Geothermal energy in Indonesia: What's the most efficient way to apply geothermal energy in Indonesia to get energy?

By Mr. Jason O'Shea, 2013

Introduction & background

Energy security for Indonesia as a developing country is one of the challenges which Indonesia has to deal with. Indonesia's rapid economic growth and the growing population have resulted in an increasing demand for electricity in the recent years, with an annual growth expected. The growing consumption and production of energy is associated with an increasing environmental impact especially in the urban areas. With the growing urban areas there is a need for more energy and fossil fuel which causes more air pollution. Indonesia depends too much on the luxury of fossil fuel consumption for their electricity. The high tariff on fossil fuels needs to be cut down so that renewable energy has an opportunity.

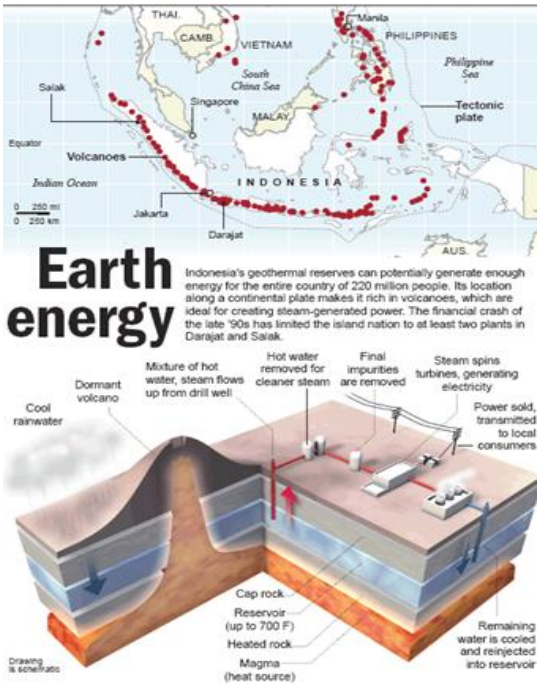
The government of Indonesia has pledged to reduce its greenhouse gas (GHG) emissions by a minimum of 26 percent in 2020. Shifting from fossil fuels to renewable energy sources is one of the ways to fulfill this commitment. The renewable energy pathway is to strengthening Indonesia's energy security and a sustainable development (ring of fire: a vision for Developing Indonesia's geothermal power,2012).With this, the infrastructure in Indonesia needs to be strengthen to accelerate the development of geothermal energy.

Indonesia lies in a geological area with lots of volcanoes where the underground is warm/hot. Indonesia is therefore a useful country to use geothermal energy, there is no need to drill deep for geothermal sources.

With geothermal energy, people need to take in count the protected forests. Indonesia alone holds 40 percent of the world's total geothermal reserves. Currently only less than 4 percent is being developed, leaving the sector wide open for growth. (pamerindo, 2013).

Here below you see a first impression where in Indonesia there are geothermal sources and how a geothermal system can work.

Figure 1: geothermal sources in Indonesia & how a geothermal system can work



Geothermal evolution office: USSG, 2011

Main question & research method

This article is concentrating on how Indonesia can fulfill the potential of the geothermal energy that Indonesia has. Applying geothermal energy has to be done in an efficient, sustainable and environmental friendly way. In this article you can read how this is possible and how this will contributes on the reduction of greenhouse emissions. The challenges and opportunities for applying geothermal energy in Indonesia are explained in this article. One of the challenges Indonesia has is the infrastructure and the deforestation when using geothermal energy plants. Up to 42 percent of potential geothermal resources

or more than 12 GW are located in protected forests areas (MEMR 2011).

The decentralization of governments is creating confusion, local governments become the official owners of the steam resource, whereas the central government plays a role providing expertise and underwriting the power purchase agreements (De Wilde 2010) beside this there are more challenges within the government.

With applying geothermal energy In Indonesia there are some barriers. There has been research in where and how Indonesia can apply geothermal energy. The main question that is used for this article is shown here below.

Main: What's the most efficient way to apply geothermal energy in Indonesia to get energy?

To support the main question and make the research clear, I've formulated sub questions. First of all there has been looked at the current energy market in Indonesia. To give a clear over view of the market where Geothermal energy lies in.
The barriers that geothermal energy has in Indonesia has to be taken into account. So these barriers can be removed.
At last but not least, the potential of geothermal energy will be showed. This to make clear how much, where and how Indonesia can profit from geothermal energy. The sub questions are shown here below.

Sub: **-**What's the current energy market in Indonesia?
-Which barriers are there when applying geothermal energy in Indonesia?
-What kind of role does the government has with applying geothermal energy?
-What's the impact on the forests when using geothermal energy in Indonesia?
-What are the problems with the infrastructure when using geothermal energy in Indonesia?
-What's the potential of Geothermal energy in Indonesia?
-Where in Indonesia are the most useful places to use geothermal energy?
-Which kind of geothermal energy systems can be used?
-Which geothermal energy system is best suitable to apply in Indonesia?

To find reliable and related information for my research there's mostly used qualitative desk research whereby various sources of information are used, for example: Scientific articles, books and internet websites. The advantages of a literature study are that the required information has already been published before. Literature is compared to one another and an attempt is made to obtain new insights and to have a critical look on statements and allegations from different parties.

Information also came from outside the written sources. The information from the guest lectures of the study Climate & Management has been used in this article. The information was told by experts from different backgrounds.

The energy market of Indonesia

This chapter will give a view on the energy market of Indonesia based on the latest information. This will give you an inside about the current situation in the energy market where geothermal lies in.

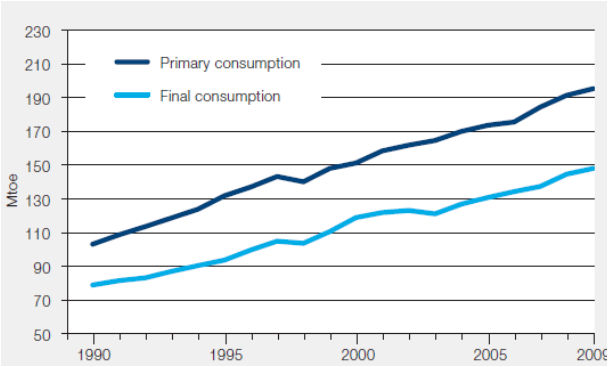
The energy consumption trend from the 1990 is a steady increase. The global economic crisis in 2009 did not affect the pace of the growing energy consumption in Indonesia. The final energy consumption has grown around 3, 5 percent annually.

In 2009 oil was Indonesia's dominant source of energy, providing 32 percent of the total energy demand. Biomass came second with 27 percent, while coal accounted for 19 percent, gas for 18 percent and primary electricity (hydroelectricity, geothermal) for 4

percent. The share of coal has increased strongly in the recent years at the expense of oil (Indonesia Energy efficiency rapport, 2011.

Energy consumption has increased by more than 8, 5 percent annually since 1990, more rapidly than total energy consumption. That large increase is explained by the use of electricity in all sectors and the increasing country's electrification rate. The current plan from the Indonesia's government is to continue the electrification process. The objective is to reach an electrification rate of 90 percent by 2020. The share of industry in electricity consumption is decreasing, from 51 percent in 1990 to 43 percent in 2000, and in 2009 accounted for 37 percent of the total; households accounted of 39 percent and the service sector for 24 percent. In the figure here below you see the overview of the energy consumption of Indonesia.

Figure 2: Primary- & Final consumption

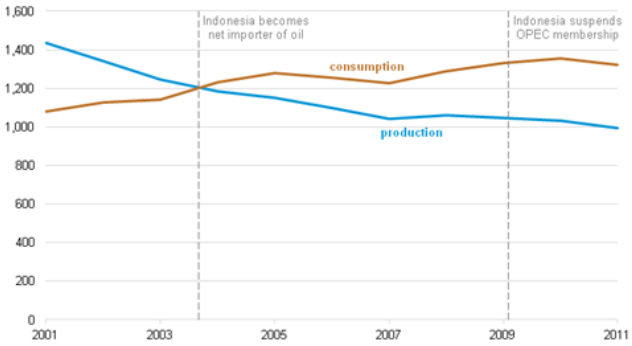


Enerdata, 2011

Throughout the Indonesian energy market the state-owned PT.PLN (a former monopoly company) controls a lot of the energy market. The company has a big invest in the development of the national electricity system, with the focus on the Java-Bali energy grid. The PT.PLN has a big debt and received a government subsidy in 1998, just to cover foreign exchange loss on fuels purchased during Asia's economic crisis.

In 1992 Indonesian state-owned enterprise law was changed to allow private companies to produce and sell electricity in Indonesia. A program had already begun to encourage foreign direct investment (FDI) in independent power producer (IPP) projects for high demand areas (The ring of fire: The Use of Geothermal Energy in Indonesia, 2001). Indonesia was a member of the OPEC (Organization of the petroleum Exporting Countries) from 1962 to 2009. OPEC is an intergovernmental organization of growing domestic oil consumption. Limited investment into reserve replacement of oil causes Indonesia to become a net importer of both crude oil and refine products by 2009. Indonesia suspended its OPEC membership in January 2009 to concentrate on meeting demand in Indonesia. In the figure (3) you see the shift of oil supply and consumption in Indonesia.

Figure 3: oil supply and consumption, Indonesia 2001-2011



Energy information administration, international energy statistics 2012

The role of the government

In the beginning of the research there was no clear information that the government of Indonesia was not supporting geothermal energy. After some research there were barriers within the government. Although the government of Indonesia is supporting the geothermal energy some energy policies continue to rely on fossil fuel. Like the energy pricing and subsidies are not accelerating the geothermal development. To accelerate the geothermal energy development the economic needs to cahnge like reforming energy tariffs so they reflect the true market prices.

There is a lack of clarity around the Indonesian's energy policy framework and the rules around geothermal energy. Including the bureaucracy and the legal system and tendering processes, this discourages investment in the industry. The involvement of different ministerial institutions in the Indonesia energy sector also creates confusion in terms of coordination (Bret Mattes of star energy, 2011).

Developing WKPs (Wilayah Kerja Pertambangan/ Mining Working Area) is likely to be one of the bigger challenges in realizing geothermal energy development, as the tendering process requires interest, ownership and strong capacity at the local level (the ring of fire: a vision for Developing Indonesia's geothermal power,2012).

Another source of confusion is the division of power between central- and local government. The regional government plays a critical role in decentralization of the government because they are the official owners of the steam resources. Where as the central government plays the same role providing expertise and underwriting the power purchase agreements (De Wilde 2010). The decentralization seems to have only raised transaction costs (lacey 2010). Many local governments do not have the expertise needed to gather the data on potential sites. The administer of tenders needs to be more effectively. The data is not available to administer the areas effectively before exploration begins. The local government needs to find balance in their project ambitions with date & finance. (Global business guide Indonesia, 2012)

Subsidy policy

The Soeharto government wanted to establish a social stability concentrating on the food and energy security. Therefore the central government subsidized the price of a variety of energy products, including electricity to ensure energy was affordable and available for everybody (agustina et al, 2008). The consumer tends to cause overconsumption of the resources, since the market price does not reflect the actual cost of producing petroleum. The subsidy discouraged energy efficiency measures and the development of alternative or renewable energy sources by way of low electricity tariffs.

The fossil fuel prices are based on political considerations, including social instability. One of those social instability is that people from Indonesia protested in 2011 against government plans to reduce fuel subsidies by a third. In the end, the government rejected the planned cuts.

Mister Anthony Kuhn says that geothermal provides a good, steady supply unlike solar or wind doesn't depend on the weather. It provides a good underlying input of energy which doesn't exist in Indonesia at the moment that has to come from coal or oil. (For future energy, volcanic Indonesia bets on heat, 2012)

The Indonesian government is denying access to nearly half of the population. This policy mostly favors the urban population or those who are privileged enough to have access to electricity. Geothermal could help this problem by generating electricity which could then be used to power urban mass transit for everyone. (Resosudarmo et al. 2010)

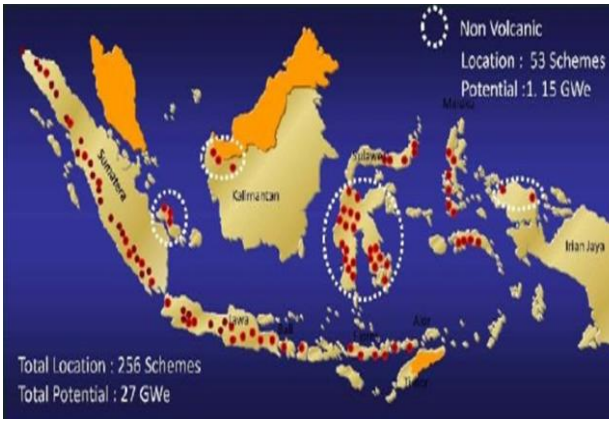
The Geothermal energy resources

This chapter will show you where and how much of the geothermal sources are situated in Indonesia. Indonesia is located between the eastern end of Mediterranean Volcanic Belt and the western side of Circum Pacific Volcanic Belt. With this geological lying Indonesia has a lot of Geothermal resources potential.

From research of the WWF approximately 40 percent of geothermal energy in the earth's crust is released in the Indonesian and neighboring areas and put this country as the biggest geothermal energy potentials in the world. Indonesia Geothermal Association (INAGA) and NGAI reported that Indonesia is composed of 256 geothermal potential locations in which is surrounded by 29 locations (2,795 MW) of prospective geothermal energy in which 18 locations

(1,205 MW) planned to develop and operated by existing developers mainly composed of Pertamina Geothermal Energy and its partnerships while 3 locations (1,590 MW) have been tendered and 6 others are still waiting for the new bidding. Here below you see where the sources are, and which sources are volcanic related and which are not.

Figure 4: geothermal energy sources



Geothermal Energy Update: Geothermal Energy Development and Utilization in Indonesia,2010

The developed geothermal locations distribute in 7 areas: Kamojang, Darajat, Wayang Windu and Salak in West Java; Dieng in Central Java; Sibayak in North Sumatera and Lahendong in North Sulawesi. On the right you have an overview (table 1) of the resources and reserves of the geothermal recourses in Indonesia. This gives an view where and how much of potential geothermal energy are in the 7 areas (Geothermal Energy Update: Geothermal Energy Development and Utilization in Indonesia,2010).

Most of the 256 prospects of Indonesia have high temperature geothermal resources. All the high temperature geothermal systems are found within the Sumatra, Java, Sulawesi, and Eastern Island Volcanic Zone, which lies over an active zone. According to the Geological Agency of Indonesia (GIA), the potential resources for geothermal energy of around a total 29,000 MW, of which about one third are located in Java and Bali, with the highest demand for electricity.

Table 1 : Geothermal resources and reserves in 2011

No	Location	Resources		Reserves			Total
		Speculative	Hipotethic	Probable	Possible	Proven	
1	Sumatra	4,059	2,543	6,524	15	380	13,521
2	Java	1,710	1,826	3,708	658	1,815	9,717
3	Bali-Nusa Tenggara	410	359	983	0	15	1,767
4	Sulawesi	145	0	0	0	0	145
5	Maluku	1,287	139	1,285	150	78	2,939
6	Kalimantan	545	97	409	0	0	1,051
7	Papua	75	0	0	0	0	75
	Total	**8,231**	**4,964**	**12,909**	**823**	**2,288**	**29,215**

(Geological Agency,2011)

Infrastructure problems

When building/applying a geothermal energy plant and maintaining the plant in Indonesia there is a challenge with the infrastructure in the most areas such as roads, air transport, and electricity supply (ADB, ILO & IDB 2010). Indonesia has one of the lowest road densities and paved roads among major economies in Southeast Asia; more over about 36 percent of the road network is damaged.

The availability and conditions of key infrastructure across geographic regions are causing differences in the regional regions. Problems in the transport networks and electricity supplies are a concern. The geographical areas where infrastructure improvements are needed the most have received far less private investment than other regions (The Global Competitiveness Report 2009–2010).

Problems in infrastructure are more severe outside Java and Sumatra, which causes for investment flows, economic decrease and poverty (Indonesia Critical Development Constraints, 2010). Indonesia has the largest and most intensively used rail network in

Southeast Asia. However, the network is limited to Java and Sumatra, and is mainly single track and hence inefficient.

Grid capacity

The grid capacity is important for geothermal energy to fulfill the geothermal potential. There is a struggle with the energy grid in Indonesia, only one third of the people in Indonesia are connected with the energy grid. Without expending the grid system, geothermal energy development is likely to remain sub-optimal (the ring of fire: a vision for Developing Indonesia's geothermal power,2012).

One of the more fundamental obstacles to reaching the government target is the fact that most geothermal resources are located in remote areas, which means additional financing is required to connect electricity production to the main grid (Tanoto & Wijaya 2011). Nationally, only 65 percent of the country's territory is connected to PLN's grid, most of it in the more developed Western islands; only 45 percent of eastern Indonesia is connected to the grid (Jakarta Post, June 2012)

The electricity sector is known by a low electrification rate, low consumption, and high inefficiency in transmission and distribution. Investment's in generation, transmission, and distribution has not been able to keep up with the growing demand, resulting in power shortfalls.

Environmental impacts of geothermal energy use

Environmental issues are a concern when applying geothermal energy in Indonesia. This chapter will give a view on several environmental impacts.

Deforestation

When applying geothermal energy, the geothermal energy plant and pipes need land. Therefore the area needs to be without trees. Around 70 percent of potential sites are in conserved forest according to the Minister of Forestry, Zulkifli Hasan. The Forestry Law No 39/2004 prohibits open mining in forest areas and places protected forests off limits. This law has been a major hindrance to the development of geothermal exploration.

A local government has gone outside this law and permitted geothermal mining and power plants of strategic importance in areas of protected forest (Global business guide Indonesia, 2012). More than 12 GW are located in protected forest areas (MEMR 2011) and are subject to the law on pristine forests, which include stricter conditions under which licenses are issued (Girianna 2009; Satriastanti 2011; The Jakarta Post 2011).

As sustainability solutions become urgent, there needs to be a local power that manages these resources properly, otherwise various IGO's will make their own decisions. On the other hand, an investor which handles this issue successfully may gain trust. Currently, PLN requires its partners in geothermal projects to conduct reforestation to compensate for any deforestation needed to build the plant. However, this only applies to projects run in partnership with PLN.(Geothermal energy in Indonesia heating up, 2012)

Figure 5: Geothermal plant in the Philippines

© Christopher Ng / WWF-Philippines

Underground

When using a heat source there are several factors to be taken into account. When soil´s heat is used, its temperature drops gradually over time until it stabilizes at a new lower level. Therefore, heat pumps in geothermal systems need to work harder to raise the temperature sufficiently.

This can be avoided if the geothermal collector system is combined with a solar collector. This will heat up the water again and on returns (stores) heat in the soil during the hot summer months. This may in turn mean that the soil's temperature rises to a higher level.

The moister the soil, the better it is for extracting heat from and for storing heat in. However, water can also be a disadvantage if the water is in motion. The borehole may cool the water down; this may be important if the water flows into a stream. If there are several geothermal wells there is a possibility that one well is extracting warmer water then others and gradually the water becomes cooler, the groundwater flow can take the heat away as well.

There are a number of unknown factors that have to be uncovered. Although geothermal energy is a heat source that is renewable and has a low CO2-emission.

So the benefits must be weighed against the environmental impact, that an increased use of geothermal energy might pose, says Lotte Thøgersen, Head of Center of Applied Research and Development, Ph.D., VIA University College.

Geothermal energy systems

To decide whether geothermal energy is technically possible for Indonesia, understanding available technologies is important. There are three main conversion cycles currently used in geothermal power generation plants (Direct steam power cycle, flash cycle& binary cycle).

The nature of the technology allows a steady production of heat, and is suitable to serve as a source for base load electricity generation. Only from constructing the power plants and the wells have CO2 emission (Goldstein et al. 2011).

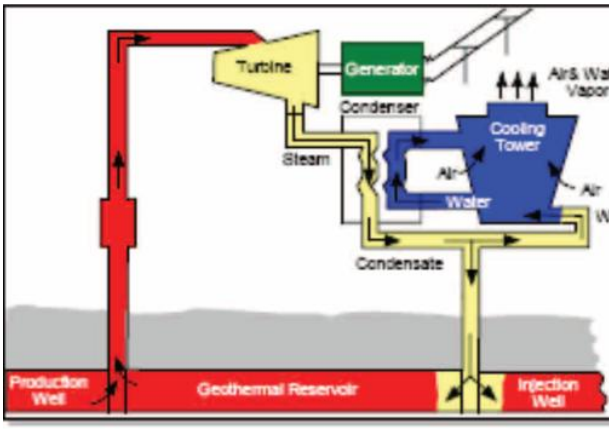
Costs

Applying geothermal energy would create jobs for the people in Indonesia but it also brings costs and risks. The costs for building and maintaining a geothermal plant can be a burden for the Indonesian government. Many local governments do not have the expertise needed to gather the data on potential sites. The costs involved for initial exploration estimated at $4-5 million per exploration well fall outside of local budgets so the data is not available to administer the areas effectively before exploration begins. So there needs to be better data and better expertise so the risks are less. You can find more information about this subject in the research of the WWF igniting the ring of fire (igniting the ring of fire: a vision for Developing Indonesia’s geothermal power, 2012).

Direct steam power cycle

The direct steam geothermal plant is used for reservoirs that are vapor-dominated. The plant is also developed based on the natural geothermal fluids condition (Anderson & Lund 1979). The steam, after passing through separators (which remove sediments from the flow) is fed to the turbine. Vapor-dominated reservoirs are the rarest of all geothermal resources and exist in only a few places in the world, including Indonesia. A dry steam power plant has a very low potential impact on the environment. The fluid from the well is comprised solely of steam. Non-condensable gases in the steam are usually removed by means of vacuum pumps or steam jet ejectors

Figure 6: direct steam power cycle

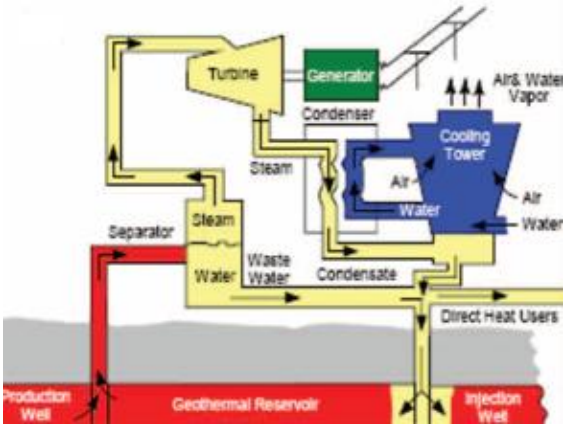


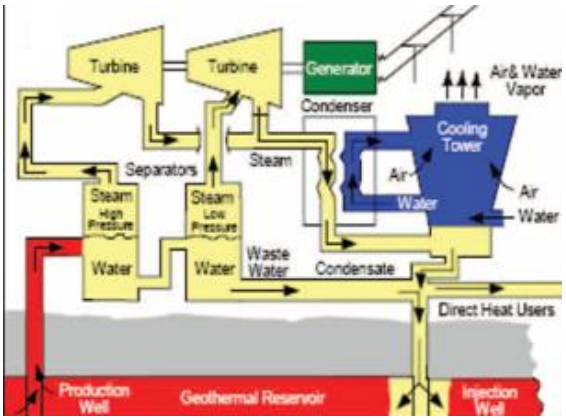
Schematic of a direct steam cycle(Idaho National Laboratory 2011)

Flash cycle

Flash steam plants are employed in cases where the geothermal resource produces high-temperature hot water or a combination of steam and hot water. Plant units are usually rated at 30 MW, which are supported by 5-6 wells, and 2-3 wells for re-injection of the spent brine. The fluid from the well is delivered to a flash tank where a portion of the water flashes to steam and is directed to the turbine. The remaining water (referred to as brine) is directed to re-injection wells.

Figure 7: flash cycle



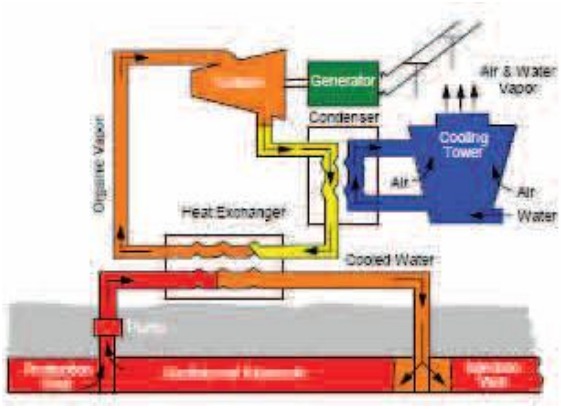


Schematic presenting of a single-flash cycle & schematic presenting of a double-flash cycle(Idaho National laboratory 2011)

Binary cycle

In the binary plant, a secondary fluid in a closed cycle is used to operate the turbine rather than geothermal steam. Geothermal fluid is passed through a heat exchanger where the heat in the geothermal fluid is transferred to the working fluid causing it to boil. The working fluid vapor is passed onto the turbine where its energy content is converted to mechanical energy and delivered, through the shaft, to the generator. The vapor exits the turbine to the condenser where it is converted back to a liquid. Cooling water is circulated between the condenser and a cooling tower to reject this heat to the atmosphere. The binary cycle is the type of plant which would be used for low temperature (i.e. T<170oC) geothermal applications (Di Pippo 2005).

Figure 8: Binary cycle



Schematic of a binary cycle(Idaho National Laboratory 2011)

Best suitable geothermal energy system for Indonesia

According to a 1997 detailed survey, it is reported that one third of the prospects of geothermal energy are categorized at high temperature reservoirs (T>220oC (GWe) (Prijanto & Sudarman 1997).

The single flash cycle is seen to be the most widely used electricity generation method for the conditions prevalent in the Dieng, Darajat, Gunung Salak, Lahendong and Sibayak (Di Pippo 2005). Close to 49 percent of the potential for geothermal sources lies in Sumatra (Prijanto & Sudarman 1997). Given the fact that flash cycle is a mature technology and has been used widely in various Indonesian power plants throughout the years, it would seem to be among the most favorable technologies if more geothermal power plants are to be built on this region (Di Pippo 2005). The high-temperature hydrothermal flash plants in Indonesia are seen to be well suited to contribute to increase the production capacity (IEA 2010). So the flash-cycle would appear the best for Indonesia because they have a lot of high-temperature geothermal resources.

Conclusion

To use the geothermal energy potential in Indonesia most efficiently there some points to be improved. The Indonesian government needs to make clear laws within the energy market and the geothermal resources. Hereby regulate the power between the central government and the local government. And create less as possible intervenes between these powers and give every company a fair chance. Next to that the government needs to cut the tariffs on the fossil fuels. To give renewable energy a fair change in the market. The lack of expertise in the local government is a problem that needs to be solved. The infrastructure needs to be improved because of the lack of accessibility. This gives access for technology of the geothermal energy plants and wells can be delivered in remote areas. There will be access to the geothermal sources. Also the energy grid needs to be expanding to the remote areas in Indonesia. So the potential of geothermal energy can be fully profit of. When applying geothermal energy the protected forest needs to be taken into account. There needs to be research in how much of an impact a geothermal plant has on the forests areas. And if so, it needs to be compensate within the damage that is caused.

Indonesia has a large potential of high heat geothermal recourses, within these recourses the best system is to use the flash cycle.

For the other sources the direct power system is best suitable because this system doesn't have a big environmental impact. The system doesn't condense gasses nor has a big influence on the groundwater flow. A geothermal collector system can be combined with a solar collector. This will heat up the water again and on returns (stores) heat in the soil during the hot summer months. This may in turn mean that the soil's temperature rises to a higher level.

Discussion

Do geothermal plants need to be build in protected forests?

In the article you've read that the most geothermal resources are located in protected forests. Although a geothermal plant doesn't need a lot of land it still has an impact on the forests. If these sources are used, trees need to be cut down and creates deforestation. It also will have an impact on the habitants in these areas. So are the advantages of renewable energy more important then the protected forests. On the one hand geothermal power is good for the sustainable energy and CO2 emission and the other hand it has an environmental impact. Bali governor Made Mangku Pastika is against applying geothermal energy plants in protected forests (ECO-buisiness, Bali govenor opposed to geothermal project in Bedugul, 2013).

How to deal with the social impacts of applying geothermal energy?

The government of Indonesia needs to cut down the tariffs on fossil fuel to make renewable energy more profitable. In 2011 people from Indonesia have been protesting against government plans to reduce fuel subsidies by a third. In the end, the government rejected the planned cuts. The people protested because they're used to low cost for the energy/fossil fuels. If the prices will go up there is a possibility that not all the people are able to afford energy. So how can the Indonesian government cut the tariffs on fossil fuel without harming the people? In some areas in Indonesia people are against geothermal energy because of their religion or culture. Also people living near the geothermal sources don't know what to expect when geothermal energy will be applied.

Does the energy grid in Indonesia need to be extending in the rural areas?

Some people say that the people in the rural areas don't need electricity because they don't use electricity and it harms the environment. Jacqueline Vel and I.G Made Raspita from Hivos say that people in rural areas need to have electricity for there agriculture and water use. It also helps for clean and healthy cooking. At the moment they're using wood for cooking which causes deforestation and is not healthy.

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