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Policy Directions of Geothermal Potential at Sembalun District of East Lombok Regency in Nusa Tenggara Barat Province, Indonesia

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Abstract

This research attempted to study physical characteristics of geothermal and formulate policy directions of geothermal potential through the process of ISM (Interpretative Structural Modelling) analysis in Sembalun District of East Lombok Regency. This descriptive qualitative research design used observation, interview, and documentation for collecting the data. Two types of data were collected, namely primary and secondary data. The result of ISM analysis on the data found that the geology of Sembalun area is the remains of an old volcano which has gone through destruction process with today's remains' characteristics of rough, rocky and steep ground surface and 550-2250 masl height. The geomorphology of Sembalun is classified into three units, namely morphology of steep volcano, morphology of sloping volcanic hills, and morphology of denudational plains. Sloping volcanic hills stretch from the northwestern to the southwestern areas and some in the southeastern area as a part of protected forest and national park of Mount Rinjani. The slope is between 30-70 degrees and arranged by volcanic rocks. Policy directions of geothermal potential are 1) as geothermal power plants for power sources, 2) geothermal energy for crop drying, 3) geothermal energy for sterilization of planting media in the future, and 4) geothermal energy for tourism sector.

Keywords: Policy Direction, Geothermal

Introduction

Indonesia is known to have the greatest geothermal potential that is about 40% of world's geothermal reserves. This is because Indonesia lies on a ring fire so that Indonesia has a great geothermal energy potential. The ring fire ranges from Sumatera Island to the south part of Java Island and continues to Bali Island, Lombok Island, and Nusa Tenggara then turn northward to Sulawesi Island, Maluku islands and finally stops at Philippines archipelago. Hence, geothermal system which is on volcono track generally associates to volcanic activities whose residual magma serves as geothermal sources (Sudoro, 2007; Hermon, 2014; Hermon, 2017).

The existence Geothermal system as one of potential environmental services in a conservation area is increasingly taken in account. Geothermal potentials in Indonesia spread forming a ring fire, ranging from islands of Sumatera, Java, Bali, Lombok Nusa Tenggara, North Sulawesi to Maluku. According to data from Ministry of Energy and Mineral Resources (ESDM), the length of the ring fire is approximately 7.500 km and the width is 50-200 km with a total power potential of 29,543.5 Mega Watt (MW). Those potentials are scattered in 330 locations which are of forests including production forest, protecting forest, and conservation forest. The utilization of these potentials is considered low, that is only about 5.12% or 1,513.5 MW (Ministry of Environment and Forestry, 2017).

Geothermal resources stored in earth's inner core in Indonesia are classified into two groups. The first is volcanic geothermal resources which exist along the ring fire and scattered in Sumatera, Java, Bali, NTB, NTT, North Sulawesi and North Maluku. The second is nonvolcanic geothermal resources that are scattered in Island of Bangka-Belitung, West Kalimantan, South Sulawesi, Southeast Sulawesi, Central Sulawesi, Maluku and Papua. In general, all geothermal resources, both volcanic and non volcanic, are scattered at 265 areas in Indonesia. Geological Agency of the Ministry of Energy and Mineral Resources has identified the potencies of geothermal energy at various areas in Indonesia. One of them is at Sembalun. Sembalun is a district in East Lombok Regency which has an area of 217.08 Km^2 consisting of 6 villages, namely Sembalun Bumbung Village, Sembalun Lawang Village, Sajang Village, Bilok Petung Village, Sembalun Village, and Sembalun Timba Gading Village.

Geographically, Sembalun District is bordered by Sambelia District to the north, Aikmel and Pringgasela to the south, West Lombok Regency to the west, and Pringgabaya District to the East. Locating on the ring fire of Indonesia, Sembalun District indicates the existence of geothermal energy potential which is manifested by geothermal pehnomena on its surface. Specifically, the geothermal area of Sembalun is located at coordinates of 115^0 45'00"E-119^0 25'00"E and 8^0 05'00"S-9^0 10'15"S. The area is manifested by hot water resources and resource alteration activity. The three hot water resources, that are Aik Kukusan, Aik Kalak and Aik Sebu appear outside the caldera wall of Sembalun at lava rocks while the alteration occurs in caldera wall near the upstream of Orok River. From survey, it was known that geothermal prospect of Sembalun had an expected total power of 70 MW. This quite high power is scattered at two large areas including Sebau and Sembalun. Sebau group (of geothermal resources) has a prospect of 25 MW. The total of explorated and exploited area is about 5 km^2. Furthermore, the area of Sembalun has an expected power of 45 MW and needs 9 km^2 area for exploration and exploitation (Kasbani, 2010).

Method

This research was a descriptive qualitative research that used techniques of observation, interview and documentation for data collection. The data being collected were primary and secondary data. Primary data was collected through interview with informants and field observation and from related information from internet and published journals or documents. While secondary data was obtained from governmental institutions of East Lombok Regency such as Central Bureau of Statistics (BPS) and Regional Energy and Mineral Resource Agency (ESDM). The research informants were the people of Sembalun. To analyze the data, the researcher conducted a triangulation and policy directions of geothermal potential was analyzed by using *ISM* technique (Hermon, 2017).

Results and Discussion

Physical Characteristics of Geothermal in Sembalun District of East Lombok

Geothermal is a thermal energy stored in rocks in subterranean earth containing fluids which is usually found in volcanic area (ring fire). However, not all thermal energy is geothermal. There are six conditions for the categorization of geothermal. First, there are geothermal rocks like magma. Second, there is an enough groundwater supply near the source of magma to form hot steam. Third, there are reservoir rocks to keep steam and hot water. Fourth, there are hard cap rocks to prevent the disappearance of hot water and steam. Fifth, there are tectonic symptoms in the form of factures on the earth's crust which allow steam and hot water to move up the earth's surface. Sixth, the minimum temperature should be about 180° – 250 °C (Mochammad, 2007; Hermon, 2012).

Basically, geothermal system is a result of a thermal movement from thermal source to its surrounding (transfer) by conduction and convection. The conduction transfer occurs through rocks while the convection transfer occurs due to the contiguity between water and a heat source. The convection transfer is basically occurs because of buoyancy. Due to gravitation, water tends to move downwards but when it makes a contact with a heat source there will be heat transfer which will increase water's temperature and make the water buoyant. This phenomenon causes hotter water moves upwards and cooler water moves downwards, and this circulation is also called convection transfer (Suhartono, 2012).

The geology of Sembalun area is the remains of an old volcano which has been going through destruction process with today's characteristics of rough, rocky and steep ground surface and a height of 550 – 2250 masl. Its geomorphology is classified into three units, namely the geomorphology of steep volcano, the

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geomorphology of sloping volcanic hills and the morphology of denudational plains. The morphology of steep volcano is on the middle of highest top consisting of Mt.Batujang/Mt.Anakdare, Mt.Banjer, Mt.Nangi, Mt.Tanakiabang, Mt.Seribu, Mt.Bonduri, Mt.Pusuk and Mt.Talaga. A horseshoe like caldera morphology exists in this unit precisely at the centre where its open part facing the north (Perwadi, 2011).

The morphology of sloping volcanic hills is located at the southwest and the north west and partly at the southeast as a part of protected forest and national park of Mt. Rinjani. The stream pattern is categorized in the mature stage of erosion with a U-shaped valley. The slope is 30-70 degrees, arranged by volcanic rocks in the form of andesites as the products of Sembalun Volcano and Mount Rinjani. Other than that, there are pyroclastic flow of Sembalun and pyroclastic fall of Mount Rinjani. Furthermore, the geomorphology of denudational plains is positioned at the north and the west. The flow pattern falls into category of mature stage of erosion with a U-shaped form. The composing lithology is lava and pyroclastic rocks. As a whole, this area is the bed of Sembalun caldera.

Geothermal area in Sembalun is generally caused by volcaniv activities in Sembalun. Its today geomorphology is the remains of an old volcano destruction process. The first phase was the formation process of a volcano followed by its destruction process due to the activity of the volcano. The formation process of Sembalun volcano was initiated by a repetitive effusive and explosive eruption which produces stratovolcanic sediments in the Lava Unit of Sembalun. this unit consists of andesite, basaltic and pyroclastic lava which today is a vocalno remain with a caldera, Sembalun Caldera.

In the last volcanic period of Sembalun, Sembalun Volcano was formed with a height of more than 2500 masl. The volcano can be reconstructed from its today's remains back to its first shape before the destruction. After the formation process of Sembalun Volcano ended the next process was self destruction of the Volcano. Broadly, the destruction process was going through two phases, the first is eruption and the second is collapse. The collapse of Sembalun volcano top was due to developing faults and today they are classified to Normal Pusuk Fault, Bonduri Fault, Seribu Fault, Tanakiabang Fault, Lantih Fault, Sesar Lentih Fault, Orok Fault, Libajalin Fault, Batujang Fault, Grenggengan Fault And Berenong Fault. The erupsion process was a big erupsion that triggered the destruction of Sembalun Volcano top that formed current volcano. This big eruption involved the formation of pyroclastic flow in the past. Erepution in that period occured enormously to Sembalun Volcano releasing free solid material (eflata) from its stomach (Soetoyo, 2017). Geothermal prospect in Sembalun covers two areas with a total expected power source of 70 MWe consisting of :

1. Sebau group. The potential area of Sebau is supported by geophysical results such as low type of resistance, high boubuer anomalies (considering as an area of intrusion), low magnetic value and high Hg anomalies. The potential area is about 5 km^2 with expected power source of 25 MWe.
2. Sembalun Grou. There is an (geophysical) indication of low resistance anomaly and the change in the eastern Sembalun while geochemically it does not indicate any anomaly. Resistance structure of this group shows low layer thickness which can not be measured yet. The prospect area of Sembalun is about 9 km^2 with expected power source of 45 Mwe

The following table contains information about the manifestation of geothermal potential in Sembalun of East Lombok Regency.

No	Description	Aik Kuku	Aik Kalak	Aik Sebau
1	Appears at a height of	750 masl	730 masl	1280 masl
2	Water temperature	44^0C	41^0C	36^0C
3	Air temperature	25^0C	24^0C	24^0C
4	Debit	0,4 l/Sec	0,95 l/Sec	2,4 l/Sec
5	Taste	Brackish	Tasteless	Tasteless
6	Odor	Odorless	Odorless	Sulfur Odor
7	Appearance	Sized 1,5 x 3 m^2	Sized 1,5 x 3 m^2	Sized 2 x 4 m^2
8	Subsurface reservoir temperature with an approximate average of 200^0C	112^0C	128^0C	250^0C
9	Types of hot spring	sulfate – Acid High concentration of sulfate	-	Chloride – sulfata High chloride ions
10	pH	7.5- 8.3	-	7.54

Source : Department of Energy and Mineral Resources of NTB Province

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Policy Direction of Geothermal Potential in Sembalun District of East Lombok Regency

The directly and indirectly use of geothermal sources basically depends on their capacity and potential scale. The classification of use is based on the category or type of reservoir temperature. From reservoir temperature it can be known the source's types of reservoir fluid. According to the reservoir temperature and fluid, suitable geothermal utilization can be revealed and then the technology that will be used can be chosen or decided. For example, for a geothermal resource with highest reservoir temperature (more than 220^{0}C) and water or steam reservoir fluid can be directly or indirectly used for power source or supply. For (indirectly) power source the technology that can be used is flash steam, a cycle combination (flash and binary). Meanwhile, direct power source can use technologies like direct fluid use, thermal pumps, and heat exchanger. This high potential at least can be used by Sembalun for medium-scale geothermal power plants that supply electricity of the village and tourism development in the area. Other than facilitating tourism in the area, geothermal energy can also be used for drying and processing agricultural and plantation products (Qinghaiguo, 2014).

Elements of Geothermal Potential's Policy Direction

According to research result, it suggests various sub-elements to be considered for deciding policy directions of geothermal potential in the research location. They are:

1. Geothermal power plant
2. Geothermal energy for crop drying
3. Geothermal energy for the sterilization of planting media in the future
4. Geothermal energy for tourism sector

According to *Matrix Final* of geothermal potential policy directions, there are 4 sub-elements with same highest supporting values. These sub-elements are: 1) geothermal power plants for power source, 2) geothermal energy for crop drying process, 3) geothermal energy for the sterilization of planting media in the future, and 4) geothermal energy used for tourism sector.

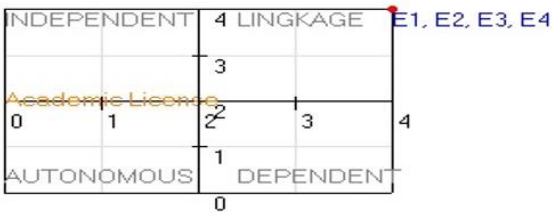

Figure 1. Relationship: Drive Power and Dependence

Figure 1 above is a graph of relationship between *drive power* and *dependence* in policy directions of geothermal potential. All sub-elements are positioned quadrant III. The sub-elements in quadrant III the Linkage between sub-elements at quadrant II and quadrant IV. Sub-elements at quadrant III should be studied carefully because every action done on one sub-element will affect other sub-elements including at quadrant II and IV. Sub-elements of quadrant III are: 1) Geothermal power plants , 2) Geothermal energy for crop drying, 3) Geothermal energy for the sterilization of planting media in the future, and 4) Geothermal energy for tourism sector.

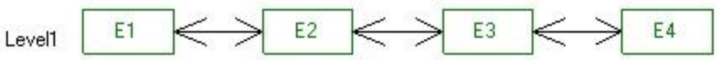

Figure 2. Hierarchical Structure of Geothermal Potential Policy Dirction

Hierarchically, the policy directions of geothermal potential are hoped to have hierarchical structure like in Picture 2 above. EI, E3, E3, E4 have the same value. The four policy directions of geothermal potential in Sembalun according to the result of *Reachability Matrix Final* have the same important value.

1. Geothermal power plant

The utilization of geothermal energy for power plants is generally carried out by first checking the sources. If an area has geothermal sources that produce hot steam, then it can be directly used. The steam is directly directed to the turbine to generate electrical energy. After that, the steam is directed to condenser to become water. This water is then naturally recycled into steam. However, if the geothermal source produces hot water, the water must be first transformed into steam. The transformation process needs a *heat exchanger* where the hot water is flowed and then transformed into steam.

Geothermal potential in Sembalun is highly possible to supply electricity in the district and even electrical needs in other districts. So, this has a high contribution to regional revenue. In developing geothermal potential, government should invite investors to involve in the development of geothermal power plants because it requires a large cost for technology exploration and a high risk of failure. In addition, it should be supported through minimizing convoluted bureaucracy which usually results in swelling exploration costs. The high exploration costs will result in the high cost of electricity (Ministry of Energy and Mineral Resources, 2017)

2. Geothermal energy for crop drying

Geothermal energy can also be directly used for a simple drying process of agricultural, plantation, and fishery products. Hot water with a high temperature coming from hot springs or geothermal production wells is flowed through a heat exchanger which then heats up drying room especially made for drying the products. Some of agricultural and plantation products that can be processed in the drying room are paddy and coffee. Based on an experiment, geothermal drying process is faster and results in better product quality than solar thermal drying process.

3. Geothermal energy for the sterilization of planting media in the future

Based on the land characteristics, Sembalun is very suitable for the development agro industry. Various crops especially vegetables and fruits like tomato, chili, Onion can be well grown here. Green houses should also be built. In order to kill soil pests in early planting, planting media must be sterilized. The sterilization can be done by heating the media at a certain temperature until the pests die. The heating can be done by using geothermal energy. For this purpose, the heat coming from geothermal wells is directed on heat exchanger before being re-injected in to the rocks (Ozcan, 2011).

4. Geothermal energy for tourism sector

Geothermal energy can be used in tourism sector as tourist attraction for visitors to enjoy. The existence of geothermal sources hot spring and hot steam can attract people to visit the attractions. These geothermal sources or energy can be managed as hot spring tourist attraction. Hot spring which has many health benefits is important for the development of tourism business in Sembalun.

Conclusion

Geothermal is a thermal energy stored in rocks in subterranean earth containing fluids which is usually found in volcanic area. However, not all thermal sources can be categorized as geothermal energy. Geology of Sembalun is the remains of an old volcano which has been going thorugh destruction process with the characteristics of rough, rocky and steep ground surface and a height of 550 – 2250 masl. Geomorphology of Sembalu is calssified to three units. They are the morphology of steep volcano, the morphology of sloping volcaninc hills, and the morphology of denudational plains. The morphology of sloping volcanic hills are located in the northwestern to southwestern area and some are in the southeastern area as a part of protected forest and national park of Mount Rinjani. The slope is 30-70 degrees and formed by volcanic rocks. The policy directions of geothermal potentials in Sembalun are as geothermal power plants, geothermal energy for crops drying, geothermal energy for the sterilization of planting media in the future, and geothermal energy in tourism sector.

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