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A Review and Feasibility Study of Geothermal Energy in Indonesia

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Abstract

Driven by the increase in the population every year, the demand for electricity in Indonesia also increases rapidly. There are still roughly 50 million Indonesians who are still lacking access to electricity. However, due to the rapid economic growth in recent years, the Indonesian Government focused more on developing renewable energy in their country. One of those initiatives is to produce electricity using geothermal energy. Indonesia is located in a strategic location with volcanoes which makes the country the world's largest geothermal storage. Despite all the cons caused by geothermal energy, the Indonesian Government still looks forward to turning Indonesia into the world's largest geothermal electricity producer over the next ten years. The focus of this research is to identify and eliminate the obstacles in adopting the best approaches in developing geothermal energy in Indonesia.

Keywords: energy; geothermal energy; electricity; Indonesia; renewable

Introduction

Geothermal energy is defined as thermal energy that is generated and stored in the Earth. It is a kind of energy that is used to determine the temperature of matter and also an environmentally friendly energy source. It initiates from the novel formation of the planet which occupies 20% of the total geothermal energy produced while the rest originates from radioactive decay of materials [1-3].

Mostly, geothermal energy is used to generate electricity. Besides, it can also be used in heat pumps, bathing, space-heating, aquaculture, and other activities related to the industries. The top five countries that generate electricity using geothermal energy are the United States, the Philippines, Indonesia, Mexico, and Italy [4,5].

In recent years, the geothermal power market grew significantly due to rapid economic growth. The growing economic causes a lot of low income and rural communities to demand more electricity. Due to the limitation of non-renewable energy, many governments start to research cheaper and marketable renewable energy and geothermal energy is one of them [6-8].

Our neighboring country, Indonesia, is one of these emerging markets that see its electricity demand increase by about 10% per year [9-11]. Hence, Indonesia needs about 6GW per year in additional generating capacity [12]. Indonesia has an electrification ratio of 80.38% at the end-2013, which implies that there are still roughly 50 million Indonesians who are still lacking access to electricity [13-14].

As a result of volcanic geology, Indonesia occupies 40% of the world's potential geothermal resources [15-16]. The government has high hope for this kind of renewable energy as the country contains the world's largest geothermal reserves [17]. In the next few years, the country is looking forward to being the world's largest geothermal electricity producer due to the large storage of geothermal resources [18-19]. Energy generation from solar [20-31], wind [32-34], and biomass [35-39] have advantages and disadvantages. Similarly, Hydropower has pros and cons [40-42]. The proper way of energy distribution and considering economic and environmental impact may

mitigate the drawbacks [43-46]. Moreover, people can use less energy through green buildings [47-49]. However, using geothermal energy would certainly advantageous.

Further discussion based on the development of geothermal energy in Indonesia will be highlighted throughout this research report and recommendations and conclusions will be discussed at the end of the report.

Geothermal Energy

Geothermal is defined as the heat derived below the surface of the earth which can be harnessed to be used as renewable energy.

The geothermal energy produced by the Earth's crust consists of 20% of the novel formation of the earth and 80% of the radioactive decay of the materials below the Earth's crust [12]. Magma is a mixture of molten or semi-molten rock locating below the Earth's crust. It continuously produces the heat resulting from the decay of naturally radioactive materials such as uranium and potassium.

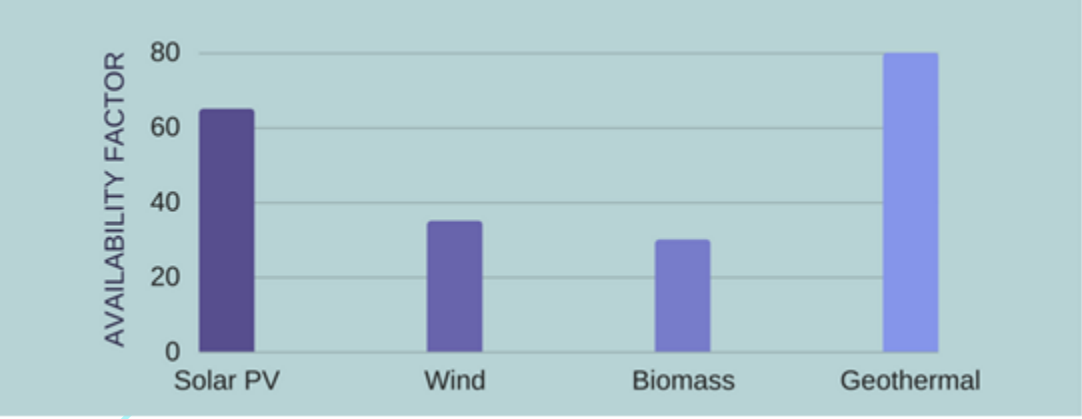


Figure 1: Reliability of Geothermal Energy source [50]

Geothermal energy is a constant source of energy since it is not dependent on wind or the sun. It is available all year long. When looking at the availability factor shown in figure 1, it can be seen that how reliable and constant specific energy sources are, geothermal is ranking on the top, way above the other groups, which supports the argument of its independence on inconstant external circumstances when delivering energy [50].

Uses of Geothermal Energy

There are a few uses of geothermal energy in daily life. During winter, hot water is necessary for bathing. The hot water from the geothermal heat pump can heat the entire bathroom when a person is bathing. To get the hot water directly from beneath the Earth's surface, some countries build geothermal reservoirs of hot water. Some of the reservoirs serve the purpose of industrial and commercial uses besides residential use. In ancient times, people were using hot springs for bathing, cooking food, and loosening feathers and skin from the game. Today, hot springs are still used as spas as it contains mineral-rich spring water for medicinal baths.

In modern days, hot water is provided by a geothermal reservoir. To do this, a well is drilled into the geothermal reservoir to pump the water from the inner part of the Earth by loops in the geothermal pump. The mechanical systems consist of a piping system, a heat exchanger, and some controls. Besides bringing the water up through the well, these mechanical systems can be used as delivery systems for the heat directly for other potential uses. To reduce the amount of cold water from the system, a disposal system is installed to either inject the cold water back to the underground or dispose of it onto the Earth's surface [2].

In some countries, geothermal energy is used in greenhouse and aquaculture facilities. These two facilities are the primary uses of geothermal energy in the agribusiness industry. This is because geothermal resources can save the use of traditional energy sources by about 80%. This is crucial as the use of traditional energy resources such as fuel energy does cause lots of pollutions to the environment and the operating cost is relatively higher than the cost of geothermal energy. The use of geothermal energy in rural areas can provide clean air and clean water, reduce disease problems, and provide a stable workplace for the people living in rural areas [5-6].

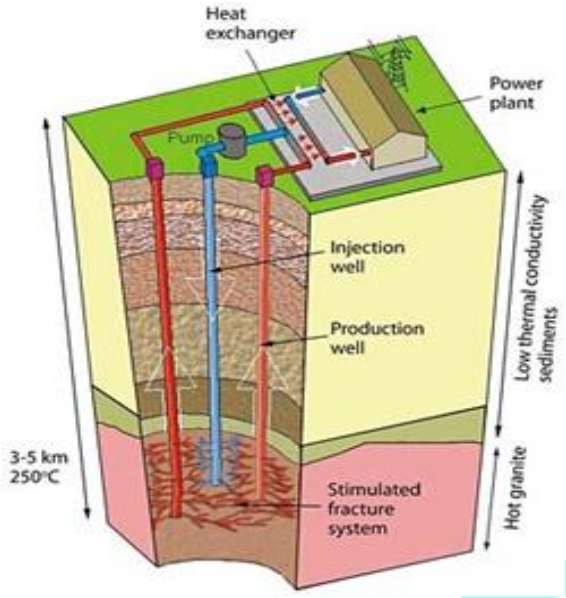


Figure 2: Geothermal Energy Capture technique [51].

Figure 2 explains how geothermal energy can be captured. At first, cold water is pumped at high pressure down into the hole. The water exchanges the temperature and become very hot by the fractured hot rock. Then the hot water comes back on the top and is directed through a heat exchanger. After giving up its heat the cooled water is recycled back down the injection borehole into the hot rock bed. The working fluid, a low boiling point liquid, circulating through the secondary circuit of the heat exchanger is vaporized by the heat extracted from the well water and used to drive the turbine [51].

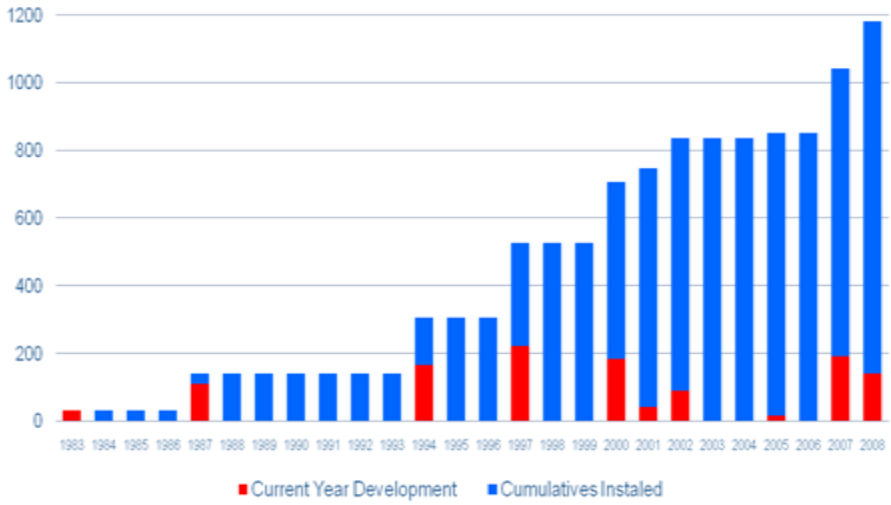


Figure 3. Installed capacity Indonesian geothermal power plant [52].

Figure 3 shows the installed capacity in Indonesia over the years. It can be seen that it is increasing rapidly. Mainly geothermal energy has been used to generate electricity. It can also be applied in some industrial activities such as food dehydration, laundries, milk pasteurizing, etc. It is very common to use geothermal energy to dry the vegetable and fruit in the food industries.

Why Geothermal Energy in Indonesia

Locating next to Malaysia, Indonesia is among the top five countries in the world which generate electricity by using geothermal energy. The other four countries are the United States. The Philippines, Mexico and Italy, and Indonesia are among the top three countries ahead of Mexico and Italy.

The geothermal power market had grown significantly in recent years due to the rapid growth of the economy. This causes the increasing demand for electricity in rural areas as most of the communities are connected to the electricity grid. Due to the limitation of fuel energy, many governments start to focus more on exploiting more renewable energy as fossil fuels are expensive and environmentally unfriendly.

Indonesia is among the country that benefits a lot in searching for alternative energy replacing fossil fuel energy. The electricity demand of Indonesia increases by 10% every year particularly outside the island of Java as more rural communities in those islands need more electricity. Thus, to fulfill the increasing electricity demand of the residents in Indonesia, the government needs to generate an extra 6 GW per year.

Compare to all the countries in the world, Indonesia has the biggest potential to further develop geothermal energy in the country as it has the world's largest geothermal resources. In other words, Indonesia has 40% of the world’s potential geothermal resources.

Another reason why geothermal energy is growing rapidly in Indonesia is that the geography of Indonesia is dominated by volcanoes. These volcanoes were formed due to subduction zones between the Eurasian Plate and the Indo-Australian plate [8-10].

Pros and Cons of the Geothermal Energy

Despite the potential of Indonesia to become the largest geothermal electricity producer in the world in the future, there are some pros and cons of geothermal energy that have to be taken into consideration.

Geothermal energy benefits a country with volcanic geology a lot such as Indonesia as geothermal energy is reliable energy if the geothermal resource is sufficient. Geothermal power can be produced non-stop regardless of the changing of the climate. That means a geothermal power station operates 24 hours a day, 7 days a week and this ensures a uniquely reliable and source of clean energy is supplied continuously. Geothermal is also capable of achieving a high capacity factor. Capacity is defined as the measurement of actual output over some time. The capacity factor that can be achieved by geothermal is usually more than 90% and this is higher than the other power sources such as coal-fired and nuclear power plants.

More and more employees are needed in Indonesia due to the rapid growth of their economy. In other words, any industrials creating more job opportunities stand a chance to be further developed by the government. Geothermal projects provide economic growth and jobs, especially in rural areas with high unemployment. An example can be seen in the United States like California, one of the country's highest unemployment states had provided a total of 380 working opportunities during the construction of the geothermal power plant. Table 1 shows the job types through the project timeline during the development of the geothermal industry.

Year 1	Year 2	Year 3	Year 4	Year 5
Start-up	**Exploration**	**Feasibility Drilling**	**Drilling & Construction**	**O & M**
Geologists	Geologists	Mud Loggers	Engineers	Plant Managers
Wildlife biologists	Engineers	Drilling Engineers	Welders	Engineers
Hydrologists	Consultants	Casing Crows	Steel Erectors	Plant Technicians
Lawyers	Clerical Staff	Welders	Concrete Placers	Site Operators
Paralegals	Management Staff	Safety Managers	Field Engineers	Service Repairmen

Table 1: Job Types through Project Timeline

Table 1 above has been derived from the Geothermal Energy Association. Today, renewable energy is more preferable to non-renewable energy as renewable energy is more environmentally friendly [13]. Geothermal power plants do not involve any combustion process during the production of geothermal energy. Compared to fossil fuel energy production, geothermal power plants emit lower levels of greenhouse gases. Geothermal heat pumps for the heating and cooling of the buildings are very effective as they have low electricity consumption and low emission of harmful gases.

Despite all the advantages of geothermal energy, there are still some disadvantages caused by geothermal energy which are unavoidable. Geothermal energy requires heat and matter from the Earth's crust to generate the energy. To have easier access to the heat and matter from the Earth's crust, areas with volcanic geology is preferred. These cause the prime sites of the geothermal power plants are very location-specific as volcanoes are only found in some of the countries. The prime sites are usually located far from the population centers as not many residents are willing to live near the volcanoes. The long-distance transmission of electricity may cause some energy losses during the harnessing of geothermal energy.

Although geothermal power plants emit lower greenhouse gases than fossil fuel plants, they still emit some hazardous gases to the environment such as sulfur dioxide and silica. Sulfur dioxide contributes to the formation of small acidic particles that can be absorbed by the human and cause heart and lung disease.

Geothermal power plants can alter both water quality and consumption. Hot water that comes from the underground reservoirs contains a high level of sulfur and other minerals. Most geothermal facilities are using closed-loop water systems. This system pumps the extracted water back into the reservoirs after the process. There is a risk that the water may flow to the surrounding and causes pollution to the river or land nearby if the disposal of the water is not done properly.

Development of Geothermal Energy by the Indonesian Government

For the past few years, the Indonesian Government had tried some projects to further develop geothermal energy in Indonesia as they were looking forward to making Indonesia the largest geothermal electricity producer in the world surpassing the Philippines and the United States. There are a total of 276 locations that had been verified with geothermal energy potential that is estimated to have resources sufficient to generate 29 GW of electricity. This equates to 40% of the world's geothermal reserves.

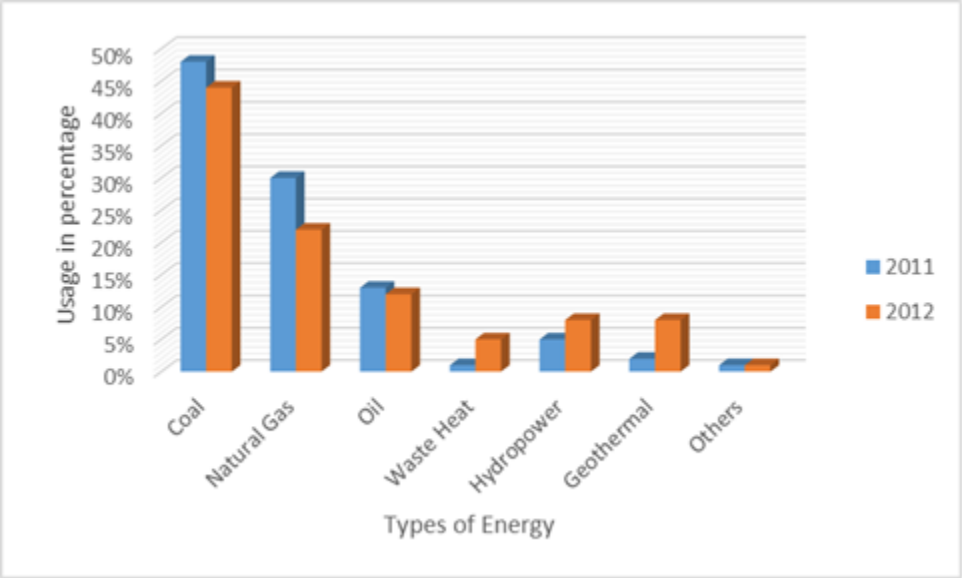
The first geothermal power plant in Indonesia was built in 1983 named the Kamojang Power Plant. It reserved a total of 333MW of energy and could produce 200MW every year for the people living in Indonesia. Since then, more geothermal power plants were being built in Indonesia such as Gunung Salak (1994), Darajat (1994), Sibayak (1995), Wayang Windu (1999), Lahendong (2001), and Dieng (2002).

In recent years, The Indonesian Government had announced several plans named the "fast-track" plan as a part of the geothermal energy development plan. The plan will increase Indonesia's electricity generation network by almost 10,000 MW in total. At the end of 2014, the government managed to speed up the development of 3,977 MW new geothermal power plants which require a total of US$ 12 Billion.

Besides building new geothermal power plants around Indonesia, the government had also applied some geothermal policies to protect the development of geothermal energy. The new geothermal policy by the Indonesian Government caused the paradigm of national energy management to shift from Supply Side Management to Demand Side Management. Supply Side Management mainly focuses on fossil fuel energy sources whereas Demand Side Management targeting more on optimizing energy efficiency and new renewable energy sources. The geothermal policy by the Indonesian Government gave Indonesia to have a high potential for energy savings and the development of more new sustainable energy other than geothermal energy.

Comparison between the Energy Demand in Indonesia for 2011 and 2012

According to a report done by the U.S Energy Information Administration, Indonesia had an estimated 44GW of installed capacity in 2012 and generated 200 billion kWh. In the report, it was stated that there were roughly 91% of the electricity in Indonesia was generated by non-renewable energy sources such as coal, natural gas, and oil. The usage of coal almost accounted for half of the electricity generation in Indonesia. The table below shows the usage of non-renewable and renewable energy for electricity and power generation in Indonesia from the year 2011 to 2012.



From Figure 4, it is clear that the usage of non-renewable for the production of electricity in Indonesia had dropped by a certain percentage from 2011 to 2012. The good news was that the usage of renewable energy such as waste heat, hydropower, and most importantly the geothermal energy had increased from 2011 to 2012 [18].

In 2011, there was a total of 91% of non-renewable energy such as natural gas, oil, and coal were used to produce electricity in Indonesia. However, in 2012, the number dropped to 78% compared to the previous year. The result showed that the efforts made by the Indonesian Government had been paid off.

The Indonesian Government had set a national goal which is by 2020, 90% of the households would have accessibility to electricity. To solve the capacity storage problem, the government had several plans in mind. Although the generation of electricity increases from year to year, the Indonesian Government managed to transform some of the energy used for electricity production from non-renewable energy to renewable energy.

One of the most significant pieces of data in the graph shown above is the increment of the usage of geothermal energy from 2% in 2011 to 8% in 2012. While the usage of other renewable energy such as hydropower and waste heat also increased in a small amount. This had shown that the Indonesian Government was slowly approaching its ultimate mission; the largest geothermal electricity producer in the world.

Recommendations and Conclusions

Currently, there are still numbers of people in Indonesia who are still lack of accessibility to electrical energy. The energy consumption growth of Indonesia is 7% per year and this is not yet balanced with the energy supply. The dependence on fossil fuel energy is still high although the energy reserved is limited as the fossil fuel subsidy is increasing every year.

One recommendation for this phenomenon is that the Indonesian Government has to start funding for energy development. They should try to increase the subsidy for renewable energy development especially geothermal energy by decreasing the subsidy for fossil fuel.

There are some obstacles to the development of geothermal energy in Indonesia as the operational cost is high. During the exploration stage, the risk percentage is higher. Hence, big owner-investment is needed to support geothermal energy development. Although the geology condition in Indonesia is suitable for harnessing geothermal energy, there are still some issues when comes to searching for a big and wide land to build a geothermal power plant. They have to prevent building the power plant in some areas such as protected forests and cultural sites. The government has to put some effort to solve this problem.

In short, geothermal energy has the potential to be further developed in Indonesia. All the authorities should co-operate with each other as the use of renewable energy can save the environment.

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