Study of Kaliandra Tree as Source of Primary Energy

Surya Tarmizi Kasim[1], Riki Ananda[1] and Fahmi[2]
[1]*Department of Electrical Engineering, Faculty of Engineering, University Sumatera Utara, Medan,Indonesia*
[2] *Centre of Excellence Sustainable Energy and Biomaterials, University Sumatera Utara,Medan,Indonesia*

Keywords: Renewable energy, kaliandratree, electrification, wood pellet.

Abstract. Fulfilling the need for energy is still heavily dependent on fossil fuels. Meanwhile, our fossil energy reserves are declining. On the other hand, Indonesia's electrification ratio is still at 80.4%. The lowest electrification ratio is in East Nusa Tenggara (54.77%) and Papua (36.41%). Low electrification ratios mostly occur in remote areas as well as small islands. Inadequate infrastructure and also the high cost of building transmission lines to remote areas as well as small islands are the main obstacles. One of the efforts made to overcome the electricity crisis is to utilize Renewable energy resources (Renewable energy resources). This study discusses the study of the utilization of Kaliandra wood pellets as fuel for the power plant. Research methodology is done by analyzing the results of lab tests conducted at PT. Sucofindo to Kaliandra Pellet samples. The research was conducted by calculating Low Heat Value of Kaliandra pellets. The results shows that 1 kg of Kaliandra pellet produces 5,477 kWh with the price of Rp. 744, 24 / kWhso it is possible to be used as fuel for the steam power plant for small scale.

1 INTRODUCTION

Today electrical energy has become a primary need for modern society. The need for electrical energy is increasing along with the progress of science, technology, and civilization of a nation. This increasing power demand must be offset by the construction of new plants. Most of the fuel for our plants is fossil fuels such as fuel oil, coal, and gas. Fossil fuels are non-renewable fuels. In contrast to the growing need for electrical energy, the energy reserves of fossil fuels are even less and will soon run out.

Indonesia is still heavily dependent on fossil fuels. Meanwhile, our fossil energy reserves are declining. On the other hand, Indonesia's electrification ratio is still at 80.4% (*PLN*, 2014). The lowest electrification ratio was in East Nusa Tenggara (54.77%) and Papua (36.41%).

Low electrification ratios mostly occur in remote areas as well as small islands. Inadequate and costly infrastructure to build transmission lines to remote areas, as well as small islands, is a major obstacle.

To increase the electrification ratio in remote areasand islands is the development of new plants. The construction of power plants in small areas is done in small capacity according to need. In addition, efforts should also be made of the fuel that is easily available in the area for the sustainability of electricity generation.

One of the efforts made to overcome the electricity crisis is to utilize Renewable energy resources (Renewable energy resources). In Indonesia, there are a lot of energy resources that can be utilized. One of them is biomass. One alternative fuel for power plants in remote and remote islands is from Kaliandra trees.

1.1 Biomass

Biomass is an organic material produced through photosynthetic processes, both in the form of products and waste. Examples of biomass include plants, trees, grasses, yams, agricultural wastes, forest waste, feces and livestock manure. Besides being used for the primary purpose of fiber, foodstuff, animal feed, vegetable oil, building materials and so on. Biomass is also used as a source of energy (fuel).

Biomass energy sources have several advantages such as a renewable energy source that can provide a sustainable source of energy. In Indonesia, biomass is a very important natural resource with a variety of primary products as fiber, wood, oil, foodstuffs, and

Kasim, S., Ananda, R. and Fahmi, .
Study of Kaliandra Tree as Source of Primary Energy.
DOI: 10.5220/0008881800260030
In *Proceedings of the 7th International Conference on Multidisciplinary Research (ICMR 2018)* - , pages 26-30
ISBN: 978-989-758-437-4

others that are used to meet domestic needs also exported and become the backbone of the country's foreign exchange.

The Government encourages the Development of Biomass and Biogas PLT through Minister of Energy and Mineral Resources Regulation No. 27 of 2014 on the Purchase of Electricity from Biomass Power Plant and Biogas Power Plant by PLN.

1.2 Biomass as a Source of Energy

Biomass as a Renewable Energy Source that can always be replanted and harvested in ways that humans use it as fuel from time immemorial. Activity utilizing biomass as energy fuel is often also referred to as "green farming" activity without the need for capital / cost which is too high but able to involve labor so-called "pro job action."

Biomass utilization has the following effects (Kong, 2010):

1. The air around the biomass burning process is cleaner than the air quality near the burning process of fossil fuel.
2. For managers of biomass-fueled power plants, this can put pressure on investment costs an unnecessary overhaul unit of emissions as well as daily operational costs. The more complex the operation, the greater the electrical energy required because each pollution prevention unit also needs electrical energy.
3. CO2 of biomass burning is categorized as "carbon neutral" because it is reabsorbed by plants to sustain its growth.
4. Planting energy plants in marginal lands in addition to boosting local people's income can also prevent soil erosion and thus reduce the potential for landslides.
5. When the "sleeping" areas are used for crops, then the rainwater absorbing function is reactivated as a means of preventing flooding.

The potential of biomass in Indonesia that can be used as an energy source is very abundant. Waste derived from animals and plants are all potential to be developed. Food crops and plantations produce considerable waste, which can be used for other purposes such as biofuels.

Utilization of waste as a biofuel provides three immediate benefits. First, the improvement of energy efficiency as a whole because the energy content contained in the waste is large and will be wasted if not used. Second, cost savings, as often waste disposal can be more expensive than using it. Third, reducing the need for landfill sites due to the provision of landfills will become more difficult and expensive, especially in urban areas.

1.3 *PLTU* Fueled from Wood Pellet Red Kaliandra

PLTU is a plant that uses steam as the prime mover. To produce steam, there must be a combustion process to heat the water. PLTU is a power plant system that converts chemical energy into electrical energy by using water vapor as its working fluid, with turbine blades moving the turbine shaft, for the next turbine shaft to move the generator which is then generated into electrical energy.

Steam Turbine is one of the basic components in a steam power plant. Where the main components of the system are: kettle, condenser, boiler water pump, and turbine itself. Steam that serves as a working fluid is produced by a boiler, a device that serves to convert water into vapor.

Energy Conversion Process at PLTU has three stages, namely (Suyitno, 2011):

1. Chemical energy in the fuel is converted into heat energy in the form of high-pressure steam and high temperature.
2. Heat energy (steam) is converted into mechanical energy in the form of rotation.
3. Mechanical energy converted into electrical energy.

The process of converting chemical energy into electrical energy can be seen in Figure 1:

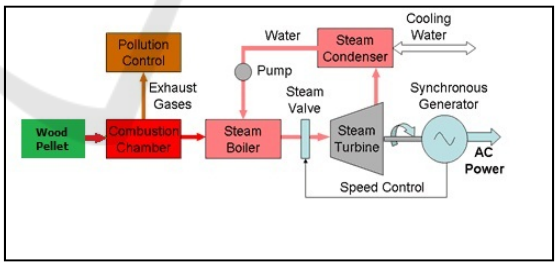

Figure 1: Wood Pellet Power Plant diagram block.

Almost all electrical energy is generated by using a synchronous generator. Therefore, synchronous generator plays an important role in a power plant. Synchronous generator (often called an alternator) is a synchronous machine that functions to convert mechanical energy in the form of rotation into electrical energy back and forth (AC)

The working principle of a synchronous generator is (Marsudi, 2005):

1. The field coil present in the rotor is connected to a particular excitation source which will supply

direct current to the field coil. Given the direct current flowing through the field coil, it will cause a flux whose magnitude over time is fixed.

2. Prime Mover which is already coupled with the rotor is immediately operated so that the rotor will rotate at its nominal speed. This corresponds to Equation 1.

$$n = \frac{120f}{p} \quad (1)$$

where:

n = Rotary speed of rotor (rpm)
p = Number of rotor poles
f = frequency (Hz)

3. The rotation of the rotor will simultaneously rotate the magnetic field generated by the field coil. The rotary field generated on the rotor will be induced on the anchor coil so that on the anchor coil located in the stator will be generated magnetic flux which varies with time. Any change in the magnetic flux surrounding a coil will induce an induced emf at the ends of the coil, according to Equation 2 (Zuhal, 1993):

$$e = -N\frac{d\emptyset}{dt} \quad (2)$$

$$e = -N\frac{d\emptyset max \sin wt}{dt} \quad (3)$$

$$e = -Nw\emptyset max cos wt \quad (4)$$

where:

E = emf induction (Volt)
N = Number of turns
C = Constants
p = Number of poles
n = Rotation speed (rpm)
f = Frequency (Hz)
ϕ = Magnetic flux (weber)

For a three-phase sync generator, three anchor spools are placed in the stator arranged in a particular shape, so that an anchor coil arrangement such as that will generate an induced voltage across the three equal-but-different 120° phase of each anchor coil. After that, the three anchor coil terminals are ready to operate to generate electrical energy.

2 MATERIAL AND METHOD

The steps in conducting an analysis of calculation study of Kaliandra tree utilization as a primary energy source are:

1. Calculating the availability of Kaliandra pellet fuel per year.
2. Determining the hours of operation of the plant used in a year.
3. Determining the low energy content of the fuel and its equivalence with the energy generated per hour
4. Determining the cost of red Kaliandra pellet fuel per kWh

3 RESULTS AND DISCUSSION

After the measurement, it can be known that fuel availability per year, fuel energy content of Low Heating Value (LHV), hours of operation of the plant in a year, the output power generated per hour, and the price of fuel.

3.1 Wood Pellet Availability per Year

Wood fuel availability of Kaliandra wood pellets is highly dependent on the area of land developed for growing wood pellets. According to ICCTF (Indonesian Climate Change Trust Fund), the wood pellet that can be processed from 1 ha of crops in one year is 30 tons. So that in 200 ha of Kaliandra plant obtained fuel of 600 tons.

3.2 Hours of Operation

Forced Outage Rated (FOR) is a rating that describes the number of hours of interruption (generator not in operation) by the number of hours of operation with the added number of hours of interference. FOR on hydropower ranges from 0.01.As for the PLTU is in the range 0.01 - 0.05. The more reliable a generating unit, the smaller the value of its FOR.

Length of time of year-long disruption according to Equation 5 (Suyitno, 2011)

$$Hours\ of\ Operation = FOR \times 8760 \quad (5)$$

The value of FOR in this study is assumed to be 0.05. So the amount of disturbance obtained by multiplying FOR by the number of hours in a year

so that the hour of disturbance that occurs within a year is 438 hours. By knowing the number of disturbances in a year, it can be determined hours of operation of the plant within a year. The hours of operation of the plant are known by performing a reduction operation against the number of hours in a year subtracted by the amount of interference:

Hours of operation = 8760-438 = 8.322 hours

From the above calculation then we can get the hours of operation of the plant in a year is equal to 8,322 hours. From these calculations, the fuel used per hour in a year results from the amount of fuel availability in a year is distributed by the number of hours of operation of the plant within a year. Thus, the fuel used in one hour of operation is 720.98 kg / hour.

3.3 Energy Content

Heating Value (HV) or Caloric Value is the calorific value incurred by 1 kilogram of fuel. The calorificvalue areof 2 kinds, namely Low Heating Value (LHV) / Top Value and High Heating Value (HHV) / Value down.

Fuel combustion at thermal power plants releases exhaust gases at temperatures well above the water dew point; the energy balance calculations are based on lower calorific values because at the high exhaust gas temperature the water is in the vapor phase. Calorific Value (LHV) also called Gross Calorific Value.

Table 1 shows the measurements of the Red Kaliandra wood pellets.

Table 1: Measurement of Kaliandra Calorific Value.

Parameters	**Unit**	**As Received**	**DB (Dried Basis)**	**Test Method**
Total moisture	% wt	5.8	---	ASTM D 2961-11
Ash content	% wt	4.7	4.9	ASTM D 3174-11
Volatile matter	% wt	73.5	78.1	ASTM D 3175-11
Fixed Carbon	% wt	16.0	17.0	By difference
Total Sulfur	% wt	0.16	0.18	ASTM D 3177-07
Gross Calorific Value	% wt	4436	4710	ASTM D 5865-11a

From Table 1 it can be seen that Kaliandra Gross Caloric Value (LHV) is 4710 kcal / kg. As for 1 kcal is equivalent to 1.163 wh, so 4710 kcal is equal to 5,477 wh.

3.4 Power Output

The generator output is obtained by performing multiplication operations between Gross Caloric Value (LHV) wood pellet fuel and generating efficiency. So the energy produced is (Fransescato, 2008):

$$P = \text{Low Heating Value} \times \text{efficiency}(\eta) \quad (6)$$

= 5.477 x 0.27
= 1.478 watt hour

Thus, Power (P) obtained is 1,478 watts hour.

The power that can be generated for operations for a year is the multiplication of the amount of fuel available with the fuel power output per kilogram. From the calculation it is obtained 1.124 Mwh for 200 ha of land.

3.5 Fuel Costs

Kaliandra tree that has been processed into wood pellet fuel price ranges between Rp. 1,100 per kg orRp. 1,100,000 per tonne (ICCTF, 2011). If the wood pellet used is 720.98 kg / hour. Thus, the cost of wood pellet fuel per hour is:

720,98 x Rp. 1.100=Rp. 792.000

The price per kwh is:

$\frac{\text{Rp.792.000}}{1.382{,}5\ kwh}$ = Rp. 572,87/ kwh

4 CONCLUSION

From the studies that have been done, it some conclusions can be taken:

1. Wood Pellet Fuel Kaliandra is one of the alternative materials of *PLTU* in the future with the decreasing of fossil fuel reserves.
2. Our dependence on fossil-fuel-based fuels should be reduced by developing biomass-based technologies (bioenergy).
3. The easy and cheap breeding and processing of Kaliandra wood pellets will make it an alternative fuel in the future that will be taken into account.
4. Wood pellet processing technology and also the efficiency of a generation still need to be improved.

REFERENCES

Francescato, Valter. 2008. *Wood Fuels Handbook, Productions, Quality Requirements, Trading*. Agripolis: Italian Agriforestry Association.

Kong, GanThay. 2010. *PeranBiomassaBagiEnergiTerbarukan*. Jakarta: PT. Elex Media Komputindo.

Marsudi, Djiteng. 2005. *PembangkitanEnergiListrik*. Jakarta: PenerbitErlangga.

PT. PLN (Persero).2014. *Rencana Usaha PenyediaanTenagaListrik (RUPTL) 2015-2024 PT. PLN Persero*. Jakarta: PT. PLN (Persero).

Suyitno, M. 2011. *PembangkitEnergiListrik*. Jakarta: PenerbitRinekaIlmu.

Zuhal.1993. *DasarTeknikTenagaListrikdanElektronikaDaya*. Jakarta: GramediaPustakaUtama.