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ECONOMIC FEASIBILITY STUDY BIOGAS POWER PLANT AT 80 TON/HOUR PALM OIL MILL

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ABSTRACT:

This research discusses the potential of organic liquid waste to generate power for palm oil mill processing. Currently the waste is used as fertilizer in a palm oil plantation. The waste releases methane into the atmosphere causing a greenhouse effect that can endanger the environment. On the other hand, methane contains potential as an energy source for electricity generation. This paper discusses the economic potential of this organic liquid waste from 80 ton/hour palm oil mill as a renewable energy. The analysis was carried out quantitatively in the form of total energy analysis and economic feasibility analysis of biogas utilization. Overall, this project is feasible to be executed based on the raw material supply and the electricity demand. With total investment about Rp. 57,9 billion and operational cost 2,7 billion rupiah/year, the company can make profit of up to 11 billion rupiah/year from selling the electricity, saving diesel fuel and saving shell. Total savings through diesel is around 1 billion rupiah/year. While the total sales of shell is about 1,2 billion rupiah/year. The economic analysis result is IRR 24,51%, payback period 4,68 year, NPV 62.995 billion.

KEYWORDS: biogas, palm oil, organic liquid waste, greenhouse

INTRODUCTION:

Biogas is formed from the metabolic process of organic compounds by anaerobic bacteria. The biggest content of biogas is methane. The energy produced from burning biogas can be utilized for household, transportation and industrial fuels. Biogas can produce heat and electricity through a gas engine. All organic matter has the potential to produce biogas but not all have a significant beneficial economic value. One of the main attractions of biogas technology is its ability to produce biogas from cheap organic waste such as Palm Oil Effluent Mill (POME).

POME is a liquid waste from a palm oil processing mill. Typically, this waste is treated until it is within the safe limits for disposal into waterways or used as fertilizer. Although this method is economical, unfortunately a large amount of methane gas from organic decomposition that occurs is wasted into the atmosphere. Methane release from the POME treatment system accounts for up to 70% of total greenhouse gas emissions in Crude Palm Oil (CPO) production.

Methane content in biogas can be used in various implementations such as boiler fuel and electrical energy sources. Burned methane gas can help maintain boiler temperatures so as to save the use of shells and fibres. As a power plant, methane is fed to gas turbine which will be converted into electrical energy. In the end, electricity can be used for own needs or can be sold to PLN to generate additional income. (Rahayu Sri Ade, Dhiah Karsiwulan, Hari Yuwono, Ira Trisnawati, Shinta Mulyasari , S. Raharjo, Sutanto Hokermin, 2015).

Waste stabilization ponds for processing without biogas recovery seems less favourable than the application of anaerobic digestion. Moreover, the income generated in terms of electricity and gas for burner can help finance investments made in biogas plants (Mohammed et al., 2017). The economic viability of a biogas plant depends on the amount of methane produced, because it affects the performance of the co-generation system and the balance between costs and income (Baccioli et al., 2019). In order to be profitable, biogas plant needs to look for alternative income, for example, from utilization of solid waste (Gebrezgabher et al., 2010).

(Sudaryanti, 2017) show the financial feasibility of processing POME into biogas through 2 scenarios where on scenario 1 is the conversion of POME biogas to biopower as a replacement diesel, with the general scheme of generating negative NPV values, IRR of 5 percent. This scheme is only beneficial by adding carbon credits but this situation is difficult to prove. Then from the feasibility analysis based on the scenario 2 namely the conversion of POME into biopower as a substitute for diesel and sales electricity produces a positive NPV value, IRR of 17 percent. Although the results show a positive value but when compared with other investment interest, this value is still considered unprofitable. So, this research will discuss some savings and other income to show how economic potential regarding the use of palm oil waste into bioenergy.

LITERATURE REVIEW:

(Gebrezgabher et al., 2010) analysed the feasibility of a biogas plant by comparing 6 scenarios, including: Economic analysis is based on the concept of NPV and IRR to assess the cost effectiveness of biogas systems. (Mohammed et al., 2017) analysed that economic efficiency depends on investment costs, operating costs of biogas plants and optimal methane production. Profitability also lies in its use directly for burner or converted to electricity. Biogas used for burner is by far the most feasible option with a 5-year return period (PBP). Sensitivity analysis also reveals the cost of capital, factories and machinery as the most effective factors that have an impact on NPV and internal rate of return (IRR). (Nandiyanto et al., 2018) evaluated the feasibility study on the development of biogas in dairy farming. In short from the production process, biogas is produced by utilizing waste from the dairy farming industry (cow dung and cassava skin). In an economic evaluation, the results show that direct biogas conversion is not profitable. (Hakawati et al., 2017) show the efficiency of biogas that used as source of energy either directly or through various channels. Energy efficiency varies between 8% and 54% for power plants; 16% and 83% for heat; 18% and 90% for electricity and heat; and 4% and 18% for transportation. The direct use of biogas has the highest efficiency, but the use of this fuel is usually limited to locations close to anaerobic digestion facilities, limiting market availability and applications. (Kalinichenko & Havrysh, 2019) evaluate the future production and maturity of the generalized Weng model of biogas technology which has proven effective, because it has a minimum error. A simple algorithm for determining parameters has been proposed. Biogas and CHP boilers have the highest heat efficiency, but biogas (biomethane) has the highest potential to produce as a substitute for gasoline. The use of biogas increases by products (carbon

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dioxide) increases the profitability of biogas projects. (Lantz, 2012) conducted an economic feasibility evaluation of various technologies, also of different scales, for combined heat and power production from fertilizer-based biogas in Sweden. The overall conclusion is that the production is not profitable under current conditions. Thus, the gap between calculated biogas production costs and costs acceptable for breakeven must be bridged by, for example, different policy instruments. In general, scale efficiency prefers large-scale plants to those of individual agricultural scales. (Sudaryanti, 2017) found a picture of the potential amount of electricity that can be generated from POME that is converted into biopower; estimating economic value added from internalizing the costs of externalities that can be generated by the conversion of POME into biopower; estimating financial and economic viability through utilization scenarios with solar replacement schemes and electricity sales from biopower generated by the conversion of POME to bio-power and analyse the risks faced by the conversion of POME into biopower. (Tsydenova et al., 2019) estimate project profitability through a cost-benefit analysis (CBA) approach. The net present value of the project is positive, and the model produces a 7-year payback period. The obstacles identified for the feasibility of generating energy through MSW biogas in Mexico include the need for large investments, low profitability through electricity sales, and not being used to generate heat. An attractive panorama for clean energy in Mexico is not proven, even though the Energy Reform took place in 2013. However, environmental analysis also shows a positive environmental impact of 730 kg CO2 per 1 Mg MSW. Therefore, support incentives are needed to promote the use of other by-products of the anaerobic digester process, such as heat and digestion.

METHODOLOGY:

The method of research conducted refers to (Sudaryanti, 2017) with additional assumption data as show in table 1. An interview was done at a palm oil processing factory in Kalimantan to get the actual data of financial information and operational. Also supported by various sources such as text book, e-books, journal and articles and website (Hasanudin, 2018). The analysis was carried out quantitatively in the form of total energy analysis and economic feasibility analysis of biogas utilization.

Table 1. Assumption Data

	%Shell	%Fibre	Boiler Capacity	Gas Engine Capacity	Running Days	KWh Price	USD Exchange Rate	Discount Factor	Tax Rate	Solar Price (Rp/Ltr)	Shell Price (Rp/Kg)
ASSUMPTIONS	5.68%	12.5%	30 Bar	2880 KWh	313 Days	Rp. 805	Rp.14400	10%	25%	Rp. 9500	Rp.500

DISCUSSION / ANALYSIS:

The amount of electrical energy required by a palm oil processing mill during the process is 1755 kWh. At this time, electricity is fully supplied by the Steam Turbine Generator (STG) system. Even though methane is produced during anaerobic metabolic process, the use of STG during processing time cannot be replaced by the Gas Turbine Generator (GTG) system because the remaining steam produced by this system is also used as a heater in the sterilization process.

STG boiler fuel source comes from solid waste FFB such as fibres and shells with a presentation of 65% fibres : 35% shells. The use of new turbine can be replaced by gas engines during non-processing hours and holidays so the use of shells as boiler fuel can be reduced. Based on (Oti & Kinuthia, 2015) it is known that the shell can be utilized to be concrete so that it has a higher economic value when sold(Abas et al., 2013).

The number of shells needed to produce steam with a capacity of 30 bar is 4500 kg/hour. When biogas has been applied, the amount of shell used for the boiler can be reduced to 3957 kg/hour. Margin of shell usage would be sold to market and generate new income for the company.

Table 2. POME to Electricity Conversion

Mill Capacity	Pome Ratio	COD	Lagoon COD Removal	CH_4 Conversion1	CH_4 to Power	Engine Efficiency
TPH	%	kg/m^3	%	Nm^3/kg	kW/Nm^3	%
80	50	90	70	0,4	3,6	80
	40	3600	2520	1.008	3609	2887 kWh

Besides saving shells, the use of a gas engine when the turbine is not operating and holidays will also result in savings on diesel fuel. The amount of electricity that must be met by a diesel genset can reach 950 kWh/hour. The use of diesel fuel can be replaced by utilizing biogas from POME. Table 1 shows the potential of electrical energy from POME waste which is capable of being produced by 80 TPH achieves 2887 kWh. This power is greater than power demand for the mill and its facilities. Therefore, excess power can be sold to the government or other third parties reach 1800 kWh. This excess is considered to be most feasible supply which is expected to be able to fulfil surrounding neighbour needs.

Furthermore, to find out the economic potential of the conversion of POME into biogas, it is necessary to calculate the amount of Capital Expenditure (Capex). This calculation includes all equipment, installation, transmission and construction costs to build a biogas power plant.

CAPITAL EXPENDITURE:

Table 3. Capital Expenditure

Component CAPEX:	CAPEX
1. Gas Engine + Instrument + Installation	Rp 25.742.000.000
2. OHPL + Fibre Optic + Control Room	Rp 21.203.000.000
3. Indirect Cost + Contingency Cost + Feasibility Study	Rp 11.034.000.000
Total Capital Expenditure	**Rp 57.979.000.000**

From (Mohammed et al., 2017) the sensitivity of economic analysis is influenced by the capital expenditure. The largest investment cost comes from the purchase of 3 units of gas engines, each with a capacity of 1,2 MWh along with its instrumentation accessories up to 25 billion Rupiah. The second largest investment cost comes from Overhead Powerline (OHPL), where customer substations need to go as far as 15 Km to the power plant. Due to long distance, the cost of electrical transmission can reach 21 billion Rupiah. Meanwhile, the installation costs are targeted at 11 billion rupiah.

Operation Cost:

Table 4. Operational Expenditure

Component OPEX:	OPEX/year
1. Maintenance Gas Engine + Instrument	Rp 1.377.467.000
2. Depreciation	Rp 1.287.082.000
Total Operational Expenditure	**Rp 2.664.549.000**

Operational costs include the cost of repairing gas engines and other equipment such as instrumentation and electricity up to 1.3 billion rupiah/year. While the second operational cost is equipment depreciation due to usage can reach 1.2 billion rupiah/year. Accordingly, total operational costs reach 2.6 billion rupiah/year.

REVENUE:

Table 5. Revenue

Revenue and Savings :	Revenue/year
1. Power to Grid (Average 1.800 kWh)	Rp 15.513.422.000
2. Saving Diesel Fuels	Rp 976.452.000
3. Shell Saving	Rp 1.155.907.000
4. Saving Overhead Diesel Genset	Rp 145.000.000
Total Revenue and Savings	**Rp 17.790.782.000**

The source of income for this project comes from 4 sources. First, the income from selling excess electricity. With 1177 kWh excess power and government selling price 805 rupiah/kWh, company will get a profit of up to 15 billion rupiah/year. The second largest income comes from shell savings. If the diesel generator set is deactivated, the company can save on purchasing diesel fuel for diesel generator units reaching 1 billion rupiah/year. In addition, due to the non-operational diesel generator set, it also means a reduction of maintenance costs which can reach 150 million rupiah/year. Finally, shell savings due to non-operation of turbine during non-working hours or holidays can reach 1.2 billion rupiah/year.

Table 6. Net Income

Profit & Loss Per Year	Rp 15.126.233.000
Tax Per Year	Rp 3.781.558.000
Net Income Per Year	**Rp 11.344.675.000**

After knowing the cash flow of expenses and receipts in this project, the profit margins of this project can also be known. With revenue of 17.7 billion rupiah/year and expenditure of 2.6 billion/year, the company will benefit 15 billion/year. Then reduced by corporate taxes, the net profit from this project is worth 11.3 billion/year.

Table 7. Financial Indicator Summary

IRR	**24,51%**	
Payback period	**4,68**	**year**
NPV	**Rp 62.995.000.000**	

When compared to the initial investment with cash flow per year, the project is expected to break even in the 5th year. With an IRR of 24.51%, this project is considered quite promising because other investment instruments only offer around 7.11% (10-year BI bank deposits). The NPV values reaching 62 billion rupiah indicates that this project is very profitable in the future.

CONCLUSION:

Overall, this project is feasible to be executed based on the raw material supply and the electricity demand. With total investment about Rp. 57,9 billion and operational cost 2,7 billion rupiah/year, the company can make profit of up to 11 billion rupiah/year from selling the electricity, saving diesel fuel and saving shell. Total savings through diesel is around 1 billion rupiah/year. While the total sales of shells are about 1,2 billion rupiah/year. The economic analysis result is IRR 24,51%, payback period 4,68 year, NPV 62.995 billion.

For further research, it is necessary to examine the price sensitivity and other factors that influence the economic value in the project such as the electricity price policy offered by the government, shell price fluctuations according to market prices and diesel fuel price controls. These three things can affect the company's revenue so that it changes investment indicators such as IRR, NPV and Payback Period.

LIMITATION AND STUDY FORWARD:

This study is limited to several conditions, such as:

1. This study does not consider changing government policies
2. Some facilities is already exist are not included in expenditure

3. Scope of study is a 10-year frame under several financial assumptions
4. Projection of feedstock under normal circumstances without force majeure happened.

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