Jejak Vol 16 (2) (2023): 343-352 DOI: https://doi.org/10.15294/jejak.v16i2.43208

JEJAK

Journal of Economics and Policy

http://journal.unnes.ac.id/nju/index.php/jejak

Strategy of Palm-Based Biogas Power Plant Development (Review The Needs and Financing Scheme)

Okta Malinda[1]✉, Lely Marce Margareta[2], Ahmad Yani[3], Natasya Iasa Thintia[4], Ashari[5], Ni Wayan Ernawati[6], Niara Orcha Thistania[7], Ali Akbar Putra Alam[8]

[1]Faculty of Economics and Business, Palangka Raya University, Central Kalimantan
[2,4]Faculty of Economics, Megou Pak Tulang Bawang University, Menggala Lampung
[3]Faculty of Engineering, IIB Darmajaya, Lampung
[5,6]Faculty of Mathematics and Sciences, Megou Pak Tulang Bawang University, Menggala Lampung
[7,8]Faculty of Law, Megou Pak Tulang Bawang University, Menggala Lampung

Permalink/DOI: https://doi.org/10.15294/jejak.v16i2.43208

Received: May 2023; Accepted: July 2023; Published: September 2023

Abstract

The purpose of this study is to provide a strategy for the development of palm based biogas power plant (BPP) seen from the analysis of needs and financing schemes. From the research, it is known the dangers of POME waste to human health and the environment, the benefits of POME as a renewable energy source, the large cost of developing BPP, and the benefits that can be obtained if POME is used as fuel for BPP. In addition, it is also known that there are changes in regulations that reduce the interest of palm oil factory (POF) and investors to develop BPP. From the SWOT analysis conducted, the following strategies are given. The government set a policy that each POF has one BPP or cooperates with other POF to build BPP, reallocated fuel subsidy funds to the development of BPP, and abolished the Minister of Energy and Mineral Resources No. 12/2017 and re-enact the Minister of Energy and Mineral Resources No. 27/2014 in order to increase the interest of POF and investors to build BPP, involve an independent third party as a project supervisor and provide sanctions for project termination if it is identified that the construction qualifications of the materials used are not in accordance with the required standards.

Key words : Strategy, BPP Development, Needs, Financing, Palm Waste

How to Cite: Malinda, O., et al. (2023). Strategy of Palm-Based Biogas Power Plant Development (Review The Needs and Financing Scheme*). JEJAK: Jurnal Ekonomi dan Kebijakan, 16*(2). doi:https://doi.org/10.15294/jejak.v16i2.43208

✉ Corresponding author : Okta Malinda
Address: Jln. Yos Sudarso Palangka Raya 73111,
Central Kalimantan, Indonesia
E-mail: oktamalinda1986@gmail.com

p-ISSN 1979-715X
e-ISSN 2460-5123

INTRODUCTION

Changes in the world climate caused by carbon emissions due to the use of fossil fuels have led countries around the world to declare net-zero emissions for carbon gas. Net-zero emission (NZE) or zero carbon emissions is a situation where the amount of carbon released into the atmosphere does not exceed what the earth absorbs. To achieve this, a transition from the current energy system to a cleaner energy system is needed to achieve a balance between human activities and natural balance (Zahira & Fadillah, 2022). Many countries have committed to achieving net-zero emissions of carbon gases,

including Korea, Japan, and the European Union in 2050, and China in 2060 (IEA, 2021). Indonesia itself has committed to reducing greenhouse gas emissions by 29% from "business as usual" levels in 2030 (Electricity Supp-ly Business Plan State Electricity Company Year 2016 to 2025).

One way to achieve NZE is the energy transition. Energy transition is an effort to divert energy sources from fossil-based energy to alternative carbon-free energy sources (Chryshna, 2022). This awareness arises because carbon gas causes a greenhouse effect which causes sunlight that should be reflected on the earth's surface to be trapped by greenhouse gases in the atmosphere. As a result, there is an increase in temperature on the earth's surface which causes global warming (Aswad & Hendriyanto, 2018).

Many countries have committed to achieving net-zero emissions of carbon gases, including Korea, Japan and the European Union in 2050, and China in 2060 (IEA, 2021). Indonesia itself has committed to reducing greenhouse gas emissions by 29% from "business as usual" levels in 2030 (Electricity Supply Business Plan State Electricity Company Year 2016 to 2025).

In the energy sector, NZE can be achieved through the transition from fossil fuel-based energy to electrical energy. Electrical energy is an alternative to fossil energy sources because it is free of carbon emissions. However, if electricity production still uses fossil fuels, such as Diesel Power Plants (DPP), then the production process will still produce carbon emissions. For this reason, it is necessary to develop power plants that can meet electricity needs while reducing carbon emissions. One of them is through the development of a POME (Palm Oil Mill Effluent) based biogas power plant (BPP).

POME is the liquid waste that comes from processing palm oil fresh fruit bunches (FFB) (Muhadi, 2013). Waste produced by POM (palm oil mills) is in solid, gas, and liquid form. Palm oil solid waste consists of empty fruit bunches, shells, and husks (Haryanti, et al., 2014). Among all palm oil waste, the most dangerous is POME waste because it produces methane gas which causes a greenhouse effect and can cause death if inhaled by humans (Anonymous, 2014).

Methane is a greenhouse gas (GHG) that causes global warming with 21 times greater power than CO_2 gas (Firdausi, 2020). High levels of methane can reduce oxygen levels in the earth's atmosphere by up to 19.5% and also cause fires and explosions when mixed with air. In humans, methane causes acute respiratory infections (ARI) which can cause death (Andhika, Lanti, & Setyono, 2015).

The methane produced by POME can be used as fuel for BPP. When methane is used for electricity generation it reduces greenhouse gas emissions. Thus, POME-based BPP will increase domestic clean energy production and help shift the energy transition to carbon-free renewable energy sources towards net zero emissions (NZE).

Along with efforts to develop POME-based carbon-free renewable energy, the government is faced with the reality of the high financing required for it. The right strategy is needed based on a comprehensive analysis of the strengths, weaknesses, opportunities, and challenges related to the development of POME-based BPP. For this reason, a strategy analysis was carried out using a SWOT analysis.

SWOT analysis is a fundamental tool for organizations to analyze the internal and external environment of the organization during times of uncertainty (Rozmi, Nordin, & Bakar, 2018; Rajani & Calak, 2021). SWOT analysis is a simple yet powerful management tool for measuring the capabilities and weaknesses of an organization's resources, opportunities, and threats to its future (Islam et al. 2020).

Strengths are the internal aspects of the organization that support the achievement of its goals, while weaknesses are the internal aspects

that hinder the success of the organization. Opportunity is an external aspect that helps an organization achieve its goals. Threats are external aspects that prevent an organization from achieving its goals (Benzaghta, Elwalda, & Mousa, 2021). According to David et al. (as cited in Benzaghta, Elwalda, & Mousa, 2021), internal aspects refer to features that are under the control of the business, while external aspects are factors that are outside the control of the business.

SWOT analysis basically talks about the organization's strategic choices related to the vision, mission, objectives, and internal and external analysis of the organization. It all boils down to how to gain a competitive advantage for the organization. After conducting the analysis, the next step is implementing the strategy. Strategy implementation is important for organizations to gain competitive advantage (Nogueira et al., 2021).

According to Obi et al (2019) the SWOT analysis produces a SWOT Matrix or TOWS Matrix as follows: (1) SO strategy, which is a strategy to take advantage of opportunities, (2) ST strategy, which is a strategy to avoid threats, (3) WO strategy, which is a strategy take advantage of new opportunities by reducing weaknesses and (4) WT strategy, namely a strategy to avoid threats by minimizing existing weaknesses. The matrix can be described as follows.

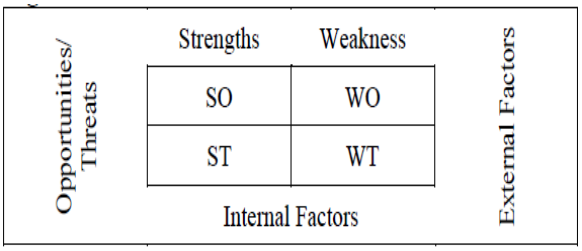

Figure 1. SWOT/TOWS Matrix
Source: Benzaghta, Elwalda & Mousa (2021)

METHOD

This research is descriptive-analytical which is also called qualitative research (Sugiyono, 2016) where in qualitative research social reality is seen as something holistic/ whole, complex, dynamic, and full of meaning. Such a paradigm is called the postpositivism paradigm. According to Soekanto (2007) research with descriptive analysis, namely the research carried out aims to create an objective picture of a situation in a situation. This qualitative research method is often also called the naturalistic research method because the research is carried out in natural conditions (natural settings) where the researcher is the key instrument (Sugiyono, 2013). The opposite of qualitative research is experimental research. Data collection techniques were carried out by triangulation (combined), data analysis is inductive and uses literature study. The results of qualitative research emphasize meaning rather than generalizations.

RESULTS AND DISCUSSION

Utilizing POME as a source of electrical energy has several advantages. First, overcoming the negative impact of POME on the environment, because after the methane gas produced is used for BPP, its content is no longer dangerous. Second, the supply of POME will always be there as long as the palm oil industry exists. Thus, the POME-based BPP project is a source of renewable energy (sustainable energy) that can create electricity independence without sacrificing the rights of future generations as well as a solution to overcome the impact of hazardous waste.

Third, POME-based BPP is very appropriate because Indonesia is the largest palm oil-producing country in the world (Regar & Harjanto, 2022). Based on data from the Director General of Plantations in September 2015, it is known that the total area of oil palm plantations in Indonesia reached 6,290,731.85 hectares owned by 1,181 oil palm plantation companies. Total palm oil production is 11.7 million tons/year or 30,831.81 tons/hour. To process palm oil plantation products, there are 702 palm oil mills (POM) spread across 18 provinces in Indonesia (Firdausi, 2020).

Fourth, the development of POME-based BPP is in line with efforts to accelerate the energy transition towards net-zero emissions for carbon gas because this system produces large amounts of energy that is environmentally friendly, sustainable, and low carbon.

The electrical energy produced from using POME for BPP also has many advantages, namely that it can be used for various purposes. Utilization can be carried out by the POM itself by directly using it for combustion in boilers or using it as fuel for generating electricity generators to supply the factory's electricity needs (Wijono, 2017).

Electricity produced from BPP can also be used as a source of electricity for other parties outside the factory by installing supporting installations so that electricity can be distributed to residential areas around the POM, even across regions/ provinces. This could be one solution to electricity shortages outside Java. The potential electrical energy from palm biogas, namely 72 MWh/ day, can be distributed to more than 3,500 homes. This is based on estimates of residential electrical energy consumption which is around 20 kWh/ day.

The distribution of POM in Indonesia is mostly located on the islands of Sumatra and Kalimantan. Based on electricity statistics data (2019), the electrification ratio of the two islands has not yet reached 100%. Riau (98.34%) and South Sumatra (98.30%), for example, have the smallest electrification ratio among other provinces in Sumatra. Meanwhile in Kalimantan, the lowest electrification ratio is in Central Kalimantan (94.60%) and West Kalimantan (97.96%). This problem can be overcome by distributing electricity from palm oil biogas to areas that do not yet receive electricity from PLN. Apart from that, POM also has the potential to earn additional income because it has helped PLN provide electricity.

Biogas produced by POME management can be used as a substitute for LPG gas or firewood as fuel for cooking. Biogas is an odorless and colorless gas that burns with a blue color similar to liquefied petroleum gas (LPG) so it can be used for cooking (Wijono, 2017). Some areas are still found using wood as fuel for cooking. As we use it every day, wood fuel can run out. This is different from biogas produced from POME, which can always be produced as long as there is still palm oil production (Indonesian Coaction, 2021).

The biogas produced by POME can also be used as fuel for motor vehicles, called gas fuel (BBG). This fuel is cleaner compared to oil fuel because its exhaust emissions are environmentally friendly (Ibrahim, Darianto, & Cahya, 2018). Apart from being fuel for cooking and motor vehicle fuel, biogas from POME can also be used as a water heater, air heater, and dryer (Pasaribu & Kusdiyantini, 2021).

The party building the BPP can be anyone, but the best is the palm oil mill itself because they always produce POME so that POME supplies can always be maintained. Apart from that, POM itself requires quite a lot of electricity to carry out its production process. This electricity need can be met by the BPP which they established. Once their needs are met, POM can sell the electrical power they produce to PLN. This is made possible by the existence of an electricity buying and selling policy between BPP and PLN called a power purchase agreement/PPA. Even though POMs can gain many benefits if they have BPP, the reality shows that not all POMs have it. This is because the costs required to build BPP are very large. This requires appropriate policies and strategies from the government. The following SWOT analysis is provided to overcome this.

Table 1. SWOT Matrix for BPP Development in Indonesia

	Strength	**Weakness**
SWOT MATRIX	1. Indonesia is a palm oil producer the world's largest so it fits perfectly to develop BPP 2. Cost of production per kWh of electricity use BPP relatively cheaper compared to fossil fuel 3. Electrical power generated by BPP big enough to increase the electrification ratio	1. The cost of building a BPP is relatively high while palm oil mills has the limited finance 2. The removal Permen of ESDM No. 27/ 2014 regarding the Purchase of Electricity from Biomass and Biogas Power Plant and the enactment of the Permen of ESDMNo. 12/2017 concerning Utilization of Energy Sources Renewable Energy Supply Electricity
Opportunitiy	Strength - Opportunity (S - O)	Weaknesses - Opportunities (W - O)
1. BPP is suitable for a transition program energy. 2. Use of methane as fuel BPP will reduce the impact hich is harmful to the environment and humans	1. The government sets policies that each palm oil factory has one BPP or cooperate with other palm oil factory to build BPP 2. Requiring State Electricity Company to provide technical assistance needed in building BPP. 3. Requiring State Electricity Company to buy electricity generated by BPP in accordance with applicable regulations	1. Reallocating fuel subsidy funds to BPP development 2. Palm oil factory cooperates with banks to get development financing BPP 3. Making policies easier BPP investment by private parties that are not farm oil factories 4. Removing the Permen of ESDM No. 12/2017 and reinstated Permen of ESDM No. 27/2014
Threats	Strengths - Threats (S - T)	Weaknesses - Threats (W - T)
1. Gas reactors can explode due to the nature of the gas methane is explosive 2. There is a risk of leaking gas pipelines	1. Imposing certain specifications in order the reactor did not explode 2. Implement a processing system and strong quality pipe material for anticipate gas leaks	1. Involving third parties independent as project supervisor to ensure fulfillment of technical aspects needed 2. Project termination sanction when identified qualifications construction materials used are not according to the required standard

From the SWOT analysis, it is known the strengths, weaknesses, opportunities, and threats faced in BPP development as presented in the SWOT Matrix above. Based on the SWOT analysis, a strategy can be made by the government. The SO strategy is used to take advantage of opportunities by using the strengths they have. The ST strategy is used to reduce threats by using force. WO strategy is used to take advantage of new opportunities by reducing weaknesses. WT's strategy to avoid threats by minimizing existing weaknesses.

S–O Strategy (Strength–Opportunity), Indonesia has the main strength to become a BPP developer in the form of being the largest palm oil producing country in the world. This makes the raw material for BPP in the form of POME to be fulfilled easily in Indonesia. POME is usually discharged into the environment after obtaining dilution so as not to harm the environment. Because POME is usually just thrown away, many palm oil companies are willing to give away their

POME for free. Even if the company asks for payment, it is only for the cost of transporting the POME from the company to the BPP location. This causes the cost of electricity production per kWh to be relatively cheaper compared to using fossil fuels.

This has been investigated by Butar-Butar, Amin, & Kasim (2013) who examined the feasibility of building BPP at palm oil mills Tandun, Riau owned by PT Perkebunan Nusantara V. At the beginning of the analysis, an analysis was carried out on the adequacy of POME raw materials to be processed into power plants. The cost analysis shows that the cost of producing electricity using biogas is IDR 250/ kWh. This cost is much cheaper than a power plant using fuel oil which reaches IDR 2,500/ kWh.

In line with this, Irwansyah, Danial, and Hiendro (2018) also examined the costs required to produce electricity per kWh from POME waste at PT Fajar Saudara Kusuma's, which is located in Sambas Regency, West Kalimantan. From the analysis carried out, it is known that if all the POME produced is used as fuel for BPP, it can generate electric power of 4,596.187 MW in 2016 and 4,703.86 MW in 2017 with a production cost of IDR 661.00/kWh.

Erhaneli and Hidayat (2019) examined the use of POME as BPP fuel by PT KSI. The company's production capacity is 45 tons/ hour, the potential flow of liquid waste is 492.25 m3/day. From the calculations, it is known that the electricity that can be generated is 1.2 MW with a production cost of IDR 498.231/ kWh.

Another advantage of BPP is that the electricity generated is quite large. This is as researched by Firdausi (2020) who examined the potential for BPP in West Tanjung Jabung Regency, Jambi Province. The results showed that with a biogas digester capacity of 15,000 m3, a generating capacity of 4.5 MW, and a potential electricity production of 42,336.00 kWh/ year were produced.

In addition to having strengths, Indonesia also has opportunities related to BPP, namely BPP is suitable for the energy transition program because it produces low-carbon energy, and the use of methane as fuel for BPP will reduce its harmful impact on the environment and humans. From the analysis of the strengths and opportunities owned by BPP, the SO strategy is given as follows: a) The government stipulates a policy that each POM has one BPP or cooperates with other palm oil mills to build BPP; b) Requiring State Electricity Company to provide the technical assistance needed by palm oil mills in building BPP; c) Requiring State Electricity Company to purchase electricity generated by BPP in accordance with applicable regulations.

W–O Strategy (Weakness-Opportunity), This strategy is taken when there are opportunities that can be exploited, but there are also weaknesses that get in the way. For this reason, opportunities are still being utilized as optimally as possible to reduce the weaknesses they have. The weakness of the BPP project is that it requires a relatively large development cost, while palm oil mills have limited capacity. This is as researched by Raksodewanto and Abrora (2017) who stated that the cost of building BPP is very high, which is around USD 2.6 million per MW. This investment cost really depends on the location where the BPP is built, which is adjusted for the Construction Expensive Index (CEI). The unavoidable fact is that the CEI in the eastern part of Indonesia is greater than in the western part, so the purchase price of electricity for BPP in the eastern region will be more expensive than in the western region. However, the investment costs needed to build BPP in the Eastern region are also much higher, so not many palm oil mills in the Eastern region can afford to build BPP.

In addition to the high cost of BPP development, there are also weaknesses in the form of regulations, namely the abolition of the Minister of Energy and Mineral Resources No. 27/2014 co-

ncerning the Purchase of Electricity from Biomass Power Plants and the enactment of the Minister of Energy and Mineral Resources No. 12/2017 concerning Utilization of Renewable Energy Sources for the Provision of Electricity. According to Febijanto (2018), the impact of changing this regulation is that the selling price of electricity changes based on the basic production cost and is no longer based on the feed-in tariff which was previously regulated by Permen ESDM No. 27/2014 by State Electricity Company. For example, with this new regulation, the selling price of electricity, which was originally IDR 1,312.5/ kWh for medium voltage in the Sumatra region, changed to IDR 1,146.7/kWh (= 85% x IDR 1,349/kWh). This economic downturn has had a broad impact on decreasing the interest of palm oil mills and developers to build BPP.

The expensive costs of managing POME to become biogas are not only contributed by installation costs but also contributed by pretreatment costs. Pretreatment is an effort to increase the digestability of the substrate, in order to increase the reaction rate in anaerobic digestion which will ultimately increase biogas production. The pretreatment process can act as a catalyst that speeds up the reaction process (Wiharja, et al., 2021). The main obstacle to the pretreatment process is the large operating costs that must be provided, starting from the cooling process which requires energy or the addition of chemicals. Wiharja et al. (2021) found a way to manage POME without pretreatment by using a fixed bed technique combined with thermophilic operating conditions. This method has succeeded in reducing the operational costs of managing POME but has not succeeded in reducing the very large costs of installing BPP.

Facing this reality, a WO strategy was given, namely: a) Reallocating fuel subsidy funds to BPP development; b) palm oil mills cooperate with banks to obtain funding for BPP development; c) Making policies that facilitate BPP investment by non-palm oil mills private parties; and d) Removing the Minister of Energy and Mineral Resources No. 12/2017 and reinstating the Minister of Energy and Mineral Resources No. 27/2014.

S–T Strategy (Strengths–Threats), This strategy is taken when there are strengths, but there are also threats that can derail the project. The threat faced in the BPP project is that the gas reactor can explode due to the explosive nature of methane gas. It is known that the nature of methane gas is flammable if it meets free air. In fact, if it has been collected in the reactor, then the gas pressure becomes very high so it will be very dangerous if it explodes. There is also a threat of leaking pipes causing methane gas to be inhaled by humans and causing death. Where as on the other hand, there are strengths that methane gas has, which can be a cheap source of electrical energy.

Facing such a threat, the strategies adopted are as follows: a) Imposing certain specifications so that the reactor does not explode; b) Implementing a strong workmanship system and pipe material quality to anticipate gas leaks.

W–T Strategy (Weaknesses–Threats), This condition is the weakest condition of the organization, namely when there is a threat when the organization has weaknesses. In general, the threat faced is the explosive character of methane gas, while the weakness is that the cost of constructing a BPP is relatively high, and palm oil mills have limited capabilities.

Facing this situation, WT's strategy was given as follows: a) Involving an independent third party as a project supervisor to help ensure the fulfillment of the technical aspects required, and b) Imposing sanctions on project termination if it is identified that the construction qualifications of the materials used are not in accordance with the required standards.

CONCLUSION

From the community side, the BPP project is needed to produce renewable electrical ener-

gy and can increase the electrification ratio in the community. From the company's point of view, the electricity produced by BPP is needed to support the company's operations and the remaining electric power can be sold to the State Electricity Company through a power purchase agreement so as to provide economic benefits to the company. From an environmental point of view, the BPP project is needed to reduce the hazard of POME waste because the use of POME as a source of electrical energy can reduce the value of waste hazard parameters such as BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand) and methane gas (CH_4) emission values with an average percentage an average of 92%. This value is very safe for the health of the environment and humans.

From the SWOT analysis of BPP project development, in general, it is known that BPP's strengths include being able to generate electricity at a relatively low cost but facing considerable construction cost constraints. Facing this reality, strategies are given that can be implemented. In terms of government policy: The government has established a policy that each palm oil mill has one BPP or cooperates with other PKS to build BPP, reallocated fuel subsidy funds to BPP development, and abolished ESDM Regulation No. 12/2017 and reinstating the Minister of Energy and Mineral Resources No. 27/2014 to increase the interest of palm oil mills and investors to build BPP.

In terms of obtaining large funds to carry out BPP construction: palm oil mills cooperate with banks to obtain funding for PLTB construction and the government makes policies that facilitate BPP investment by non-PKS private parties. In terms of project safety implementation: Involve an independent third party as a project supervisor to help ensure the fulfillment of the technical aspects required and to impose sanctions on project termination if it is identified that the construction qualifications of the materials used are not in accordance with the required standards.

REFERENCES

Andhika A. R. R., Lanti Y. R. D., & Setyono, P. (2015). The Effect of Exposure to Methane Gas (CH_4), Carbon Dioxide (CO_2) and Hydrogen Sulfide (H_2S) on Complaints of Breathing Disorders of Scavengers in the Final Disposal Site (TPA) of Klotok Waste, Kediri City. *Ekosains Journal, 7*(2)

Aswad, G., & Hendriyanto, O. (2018). Greenhouse Gas Potential (GHG) From Public Transportation Activities at Tamanan Terminal Kediri City. *Envirotek Journal, 10*(1) 46-52.

Benzaghta, M. A., Elwalda, A., Mousa, M. M. (2021). SWOT Analysis Applications: An Integrative Literature Review. *Journal of Global Business Insights, 6*, 55-73. Doi: 10. 5038/2640-6489.6.1.1148.

Butar-Butar, D. P., Amin, M. N., & Kasim, S. T. (2013). Analysis of Electricity Production Costs Per kWh Using Palm Oil Liquid Waste Biogas (Application on BPPS POF Tandun). *Singuda Ensikom Journal, 3*(1). 17-22.

Chryshna, M. (2022). Indonesia's Energy Transition: Challenges and Opportunities. Accessed from https://kompaspedia.kompas.id/baca/paparan-topic/net-zero-emission-nze-dan-tantangan-transisi-energi-indonesiaon November 1, 2022.

Erhaneli & Hidayat, A. (2019). Analysis of a Biogas Power Plant (BPP) using Palm Oil Mill Effluent. National Seminar on the Role of Science and Technology Towards Future Industries (PIMIMD-5) Padang Institute of Technology (ITP), Padang 10 October 2019. 208-214.

Febijanto, I. (2018). Optimizing the Utilization of Methane Gas as an Energy Source in Palm Oil Mills as Anticipation of Elect-

ricity Selling Prices Based on the Cost of Generating Provision (BPP). *Journal of Environmental Technology, 19*(1). 49-60.

Firdausi, M. (2020). Potential of POME for Biogas Power Plant in Tanjung Jabung Barat Regency. *PRECISION Journal. 22*(1). 48-53.

Haryanti, A., Norsamsi., Sholiha, P. S. F., & Putri, N. P. (2014). Study of Palm Oil Solid Waste Utilization. *Conversion Journal, 3*(2). 20-29.

Ibrahim, H., Darianto, & Cahya, D. D. (2018). Performance of a Power Generation System Using Liquid Waste Biogas in a Palm Oil Factory, *JMEMME (Journal of Mechanical Engineering, Manufactures, Materials And Energy). 2*(2). 78-85.

Indonesian Coaction. (2021). Using Biogas from Palm Oil Mill Liquid Waste as a Regional Electricity Supplier, Is It Possible?. Accessed from https://coaction.id/pecepatan-biogas-dari-limbah-cair-pabrik-kelapa-sawit-as-pemasok-listrik-region-maykah/ on September 19 2023.

International Energy Agency (IEA). (2021). World Energy Outlook 2020. Retrieved from International Energy Agency (IEA). Accessed from https://www.iea.orgon November 2, 2022.

Irwansyah, W. Y., Danial, & Hiendro, A. (2018). Potential for Utilization of Palm Oil Mill Effluent (POME) as Raw Material for Biogas Power Generation (BPP) in POF PT Fajar Saudara Kusuma. *Journal of Electrical Engineering, Tanjungpura University, Pontianak.* 1-8.

Islam, M. M., Akter, L., Pervez, AKMK, Nabi. M N., Uddin, M M., & Arifin, Z. (2020). Application of combined SWOT and AHP for strategy development: Evidence from pottery industry of Bangladesh. *Asian Journal of Agriculture and Rural Development, 10*, 81-94.

Muhadi, A. (2013). Study of Utilization of Palm Oil Liquid Waste in Land Application System in Oil Palm Plantation at PT Tritunggal Sentra Buana, Kutai Kartanegara, East Kalimantan. Final Project (Unpublished). Pangkajene State Agricultural Polytechnic and Pangkep Islands: Diploma IV Agroindustry Study Program.

Naibaho, P. M. (2018). *Palm Oil Processing Technology*. Medan: Palm Oil Research Center.

Nogueira, E. L, Nascimento, M. H. R., Alencar, D. B., Nascimento, M. R., Júnior, JRLP, & Silva, A. L. F. (2021). SWOT Analysis Implemented with Fuzzy Inference to Support Decision Making. *International Journal for Innovation Education and Research, 9*, 712-734.

Obi, N. E., Emoh, F. I., Egolum, C. C., & Ewurum, N. I. (2019). Foreign Direct Investment in Nigeria's Commercial Real Estate Market: A SWOT Analysis. *IOSR Journal of Business and Management (IOSR-JBM), 21*, 46-56.

Minister of Energy and Mineral Resources Regulation Number 12 of 2017 concerning Utilization of Renewable Energy Sources for the Provision of Electricity.

Minister of Energy and Mineral Resources Regulation Number 27 of 2014 concerning Purchase of Electricity from Biomass and Biogas Power Plants.

Center for Research and Development of Water Resources. (2014). Model of Greenhouse Gas Emission Reduction System from Reservoir and Peat Swamp. Jakarta: Ministry of Public Works.

Pasaribu, D. & Kusdiyantini, E. (2021). Independent Energy by Utilizing Liquid Waste in the Palm Oil Factory Industry. *Journal of New & Renewable Energy, 2*(3). 163-169.

Rajani, F. R., & Chalak, A. (2021). A SWOT Analysis of Instagram English Teaching Pages. *Journal of Foreign Language Teaching and Translation Studies, 6*, 25-43.

Raksodewanto, A. A., & Abrori, M. (2017). Mapping of Areas that are Eligible for Investment in POME Biogas Power Plants. *National Seminar on Science and Technology, Faculty of Engineering, University of Muhammadiyah Jakarta,* 1-2 November 2017. 1-6.

Regar, R. F., & Harjanto. (2022). 7 Largest Palm Oil Producing Countries in the World, accessed from https://bisnis.tempo.co/read/1613419/7-the-biggest-world-wide-country-producing-palm oilaccessed on 7 September 2022.

Electricity Supply Business Plan (RUPTL) of PT Perusahaan Listrik Negara (Persero) from 2016 to 2025.

Rozmi, A. N. A., Nordin, A., & Bakar, MIA (2018). The Perception of ICT Adoption in Small Medium Enterprise: A SWOT Analysis. *International Journal of Innovation Business Strategy, 19*, 69-79.

Sarono, Sa'id, E., Suprihatin, & Hasanudin, U. (2014). Implementation Strategy for Utilizing Palm Oil Mill Liquid Waste into Electrical Energy (Case Study in Lampung Province). *Journal of Agricultural Industrial Technology, 24*(1), 11-19.

Soekanto, S. (2007). *Introduction to Legal Research.* Jakarta: UI Press

Sugiyono. (2013). *Qualitative Quantitative Research Methods and R & D*. Bandung: Alfabeta.

Wiharja, Winanti, W. S., Prasetiyadi, & Sitowarni, A. I. (2021). Biogas Production from Liquid Palm Oil Waste Using a Fixed Bed Reactor without a Biogas Pretreatment Process. *Journal of Environmental Technology, 22*(1). 78-84.

Wijono, A. (2017). The Impact of Reducing Greenhouse Gas Emissions on the Utilization of POME for Power Generation, 2017 National Seminar on Science and Technology, Faculty of Engineering, Muhammadiyah University, Jakarta, 1-2 November 2017. Accessed from https://www.jurnal.umj.ac .id on September 18 2023.

Zahira, N. P., & Fadillah, D. P. (2022). Indonesian Government Towards Net Zero Emission (NZE) Target in 2060 with Variable Renewable Energy (VRE) in Indonesia. *JIS (Journal of Social Sciences), 2*(2). 114-119.