igMin Research STEM ISSN: 2995-8067 A Multidisciplinary Open Access Journal

ENGINEERING SUBJECT
Energy Engineering | Renewable Energy | Applied Engineering | TOPIC(S)

Article Information

Submitted: April 25, 2024
Approved: April 30, 2024
Published: May 01, 2024

How to cite this article: Sari EM, Manggala KN, Arief MF, Said PSU. Challenge and Readiness to Implemented Geothermal Energy in Indonesia. IgMin Res. May 01, 2024; 2(5): 290-298. IgMin ID: igmin178; DOI: 10.61927/igmin178; Available at: igmin.link/p178

Keywords: Future energy; Geothermal Indonesia; Renewable energy; Ring of fire; Sustainable energy

Check for updates

Research Article

Challenge and Readiness to Implemented Geothermal Energy in Indonesia

Endah Murtiana Sari[1]*, Kalyca Najla Manggala[2], Marvian Farabi Arief[2] and Panduaji Suswanto Umar Said[2]

[1]Department of Information System, Wiyata Indonesian Management Institute, Sukabumi, Indonesia

[2]Man Insan Cendekia Serpong, Tangerang Selatan, Indonesia

***Correspondence:** Endah Murtiana Sari, Department of Information System, Wiyata Indonesian Management Institute, Sukabumi, Indonesia, Email: endah.murtiana@imwi.ac.id

Abstract

Many countries have used various strategies in the effort toward transition to alternative energy as a solution in developing renewable energy. Indonesia is the second largest producer of geothermal energy in the world. The potential of Indonesia lies in the Ring of Fire along with 117 active volcanoes, giving Indonesia high geothermal potential. This research aims to reveal and formulate the potential of geothermal as renewable energy in Indonesia as an alternative energy to be used in the future. The methods in this research are qualitative and quantitative. Through the quantitative method, this research will present secondary data from various organizations as well as data from prior research on geothermal potential in the world. While qualitative method will formulate ideas of several geothermal usages from many countries by using comparison from prior research and literature from journals, books, and other publication sources. Qualitative research results will also come from in-depth interviews with stakeholders that have implemented geothermal energy in Indonesia. The result of this research will illustrate the importance of geothermal energy as an alternative renewable energy in Indonesia to replace crude oil resources as the main natural resource in Indonesia. This research recommends the mapping of resources, requiring technology as a breakthrough in processing geothermal energy to take it directly from the reservoir because of its unorthodox classification based on its source as well the cost and benefit impact on the economy related to consumer mapping to detect early the market changes of energy to geothermal.

Introduction

The increase in crude oil price will have reached from US $95 in 2009 to US $200 per barrel in 2030 Teknologi, et al. 2022, Soltani M, et al. 2019. While the need for energy in 2030 is predicted to have increased to 2.401 million BOE or equal to 381.759.000 liters of oil [1]. Because of that, new energy other than crude oil is needed, and one of the options is geothermal energy.

Geothermal comes from the words "Geo" and "Therm" where in Greek, Geo means earth and Therm means heat from the earth [2]. The distance from the center of the earth reached 4.000 miles and its temperature is at least 5000 °C. Geothermal energy is energy from the earth's heat that is very clean and sustainable because it is located in the rock layers and magma. Harnessing geothermal energy into electricity will be done by drilling into the reservoir. The geothermal will create steam that will rotate the turbines to produce electricity.

Geothermal energy is located inside the reservoir called geothermal reservoir which consists of hot rocks that produce high temperatures. Based on fluid temperature, enthalpy geothermal energy can be classified as low, moderate, and high. This classification is vague, where at least two variables are required to determine the condition of the water thermodynamics. Geothermal energy is located inside the earth and has a temperature between 250 °C - 330 °C.

The need for electrical energy will experience an increase of at least 1.6% up until 2030, as well as Indonesia is a developing country where the electrical needs are very high from 2011 to 2020 the need for electricity reached up to 8.5% per year [3]. This provides a challenge for Indonesia to create a new source of energy that is more sustainable. Looking at the potential of Indonesia for geothermal energy is very high as stated in the table below:

Table 1 explains that the potential of geothermal energy in Indonesia is very high reaching a potential of up to 28.617 MW and only 1.343,5 MW have been utilized which is only 5% of its overall potential.

Table 1: The potential of renewable energy in Indonesia [3].

Energy source	Potential (MW)	Installed capacity
Geothermal	28.617	1.343
Hydro	75.000	7.059
Mini-micro hydro	769,7	512
Biomass	13.662	75.5 on grid

Indonesia is located strategically in the Ring of Fire along with other countries like the Philippines, Japan, America, Canada, Turkey, and Australia. The Ring of Fire is an area of active volcanoes shaped in an arch that surrounds the Pacific Ocean. The ring of fire is formed by tectonic activities that cause a long collision of subduction areas. Besides that, the tectonic movements also cause the opening of magma at the bottom of the ocean. As a consequence, these areas are rich in magma and able to produce abundant geothermal energy.

Figure 1 explains the strategic position of Indonesia that allows the country to have the potential to develop renewable energy to find a better alternative for energy needs in the future.

Figure 2 shows that Indonesia placed second as the country that produces the most geothermal energy in Indonesia [4]. Other than that, several countries are in the top ten list of geothermal energy producers in the world located in the Ring of Fire (Such as New Zealand and the Philippines) [4]. This shows the potential of geothermal energy in Indonesia which is located in the Ring of Fire is very promising. However, the potential of geothermal energy in Indonesia has not been fully optimized. The government has implemented several regulations that target 17% of

Figure 2: List of 10 Countries Producing Geothermal Energy [4,5].

renewable energy in 2025. Other than the high potential of geothermal energy, the cleanliness of the energy is also an advantage. Geothermal energy comes from the center of the earth and produces clean energy with low carbon dioxide (Co_2) compared to coal and natural gas.

Figure 3 illustrates the comparison of Co2 caused by coal production and geothermal energy only produced Co2 gas of at least 81.6 kg Co2/MWh, compared to coal and natural gas at 514 kg and 1020kg Co2/MWh, therefore this characteristic makes geothermal energy safer to develop in the future and does not cause global warming or damage to the environment [6].

Literature review

Advantages and disadvantages of geothermal energy

Geothermal energy has its advantages and disadvantages that can be a reference for the development of renewable

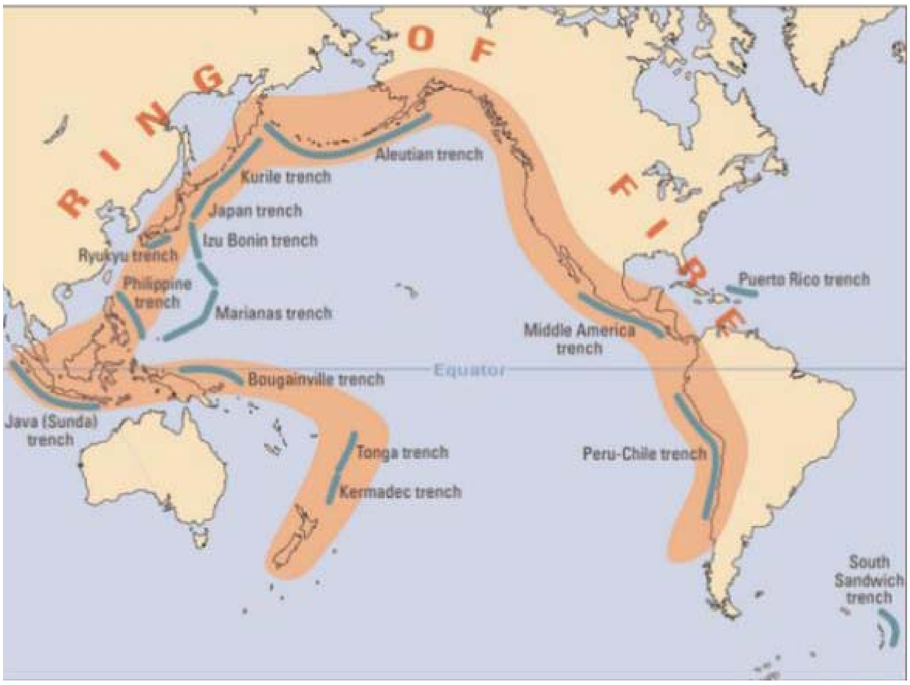

Figure 1: Countries located in the ring of fire [3].

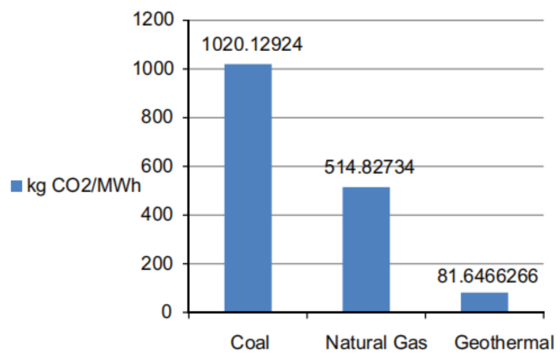

Figure 3: Co2 gas comparison to energy source [3,6-9].

energy in the future. Some of the advantages of implementing geothermal energy are as follows [2,6,10-12]:

1. Geothermal energy is environmentally friendly and does not create pollution, even though it is extracted by drilling into the center of the earth, with no damage in nearby areas even though it is used for power plants and drilling transportation.
2. Geothermal energy energy is constant, unlike wind, and keeps on changing.
3. Reduce pollution from using oil and coal energy if geothermal energy is applied.
4. Geothermal energy will give different forms, where it directly produces electricity and hot water that can be used in households and businesses.

Applying geothermal energy will have positive impacts because geothermal energy has several characteristics as follows [2,6,13-18]:

1. A source of renewable energy.
2. Does not create pollution and is environmentally friendly
3. Does not create waste from product processing.
4. Can be directly used as the energy source for cooking, etc.
5. The maintenance cost for geothermal energy is cheaper than other power plants.
6. Developing geothermal energy does not require vast land and this can protect the environment from damage.
7. Does not depend on seasonal conditions, unlike solar energy.

Geothermal energy also has its weaknesses as follows [2,6]:

1. Not every location has geothermal energy, making its reach a challenge to develop in all of Indonesia.
2. Every geothermal energy source is located far from the city and industrial area where the energy consumption is high.
3. The location of geothermal energy is vulnerable to volcanic eruption.
4. Installation costs from steam plants are high.
5. There is no guarantee that implementing geothermal energy will be profitable, therefore it needs to be constantly reviewed.
6. It is possible to release toxic gas during the drilling process.

Geothermal technology application

Several countries have developed technologies for developing geothermal energy:

Dry steam geothermal: Dry Steam Power Plant uses hydro steam that is formed because of hydrothermal fluid from magma to rotate the turbines and produce electricity. The hot steam condenses and transforms into water that is channeled back inside the reservoir to be heated again [19,20].

Figure 4 illustrates the Dry Steam Geothermal Power Plant installation using hydrothermal fluid as the steam heater.

Flash steam geothermal power plant: Flash Steam Power Plant uses hydrothermal fluid from an underground reservoir and is extracted using a steam separator. Inside the separator, hot water moves on its own with low pressure that will transform the water into steam that is used to rotate the turbines and produce electricity. Flash Steam Power Plant requires hydrothermal fluid with a minimum temperature of 182 Celsius [19,21].

Figure 5 explains the Flash Steam Geothermal Power

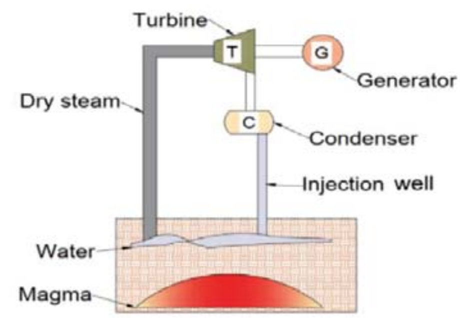

Figure 4: Dry Steam Geothermal Power Plant [8,12,14,19,20].

ISSN 2995-8067
DOI: 10.61927/igmin178

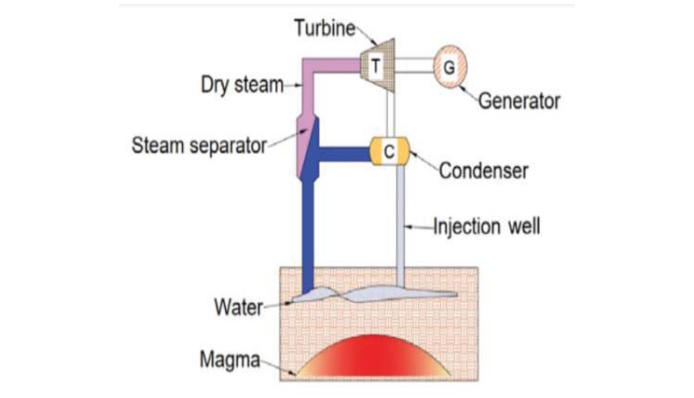

Figure 5: Flash Steam Geothermal Power Plant [19,21].

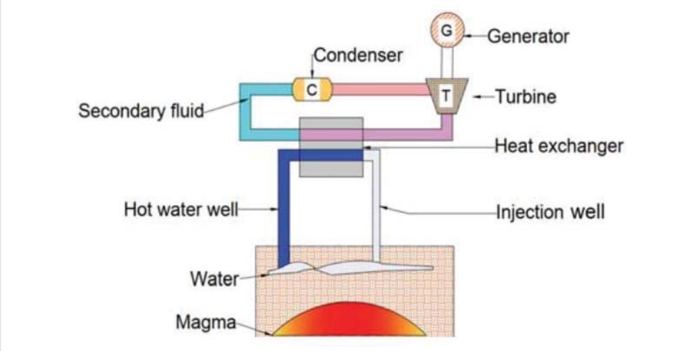

Figure 6: Binary Cycle Geothermal Power Plant [19,22].

Plant which uses a steam separator that lifts the steam into the turbine to rotate it and produce electricity.

Binary cycle power plant: Binary Cycle Power Plant uses heat from water in the hydrothermal reservoir to heat the secondary fluid to a boiling point lower than the water in the reservoir, enabling the heat from the reservoir to heat the secondary fluid into steam that will be used to rotate the turbine and produce electricity [19,22].

Figure 6 explains a binary cycle geothermal power plant that uses a secondary fluid that has a boiling point lower than the geothermal fluid.

Research methodology

Research design

The research methodology used in this research consists of quantitative and qualitative methods (mixed method) with explanation as follows:

1. Quantitative method: This comes from literature reviews (secondary data) that are presented in the form of graphics for analysis.
2. The qualitative method is based on the idea of literature reviews and journals for comparison, forming a synthesis to create a better conclusion and provide recommendations. This research is also equipped with in-depth interviews on the Geothermal Power Plant in Garut to gain expectations and prepare for a more massive implementation in Indonesia.

Below are the steps to build the systematics for this research:

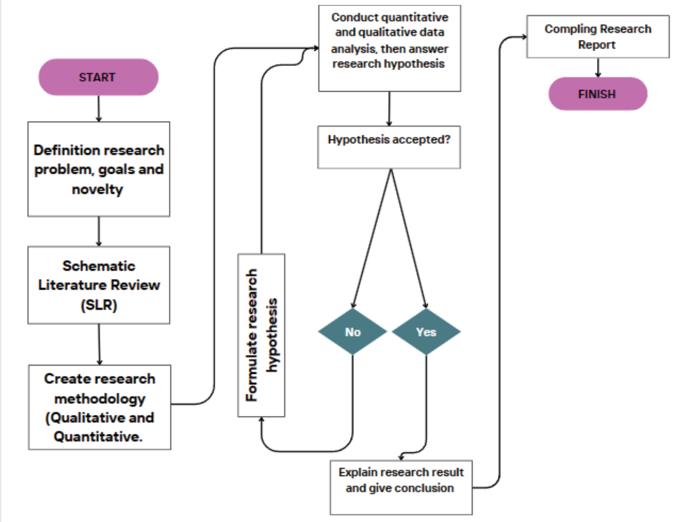

Figure 7: Research Process and Steps.

Figure 7 illustrates the stages in proving the hypothesis using qualitative and quantitative methods. This research aims to prove the following hypothesis:

Ho 1: The potential of geothermal energy in Indonesia will have a huge impact on the fulfillment of electrical energy in Indonesia in the future if developed.

Ho 2: Indonesia has a clear roadmap for geothermal energy, so it can fulfill the increasing need for energy as a renewable energy.

Participants

This research conducts in-depth interviews with the stakeholders of the geothermal energy power plant in Garut with seven experts to find out their experience, perception, and expectations for geothermal energy development in the future. The profile of the respondents interviewed has at least five years of experience in geothermal power plants and a position of at least a supervisor or manager.

Results and discussion

Global geothermal energy potential

The potential of geothermal energy globally or in Indonesia is very high, and the data below illustrate the potential that can be developed through geothermal energy.

Figure 8 explains that geothermal power plants globally are predicted to increase, which is in line with the increase of more than 50% in 2015 [22]. Katadata [26] shows the potential of geothermal energy in Indonesia becoming one

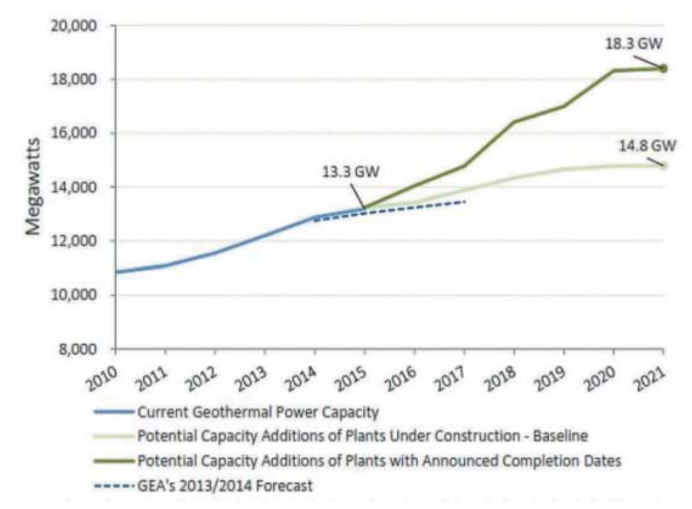

Figure 8: Global Geothermal Energy Potential [23-25].

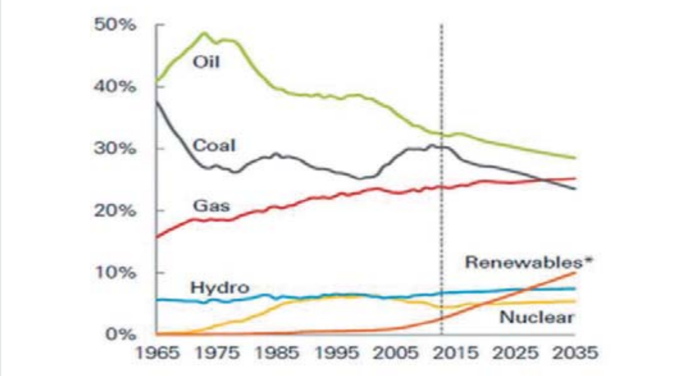

Figure 9: Energy Source Contribution in Indonesia [3,23,25].

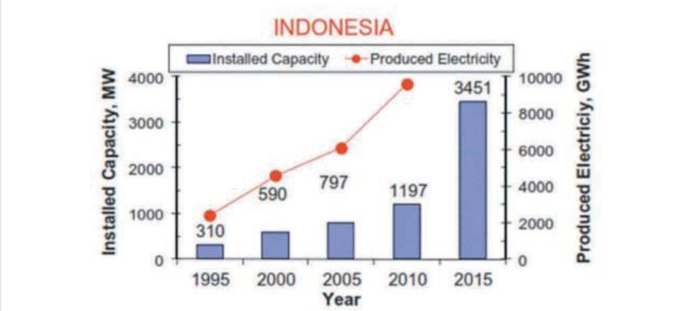

Figure 10: Geothermal Energy Installation and Production [3].

of the largest renewable energy that carries 27% of electric needs.

Figure 9 explains the potential of renewable energy in Indonesia as an alternative solution for facing the decrease in capacity of various energy sources such as coal, crude oil, and water. If geothermal energy is developed in Indonesia, it will become an alternative energy source that will be beneficial in the long run.

Table 2 shows five countries with capacity and geothermal energy production, where Indonesia placed third with geothermal capacity that has been increasing since 2007-2010.

Figure 10 Geothermal Energy Installation and Production [3]

Figure 11 illustrates the seriousness of the government in developing geothermal energy in Indonesia as part of an alternative energy (renewable).

Technology comparison of geothermal energy processing from several countries

Figure 12 explains that most technology used for Geothermal energy in the world uses binary systems. However, binary systems have a relatively low capacity which is 100 MW, then the following systems are direct steam, flash type, and hybrid system. Hybrid systems have a relatively high capacity reaching up to > 300 MW/unit.

The binary system has been implemented in more than 25 locations in the world in the last five years, increasing more than 50%, reaching up to 1.800 MW. Most of the power plants using binary systems will recover geothermal fluid heat in the range of 100°C - 200 °C. The cycle for this binary power plant has an average unit capacity of 6,3 MW and 30,4 MW. The power plants that have a capacity of more than 60 MW are located in the United States, Russia, and the Philippines. In most cases, the binary power plants are involved in the production process along with the steam cycle. The fluid requirement is to ensure safety, reliability, and efficiency for binary power plants that use fluid heat. The application of binary cycle power plants in the joint technology process allows the recovery of geothermal fluid to be more efficient. The features and advantages of binary cycle power plants that use a lot of fluids include the Kalina cycle.

Looking at the characteristics, the geothermal energy potential in Indonesia can be developed through binary and

Table 2: Geothermal energy comparison between Indonesia and other countries [23,25].

Country	Capacity (MW)	Percentage of National Electricity Supply	Percentage of Geothermal Energy Global Production
United States	3086	0,3	29
Philippines	1904	27	18
Indonesia	1197	3.7	11
Italy	843	1,5	8
Japan	536	0,1	5

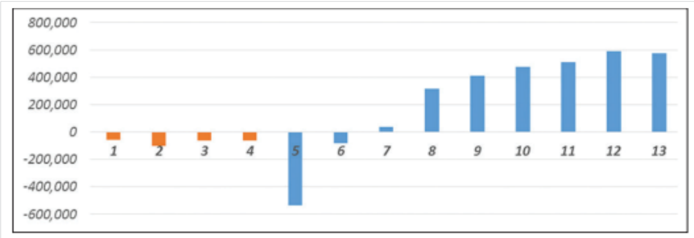

Figure 11: Investment Cash Flow Assumption [29].

ISSN 2995-8067
DOI: 10.61927/igmin178

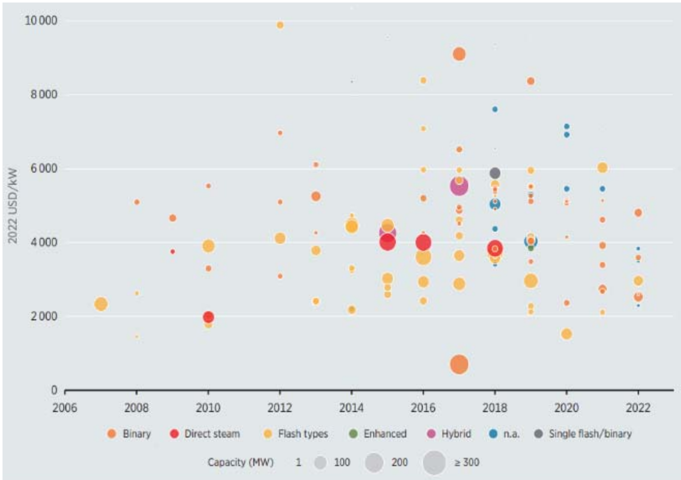

Figure 12: Technology Usage on Geothermal Energy Globally [27].

hybrid systems (joint) [22,23] however some challenges must be considered when exploring geothermal energy in Indonesia [28].

1. The challenges that may be found in Indonesia [28] are as follows: Expensive exploration cost, requiring 24% of the total geothermal energy investments.
2. Geothermal energy exploration requires a long time of up to 7-10 years.
3. The number of financial institutions willing to finance the exploration is still limited.
4. There may be problems across sectors where the geothermal energy location is in a conservation area.

Currently, the development for geothermal energy has only reached 12% located in several areas in Indonesia starting from the highest which are Sumatera, Java, Sulawesi, Nusa Tenggara, Maluku, Borneo and Papua [28].

Economic impact analysis on geothermal energy application as alternative energy

Case study geothermal energy Muara Laboh, Sumatera: Handayani [29] in her research, calculates the financial analysis of the investment of geothermal energy development in Indonesia which has also been done by MIT [6,15]. Some of the factors to be considered are as follows (Table 3):

Table 3: Cost assumption for geothermal energy development in Indonesia (Muara Laboh case study) [29].

Description	Value	Unit
Geology work and early study	2	Mio USD
Construction work	22	Mio USD
Total cost exploration	42	Mio USD
Total cost geology, geography feasibility	1320	Mio USD
Cost injection well	17,5	Mio USD
Construction cost plant	286	Mio USD
Construction Cost SAGS	88	Mio USD
Percentage Management	18.7	Mio USD
Overhead	18	Mio USD
Total Development	635,2	Mio USD

Table 4 describes the high operation cost needed to develop geothermal energy in Muara Laboh.

Table 4: Operation cost assumption [29].

Operating and Maintenance Cost	0,9	Cent USD/kWh
Overhead	0,1	Cent USD/kWh
Makeup Wells (4 Wells every 5 years)		
Per well	5.5	Mio USD/well
Average per year	4,4	Mio USD/well
Major Well Woek Over (2 wells @ 1,2 MUSD Every 3 years		
Per well	1,2	Mio USD/well
Average per year	0,80	Mio USD/year
Plant overhaul (2 Units @ 2 MUSD every 3 years)		
Per unit	2	Mio USD/year
Average per year	1,3	Mio USD/year
Total Average Annual Expenditure During Operations	6,5	Mio USD/year

Figure 11 assumes the revenue and business spending after development in four years, then the geothermal energy development project can be commercialized by producing electricity with a total of 220 MW or equal to 1.734 GWh per year. The electricity bill is 12.6 cents USD/Kilowatt h or equal to Rp 1.675/Kilowatt h. Based on the above assumptions, the gross revenue from the project is Rp 2,9 trillion per year.

Case study PGE Garut

PGE Garut uses two business models to fulfill electrical needs for Perusahaan Listrik Negara (PLN) in the Java and Bali area of up to 60 megawatts and sell hot steam to Indonesia power for 30 Megawatts. Currently operating six wells that will sustain for 40 years. The ESG is high reaching up to 8.2, and the system used is dry steam, while currently developing a binary system for long-term sustainability. PGE used non-active volcanoes, because if it is located in the area of active volcanoes it may be dangerous for the locals and the operators. Damages to the equipment will also be faster if it is located in active volcanoes. The next program will be used as hot springs, where the locations with similar manifestations will be dug further. The strategy used to maintain the steam supply is as follows:

1. Drilling makeup well
2. Hole cleaning
3. Tracer
4. Spinner survey
5. PT. monitoring
6. Production test

ISSN 2995-8067 DOI: 10.61927/igmin178

7. Enhanced steam regeneration
8. Auditing program.

The strategy used for site development will use a low-pressure well and reservoir simulation in cooperation with UGA and TC1. So, it can be seen that the location manifests with similar conditions in Indonesia with PGE Garut is many, therefore it can be seen as a potential for development in Indonesia as renewable energy.

Recommendations

Geothermal energy development roadmap in Indonesia: To develop geothermal energy as renewable energy, serious and clear strategic steps must be constructed. The Indonesian government must prepare a roadmap for geothermal energy development to ensure that geothermal energy will become a renewable energy that has huge benefits. The roadmap must be a reference for all stakeholders in developing geothermal energy in Indonesia the International Energy Agency (IEA) recommends several strategic steps in developing geothermal energy that can be a reference in Indonesia.

Figure 13 describes that developing countries in Asia have a huge portion in geothermal energy development in the future (2050), where this large portion must be optimized by exploring the geothermal energy sources in Asia, especially in Indonesia.

From Table 5, as given above, it can be concluded that the suitable system for Indonesia consists of a flash steam geothermal power plant and a binary cycle power plant. The geothermal energy development roadmap in Indonesia consists of strategic steps as follows:

Figure 14, the strategic steps made to develop the development of geothermal energy in Indonesia at least until 2050.

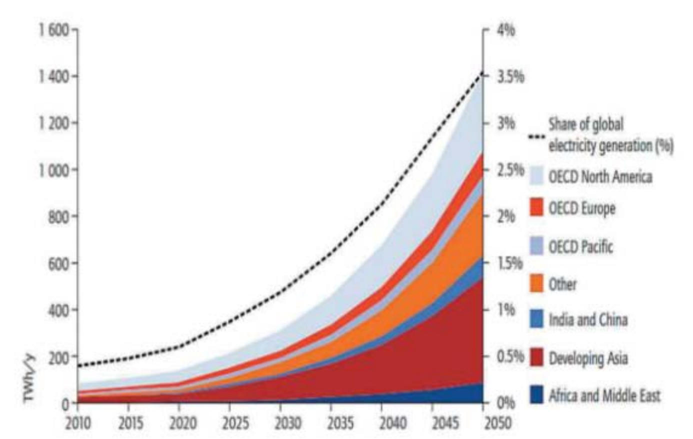

Figure 13: Development Plan for Global Geothermal Energy [2,23].

Table 5: Geothermal Energy Systems Comparison [12,30].

Aspect	Dry Steam	Flash Steam	Binary Cycle
Cost	Low (USD 6-8 million/MW)	Moderate (USD 10-12 million/MW)	High (USD 15-20 million/MW)
Reservoir Temperature	High (> 230 °C)	Moderate (150°C - 230 °C)	Low (50°C - 100°C)
Reservoir Pressure	High	Moderate	Low
Suitability in Indonesia	Rare	Common	Potential
Efficiency	High (> 30%)	Moderate (20% - 30%)	Moderate (15% - 25%)
Complexity	Low	Moderate	High
Work Principle	Steam used directly	Hot water into steam	Hot water heat work fluids
Produce Waste	Yes	Yes	No
System Type	Open-loop	Open-loop	Closed-loop

Figure 14: Geothermal Energy Power Plant Implementation Roadmap in Indonesia

From Figures 15,16, it can be seen that the potential of geothermal energy that has been exploited is still low compared to the total potential of geothermal energy in Indonesia. To be able to fully utilize the potential of geothermal energy in Indonesia, the involvement of state-owned enterprises and private sectors that are oil giants is necessary to accelerate the implementation of geothermal energy in Indonesia following the roadmap. This happens for the reasons as follows [9,16,17,27,33]:

Geothermal energy requires high investment to build power plants whereas the total cost of geothermal energy involves site exploration, drilling, building power plants, and O&M (operations and maintenance [18,27,33,34].

The tools used to explore and drill oils can be used again for exploring geothermal energy sources [27,33].

Figure 17 shows the importance of the private sector in developing geothermal energy in Indonesia, where PT Pertamina Geothermal Energy (PGE) contributes highly to the total installation of geothermal energy power plants in Indonesia, where PGE is involved in adding 1.877 MW from the total installation of 2.133 MW [4]. PGE does not only have its operation but also conducts joint operation contracts with another party.

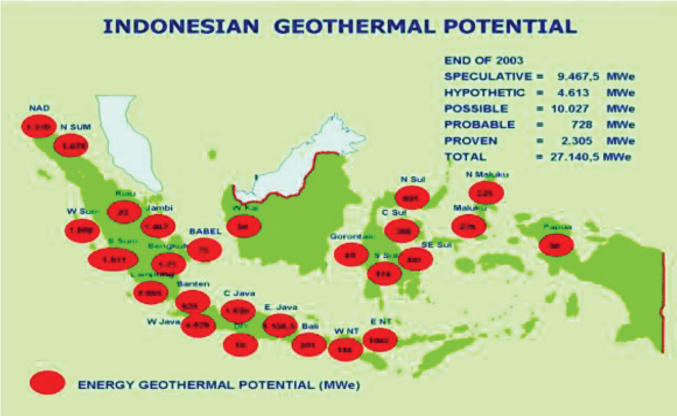

Figure 15: Total Potential of Geothermal Energy in Indonesia [31].

Figure 16: Plan Map for Geothermal Energy Development in Indonesia [32].

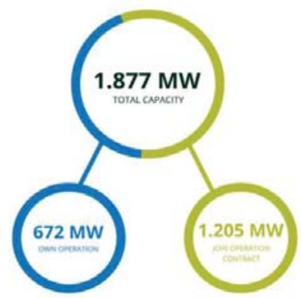

Figure 17: Geothermal Energy Power Plants Development by Pertamina Geothermal Energy [34].

Conclusion

Based on the explanation above, it can be concluded that:

1. The potential contribution of geothermal energy in fulfilling energy requirements in Indonesia until 2050 is very high where other energy sources such as coal, oil, gas, and water have decreased. At that moment, a renewable energy source is needed as an alternative energy for Indonesia, and one of the options is the development of geothermal energy.

2. Geothermal energy will become a highly potential alternative energy, so a roadmap and strategic steps are necessary for implementing geothermal energy as an alternative energy in Indonesia.

3. Looking at the two study cases on the geothermal energy locations in Indonesia, it is optimistic and confident that the massive implementation of geothermal energy in Indonesia will be a profitable investment and will have long-term sustainability.

Acknowledgment

The authors would like to thank our colleagues for their cooperation in providing important data to accomplish this study.

Funding support

This study was funded by Yayasan Enam Peduli Pendidikan (YEPP) Under Grant No. 003/YEPP/Grant/2024

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

References

1. Teknologi P. Outlook Energi Indonesia (Indonesian Energy Outlook) 2011. 2022. (website)

2. Bagher AM. Geothermal Energy. 2014; 146-168. 6: 2014. http://www.academicjournals.org/journal/JETR

3. Nasruddin. Potential of geothermal energy for electricity generation in Indonesia: A review. Renewable and Sustainable Energy Reviews. Elsevier Ltd. 2016; 53: 733-740.

4. ThinkGeoEnergy, ThinkGeoEnergy's Top 10 Geothermal Countries 2022 - 2d Policy. 2020; 10: 31-35. doi: 10.32479/ijeep.9047.

11. Kumar S. Review of geothermal energy as an alternate energy source for bitcoin mining. Kozhikode. 2022. https://www.researchgate.net/publication/358249180

12. Dalla F. Scenarios for geothermal energy deployment in Europe. Energy. 2020; 206.

13. Cetin TH, Kanoglu M, Yanikomer N. Cryogenic energy storage powered by geothermal energy. Geothermics. 2019; 77: 34-40.

14. Manzella A. Environmental and social aspects of geothermal energy in Italy. Geothermics. 2018; 72: 232-248. Mar. 2018, doi: 10.1016/j.geothermics.2017.11.015.

15. Soltani M. A comprehensive review of geothermal energy evolution and development. International Journal of Green Energy. Taylor and Francis Inc., 2019; 16: 971-1009,

16. Lund JW, Toth AN. Direct utilization of geothermal energy 2020 worldwide review. Geothermics. 2021; 90.

17. Moriarty P, Honnery D. Can renewable energy power the future?, Energy Policy. 2016; 93: 3-7.

18. Harjanne A, Korhonen JM. Abandoning the concept of renewable energy, Energy Policy. 2019; 127: 330-340, doi: 10.1016/j.enpol.2018.12.029.

19. Lawal TO, Nwankwo LI, Iwa AA, Sunday JA, Orosun MM. Geothermal Energy Potential of the Chad Basin, North-Eastern Nigeria. Journal of Applied Sciences and Environmental Management. 2019; 22: 1817.
20. Buonocore E, Vanoli L, Carotenuto A, Ulgiati S. Integrating life cycle assessment and emergy synthesis for the evaluation of a dry steam geothermal power plant in Italy. Energy. 2015; 86: 476-487.
21. Cerci Y. Performance evaluation of a single-flash geothermal power plant in Denizli, Turkey. 2003.
22. Tomarov GV, Shipkov AA. Modern geothermal power: Binary cycle geothermal power plants. Thermal Engineering. 2017; 64: 243-250. doi: 10.1134/S0040601517040097.
23. Barbier E. Geothermal energy technology and current status: an overview, 2002. www.elsevier.com/locate/rser
24. Kulasekara H. A Review of Geothermal Energy for Future Power Generation, 2019.
25. Soltani M. A comprehensive review of geothermal energy evolution and development. International Journal of Green Energy. 16: Taylor and Francis Inc. 971-1009.
26. Katadata. Indonesia's Geothermal Energy Has Great Potential - Infographic Katadata.co.id, Indonesia's Geothermal Energy Has Great Potential, (Indonesia's Geothermal Energy Has Great Potential - Infographic Katadata.co.id, Indonesia's Great Geothermal Potential) pp. 1-1, 2021.
27. I Renewable Energy Agency. Renewable Power Generation Costs in 2022. www.irena.org
28. ReforMiner Institute, constraints on Indonesian geothermal exploration, Constraints on Indonesian Geothermal Exploration, Obstacles to Indonesian Geothermal Exploration). 2022; 1-1.
29. Handayani D, Surachman E, Nur Surachman E, Sektor UV, Aren P, Tangerang Selatan K. as Financing Strategy for Renewable Energy Infrastructure: Case Study of Muara Laboh Geothermal Power Project International Journal of Energy Economics and Policy Sukuk Negara as Financing Strategy for Renewable Energy Infrastructure: Case Study of Muara Laboh Geothermal Power Project. International Journal of Energy Economics and Policy. 2017; 7: 115-125.
30. EBTKE, Geothermal Sector _ Cross EBTKE, (Geothermal Sector _ Cross EBTKE, EBTKE) EBTKE. 2023; 1-1.
31. Kanalsatu.com, Indonesia's geothermal energy potential reaches 29,000 MW _ alatsatu.com, (Indonesia's geothermal energy potential reaches 29,000 MW) Kanalsatu.com. 2013; 1-1.
32. Alamendah. PLTP Location Map _ Alamendah's Blog, alamendah blog (PLTP Location Map _ Alamendah's Blog,). 2015; 1-1.
33. Le Nian Y, Cheng WL. Insights into geothermal utilization of abandoned oil and gas wells, Renewable and Sustainable Energy Reviews. 2018; 87: 44-60. doi: 10.1016/j.rser.2018.02.004.
34. Pertamina Geothermal Energy. Our Business - Pertamina Geothermal Energy Tbk (1), (Pertamina Geothermal Energy, Our Business - Pertamina Geothermal Energy Tbk (1) Pertamina. 2023; 1-1.

How to cite this article: Sari EM, Manggala KN, Arief MF, Said PSU. Challenge and Readiness to Implemented Geothermal Energy in Indonesia. IgMin Res. May 01, 2024; 2(5): 290-298. IgMin ID: igmin178; DOI: 10.61927/igmin178; Available at: igmin.link/p178