SELECTING THE MOST POTENTIAL GEOTHERMAL DIRECT USE IN EASTERN INDONESIA, FLORES ISLAND, MATALOKO

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ABSTRACT

Flores island is located in eastern Indonesia and part of East Nusa Tenggara province. Known with the big potential geothermal reserve that spread in the 17 locations with approximately 402.5 MWe and 527 MWe reserve backup. According the big potential reserve, government arrange Flores as the island of geothermal. The aim of this arrangement is to fulfill the electricity demand by maximize the potential geothermal reserve, also with direct utilization to increase the agriculture, plantation, and tourism result.

Geothermal energy can be used indirectly or directly. Geothermal can be indirectly used to produce electricity. Direct-use applications exist on a scale ranging from heating and cooling. The direct use of geothermal energy has significant economic, environmental, and social benefits, chiefly because it reduces electricity demand as it replaces electric-driven heating and cooling applications. The focus location is in Flores, Mataloko. This is a sub-district that located in Golewa district, Ngada city, in Nusa Tenggara Timur province. This district has 3.5 km^2 land area or about 4.73% from the total area from Golewa district is Mataloko sub-district. This study describing about overview of the location, understand about the existing potential, identify all the possibilities that can be implemented for the best option of geothermal direct use in Mataloko.

1. INTRODUCTION

Indonesia is one of the country in the world with greatest geothermal energy potential. From Sabang to Merauke, Indonesian archipelago are surrounded by hotspots. With large number of hotspots, Indonesia is known as “Ring of Fire” country. This potential is very large for the utilization of geothermal energy in Indonesia so it is very important for exploration and production acitivities. According to ESDM (ESDM, 2020) Indonesian Geological Agency stated that the geothermal potential in Indonesia is 23,900 Mega Watt (MW) or 23.9 Giga Watt (GW). However, 8.9% has only been utilized or equal to 2,130.6 MW. Government plans to increase the geothermal energy utilization to 7,241.5 MW or increasing 16.8% in 2025.

One of the highest potential geothermal location in Indonesia is on the Flores Island, East Nusa Tenggara. According to (EBTKE, 2017), Flores Island have a geothermal potential with amount of 902 MW or 65% from geothermal potential in East Nusa Tenggara Province. These geothermal potentials are spread in 16 points which are Waisano, Ulumbu, Wai Pesi, Guo-Inelika, Mengeruda, Mataloko, Komandaru, Ndetusoko, Sokoria, Jopu, lesugolo, Oka Ile Ange, Atedai, Bukapiting, Roma-Ujelewung and Oyang Barang. Regarding on 16 potential spots, utilization of power plan from geothermal have been supplied from Ulumbu and Mataloko with amount 12.5 MW installed capacity.

This paper aims to identify and select the most potential geothermal direct-use application according to the data we collected and analyzed. Several alternatives will be identified and finally aim of this study is to provide examples and illustrations that can be implemented and become benefits for the surrounding community in Mataloko.

2. METHODOLOGY

This paper includes a literature review, survey region, direct use analysis, and proposed scenarios or alternatives for geothermal direct use in Mataloko, in the end of this paper will select the most potential geothermal direct-use application based on several scenarios and alternatives. The figure of workflow can be seen in **Figure 1**.

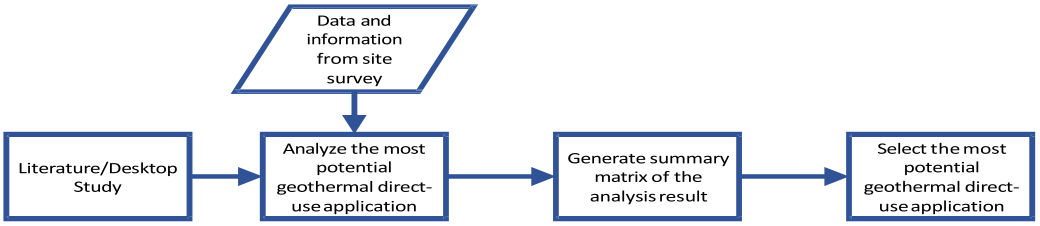

Figure 1: Workflow of Selecting the most potential geothermal direct use in Mataloko

3. MATALOKO OVERVIEW

3.1 Mataloko Areal Map

Mataloko is a sub-district located in Golewa District, Ngada Regency, East Nusa Tenggara (NTT) Province. It covers a 3.5 km^2 area which are 4.73% of Golewa District's area. Mataloko consists of three hamlets and ten neighborhoods with inhabited by 1,411

people. Most of the local people in Mataloko dominated by farmers and planters. On the land use, Mataloko Sub-district consists of 38.15 Ha rice fields, 290.53 Ha dry fields, 22.62 Ha irrigated rice fields, 250 Ha cultivated fields, and 15 Ha plantation fields (Golewa, 2020).

In geothermal direct use application, it is crucial to acquire data such as well and power plant data. Based on its source, there are three sources of geothermal data, which will be described as follows. The first data source is data acquired from surface manifestation. In East Nusa Tenggara, there are a lot of surface manifestations such as hot springs. Next in line is the data acquired from producing well such as pressure, temperature, fluid type, etc (Rigsis Energi Indonesia, 2021).

3.2 Mataloko Power Plant Data

Based on PLN data (PLN, 2019), WKP Mataloko have six wells. Those wells in PLTP Mataloko were exploration well in the beginning. But after that, the six wells are then developed and changed into delineation, development, andinjection well. The first well was AR-01 which is the exploration well type. It is 207.3 meter depth and was drillied in year 2000. AR-02 well drilling, which is the second exploration well done in February 2001 with 180 meter depth. The next drilling done was for AR-03 well. This well is meant to be a delineation well, which was drilled in 2003 and reached 613 meter in depth. Drilling for MT-4 well was also done in the same year. AR-05 well is the fifth well drilled in 2005 in WKP Mataloko with 378.2 meter in depth and was meant for development well. Then, AR-06 well is the last well drilled in 2005 with 123.3 meter in depth. Please note that all of the wells drilled for PLTP Mataloko haven't reached reservoir zone. The deepest well drilled is AR-04 well with 756.5 meter while the reservoir zone is located 800-900 meter below surface.

These are the data shown for every well located at WKP Mataloko:

Table 1: WKP Mataloko well's data (PLN, 2019)

Well	Year	Depth (m)	Maximum Temperature (ºC)	Wellhead Pressure (barg)	Remark
AR-01	2000	207.3 m	-	-	*Plugged*
AR-02	2001	180 m	192.3	12.6	*Shut In*
AR-03	2003	613 m	204.1	8.2	*Steam Flowing*
AR-04	2003	756.5 m	205.5	5.8	*Shut In*
AR-05	2005	378.2 m	103.7	-	*Steam Flowing*
AR-06	2005	123.3 m	-	-	*Reinjection*

3.3 Local Commodities in Mataloko

3.3.1 Agriculture and Plantation Commodities

The agricultural commodities can be divided into two groups, which are agriculture and forestry commodities. From the data collected, most of the agricultural commodities are located in Golewa District.

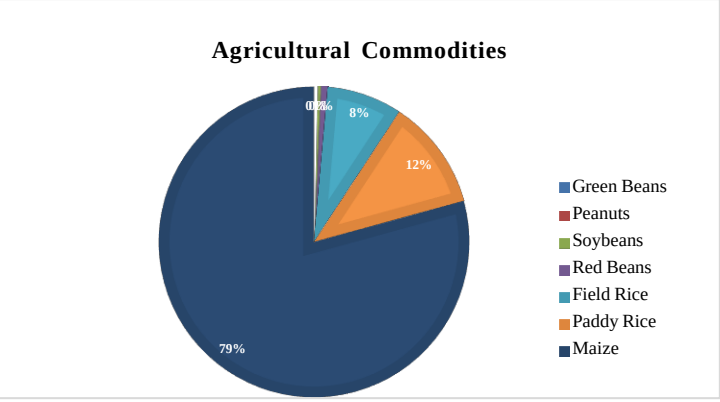

Figure 2: Agriculture commodities in Golewa district at 2019 (Golewa, 2020)

From the data stated, it can be concluded that maize is the most produced commodity, which is 2.025 ton in Golewa District in 2019 followed by paddy rice and field rice.

3.3.2 Plantation Commodities

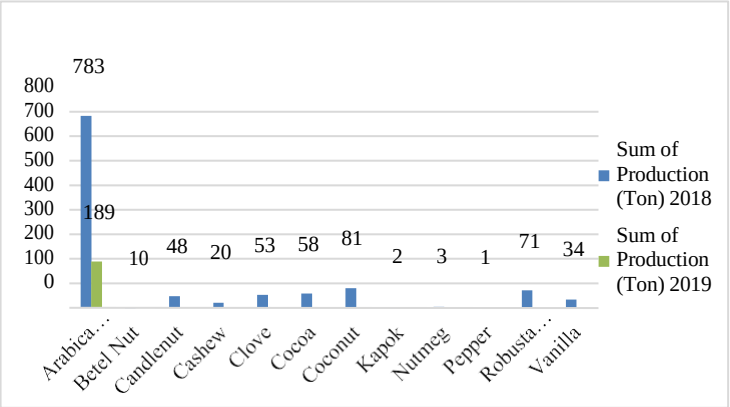

Figure 3: Production of plantation commodities in Ngada regency in 2018 (Ngada, 2019)

Arabica coffee is the highest produced commodity in Golewa District with 783 ton. Coconut and robusta coffee are placed in the second and third spot respectively. As for the Figure 3 shows that in 2019 coffee is still the highest produce on plantation commodity. Some of issue or challenges is to obtain the actual data. Because the data from desktop study is obtained from jurnal, website and other reports that showing inconsistent number. That is why the production of 2018 to 2019 has a very large drop. The conclusion from both tables that coffee is the highest plantation commodity producers in Golewa.

3.3.3 Foresty

To forestry commodities, data found are in Ngada Regency in 2018. The forestry commodities in Ngada Regency are only cutting and round woods.

Table 2: Production of forestry wood in Ngada regency at 2018 *(Ngada, 2019)*

Forestry Commodities (Ngada Regency, 2018)	Production (m^3)
Cutting Wood	**950.59**
Round Wood	**30**

3.3.4 Animal Farm Commodities

The animal farm commodities are the products originated from living stocks such as chickens, cows, and pigs. These are the animal farm commodities data in Golewa Regency 2019 the number of stocks is 5000.

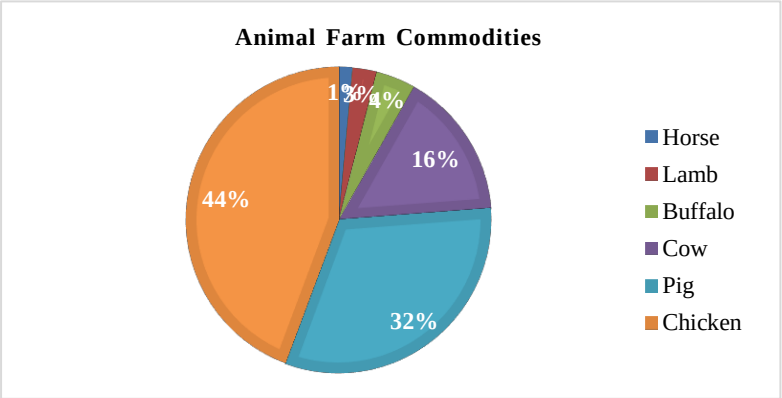

Figure 4: Animal farm commodities in Golewa district at 2019 (Golewa, 2020)

House of Worship

The majority of Mataloko Sub-District people is Catholic. Therefore, there are a lot of churches within 5 km radius of Mataloko Geothermal Power Plant, such as 2 Cathedral and 3 Chapel.

Local Government

Mataloko Sub-District Office as the center of local government is located 2.4 km from Mataloko Geothermal Power Plant. Based on the data from BPS Golewa District 2020, Mataloko Sub-District is inhabited by 1,411 people that are divided into ten neighbourhoods. There are one headman, two heads of affairs, and three heads of hamlets that live in this sub-district.

Market

The center of Mataloko economy is located in its shopping center, which includes Mataloko Market. Based on (Google Maps, 2021), distance of Mataloko Market and PLTP Mataloko is around 6.3 km.

Hot Spring Pool

Hot spring pool's source can originate from a hot spring. One of the most popular hot spring pools in NTT which is Mengeruda. Based on the study conducted, there are no hot spring pools found within five kilometer radius from PLTP Mataloko. The nearest hot spring pool is located 24 km from Mataloko Geothermal Power Plant

3.4 Mataloko Local Communities

There are three local communities in Mataloko Subdistrict. This local communities manages the plantation products, which are fruit and coffee. The first one is Trio Mandiri Hoticulture is one of the local communities in Mataloko which can be used as a target for geothermal direct use. Trio Mandiri Horticulture is located in Todabelu, Golewa District, Ngada Regency. The distance from PLTP Mataloko toTrio Mandiri Horticulture of around 700 m. Number two is Wajamala Golewa Organic Arabica Coffee Village This is located in Radabata, Golewa District, Ngada Regency, which is approximately 6 km from PLTP Mataloko. This community manages coffee as the largest plantation commodities in Golewa District. Number Three is MPIG Flores Bajawa Arabica Coffee (AFB) / Flores Bajawa Arabica Coffee Producers Community This community is also the same as the Wajamela Golewa Arabica Organic Coffee Village, which processes coffee. Based on Google Maps, (2021), the Flores Bajawa Arabica Coffee MPIG (AFB) / Flores Bajawa Arabica Coffee Producers Community is located in Mangulewa, Golewa, Ngada Regency with a distance of 8.3 km from PLTP Mataloko

3.5 Demography

Mataloko Sub-distrct is inhabited by 1,411 residents consisting of 352 families. The Mataloko Sub-district population is dominated by school-age childreen (5-19 years) that reaches 45% of the total population of Mataloko. Mataloko Sub-district area is 350 Ha or 3,5 km2, with 250 Ha are farms area. The level of education in Mataloko is quite good, because there are schools (private and public) at every level of education. In addition, there is also a seminary, which is a kind of boarding school for followers of the Catholic religion in Mataloko. The largest number of Mataloko residents who become teachers and employees are in Golewa District.

Meanwhile, from the economic side, the economic level of the Mataloko community is still in the middle to lower category based on house buildings, consumption of electrical energy, and fuel used for cooking (Golewa, 2020). Ngada Regency is classified as an area with hot, moderate, and cool climates with 5 (five) months as the rainy season from October to February and seven months as the dry season from March to September. Based on location, Mataloko is located 912 meters above sea level. According to the Köppen & Greiger classification, the climate in Mataloko is classified as Aw (wet or dry tropical savanna climate) with the lowest precipitation reaching 60 mm/month.

4. GEOTHERMAL DIRECT USE APPLICATION

After we were getting and considering the data such as local commodities which are agricultural and plantations, type of industries and well data at PLTP Mataloko, we can make some conclusion by referring to lindal diagram to identify the most appropriate direct use application in Mataloko. However, the most suitable of geothermal direct use application in Mataloko is drying utilization of agricultural and plantation products. In addition to referring on commodity data and PLTP Mataloko well temperature, another consideration for selecting this option is based on Lindal diagram below according to (Gissurarson & Arason, 2018).

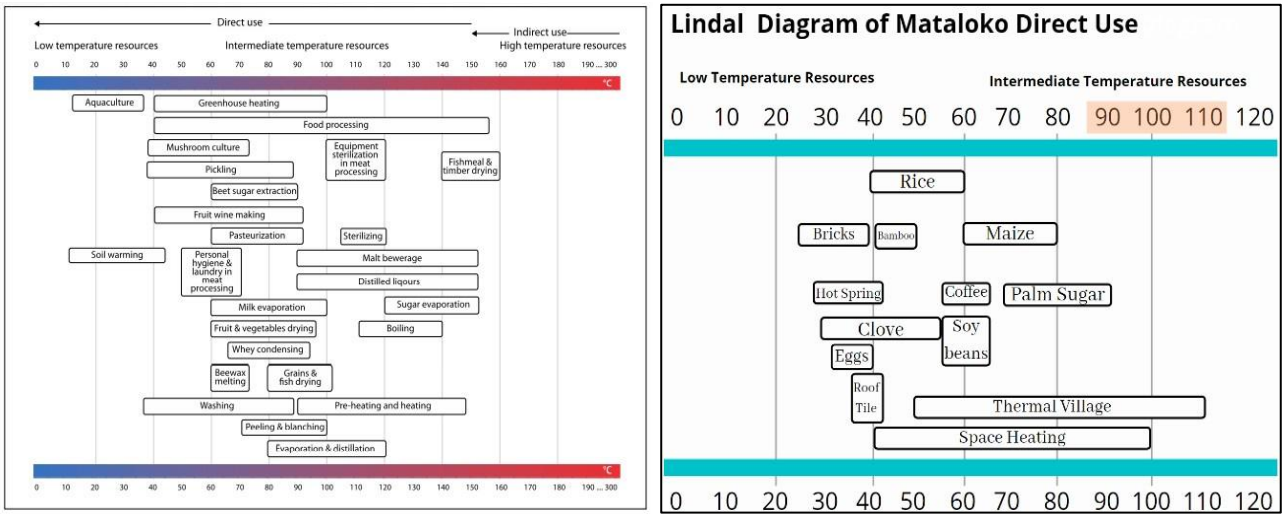

Figure 5: Lindal diagram of geothermal direct use and Mataloko Lindal diagram of Mataloko (Gissurarson & Arason, 2018)

The Lindal Diagram above explains the options for geothermal direct use that can be conduct from temperature parameters, both direct use and indirect use. Based on Table 1, the six wells at PLTP Mataloko have temperature values in the range of 90ºC-110ºC. Lindal Diagram prepared for direct use applications in Mataloko. This Lindal Diagram is based on the temperature data of local commodities and industry obtain in this study.

4.1 The potential direct-use applications

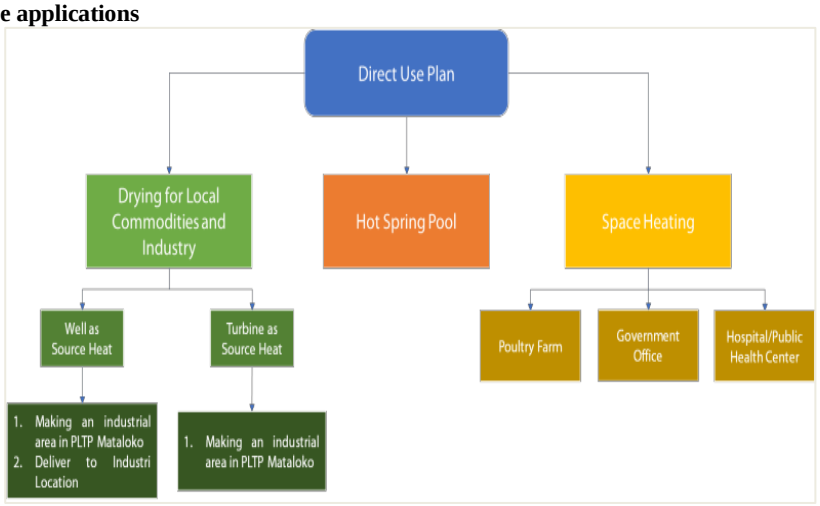

Figure 6: Direct Use Plan Flowchart

From Figure 6, it can be seen that there are 3 potential direct uses in Mataloko. However, of the 3 options/potential above, option 1 on drying for local commodities and industry is the most likely. This is because in terms of the area, Mataloko is included in the Ngada district which has great potential for local commodities. This can be seen from Figures 2 and 3 which show that agricultural commodities are very large.

As for the application, the direct use that can be done is to implement drying for the local commodity. From the above scheme the heat source can come from wells, turbines or manifestations. If the selection of heat sources comes from wells, an industry can be made around the PLTP area. The hot spring pool and space heating options have the potential for direct use, but for now it is not really necessary and a longer study and further planning is needed.

4.2. Site Survey Result

4.2.1. Heat Source from PLTP Mataloko Well

Table 3 describes the well data obtained after the site survey. You can see the wells AR-03, AR-04 and AR-05 which are still flowing.

Table 3: Well in Mataloko Geothermal Power Plant (Rigsis Energi Indonesia, 2021)

Well Name	Type	Status	Temperature (℃)	Pressure (barg)	Additional Information
AR-01	Exploration	Not flowing	-	-	• Well AR-01 does not have a well head • Around the well there is subsidence that forms a crater with a temperature manifestation between **73 - 97 ℃**
AR-02	Exploration	Not flowing	-	-	• The wellhead condition of AR-02 is good. • No geothermal activity or sign around AR-02. • The location is in the same well pad with AR-01.
AR-03	Delineation	Flowing	100.6	-	• The wellhead condition of AR-03 is good. • There is no geothermal activity around the well, but it's still flowing.
AR-04	Delineation	Flowing	104	10	• The wellhead condition of AR-04 is good. • The pressure gauge is claimed to be accurate and representative. • There is a leak in the cellar so it needs a rework on the substructure.
AR-05	Delineation	Flowing	101.3	-	• The wellhead condition of AR-05 is complete. • There is no geothermal activity around the well, but it's still flowing.
AR-06	Injection	Not Flowing	-	-	-

4.3. Heat Source from Surface Manifestation

The following Table 4 show the data from manifestations that collected from PLN.

Table 4: Surface Manifestation Information (Rigsis Energi Indonesia, 2021)

Name	Temperature (°C)	Additional Information
Wae Luja Hot Stream	91	• pH: 2.93 • TDS: 765 ppm • EH: 292.6 mV
Ratogesa Crater (Wogoalo) Mud Pool	94	-

4.4. ASSESSMENT

In this assessment, we use 2 options, namely the assessment of the heat source and the surface manifestation. And the local commodities assessment, where each assessment will be given points.

4.4.1. Heat Source from PLTP Mataloko Well

Following Table 5 it can be seen the heat source that is most feasible is well AR-04 with a total point of 3.

Table 5: Assesment for heat source from the well in PLTP Mataloko (Rigsis Energi Indonesia, 2021)

Well	Assesment parameter							
	Steam Source Existence	Point	Health, Safety and Environment (HSE)	Point	Road Access and Infrastructure	Point	Total point	Conclusion
AR-01	Exists, seen from the manifestations appearing on land	1	Warm soil, crater, and small hot springs appearance	0	Roads passed are still dirt and narrow	0	1	Not feasible
AR-02	Non existing	0	Cellar and substructure on good condition, but the land surrounding well head collapsed	0	Roads passed are still dirt and narrow	0	0	Not feasible
AR-03	Exists, seen from the activities found in the separator but there wasn't pressure	0	No collapsing signs found around drilling tread	1	Roads passed are still dirt and narrow	1	2	Not feasible
AR-04	Exists, known from the TIR temperature and pressure seen on the pressure gauge	1	H2S found on well head location was considerably small	1	Near the big road	1	3	Feasible
AR-05	Exists, seen from the activities found in the separator but there wasn't pressure	0	No collapsing signs found around drilling tread	1	Roads passed are still dirt and narrow	1	2	Not feasible
MT-06	-	0	-	0	-	0	0	Not feasible

4.4.2. Heat Source from Surface Manifestation

Table 6 shows the assessment of surface manifestation, it can be concluded that using a manifestation surface is *not feasible.*

Table 6: Assesment for heat source from the surface manifestation in Mataloko (Rigsis Energi Indonesia, 2021)

Surface manifestation	Assesment parameter							
	Steam Source Existence	Point	Health, Safety and Environment (HSE)	Point	Road Access and Infrastructure	Point	Total point	Conclusion
Wae Luja Hot Stream	Exists, hot springs	1	Steam appears randomly with its location changing	0	No Access and infrastructure	0	1	Not feasible
Ratogesa Crater (Wogoalo) Mud Pool	Exists, hot mud pool with 15 m in diameter	1	Manifestation forms a big crater, emits H2S, and were very active.	0	No infrastructure, the roads passed were hills and valleys	0	1	Not feasible

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4.5. Geothermal Direct Use Option

The options below are made by utilizing the well at PLTP Mataloko and surface manifestations around PLTP Mataloko.

Table 7: Assesment for Geothermal Direct Use in Mataloko (Rigsis Energi Indonesia, 2021)

Option	Assesment parameter											
	Temperature necessary	**Point**	**Road access**	**Point**	**Distance from PLTP Mataloko**	**Point**	**Social impact**	**Point**	**Public demand**	**Point**	**Total point**	**Conclusion**
Drying for Local Commodities	50°C - 60 °C (heated constantly)	1	**Very good,** if built around AR-04 Well	1	**Very possible**, because the drying will build around AR-04 Well or PLTP Mataloko	1	**Impactfull ,** because the majority of people work as farmers	1	**Very needed**, to accelerate the drying process of local commodities	1	5	**Feasible**
Hot spring pool	30 °C - 40 °C	1	**No access**, because it passes through hill and valley if using surface manifestation	0	**Possible,** because the distance is 2 km	1	Can be used by the local community as a tourist object	1	**Currently it is not needed**, but it could be an option for future utilization	0	3	Not feasible
Space heating	30 °C - 40 °C	1	-	0	**Not possible**, because it takes a very long piping system	0	Only impact on chicken farmers	0	**Currently it is not needed**, but it could be an option for future utilization	0	1	Not feasible

* Total points is the number of points judged:
0 = Doesn't qualify the assesment
1 = Qualify the assesment
<3 = Not feasible
3 = Feasible

4.6. Drying Option for Local Commodities

The following is an assessment of the drying options for local commodities in Mataloko:

Table 8: Assesment Local Commodities Option for Drying (Rigsis Energi Indonesia, 2021)

Local Commodities	Parameter penilaian									
	Needs for drying	**Point**	**Number of harvests / hectare**	**Point**	**Commodity prices (per kg)**	**Point**	**Market demand**	**Point**	**Total point**	**Conclusion**
Clove	Yes, need 3-5 days	2	500 kg	2	IDR. 20,000	2	Very high	3	9	Required
Ginger	Yes, but only to provide added value	1	N/A	1	IDR. 27,000	2	Very high	3	7	Not really
Coffee	Yes, because it takes up to 20 days if the weather is good	3	2000 kg	3	IDR. 50,000	3	Very high	3	12	Very required
Candlenut	Yes, need 3-5 days	2	500 kg	2	IDR. 20,000	2	Very high	3	9	Required

* Total points are the number of points judged:
1 = Low
2 = Moderate
3 = High
<9 = Not really required
9 = Required
12 = Very required

From the results of the assessment of drying options for local commodities above, it is concluded that the **coffee needs drying the most**. However, it does not rule out drying for cloves and candlenuts in the future.

CONCLUSION

There are six wells on PLTP Mataloko, namely AR-01 and AR-02 as exploration wells, AR-03 and AR-04 as delineation wells, AR-05 as development well, and AR-06 as injection well. Currently, six wells conditions are not flowing and other wells will be drilled in 2022. Data obtained from the six wells are temperature, fluid type, depth and wellhead pressure.

Mataloko Sub-district inhabited by 1,411 residents consisting of 352 families whose populations are dominated by school-age children (5-19 years old) or reaching 45% of total population in Mataloko Sub-district. These sub-district is include categorize as

land area where most of the local people are farmers. From socio-economic perspective, Mataloko people are classified as a middle to lower class income. However, in terms of education, such as school facilities are quite good, because there are 2 type of school, private and public, in every single level of education.

Based on the results of the site survey in Mataloko, there are 2 options for utilizing the geothermal sources; wells at PLTP Mataloko, and surface manifestations. Of these options, the most suitable geothermal source is the well at PLTP Mataloko, namely AR-04 Well. There are 3 options of direct use application; drying for the local commodities (coffee, ginger, candlenut, and vanilla), hot spring pool and space heating. Of these options, the most feasible option to be applied is drying for local commodities. An assessment of the direct use of geothermal energy that has been conducted shows that the AR-04 well will be used as a geothermal source with a drying scheme for coffee. It is very possible for several potential alternatives such as space heating and hot springs and other plantation commodities (not only coffee) can be implemented in the future by the relevant stakeholders.

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REFERENCES

EBTKE, D. (2017, July 4). *Penetapan Pulau Flores sebagai Pulau Panas Bumi*. Retrieved from ebtke.esdm: https://ebtke.esdm.go.id/post/2017/07/04/1697/penetapan.pulau.flores.sebagai.pulau.panas.bumi

ESDM, K. (2020, March). *Potensi Besar Belum Termanfaatkan, 46 Proyek Panas Bumi Siap Dijalankan*. Retrieved from Kementrian ESDM: http://www.esdm.go.id/id/berita-unit/direktorat-jenderal-ebtke/potensi-besar-belum-termanfaatkan-46-proyek-panas-bumi-siap-dijalankan

Gissurarson, M., & Arason, S. (2018). Geothermal Direct Use, with a focus on agriculture and agro-industry sectors. *Iceland Geothermal Conference Geothermal Direct Utilisation and food security.* Reykajvik.

Golewa, B. K. (2020). *Kecamatan Golewa dalam Angka 2020.* Golewa.

Ngada, K. (2019). *Kecamatan Golewa Dalam Angka 2019*. Retrieved from Website Resmi Kabupaten Ngada: https://portal.ngadakab.go.id/

PLN. (2019). *Profil PLTP Mataloko.* Mataloko: PLN.

Rigsis Energi Indonesia. (2021). *Site Survey Results and The Most Potential of Geothermal Direct Use in Mataloko.* Jakarta: PT Rigsis Energi Indonesia.