawatts. The utilization of geothermal energy in the Philippines has contributed significantly to the provision of sustainable energy and the reduction of dependence on imported fossil fuels (Abraham & Nkitnam, 2017).

Geothermal energy can also support economic sustainability in developing countries through the development of energy industries, as geothermal energy is a renewable energy source that can be utilized to meet the energy needs of the industrial sector. The use of geothermal energy can reduce dependence on limited fossil fuels and minimize negative impacts on the environment (Kalicki & Goldwyn, 2013).

Examples of the utilization of geothermal energy for the development of energy industries can be seen in countries such as Iceland, the Philippines, and Mexico. Iceland has successfully developed its aluminum industry by utilizing abundant geothermal and hydroelectric energy. Meanwhile, the Philippines and Mexico also rely on geothermal energy to meet their industrial energy needs.

Furthermore, the utilization of geothermal energy can also support the development of remote areas in developing countries. For example, in countries such as Kenya, the Philippines, and Indonesia, geothermal power plants have been built in remote areas, improving access to reliable and affordable electricity for local communities. In addition, the development of geothermal energy in remote areas can create local job opportunities and enhance regional economies.

Challenges In Utilizing Geothermal Energy Potential

The utilization of geothermal energy potential in developing countries still faces several challenges. One of the main challenges is the limitation of technology and finance in developing and utilizing geothermal resources. The technology required to extract geothermal energy is highly sophisticated and requires significant investment costs. Additionally, a shortage of skilled human resources also poses a constraint in developing the geothermal energy potential in developing countries.

Moreover, financial constraints are also a problem that needs to be overcome. The investment cost to build geothermal power plants is usually high and takes a long time to generate profits. The sources of funds for such investments are also limited and often difficult to obtain in developing countries.

Unclear regulations also pose a challenge in utilizing geothermal energy potential in developing countries. This is because unclear legal regulations and arrangements can affect the development and investment process in the geothermal energy sector. Uncertainty in regulations can also affect investor interest and slow down the development of geothermal energy projects.

For example, in Indonesia, there are several regulations and policies that have not been well-integrated in the development of geothermal energy. In addition, the lack of certainty in financing and contract regulations also becomes a major obstacle in developing geothermal energy projects in the country.

Furthermore, social and environmental issues are challenges that must also be faced in utilizing geothermal energy potential in developing countries. The infrastructure development process to generate geothermal energy can cause social impacts such as land conflicts, forced evictions, or injustice for local communities. Additionally, geothermal energy development can also affect the environment such as the risk of water resource damage, increased seismic activity, and the spread of toxic gases.

To overcome social and environmental problems, a comprehensive and participatory environmental study needs to be conducted before the development process begins. In addition, good environmental management and the involvement of local communities in the decision-making process are also necessary.

Case Study

1. **Geothermal Drilling Project In The Philippines**

   One case study on the use of geothermal energy in the Philippines is the geothermal drilling project known as the "Maibarara Geothermal Power Plant" located in the province of Batangas, Philippines. The project started in 2008 and was completed in 2014, with a total energy production capacity of 20 MW.

   This project was carried out by an Indonesian geothermal energy developer, PT Supreme Energy, together with several local and international partners. The project aimed to strengthen the national energy resilience of the Philippines and reduce dependence on fossil fuels.

   Moreover, the project also had positive impacts on the economy and the environment in the surrounding area. The local government provided various incentives, including tax exemptions and business permits, to encourage investment in geothermal energy.

   However, the project also faced several challenges, such as complicated permit and environmental clearance issues, as well as difficulties in obtaining funding for larger project development. Despite these challenges, the project is still considered a successful example of geothermal energy development in developing countries like the Philippines

2. **The Use of Geothermal Heating System in Iceland**

   One famous example of a geothermal heating system in Iceland is the Hellisheidi Geothermal Power Plant. The plant is not only used for power generation but also for heating the nearby city of Reykjavik through a district heating system. The plant uses a combination of flash and binary cycle technologies to extract heat from geothermal reservoirs and generate electricity. It has a capacity of 303 MW for power generation and 133 MW for thermal energy. The system typically uses pipes connected to hot springs underground and

delivers the hot water to heaters or radiators spread throughout the buildings (Mikhaylov, 2020).

The advantages of the geothermal heating system in Iceland are as follows:

1. Renewable energy, Geothermal heating is a renewable energy source that will not run out, so there is no need to worry about energy scarcity in the future.
2. Environmentally friendly, The geothermal heating system does not produce greenhouse gas emissions or other pollutants, making it environmentally friendly and helping to reduce the impact of climate change.
3. Efficient, Geothermal heating has high efficiency, resulting in relatively low operating and maintenance costs.
4. Stable, The geothermal heating system in Iceland is stable and reliable throughout the year, thanks to the abundant geothermal resources
5. Can be integrated with other energy systems, Geothermal heating can be integrated with other energy systems, such as solar panels or wind turbines, to increase efficiency and reduce operating costs.

Although geothermal heating systems have many advantages, they also have some limitations, such as the high initial installation cost and not all areas in the world having enough geothermal resources to be used as an energy source. However, in Iceland, the use of geothermal heating systems has been proven successful and provides many benefits to the local community and environment (Lygnerud, 2019).

Government Policy Related To The Development Of Geothermal Energy And the National Defense Industry

There are several connections between government policy in developing countries and the development of geothermal energy and national defense industries. For example, governments can take policy measures to strengthen the national defense industry by using geothermal energy technology as a source of energy to ensure national energy security.

According to the Ministry of Energy and Mineral Resources of the Republic of Indonesia, Indonesia has great potential in developing geothermal energy with a potential capacity of around 29,000 MW. Therefore, the Indonesian government has taken several policy measures to encourage the development of geothermal energy in the country, such as providing tax incentives and permits for geothermal energy projects (Ministry of Energy and Mineral Resources, 2021).

In addition, the government has also taken steps to strengthen the national defense industry in Indonesia. For example, the Indonesian government has formed the Ministry of Defense and carried out various programs for developing main weaponry systems to enhance the country's defense capabilities (Ministry of Energy and Mineral Resources, 2021).

In this context, geothermal energy can be used as a source of energy that can ensure national energy security, especially in building a reliable national defense system. For example, the United States Department of Defense has used geothermal energy technology to provide reliable and affordable sources of energy for U.S. military bases in various countries (U.S. Department of Defense, n.d.).

The goal of government policy in developing countries related to the development of geothermal energy is to utilize the potential of geothermal energy as an environmentally friendly source of energy that can support national energy resilience. In addition, the development of geothermal energy can also help reduce dependence on imported energy resources and reduce greenhouse gas emissions.

In achieving these goals, the government can provide incentives and financial support for research and development of geothermal energy technology, facilitate private investment in the geothermal energy sector, and increase access to and use of geothermal energy in society.

Here are some government policies in developing countries related to geothermal energy development and the national defense industry:

a. Philippines

The Philippine government launched the "Geothermal Energy Development Program" in 2012 to increase the development of geothermal energy in the country. This program includes fiscal incentives, licensing ease, and technical support to overcome investment barriers. In addition, the Philippine government also launched the "Defense Industry Support Program" in 2019 to strengthen national defense capabilities by increasing the self-sufficiency of the defense industry.

b. Turkey

The Turkish government adopted the "National Geothermal Action Plan" in 2014 to increase the development of geothermal energy in the country. This program includes fiscal incentives, regulatory and licensing improvements, technical support, and financing. In addition, the Turkish government also encourages the development of the national defense industry through the "Turkish Defense Industry Development Strategy" program, which includes financial support, training, and regulatory improvements.

c. Kenya

The Kenyan government adopted the "Geothermal Risk Mitigation Facility" program in 2012 to mitigate investment risks in geothermal energy development in the country. This program includes fiscal incentives, financing, and technical support. In addition, the Kenyan government also encourages the development of the national defense industry through the "Kenya Defense Forces Modernization Program," which includes equipment and technology upgrades, training, and capacity building.

d. Indonesia

1) The National Long-Term Electricity Development Plan (RPJPN) 2019-2038 targets 7.2 GW of electricity capacity from geothermal energy by 2030.
2) The Government Policy on Utilization of Geothermal Energy as a Source of Electricity, issued in 2017. This policy provides incentives and facilities for investors to develop geothermal energy projects in Indonesia.
3) The Government's New and Renewable Energy (EBT) Enhancement Program for National Development, which focuses on the development and utilization of renewable energy sources, including geothermal energy.
4) The Government Policy on Acceleration of National Defense Industry Development (2019-2024), which aims to increase the production and self-sufficiency of the national defense industry, including the energy sector.
5) Collaboration between the Ministry of Energy and Mineral Resources and the Ministry of Defense to strengthen defense self-sufficiency through national energy development, including geothermal energy.

CONCLUSION

Based on the discussed article, it can be concluded that geothermal energy has great potential in supporting national defense and economic sustainability in developing countries. In the context of national defense, geothermal energy can provide a stable and reliable energy supply for military needs, minimizing the risk to national energy resilience. In addition, the development of geothermal energy can also help developing countries achieve greenhouse gas emissions reduction targets and utilize renewable energy.

However, there are several challenges in utilizing the potential of geothermal energy in developing countries, such as technological and financial limitations, unclear regulations, as well as social and environmental issues. Therefore, support from the government and private sector is needed in the development of geothermal energy.

The Indonesian government has established several policies and programs to encourage the development of geothermal energy, such as the National Energy General Plan 2019-2038, the National Energy Policy, and the New and Renewable Energy Development Program. However,

further efforts are still needed to overcome existing challenges and maximize the potential of geothermal energy in Indonesia.

In the context of the national defense industry, geothermal energy can be used to meet energy needs in military operations, such as military bases and other defense installations. In addition, the development of geothermal energy can also strengthen national energy resilience and help in the development of the national energy industry.

Overall, geothermal energy has great potential in supporting national defense and economic sustainability in developing countries. However, support from the government and private sector is needed in the development of geothermal energy and overcoming existing challenges to maximize its potential.

REFERENCES

Abraham, E. M., & Nkitnam, E. E. (2017). Review of geothermal energy research in Nigeria: The geoscience front. *International Journal of Earth Science and Geophysics*, *3*(1), 1–5. Google Scholar

Andrews, N., & Nwapi, C. (2018). Bringing the state back in again? The emerging developmental state in Africa's energy sector. *Energy Research & Social Science*, *41*, 48–58. Google Scholar

Canton, H. (2021). International energy agency—iea. In *The Europa Directory of International Organizations 2021* (pp. 684–686). Routledge. Google Scholar

Ceres. (2016). *Investing in the Clean Trillion: Closing the Clean Energy Investment Gap*. Google Scholar

Darwish, A. S., & Al-Dabbagh, R. (2020). Wind energy state of the art: present and future technology advancements. *Renewable Energy and Environmental Sustainability*, *5*, 7. Google Scholar

Hartkopf, W. I. (2012). *Plotting the future of the WDS*. 80–86. Google Scholar

Hill, R. A. (2019). *Scientists, Healers and Bioprospectors: The Epistemological Politics of Traditional Medicine in Ethiopia, 1930-1998*. Stanford University. Google Scholar

Indonesia, K. B. B. (2016). *Badan Pengembangan Dan Pembinaan Bahasa, Kementerian Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesi*. Google Scholar

Ito, T., & Ruiz, C. (2017). *Geothermal power: technology brief, International Renewable Energy Agency (IRENA). Abu Dhabi*. Google Scholar

Kalicki, J. H., & Goldwyn, D. L. (2013). *Energy and security: strategies for a world in transition*. JHU Press. Google Scholar

Kehinde, O., Babaremu, K., Akpanyung, K. V, Remilekun, E., Oyedele, S. T., & Oluwafemi, J. (2018). Renewable energy in Nigeria-a review. *International Journal of Mechanical Engineering and Technology*, *9*(10), 1085–1094. Google Scholar

Lygnerud, K. (2019). Business Model Changes in District Heating: The Impact of the Technology Shift from the Third to the Fourth Generation. *Energies*, *12*(9), 1778. Google Scholar

Marpaung, C. O. P., Siahaan, U., & Sudarwani, M. M. (2020). Perancangan Sistem Microgrid Untuk Mempercepat Akses Terhadap Energi Listrik (Energy Access) Pada Kawasan Wisata Setu Rawalumbu Kota Bekasi. *Jurnal Comunita Servizio*, *2*(1), 352–378. Google Scholar

Merem, E. C., Twumasi, Y., Wesley, J., Olagbegi, D., Fageir, S., Crisler, M., Romorno, C., Alsarari, M., Hines, A., & Ochai, G. S. (2019). Analyzing geothermal energy use in the East African Region: The case of Kenya. *Energy and Power*, *9*(1), 12–26. Google Scholar

Mikhaylov, A. (2020). Geothermal energy development in Iceland. *International Journal of Energy Economics and Policy*. Google Scholar

Ministry of Energy and Mineral Resources. (2021). *Directorate General of New Renewable Energy and Energy Conservation*.

Kebijakan Energi Nasional, Pub. L. No. 79, Kemenko Maritim & Investasi (2014).