The International Journal of Engineering and Science (IJES)
|| Volume || 9 || Issue || 09 || Series I || Pages || PP 36-42 || 2020 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Potential Energy of Palm Oil Liquid Waste as Raw Material for Power Plant Gasification

Burhanuddin Hasibuan[1], Purwoharjono[2], Hardiansyah[3]
hsb.burhanuddin@gmail.com[1], purwoharjono@ee.untan.ac.id[2], hardiansyah@ee.untan.ac.id[3]
Department of Electrical Engineering, Tanjungpura University[1,2,3]
Corresponding Author: Burhanuddin Hasibuan

--- *ABSTRACT*---
The purpose of this paper is to identify and quantify the energy potential that comes from palm oil waste as a power plant. Gasification technology can be used to convert palm oil waste liquid into pome which in time can be used as a material for electricity generation to produce electricity. Each tonne of fresh fruit bunches (FFB) produces 15% empty dry fruit bunches (EFB) which provides energy as much as 5.685 Cal / kg. The results of this study indicate that the potential for liquid waste (pome) generated by 5 (five) palm oil mills in Landak Regency with a total production capacity of 225 tons of FFB / hour from 2012 to 2017 has reached a total of 350,242.5 tons. This amount has the potential to produce energy of 1,683,401.0 MWh. After deducting the 53,705,266 MWh used for 5 (five) palm oil factories and offices in 6 years, the potential energy to be channeled to the gasification reactor is 1,629,695,741 kWh. The purchase price of excess electrical power by PT. PLN is IDR 1,438.20 / kWh. The estimated energy that can be generated post-gasification, with an efficiency level of 60.75%, is 991,832,828 MWh, leaving the estimated revenue generated by 5 palm oil mills for 6 years of IDR 1,442,453,973,462 or IDR 1,430 trillion. This energy potential will increase along with the increase in production capacity, resulting in diversification of electrical energy.

Keywords:
Electrical Energy, Palm Oil, Palm Oil Waste, Renewable Energy, Pome, Oil Palm Empty Bunches, Fresh Fruit Bunches

---

Date of Submission: 16-09-2020 Date of Acceptance: 10-10-2020

I. INTRODUCTION

Electricity consumption in Indonesia continues to increase significantly from year to year, while national energy reserves (petroleum) are increasingly limited. This condition raises the idea of the need to seek energy diversification from other energy sources. Biomass is an abundant source of energy. It is important to increase the use of biomass as an energy source to support sustainable industrial development.

For this reason, the government encourages the use of alternative and renewable energy by issuing a National Energy Policy (KEN) as a means to coordinate and synergize all stakeholders in the energy sector. This policy sets a target for the use of renewable energy of up to 23% by 2025. In addition, the use of biomass can also encourage the savings of existing economic resources and accelerate the development of a healthy economy [1]. One of the industries that produces liquid biomass waste is the oil palm industry.

Landak Regency is a regency in West Kalimantan Province with its capital city is Ngabang. Landak Regency consists of 13 Districts, 156 Villages and 553 Hamlets. Located at latitude 0001'53.56 "- 0037'41.4" and longitude 109'012'.13.44 "- 110'0 15'56.56"

Based on statistical data from the Directorate General of Plantations in 2016, Indonesian Oil Palm Plantation Commodity Statistics 2013-2015, a total of 44 Plantation Business Permits (IUP) have been issued by the Landak Regency Government including plantations owned by State-Owned Enterprises (BUMN) and private companies. pure area of 451,903.06 Ha. The realization of oil palm plantations in 13 sub-districts until the end of December 2016 covered 113,800.56 ha consisting of productive oil palm plantations (TM) covering an area of 60,403.69 ha and immature oil palm plantations (TBM) of around 53,396.9 ha. From several oil palm plantations in Landak District, during the period 2012 to 2017, a total of 2,148,210,630 kg of FFB were produced. At the same time, solid waste was 283,187 tons and liquid waste, 122,520 tons.

This research was conducted to determine the energy potential of palm oil waste from oil palm factoriess in Landak Regency which has not been fully utilized and processed into a source of electricity. The use of shells and fiber solid waste by PKS (Palm Oil Plantation) in Landak District shows that some have been utilized.

As fuel to produce steam in the boiler. Hot steam is used for processing CPO and PLTU for electricity needs in factories, offices and employee housing around the factory. Meanwhile, EFB liquid waste is partly used as fertilizer, most of it is disposed of in the shelter. With the increasing production of palm oil FFB, the resulting EFB waste accumulation is quite reasonable.

Oil Palm Plantation (PKS) is developing in Landak Regency, which functions as a large amount of biomass waste. As oil palm plantations continue to increase, waste production will increase. So far, the use of EFB solid waste (empty bunches) only functions as oil palm fertilizer by spreading it around the oil palm trees. This method has caused waste to accumulate which turns into a place for pests to thrive and at the same time produces an odor that is irritating to the environment. Based on the above conditions, the problem to be examined in this study is how to use EFB waste as raw material to convert it into new and renewable energy that is environmentally friendly as a substitute for fossil energy by applying gasification technology [2]. On the other hand, the utilization of this waste can overcome the large amount of EFB solid waste which will cause waste accumulation problems. By being able to process liquid waste as raw material for power generation, it can increase the alternative energy reserves generated by power plants [3]. As a contribution to government programs in utilizing renewable energy that is more efficient and environmentally friendly.

II. BASIC THEORY

Palm oil processing can produce CPO and palm oil waste in solid, liquid and gas forms. Palm oil waste is plant residue which is neither the main product nor a byproduct of processing palm oil. A one hectare oil palm plantation can produce 2.7 tonnes of FFB per month. One tonne of processed FFB can produce: Crude Palm Oil (CPO) = 21.8% (458 kg / Ha), dry empty fruit bunches (TKS) = 22.5% (473 kg / Ha), shells = 6.7 % (14 kg / Ha), fiber = 14.3% (300 kg / Ha), kernel = 5.4% (113 kg / Ha), and POME (Palm Oil mill waste) = 54.8% [4].

The energy contained in oil palm empty bunches can be converted into gas through gasification technology. Gasification is the process of converting energy from solid fuels containing carbon to clean gas through partial high temperature oxidation, namely a mixture of gases of Carbon monoxide (CO), hydrogen (H2), Methane (CH4), Carbon dioxide (CO2), Hydrogen dioxide (H2O).) and Nitrogen (N2). The composition of the gasification gas produced depends on the type and composition of the food input and the gasification operation parameters. The advantage of using clean gas is that it has a high degree of purity, no longer contains corrosive hydrogen sulfide (H2S), and is completely harmless [5].

The gasification process takes place in a reactor called a gasifier. Based on the speed of movement of the bed material flow, the gasifier is divided into 3 (three) types, namely fixed bed gasifier, fluidized bed gasifier and Entrained bed gasifier [6].

A. Fixed bed gasifier is a type of gasification in which the bed material (coal / biomass) is in a fixed position with fluidization speed <0.1 m / sec, low consumption of gasification medium, low power generation capacity, 60-70% carbon conversion, product side in the form of ash and charcoal. The direction of moving from the feed material flow to the syngas product is the mutual flow transfer and the backflow.
B. Fluidized bed gasifier, is a type of gasification in which the bed material (coal / biomass) moves like a fluid with a fluidization speed of 1-12, / second, medium to high consumption of gasification media, 95% carbon conversion, by-products in the form of dry slag. Based on the flow rate of the bed material flow, the fluidized bed gasification system is divided into fluidized bed and fluidized bed inflating.
C. Entrain bed gasifier, different from the previous two types of gasification, the bed material flow (coal / biomass) moves very fast with a fluidization speed of more than 12 m / sec, high consumption of gasification media, carbon conversion above 95%.

The potential for solid waste from the palm oil mill produced from a mill with a production capacity of 45 tonnes of FFB / hour is as follows:

TABLE I. POTENTIAL OF SOLID WASTE AND OIL FACTORY LIQUID WASTE PALM OIL

Types of Solid Waste	***Percentage (%)***	***Hour(s)/Percentage (%)***
EFB (wet)	23	13.35
EFB (dry)	15	6.75
Serat (dry)	13	5.85
Shell (dry)	5	2.25
Boiler Ash	2,5	1,125
Solid Decanter (on the MCC using a decanter)	3.5	1.575
Palm oil liquid waste (Pome)	60-80	27-36

Source: Udin Hasanudin, Unila Tropical Biomass Research and Development Center.

The potential for electrical energy from palm oil waste produced can be seen from its calorific value. The calorific value of biomass is determined not only by the elements contained in it but also by air content, the greater the proportion of air content, the smaller the calories contained. Oil palm solid waste values are shown in Table II below:

TABLE II: COLOR VALUE OF PALM SOLID WASTE

Solid Waste	*Average Calorific Value (Kj / kg).*	*Range (kj / kg)*
Skin	20,093	19,500-20,750
Fiber	19,055	18,800-19,580
EFB	18,795	18,000-19,920
Palm Fronds	17,471	17,000-17,800
Pome	15,719	15,400-15,680

Source: Ma et all (2004)

To calculate the potential for waste energy produced TKS can be done with the following formula:

- Formulation on production potential quantities :

$$\text{Processing Capacity} = \frac{\text{Processed FFB}}{\text{Number of days x 24 hour x 1000}} \circ \left(\frac{kg}{hour}\right) \text{............}(1)$$

- Formulation on palm TKS solid waste fuel input:

$$EFB = EFB \text{ weight x calorific value } EFB, kCal \text{.........}(2)$$

- The formulation on the potential of electric energy of TKS solid waste:

$$EFB = \left[\text{Weight of EFB }(kg) x \text{ heating value } \left(\frac{kCal}{kg}\right) x \text{ Conversion } (kWh/kCal)\right] kWh \text{ ....}(3)$$

Based on research conducted by Abdul Gafur from The Sepuluh November Institute of Technology in 2017, in his thesis entitled Study of Palm Oil Holster Gasification Improving the Performance of Downdraft Reactors with Multiple Air Input, gasification technology power plants have an electrical energy conversion efficiency of 60.86%.

III. METHOD

A. Data collection and processing

Primary data is obtained through direct observation to the company, research targets while secondary data is obtained through the management of PT. Kapuas Rimba Sejahtera, PTPN XIII Ngabang, PT. Agro Nusa Investama, PT Multi Perkasa, Sejahtera, PT. Satria Multi were successful, as well as from the Landak District Forestry and Plantation Service. In addition to that, national and international scientific literature data were also used.

The research approach used in this study is non-experimental qualitative research. The variables studied were:

- Number of oil palm plantations.
- Number of palm oil mills.
- Amount and capacity of FFB production.
- Total solid waste from oil palm EFB
- The heating value of EFB waste

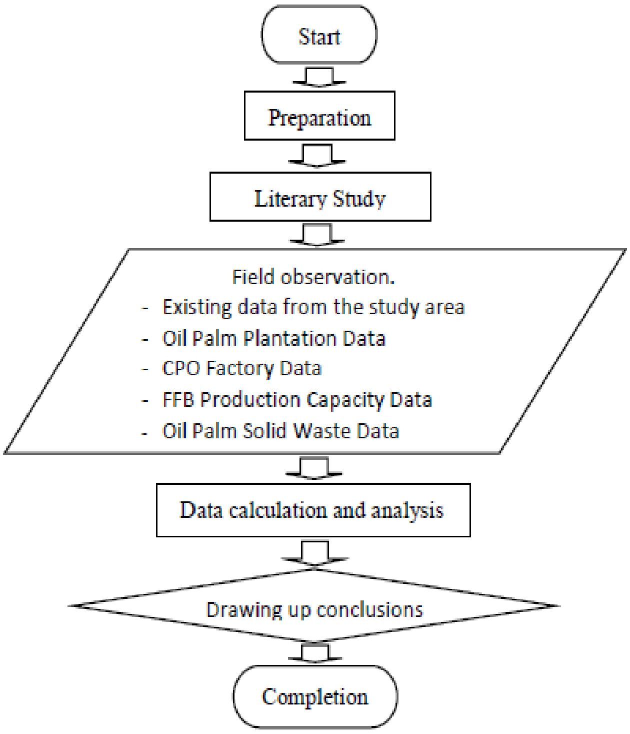

Figure 1. Flow Chart Diagram on Research Implementation

B. Study Procedure

This research was conducted by studying the literature and supporting theory, observing objects to determine the direction of research, studying the influencing factors that might cause EFB waste not to be fully utilized.

Collect primary and secondary data, identify total FFB production and EFB waste produced, analyze the utilization of EFB solid waste as fuel for existing power plants, and calculate the energy potential of EFB solid waste as raw material for gasification for electricity generation.

IV. RESULTS AND DISCUSSION

A. Palm Oil Mills in Landak District

Palm oil mills in Landak District are spread across Indonesia in several districts with a total production of 5 factories of 225 tons / hour (TABLE III). Should the factory operate 25 days / month and 24 hours / day with 15% dryness EFB waste, so the total dry EFB waste will reach 243,000 tons per year.

TABLE III. DATA ON PALM OIL MILLS IN LANDAK DISTRICT

No	Name of Palm Oil Factories	Production Capacity
1	PT. Agro Nusa Investama	30 tons FFB/hour
2	PT. Perkebunan Nusantara XIII	60 tons FFB/hour
3	PT. Satria Multi Sukses	60 tons FFB/hour
4	PT. Multi Perkasa Sejahtera	30 tons FFB/hour
6	PT. Kapuas Rimba Sejahtera	45 tons FFB/hour
Total		225 tons FFB/hour

Source: Environment Agency of Landak Regency 2016

Based on data from 5 mills units, it was learned that they produce large amounts of solid EFB waste as shown by the data in TABLE IV:

TABLE IV. PRODUCTION OF SOLID WASTE OF PALM OIL PLANT IN LANDAK DISTRICT 2012 – 2017

Year(s)	*FFB Total (tons)*	*Total dry EFB (tons)*	*Shell (tons)*	*Fiber (tons)*
2012	351,309.8	52,696	21.065	47.540
2013	373,997.2	56,100	21.905	50.663
2014	331,475.4	49,721	19.621	44.967
2015	417,830.8	62,675	23.649	53.987
2016	483,994.0	72,559	25.864	61.195
2017	189,603.5	28,441	11.208	24.835
Total	2,148,210.6	322,232	123.313	283.187

Source: Processed data

FFB production as stated in TABLE IV above does not fully reflect the production of palm oil at the factory in Ngabang district, because there are still several factories that have not been able to calculate the overall production data for 2015 and 2016.

Calculation of the potential for electrical energy derived from solid waste oil palm after conversion using formulas (1) and (2), then the total heating value of each palm oil waste is as shown in Figure 1.

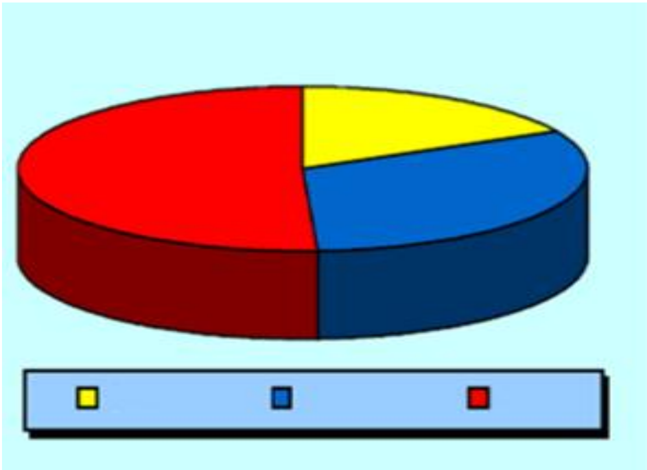

FIGURE 1: GRAPHIC OF CALORIFIC POTENTIAL (MCal) YEAR 2012-2017

B. EFB solid waste potential analysis based on the production of 5 (five) Palm Oil Mills

The production of solid waste from five palm oil mills in Indonesia in the form of shells and fiber has been used to heat boilers in CPO mills by burning them directly. While only a small amount of EFB serves as compost and most of it is stored in stock. The estimated untapped potential EFB waste energy is as calculated in formula (3), the results of which are shown as follows.

TABLE V. ENERGY POTENTIAL OF EFB WASTE HAS NOT BEEN USED

Year	TBS Total (ton)	EFB Total (ton)	Energy (Mwh)
2012	351,309.8	52,696	277,297
2013	373,997.2	56,100	298,075
2014	331,475.4	49,721	258,754
2015	417,830.8	62,675	325,424
2016	483,994.0	72,559	374,272
2017	189,603.5	28,441	146,579
Total	2,148,210.6	322,232	1,680,401

Source: Processed data

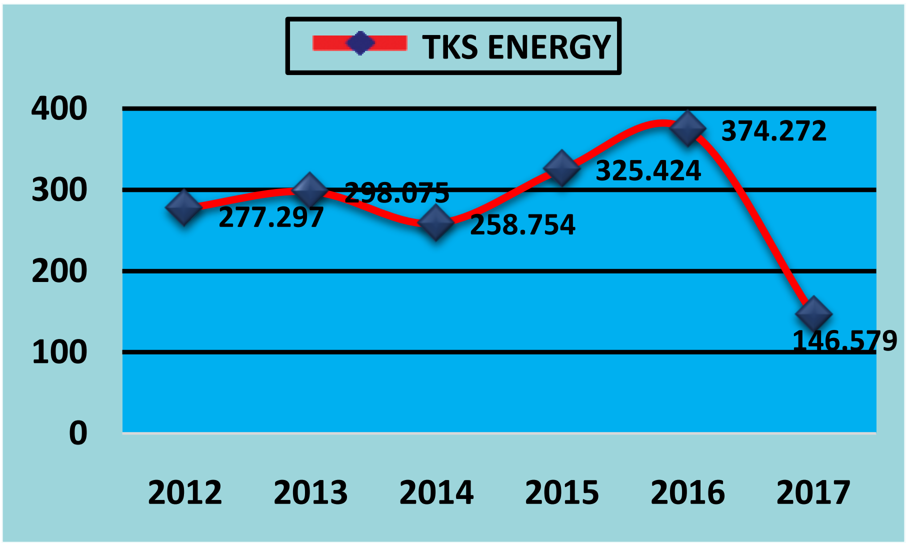

FIGURE 2: POTENTIAL ENERGY GRAPHIC EFB (MWh) YEAR 2012-2017

Production in 2016 decreased due to unavailability of data from PT Agro Nusa Investama and PT. Perkebunan Nusantara XIII State-Owned Palm Oil.

The potential energy EFB after gasification, with an efficiency of 60.86%, by multiplying the amount of energy before gasification by the gasification efficiency value will produce 1,024,517,852.9 MWh. If multiplied by the price of Rp. 1,438.2 per kWh, it will generate income of IDR 1.47 trillion.

C. EFB solid waste potential analysis with reference to the extent of the plant production area.

Landak District has oil palm producing areas in Kalimantan of 60,403.69 ha. Field observations resulted in the result that 1 (one) hectare of oil palm plantations averaged ± 2.7 tonnes of FFB / month. Based on these observations, and the average productive age of oil palm can be up to 20 years, the amount of FFB each year produced by the palm oil producing area (TM) is 1,522,157.11 tonnes of FFB / year. Solid waste generated by EFB is 228,324 tonnes per year. The above-mentioned amount of solid waste if converted will produce dry EFB energy as shown in TABLE VI below:

TABLE VI. ESTIMATION OF EFB POTENTIAL ENERGY FROM PLANT PRODUCING PER YEAR..

Area TM (Ha) Estimates Potential Area TM (Ha))	Area TM (Ha) Estimates Potential Calory(MCal) Es Area TM (Ha)	Area TM (Ha) Estimates Calory (Potential MCal) Estimates Energy Potential (MWh)
60,403.69	1.343.100,21	1.562.025,54

D. Analysis of the potential of solid waste based on the extent of immature plants

In the next few years, the immature plants will start producing so that it can increase the amount of energy potential from EFB solid waste. The estimation of potential electrical energy from the immature plantations (TBM) could be calculated as above. The result of the calculation shows that the immature plantations (TBM), occupying an area of 53,396.9 Ha, can produce an additional fresh fruit bunches (FFB) of 1,762,097.70 tons / year and EFB waste of 264,314.66 tons / year. The waste itself can generate energy potential as shown in Table VII below:

TABLE VII. ESTIMATED ENERGY POTENTIAL EFB PLANT IMMATURE (TBM) PER YEAR

Area TM (Ha)	*Estimasi Calory Potential (MCal)*	*Estimasi Calory Potential (MCal*
53,396.9	1.187.301,43	1.380.831,56

The total estimated potential waste of oil palm, when analyzed from the availability of mature plants (TM) and immature plants (TBM)) per year in all Landak District with a total area of 113,800.59 Ha, will produce an estimate of EFB energy potential as shown in Table VIII following:

TABLE VIII. ESTIMATED TOTAL ENERGY AND TKS INCOME PER YEAR.

Area TBM (Ha	*Estimated Calory Potential (MCal)*	*Estimated Energy Potential*
Area TBM (Ha	2.530.401,64	2.942.857,11

If the energy potential in TABLE VII is converted into Syngas, it will produce Syngas energy of 1,791,022.83 MWh. If calculated at a price of IDR 1,338.2 per kWh, it will generate a potential income of IDR 2.57 trillion per year.

E. Influencing Factors

Utilities EFB, as a byproduct of the CPO mill, as a renewable energy source still contains 60-70% moisture. Therefore, it is necessary to carry out a drying process before using it as a gasification raw material to obtain a higher calorific value.

The energy released during the gasification process will be affected by the efficiency of the gasifier used, because the efficiency will be related to the gasifier parameters.

When using gasified products as fuel for power generation, consideration needs to be made regarding the screening process to keep tar and ash content within established safety limits. Tar and ash that exceed regulatory limits are corrosive to metal-made materials, and can affect the operation of the nozzles and converters and cause charred combustion residue to remain in the engine.

V. CONCLUSIONS

The residual potential energy from EFB waste (TABLE V) can be used as excess power with an energy value of 1,024,517.85 MWh, and if calculated based on the selling price per kWh of Rp. 1,438.20, it will generate a total revenue of IDR 1.47 trillion. In the next few years, when immature plantations begin to produce fruit, estimates of the potential EFB palm oil waste, as a whole, from

The combined production area and immature plantations covering an area of 113,800.59 hectares (TABLE VIII), can produce Syngas energy potential of 1,791,022.83 MWh / year and an estimated income of IDR 2.57 trillion per year.

REFERENCES

[1]. Restuti, D. & Michaeliowa, A., 2007, potential economic potential of bagasse cogeneration as a CDM project in Indonesia ', Energy Policy, March 2007, pp. 3952-3966.

[2]. Yusoff, S., 2004, 'Renewable energy from palm oil - an innovation for effective waste utilization, Journal of Cleaner Production, vol.14, pp. 87-93.Billy Santoso. 2006. WCDMA Cellular Systems. Graha Science. Yogyakarta.

[3]. McKendry, P. 2002. Energy production from biomass (part 3): gasification technology. Bioresource Technology. Vol. 83: 55-63.

[4]. Hayashi, K 2007, Environmental Impact of the palm oil industry in Indonesia ', Proceedings of the International Symposium on Eco Topia Science 2007, EcoTopia Science Institute, Nagoya, Japan, p. 646-651

[5]. Mclellan, R 2000, 2.5 MWe biomass gasification power plant module design, ETSU B-T1-00569-REP, Wellman Process Enginering Limited.

[6]. Ramirez, J.J., Martinez, J.D and Petro, S.L., (2007), Basic Design of Fluidized Gasifier Bed for Rice Husk on a Pilot Scale, Latin American Applied Research, 37: 299-306 (2007).Lingga Wardana. 2011. 2G / 3G RF Planning and Optimization for Consultant. Nulisbuku.com. Jakarta

[7]. A.B. Nasrin and et.al, Oil Palm Biomass as Potentia Substitute Raw Material for Commercial Biomass Briquette Production, American Journal of Applied Science 583): 179-183, 2008