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DIRECT USE OF GEOTHERMAL ENERGY FOR DRYING AGRICULTURAL PRODUCTS AND MAKING PALM SUGAR CRYSTALS

Scope of Study :

Paddy Drying, Crystal Palm Sugar Production, And Community Respond To The Existing, Benefits, And Impact Of Geothermal Power Plant In Lahendong

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ABSTRACT

Geothermal energy utilization for electrification still developed, but the use of direct support for the agricultural industry is still being pursued. Potential Geothermal Indonesia is approximately 40% of the world's geothermal potential of 27,000 MW and spread over most of the islands and about 815 MWe identified in the northern part of the island of Sulawesi , that is Tomohon in the moment with an installed capacity of 80 MW.

Tomohon with high rainfall, is a frequent problem faced by farmers for drying the product, as well as the limitations of the fuel for the manufacture of palm sugar crystals obstacles facing shortage of fuel wood dwindling availability, as well as dealing with the issue of global warming in which one just went reforestation effort is. In connection with these two direct utilization of geothermal energy in order to enhance the local community's economy already in trials for drying agricultural and forestry products such as Chili, Corn, Vanilla, Copra and Wood for furniture as well as on the process of making crystal palm sugar from sugar palm sap. To note that the factory making crystal palm sugar in Tomohon is the only plant existing in the world.

The results obtained are very satisfactory, so the effort for the development towards more economical under review. Expected that, local communities can benefit directly of geothermal energy to extend the endurance to keep, improve quality and make new innovations for local agricultural and forestry products to boost the economy and support the food security of the nation.

Keywords: *direct use of geothermal heat, drying agricultural products, economic recovery, empowerment,*

INTRODUCTION

Background

Geothermal comes from the Greek, geo means earth, thermal means heat, it can be interpreted as geothermal heat generated from the earth. While a geothermal system can be described as a water convection at the upper crust in the room are depressed, then heat transferred from the heat source to the place where the heat is released, usually on the surface of the earth. (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2007).

There are three (3) key elements that affect the geothermal system, namely: (1) heat source, (2) reservoir and *caprock*, and (3) fluid. As described above, the source of heat in the geothermal field is magma that comes from the depths of 50-100 km, move up, intrusion rock layers with a high temperature (900-1200 ^{0}C) to shallow depths ranging between 2-10 km. The shape of the intrusion is usually little intrusion as dikes recurrent (dike) (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2007).

North Sulawesi area until 2012 has produced some geothermal wells and injector wells that enable the produce of waste (waste heat) to be used for the processing of agricultural needs for food and

agricultural products in the vicinity of the geothermal. With the implementation of Law 27 of 2003 on Geothermal direct use of geothermal energy (direct use) began to develop rapidly in Indonesia. For that, use this direct activity should be regulated by the government so that its implementation can work well and be able to make a significant contribution to the diversification and energy saving, fuel substitution, and increasing the standard of living of the communities. So that these settings can be right on target, the Government needs to identify a variety of potential geothermal resources that can be utilized for direct use, and the potential of agriculture and agro-industries in the area that have geothermal resources.

Lahendong Geothermal is one area in North Sulawesi are used for power generation to supply electrical energy in North Sulawesi. Lahendong geothermal technology produces steam waste heat energy (waste heat) is large and returned to injection cycle (reinjection). Abundant steam waste heat through the exhaust pipes have been drained to palm sugar processing unit and 1 unit of agricultural product drying equipment, mainly for drying grain. Especially for drying grain has been cultivated for drying grain and corn. From the observation of surprisingly large waste heat energy for agricultural products processing applications.

Besides technology, acceptance of the community aspect is also one of the determinants of successful application of these technologies and the existence geothermal power plant . If people benefit directly from the geothermal power plant community resistance levels will be reduced to the existence of geothermal power plant. Those will need requires an examination of the public response to the existence, benefits and impacts of the geothermal power plant also public response to technologies derived from the geothermal power plant in the form of the use of geothermal energy in the field of agro-drying technology (dryer) agricultural products.

Problems

Based on the background above, the problem formulation of the problem is formulated as follows:

1. What percentage of the total drying efficiency of drying facilities for agricultural products in the location of Lahendong Geothermal Power Plant ?
2. How about the public response to the presence of Lahendong Geothermal Power Plant, and Direct Using Technology for drying of agricultural products ?
3. Why the production of Crystal Palm Sugar using steam from geothermal is decrease?

Objectives

Based on the formulation of the problems ,the goals of this research is formulated as follows:

1. To find out what percentage of the total drying efficiency of drying facilities for agricultural products in the location of Lahendong Geothermal Power .
2. To study and find out the community response about the location of the existence Lahendong Geothermal Power Plant, including the Direct Using technology for drying agricultural products
3. To find out problems faced by manufacturers of crystal palm sugar production decline

Benefits

Research is expected to be useful for:

1. For the geothermal energy management , this study can be used as the initial information about the public response to the geothermal power plant and geothermal technologies for drying agricultural products.. So that can be the basis of the development of Geothermal Power Plant decisions at the future.
2. For the Communities around the Lahendong Geothermal Power Plant this study gives a knew knowhow about energy alternative for drying agricultural products and can be used as a media digging aspirations that can be used as an important input to the geothermal management and local governments.
3. For local governments, this study can be used as a reference to make policy and local regulation on the notice Geothermal Power Plant socio-economic and environmental aspects.

THEORITICAL BASIS

Geothermal System

Earth as well as the sun generates heat naturally. The energy generated by geothermal energy, such as solar energy, is very large, but the release of naturally in nature is very small, averaging about 1/16 of the earth's surface watt per square meter. Although anyone can convert geothermal energy into electricity with an efficiency of 20%, would need all the heat flow from the area of a football field to turn on the lights to 60 watts. Normal temperature gradient (temperature increases in proportion to its depth) from the surface to the Earth's crust is generally at 17-30 ºC per kilometer of depth.

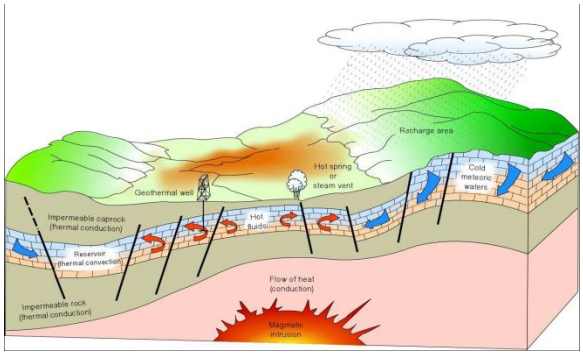

Figure 1. Schematic Ideal of Geothermal Systems. *Source* from Tim Panas Bumi, Pusat Teknologi Konversi dan Konservasi Energi Badan Pengkajian dan Penerapan Teknologi, 2011.

Mechanisms that occur in geothermal systems are fluid convection. Convection is caused by heating, and heat transfer by convection fluid. Heat is supplied on the basis of the circulatory system is the energy that drives the system (Figure 2). Heating by magma would be long, and this means a geothermal system also can be long. From the illustration ideal geothermal system (Figure 1) shows that when the watershed is lost, then the fluid entering the reservoir is frozen. This means that a geothermal system stops.

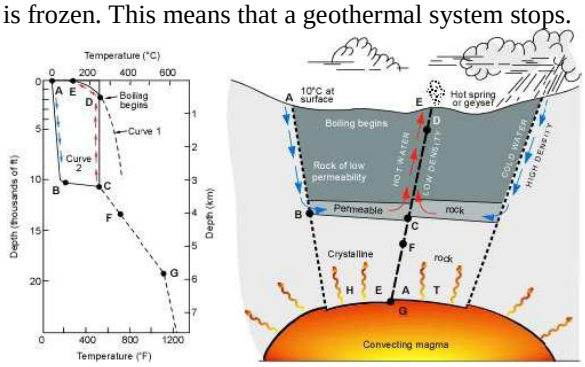

Figure 2: Model of Geothermal System. Source from website International Geothermal Association, 2002 and White, 1973) *in* Tim Panas Bumi, Pusat Teknologi Konversi dan Konservasi Energi Badan Pengkajian dan Penerapan Teknologi 2011

In (a) the temperature on the depth chart looks. Plot the curve 1 (curve 1) shows the curve for the boiling point of pure water. While the second curve (curve 2) shows the temperature profile along the circulation route from recharge area (point A) to the discharge area (point E). Figure (b) shows the model of geothermal and water circulation processes that are in the system.

Geothermal Energy Utilization

Before the twentieth century, the geothermal fluid (geothermal) is only used for bathing, washing and cooking. Today the utilization of the geothermal fluid is very diverse, both for electricity generation and for other purposes in the non-electricity, which is for spa heating, greenhouses, agricultural land, agriculture and animal husbandry. Utilization of geothermal energy in general can be divided into 2 types, namely utilization (indirect use) and use (direct use). Utilization of the indirect use of geothermal energy for power generation, while the direct use of the direct use of heat contained in the geothermal fluid to various fields such as agriculture / agro-industry, fisheries, tourism, etc.

In addition to the utilization of geothermal energy for power generation, geothermal energy can also be used directly to support the processes associated with heating, drying, sterilization and pasteurization. Some examples of direct use of geothermal energy (direct use) can be seen in Figure 2.3. Lindal diagram (1973) demonstrated the usefulness of geothermal energy in accordance with the temperature.

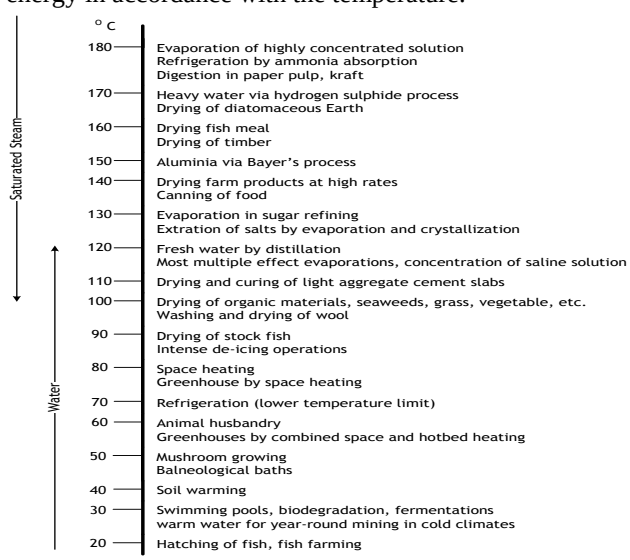

Figure 3: Lindall Diagram (1973). *Source* from Tim Panas Bumi, Pusat Teknologi Konversi dan Konservasi Energi Badan Pengkajian dan Penerapan Teknologi 2011.

The main characteristics of Indonesian geothermal resources are located in mountainous areas with fertile land, making it suitable for agriculture, agro-industry or tourism in the vicinity. In the areas of geothermal energy can be used for processes such as drying and preserving agricultural products (eg tea, coffee, cocoa, grains), sterilization of growing media (such as mushrooms, potatoes), livestock products (eg. laying hens, broilers, pasteurized milk, shrimp,

catfish, etc.), space heating, hot water bath, as well as many other types of utilization.

The utilization of geothermal energy is directly done by taking heat from the fluid in the soil, either through wells drilled or naturally flowing like a spring. Heat removal is assisted by a device called a heat exchanger (heat exchanger). Direct use of geothermal energy geothermal sources typically use low-to moderate-temperature (< 150 ^{o}C) and generally not economically used for power generation. Geothermal resources that can be utilized for direct use are as follows:

- Hot water waste geothermal fluid separation results in the area of Geothermal Power Plant
- Geothermal wells entalphi / low temperature
- The hot springs.

At present there is no accurate data on the type and capacity utilization nationally because it is difficult to identify and calculate the quantity. Some examples of direct utilization of geothermal energy in Indonesia is as follows.

Geothermal Water

Direct use of geothermal water are the most common and traditional is for baths and hot springs pool. Examples of geothermal baths with warm water are as shown in Figure 4 and 5 below.

Figure 4: Utilization of Geothermal Water for Traditional Baths.

Figure 5: Utilization of Geothermal Energy for Air Baths Commercial in Cipanas.

Some places like Ciater Cipanas in West Java and managed commercially. Since about 10 years ago, Pertamina has been utilizing geothermal steam to heat fresh water for domestic water purposes and office Kamojang geothermal field, but we did not measure the capacity and use of the annual amount of energy.

Agriculture

Direct use of geothermal energy for agriculture in Indonesia was started by a group of researchers geothermal BPPT (Agency for the Assessment and Application of Technology), in cooperation with Pertamina in implementing a pilot plant for the utilization of geothermal energy. Examples of geothermal energy for agriculture are as shown in Figure 6.

Figure 6: Examples of Dried Agricultural Products using Direct Use of geothermal.

Since 1999, BPPT in cooperation with PT.Pertamina Geothermal Energy (Indonesian State Enterprise) implementing a pilot plant for the utilization of geothermal energy in the field of mushroom cultivation geothermal Kamojang (West Java). In addition, the BPPT also built a pilot plant utilization of natural geothermal wells to dry coconuts into copra geothermal area Wai Ratai (Lampung).

At geothermal area Lahendong (North Sulawesi), a Masarang foundation has been built a crystal palm sugar manufacturing plant utilizing geothermal steam. In the same place PT.Pertamina Geothermal Energy area Lahendong also has built a pilot plant to utilization of geothermal steam for drying coconuts become copra.

Crystal Palm Sugar Production

Direct use of geothermal steam for crystal palm sugar production process is carried out by the Masarang foundation in cooperation with Pertamina geothermal energy area Lahendong with a capacity

of 2-5 tons / day. But current production is only 1 ton / day, even there is no production et all. . Palm sugar production process is as shown in Figure 7.

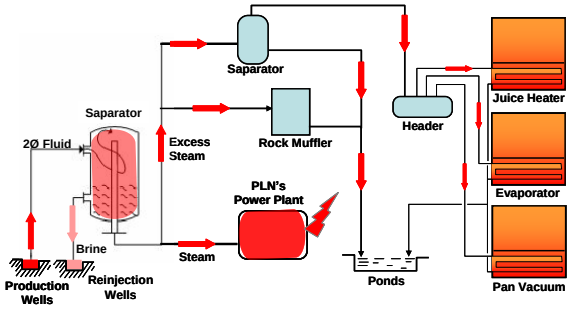

Figure 7: Process of Crystal Palm Sugar Production. *Source* from Tim Panas Bumi, Pusat Teknologi Konversi dan Konservasi Energi Badan Pengkajian dan Penerapan Teknologi 2011.

Those stages that utilize geothermal steam production process is juice heater, evaporators, vacuum pan. Crystal Palm sugar products using direct use of geothermal energy is mostly exported to the Netherlands.

METHODS OF RESEARCH

Research Design

This study used two approaches are experimental and descpritive. Experimental method used to measure the technical aspects of agricultural drying technology facility with geothermal (steam) from existing geothermal power plant. While descriptive is field research to determine the public's perception about the location Geothermal Power Plant / and drying facilities available.

Population and Sample

The population in this study are all the community that exist around Lahendong Geothermal Power Plant . However, in this study using a sample of 20 respondents. Respondents are spread in villages near the geothermal power plant, such as: Pangolombian village, Tondangow, Kayawu and Kakaskasen.

Data and source of data

The data used are secondary and primary data. Secondary data is data obtained from other sources (institutional) associated with this research. While the primary data obtained directly from the field.

Data Collection Technique

1. Documentation, the method of data collection by recording experimental results.
2. Observation is a data collection method by observing the workings of drying facilities and the attitude of the respondent when the research was conducted.
3. Kuestionare is question list to collecting data by dividing and tabulate respondents. Kuestionare was distributed to respondents.
4. Interview is collecting data by conducting interviews with respondents.

Research Variables

In this study, the variables used are:

1. Observed drying process, which is:
   a. Sample drying rate during drying process
   b. Heating efficiency and drying efficiency from dryer using geothermal energy.

2. to measuring the perception of the respondents, using variables:
   a. Characteristics of respondents: initials, address, occupation, income, local organizations membership, marital status, and education
   b. Knowledge and benefit Geothermal Power Plant (use 15 indicators).
   c. Impact Geothermal Power Plant (use four indicators).

Analysis

1. Measuring characteristic of drying process of materials consist of drying rate process as graphically.
2. Measuring heating efficiency and drying efficiency from dryer during drying process. Those equation are :

Heating efficiency : $E_{pn} = \frac{q}{Q_g} \times 100\ \%$ ……(1)

Drying efficiency : $E_{pr} = \frac{w \times h_{fg}}{Q_k} \times 100\ \%$ ……(2)

3. Perception of respondent using descriptive and mathematical statistics method.

RESULT

Drying Rate

Characteristic Sample using Geothermal Energy Drying equipment

Materials used in the drying experiments is Paddy. Before using geothermal dryer materials have wind-dried until the moisture content has reached 17.82% . Paddy, were dried for 5 hours with final moisture content is 4.37 %wb at the bottom tray (see table 1.). This phenomenon indicates the paddy moisture content is too low at the end of drying process and it shows in a state of over drying. Result of moisture content each tray on table 1 and decreasing of moisture content while drying process shown in figure 7.

Also, this could make plenty of humid air at the surface area of plenum and could reduce moisture transferred inside of the materials.

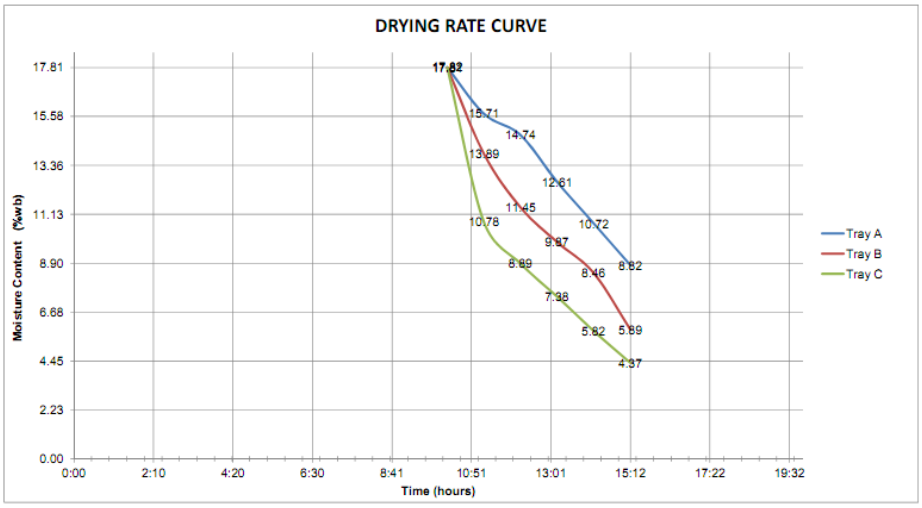

Figure 8. Moisture Content Drying Rate of Each Tray

Table 1: Results of Moisture Content Each Tray During Drying Process

Time (hours)	Moisture Content (%wb)			Plenum (^{O}C)
	Tray A	Tray B	Tray C	
10:12	17.82	17.82	17.81	60
11:12	15.71	13.89	10.78	62
12:12	14.74	11.45	8.89	59
13:12	12.61	9.87	7.38	60
14:12	10.72	8.46	5.82	61
15:12	8.82	5.89	4.37	60

Based on table 1, final moisture content of each tray was different. This condition caused by the air flow from heat source was came direct from side of each tray also the exhaust windows were placed at the bottom on rear of building. It makes the humidity at the upper tray more humid than the bottom tray even the air flow as generally same from side area of trays.

Dryer Geothermal Energy Efficiency

Efficiency of dryer was measurement from equation (1) and (2). Results from those equation for heating efficiency and drying efficiency from dryer that using geothermal energy at geothermal power plant area in Lahendong are 82,50 % and 51,10% respectively.

Based on those results, heating from heat source provide enough heat to dried the materials. Heat source that came from geothermal energy was available abundantly and transferred constantly to heat exchanger and blow up to plenum constantly.

Mean while, for drying efficiency was average to dried the materials. The results caused by the ventilation windows were placed at the bottom area of rear building. It could makes the air flow of humid air could not reach ventilation windows successfully.

Community Response

***Characteristics of Respondents* :**

Data on Table 2 up to 6 explained the characteristics of the respondents i.e : distribution of respondent, work, revenue per month, membership of the local organization, and latest education., and then tabel 7 up to 25 about understanding of the existence of geothermal around the community, direct using of geothermal benefits, negative impacts and others.

From the surveys and interviews provide information that the community are stay in villages located around the geothermal plant will be impacted directly or indirectly and should be prioritized for direct using the geothermal energy in the form of agricultural products drying technology. Most of the respondents were farmers and that their income from agriculture has not been optimal in enhancing the investment allocation of public revenue (tabel 3 and 4).

The consequence of it is development of the economic structure in the area not developed, and only farm-based economic structure (economic nature) have not switched to the structure of trade, service or technology. It can be seen from the revenue that are just average 1 million per month (Table 4), most of them just only completed a study on senior high school (Table 6), nevertheless their understanding of geothermal energy is very good that is 95 % (Table 7).

Benefit of Geothermal Power Plant .

Data on Table 9 showed that 85 % of respondent know the benefits of geothermal power plant for generate electricity, and 65 % know for drying agriculture products (Table 10), therefore they are expecting geothermal can be used directly for drying agricultural products as the main commodities in village (Table 11). It happen because they already know that geothermal energy can be used for drying agricultural products (Table 12) and the drying technology is already available in the location in which they live (Table 15) and have even been using the technology (Table 16).

Until now, the method of drying by the people is still dominated by solar (Table 12) so it is difficult to solve the problem if the rainy season especially Tomohon located at an altitude between 800-1200 meters above sea level.

It is interesting that about 95 % of respondents are interested in using this technology (Table 17), 50 % expect drying equipment prepared by the management of the power plant (Table 18) and 45 % expect it be manage by local communities group (Table 18). Also, interesting that some respondents 45 % alarming negative impact that would occur (Table 23), as illustrated in Table 24 the springs dried up 33.33 %, 30.30 % dead plants and deforestation, flooding and uncontrolled bursts of toxic gas. Even so the presence of a power plant that is still accepted by people around 70 % (Table 25) with some hope :
the management of geothermal powerplants, have to follow the farmers grumbling that damaged Paddy field when there is overflow of hot water in the well 24. Tondangows communities who has fields at Zanomeha note that their needs fix up for the road access. Because that is was damaged due to the mobilization of heavy equipment and also must employed local labor that are on the site as employee at power plant management.

Palm Sugar Production

Production of Palm Sugar previous section described the current obstacles and even temporarily halt production. The result of our interviews with the owners are :

1. The problem caused by decreased of Brine / steam pressure. In 2007 when the factory was inaugurated management gets the steam supply to a pressure of about 8 bar, but now only at range of 1-2 bar, this resulted in production can not be continuous because cooking of Nira Aren (sap) are very limited. Nira from farmers were decreased and does not run well, so that the farmers who had already enjoyed sales Nira be no longer earn benefits.
2. Brine quality that tends to containing silicate cause blockage and scaling on pipes and some production equipment resulting in uninterrupted production process. Currently seeking supplying separator plant but did not final yet.

CONCLUSION

1. Heating efficiency for Paddy drieying of the Dryer is 82.50% and total drying efficiency reached 51.10%.
2. Local people welcomed the direct using of geothermal technology for drying agricultural products and geothermal management on site should pay attention to all public facilities in the village surround the power plant throughout it was safe because it is available in the location and sustainable
3. Decrease the production of crystal palm sugar causes absorption of sugar palm sap from the farmer soround the location sales decreased and their incomes reduced.

RECOMENDATION

1. For replication equipment need to do research or study for the excessive energy and modify the drying chamber to be use for other agricultural products.
2. Local people welcomed the direct use of geothermal drying technology because it is available in the location and sustainable.
3. Needs to be done research and or study about the supply of brine for crystal palm sugar production for sustainability of the the industry in order
4. To ensure the sustainability of the direct using of geothermal energy, needs the local government regulations

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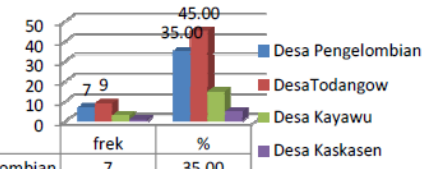
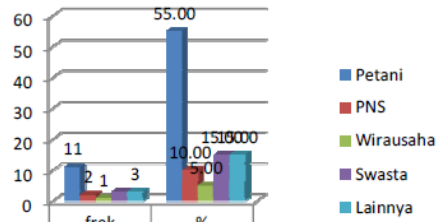
TABLE ATTACHMENT

Tabel 1. Sebaran Responden



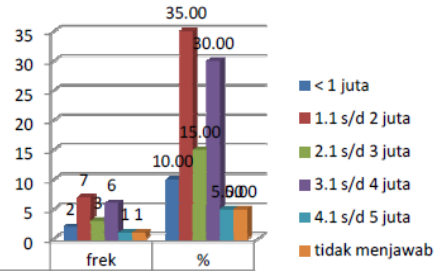
	frek	%
Desa Pengelombian	7	35.00
DesaTodangow	9	45.00
Desa Kayawu	3	15.00
Desa Kaskasen	1	5.00

Tabel 2. Pekerjaan Responden



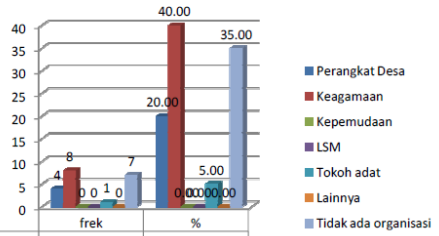
	frek	%
Petani	11	55.00
PNS	2	10.00
Wirausaha	1	5.00
Swasta	3	15.00
Lainnya	3	15.00

Tabel 3. Pendapatan Rata rata per bulan



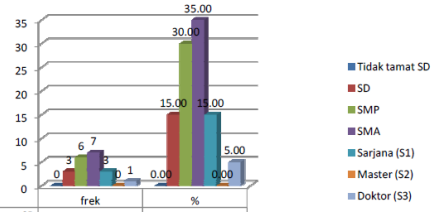
	frek	%
< 1 juta	2	10.00
1.1 s/d 2 juta	7	35.00
2.1 s/d 3 juta	3	15.00
3.1 s/d 4 juta	6	30.00
4.1 s/d 5 juta	1	5.00
tidak menjawab	1	5.00

Tabel 4. Keanggotaan Organisasi Lokal



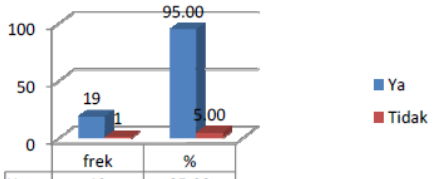
	frek	%
Perangkat Desa	4	20.00
Keagamaan	8	40.00
Kepemudaan	0	0.00
LSM	0	0.00
Tokoh adat	1	5.00
Lainnya	0	0.00
Tidak ada organisasi	7	35.00

Tabel 5. Pendidikan Terakhir



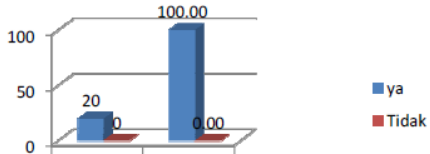
	frek	%
Tidak tamat SD	0	0.00
SD	3	15.00
SMP	6	30.00
SMA	7	35.00
Sarjana (S1)	3	15.00
Master (S2)	0	0.00
Doktor (S3)	1	5.00

Tabel 6. Pernah Mendengar PLTPB ?



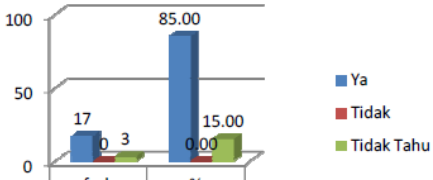
	frek	%
Ya	19	95.00
Tidak	1	5.00

Tabel 7. Mengetahui Lokasi PLTPB di Sekitar Tempat Tinggal / Daerah anda



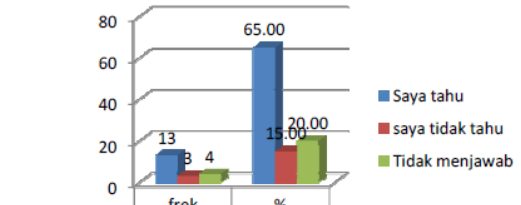
	frek	%
ya	20	100.00
Tidak	0	0.00

Tabel 8. Apakah PLTPB memberikan Manfaat bagi anda?



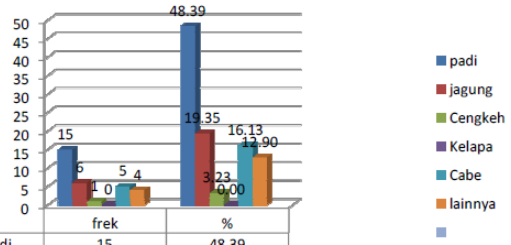
	frek	%
Ya	17	85.00
Tidak	0	0.00
Tidak Tahu	3	15.00

Tabel 9 PLTPB dapat digunakan Untuk pertanian ?



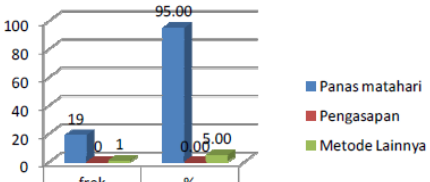
	frek	%
Saya tahu	13	65.00
saya tidak tahu	3	15.00
Tidak menjawab	4	20.00

Tabel 10 Produk pertanian yang dihasilkan petani



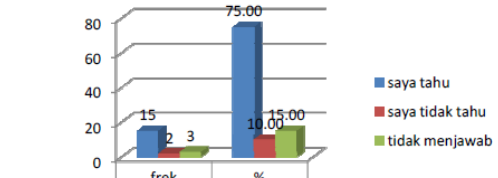
	frek	%
padi	15	48.39
jagung	6	19.35
Cengkeh	1	3.23
Kelapa	0	0.00
Cabe	5	16.13
lainnya	4	12.90

Tabel 11 Metode Pengeringan produk pertanian oleh penduduk



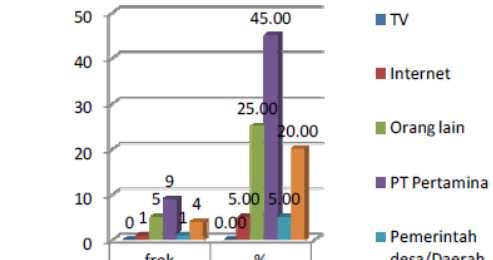
	frek	%
Panas matahari	19	95.00
Pengasapan	0	0.00
Metode Lainnya	1	5.00

Tabel 12 Energi Panas Bumi dapat digunakan dlm proses pengeringan produk pertanian



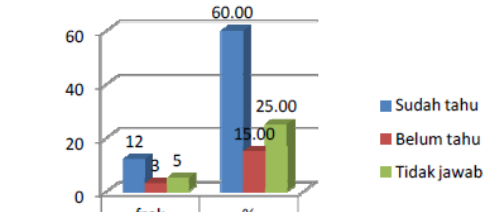
	frek	%
saya tahu	15	75.00
saya tidak tahu	2	10.00
tidak menjawab	3	15.00

Tabel 13. Sumber informasi penggunaan PLTPB untuk pertanian



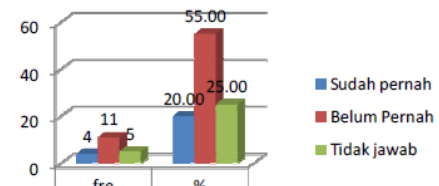
	frek	%
TV	0	0.00
Internet	1	5.00
Orang lain	5	25.00
PT Pertamina	9	45.00
Pemerintah desa/Daerah	1	5.00
Lainnya	4	20.00

Tabel 14. Teknologi Pengeringan dari energi panas bumi telah tersedia di daerah anda



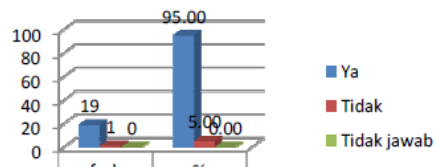
	frek	%
Sudah tahu	12	60.00
Belum tahu	3	15.00
Tidak jawab	5	25.00

Tabel 15. PErnah menggunakan teknologi pengeringan dengan energi panas bumi



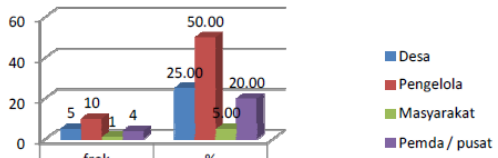
	frek	%
Sudah pernah	4	20.00
Belum Pernah	11	55.00
Tidak jawab	5	25.00

Tabel 16. Tertarik Gunakan Teknologi Ini ?



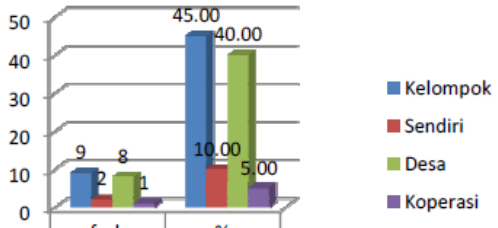
	frek	%
Ya	19	95.00
Tidak	1	5.00
Tidak jawab	0	0.00

Tabel 17 Pihak Penyedia Teknologi



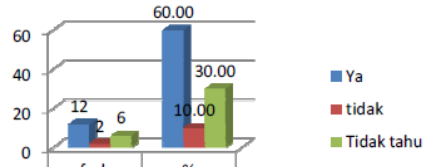
	frek	%
Desa	5	25.00
Pengelola	10	50.00
Masyarakat	1	5.00
Pemda / pusat	4	20.00

Tabel 18 Pengelola Fasilitas Pengeringan



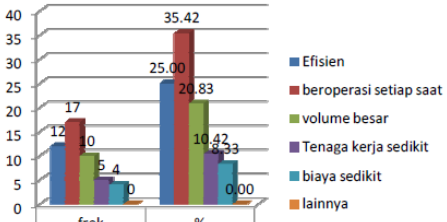
	frek	%
Kelompok	9	45.00
Sendiri	2	10.00
Desa	8	40.00
Koperasi	1	5.00

Tabel 19. Teknologi ini Menguntungkan ?



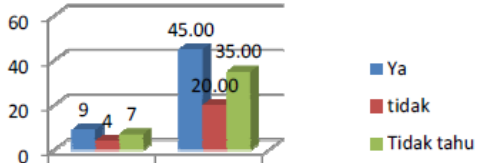
	frek	%
Ya	12	60.00
tidak	2	10.00
Tidak tahu	6	30.00

Tabel 20 Manfaat teknologi Baru Ini



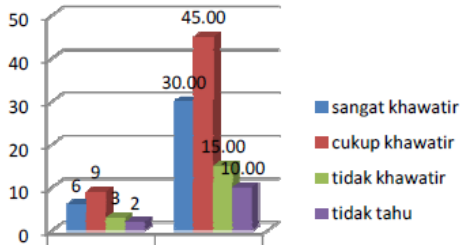
	frek	%
Efisien	12	25.00
beroperasi setiap saat	17	35.42
volume besar	10	20.83
Tenaga kerja sedikit	5	10.42
biaya sedikit	4	8.33
lainnya	0	0.00

Tabel 21 apakah Pertamina Memiliki Teknologi Ini ?



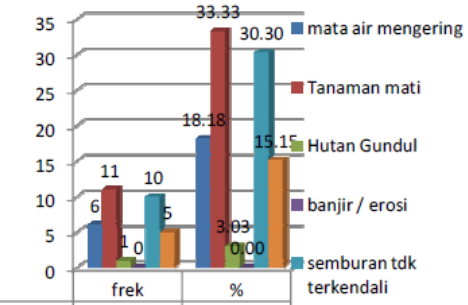
	frek	%
Ya	9	45.00
tidak	4	20.00
Tidak tahu	7	35.00

Tabel 22 Dampak Negatif PLTPB



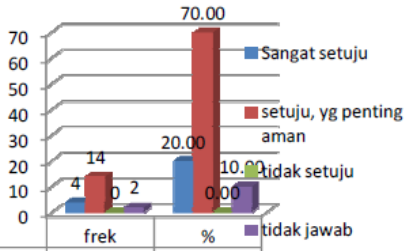
	frek	%
sangat khawatir	6	30.00
cukup khawatir	9	45.00
tidak khawatir	3	15.00
tidak tahu	2	10.00

Tabel 23 Jenis Dampak negatif PLTB Menurut Responden



	frek	%
mata air mengering	6	18.18
Tanaman mati	11	33.33
Hutan Gundul	1	3.03
banjir / erosi	0	0.00
semburan tdk terkendali	10	30.30
lainnya	5	15.15

Tabel 24 Setuju dengan PLTPB



	frek	%
Sangat setuju	4	20.00
setuju, yg penting aman	14	70.00
tidak setuju	0	0.00
tidak jawab	2	10.00