Analysis of Utilization of Palm Oil-Based Circular Bioeconomy in Supporting the Acceleration of East Kalimantan's Energy Transition

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Abstract. This study researches the utilization of the waste generated from the palm oil agro-industry in Indonesia based on the implementation of two concepts, i.e., bioenergy systems and circular bioeconomy. This study aims to develop a strategy to accelerate the energy transition from fossil to renewable energy using bioenergy. At the same time, the methods applied are secondary data analysis, literature review, and discussion with several experts in the field. The results of the study indicate that the potential of the palm oil agro-industry can become a new supporting element for the enhancement of the economy by utilizing palm oil waste as a renewable energy source to support the energy transition, even as a contributor toward the national foreign exchange through bioenergy products export. The strategy to implement and realize the potential should be persistently conducted following the regional regulations and policies. In conclusion, regional strengthening through energy supply and accumulation of the local potential, as well as technology conversion need to be continuously carried out to encourage achieving the target.

Keywords: palm oil waste, biomass, regional development, renewable energy

1 First Section

1.1 Background

Refer (Kahar et al., 2022), With 20 million hectares of palm coconut plantations, Malaysia and Indonesia are the world’s largest producers and exporters of raw palm oil declared at the Palm Oil Top Global Producers 2020/2021. The domestic component of palm coconut is up to 87% which causes the palm coke products in Indonesia to have strong competitiveness, as it dominates the supply chain from raw materials to the final product, which is not owned by other agricultural commodities. (Pusat Sosial Ekonomi dan Kebijakan Pertanian, 2017).

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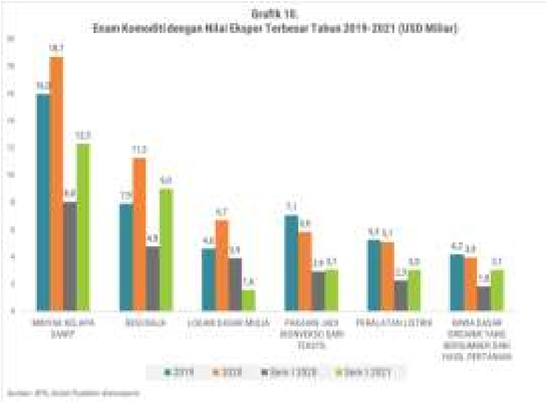

Fig. 1. Six commodities with the highest export value in 2019-2021 (USD Miliar) Source: BPS, Pusdatin Kemenperin

From the Kemenperin data of six commodities with the largest export value in 2019 – 2021, Palm oil is the largest contributor to the export value. In 2019, palm oil production reached 48.4 million tons, obtained from the area of plantation area of 14.6 million Ha, of which about 54.42% represents area of Large Farming and about 41.35% is area of cultivation.In addition to being a contributor to the country's continuously advanced currency, the sector has also become a driver of the region's perkenomian as well as providing a huge job space can also overcome poverty in the countryside. In 1980 from an area of only 300 thousand hectares in 1980 currently 16.1 million hectares with CPO production of 40 million tons (Tsabita, 2021).

However, the operation of palm plantation and the processing of crude palm oil (CPO) always leaves behind biomass that is often also referred to as palm industry waste. Biomass waste becomes an environmental problem if only discarded or left. There will be many negative environmental issues, according to (Kahar et al., 2022) among the waste produced by the palm coconut industry, TKKS, OPT, and POME is substantial pallet oil waste that contributes significantly to environmental damage and GRK emissions.

(Loh, 2017) stating the problems posed by the increase in palm plantation can be answered that actually the palm coconut industry can also be maximized to be the main sector that produces abundant biomass as a renewable source; these include empty fruit bunches (EFB), mesocarp fibers (mesocarp fibre / MF, palm shell (pump shel / PS), palm leaves (Oil palm fronds / OPF) and palm palm trunks (OPT).

With the presence of the program of a million hectares of palm coconut gardens especially in Eastern Kalimantan, the production of waste will increase rapidly, empty bark, shells, fiber and palm kernels, then the idea - a strategic idea to take advantage of the huge potential of waste as a bio-pellet raw material, that is, a renewable energy product and export-oriented as well as an added value economically and also of course beneficial for the environment. (Hidajat & Amirta, 2006) not only that, the use of palm coconut solid waste as a bio-pellet raw material will also be highly strategic in providing environmentally friendly alternative energy, especially if linked to the efforts of the region and the country to play an active role in reducing global warming and climate change caused by emissions from fossil fuels.

Based on (Praevia & Widayat, 2022), on the data of the Central Statistics Agency in 2021, the total area of palm plantation in Indonesia is 146.63.60 hectares and East Kalimantan accounts for the area of 1.366.10 hectares.

The potential of Sawit Farming in Eastern Kalimantan is large enough and can be maximized for the use of biomass as a source of electric energy, is one of the solutions to increase the ratio of electrification, while accelerating the realization of national energy sustainability and energy transition to pursue carbon neutral target by 2060.

1.2 Objective

The aim of this study is to analyze the use of coconut-based circular bioeconomy in supporting the acceleration of the Eastern Kalimantan energy transition

1.3 Benefits of research

Contribution to the study of the Strategy of Integration of Bioenergy System Concepts and Crop Circular Bioeconomy based on coconut palm in the Acceleration of the Energy Transition in Eastern Kalimantan. This research is expected to be useful for academics in developing the theory of bioenergy and circular bioeconomics based on coconut palm and also accelerating the energy transition in Indonesia through the use of biomass.

2 Theoretical Review

2.1 Background Potential of Coconut Industry in East Kalimantan

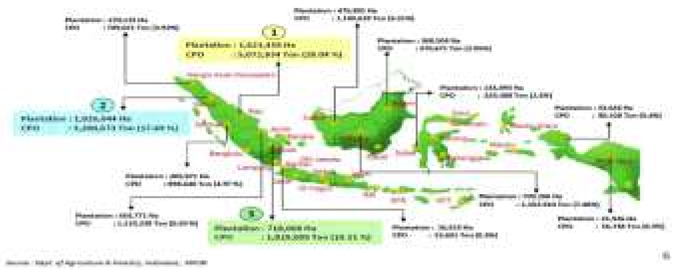

Fig. 2. Industry Potential in Eastern Kalimantan. Source: Dept of Agriculture & Foresty, Indonesia, MPOB

Seeing from the image II.2 above, Eastern Kalimantan has an area of palm plantation of 368.504 Ha and produces 1.140.639 Tons. According to GAPKI, to date, palm coconut oil productivity is the largest among other vegetable oils, that is, 4–5 tons per hectare, while palm oil is only 900 kg per hectar, sunflower oil is 700 kg per hektar, and soybean oil is 500 kg per ha.

According to the data of the EastKalimantan Provincial Farming Department in 2021, it is stated that the palm oil plant (PKS) has installed capacity of 5,005 tons and used capacity is 4,337 tons. In total, 94 units of the plant are spread across 7 districts in East Kalimantan. Of the 7 district that has palm petroleum processing companies are among them, namely 17 factories in Paser district, 7 in Penajam Paser Utara, there is 1 factory in Mahakam Ulu, 6 in Kutai Barat, 24 in Kutai Timur and 18 in Berau district..

East Kalimantan Province is the province chosen to be the new capital of the Republic of Indonesia. The palm coconut industry has a potential of about 1.25 million hectares and 95 palm oil industries have been operating with a capacity of 5000 tons/hour for FFB and producing 3.8 million CPO (Crude Palm Oil). The Sawit Coconut Industry is predicted to accommodate 300,000 workers spread across 10 districts in East Kalimantan. This huge potential can continue to be developed if East Calimantan can maximize the Bioenergy Integration and Circular Bioeconomy industry.

2.2 Integration of Bioenergy Systems Concepts and Circular Bioeconomy

The Concept of Bioenergy System. Based on (HAMBALI et al., 2016) bioenergy is a renewable new energy source (EBT) that can be used as a substitute for the role of fossil energy as an electricity supplier or fuel. Bioenergy are considered to be the easiest type of energy source to be converted into fuel or electricity. Bioenergy is also one of the sources of renewables energy supply in addition to solar, wind, hydro, earth heat, waves and ocean currents. Unlike other types of renewed energy, bio-energy products can be obtained in three forms: liquid, solid, and gas so it is easy to be transported to other regions. (Thrän et al., 2017) bioenergy can be used as a commodity because it can be produced in liquid forms such as biodiesel or bioethanol, in a form of gas or known as biogas and in a solid form such as pellets, bricks or biobricks (Soerawidjajaja TH, 2011.).

Bioenergy is now one of the renewable energy sources that is being massively developed in Indonesia, not only because its energy sources are easy to find in Indonesia but also because of its varied variety. (Abdullah, 2006), Indonesia is estimated to produce 146.7 million tons of biomass per year, equivalent to about 470 GJ / year. Biomass energy sources are scattered throughout the homeland, but the potential on a concentrated scale can be found in the islands of Kalimantan, Sumatra, Irian Jaya and Sulawesi. Land covering 188,20 million ha comprising 148 million ha of dry land and 40,20 million hectares of wetland with various types of soil, climate, physiography, mother material (fertile volcanoes), and elevation. These conditions allow for the cultivation of various kinds of plants including bioenergy producing commodities.

Circular Bioeconomy. According to (Gligo et al., 2020) the birth of bioeconomy, understood as "the process of transforming the knowledge of life sciences into the creation of new, sustainable, eco-efficient and competitive products" and paying attention to things for sustainability also involves anthropological issues as ethics, constraints that are increasing factors in modern context (Patermann & Aguilar, 2018). According (Missemer, 2017), it is clear that theft and fraud in the unequal empowerment of natural resources can trigger social breakdown and even inhibit economic growth.

In the Circular Bioeconomy, efficient valorisation or pricing of biomass through strategic resource use is essential in terms of producing valuable products, sustainable development, and maximizing ecological and socio-economic utilization. Based on (Awasthi et al., 2020), technology is being developed and enhanced to optimize abundant biomass use and to produce some value-added products.

Integration of bioeconomy and circular bioeconomy

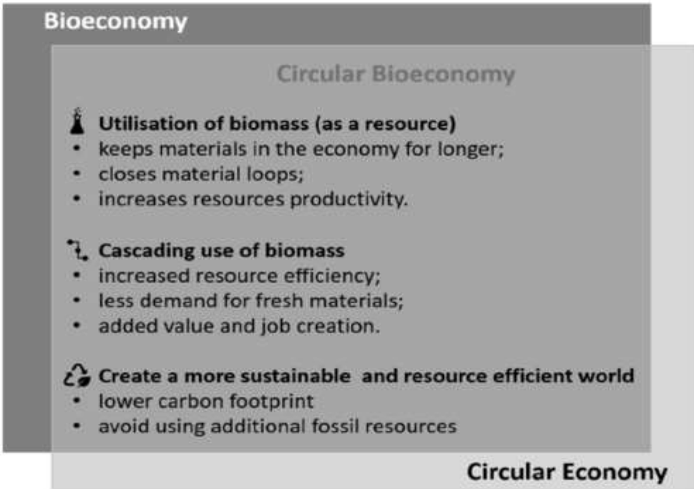

Fig. 3. II. 1 Circular Bioeconomy *Source:* (Panchaksharam et al., 2019)

The concept of circular economy increases resource productivity. Secondly, derivative use of biomass products, that is, sequential recycling of one material into another type of product after use. According to (Panchaksharam et al., 2019) the main objective of the use of derivative products Bioeconomy and Circular Bioeconomie is to increase resource efficiency and decrease demand for raw materials, where both will also be connected with added value and also the creation of jobs.

The use of palm coconut waste as a renewable energy source that is environmentally friendly. Biomass from palm coconut waste, empty fruit bunch, pellet, shell and kernel press cake is used for the production of bio-pellets, renewable-green energy alternatives in Eastern Kalimantan, which are potentially to be exported abroad. Palm coconut solid waste, made biopellets of palm Coconut Solid waste is obtained by mixing 0 – 85%, shell 0 - 85%, kernel 5% and 10% natural adhesive can produce a calorie value of around 4104 – 5117 kcal/kg.

Fig. 4. II. 2 Solids waste coconut palm used as a bio pellet

The exploitation of the potential of palm coconut waste as a renewable energy product and export-oriented as well as adding value economically and of course also beneficial to the environment. Not only that, the use of the solid palm coke waste as the bio-pellet raw material will also be very strategic in providing environmentally friendly alternative energy, especially if linked to the efforts of the region and the country to play an active role in reducing global warming and climate change caused by emissions from fossil fuels. (Hidayat & Amirta, 2011).

Challenges of Transition to Renewable Energy. According to (Gabriela & Simamora, 2020), energy transition is a path toward the transformation of the global energy sector from fossil-based to zero-carbon in the second half of this century. Meanwhile, according to (Jakob & Steckel, 2016) a fair transition of energy is “a way to reconcile the poorest human material needs on the planet with the need to maintain Earth’s climate stability”.

3 Methodology

Research Location. In this case, the research location is located in East Kalimantan – Paser district which is in several palm coconut factories including PT Agro Bintang Dharma, PT Buana Wirasubur Sakti and PT Agrointi Kencana Mas.

Research Time. April 2022 to October 2022

Systematic Literature Review (SLR). Systematic Literature Review is a term used to refer to a specific research or research methodology and development carried out to gather and evaluate research related to a particular topic focus.

Interview. Advanced qualitative research is conducted by Expert Judgment in-depth interviews with several Experts in the fields of Bioenergy and Bioeconomy. Interviews are conducted to obtain data and information from sources in depth (in-deepth). The interview is carried out by giving open questions to stakeholders of the palm industry business in East Kalimantan. Observation is an approach to obtaining data and info by observing data objects directly. The observation is done by defining data, creating a data collection plan, recording and recording data (Riduwan 2015). Observations in this study take advantage of the research activities of the top data desk and information production industry of palm coconut in East Kalimantan.

4 Result and Discussion

Industrial coconut waste data in East Kalimantan. The results of data collection obtained data on palm oil waste from the palm oil industry in several districts/cities, waste can be classified into solid waste, namely Empty Bunches, Palm Shells, Palm Mud, fibers and liquid waste.

Fig. 5. Production data

Figure 5. The data showed the production of palm waste in several districts/cities based on the classification of solid waste with the type of empty Tandan most in the area of Eastern Kutai District reached 1.190.250 Ton TBS per Hour, the most second production type of Empty waste Tandan District was Paser District of 921.150 Ton Tbs per Hora, then the third most occurred in Kutai Region of Kartanegara 631.350 TBS Per Hour. Based on the production of empty fruit bunch type palm waste, this additional PKS plan was carried out for 6 (six) districts/cities in the East Kalimantan Province of 714.150 tons of TBS per hour.

The same is also shown in the production data of palm waste with the type of Sawit Cangkang, showing the amount of production of most palm residue obtained in the area of Eastern Kutai District of 336.375 tons TBS per hour, The second occurred in the district of Paser as many as 260.325 on TBS per Hour, then the third most in Kutai Kartanegara district as much as 178.425 Ton TBS Per Hour. While the production of the lowest type of waste Cangkang Sawit occurred in the West Kutai district of 39.488 tons TBS per hour. Based on the production of palm waste type Cangkang Sawit this additional PKS plan for 6 (six) district/city area in the East Kalimantan province of 201.825 tons of TBS per hour.

Data production of palm wastes with the type of Coconut Mud, showing the amount of production of the most palm waste obtained in the area of Eastern Kutai district of 207.000 tons TBS per hour, the second most occurred in the Paser district as many as 160.200 tons per hour TBS, then the third most occurs in the Kutai District of Kartanegara as much as 109.800 tons TBC per hour. While the production of the lowest type of waste Coconut mud occurred in the West Kutai district of 24.300 tons TBS per hour. Based on the production of palm waste type Lumpur Sawit this additional PKS plan for 6 (six) districts/cities in the East Kalimantan Province of 124.200 tons of TBS per hour.

Based on the production data of palm waste with the type of fiber, showing the amount of production of the most palm wastes obtained in the area of the Eastern Kutai district of 672.750 tons TBS per hour, the second most occurred in the Paser district as much as 520.650 tons per hour TBS, then the third most occurs in the Kutai District of Kartanegara of 356.850 tons tbs per hour. While the production of the lowest type of Fiber waste occurred in the West Kutai district of 78,975 tons TBS per hour. Based on the production of palm waste type Serabut this additional plan PKS for 6 (six) district/city area in the East Kalimantan Province of 403.650 tons of TBS per hour.

Then based on the data of the production of palm waste with the type of liquid waste, showing the amount of production of the most palm wastes obtained in the territory of the Eastern Kutai district of 2.587.500 TBS per hour, the second most occurred in the Paser district as 2.002.500 Ton TBS Per Hour, then the third most occurs in the Kutai District of Kartanegara as 1.372.500 Tbs per hour. While the production of the lowest type of Liquid Waste occurs in the West Kutai district of 303,750 tons TBS per hour. Based on the production of palm waste type Limbah Cair, this additional PKS plan is carried out for 6 (six) districts/cities in the East Kalimantan province of 1.552.500 tons of TBS per hour.

Analysis of the author, showed that the amount of production of solid palm waste that is empty Tandan, Sawit Cangkang, Lumpur Sawit, serabut and liquid waste obtained with the highest production capacity with the top position occurred in the Eastern Kutai Kabuputen, followed by the second position of the Paser district, then the third position occurs in the Kutai Kartanegara district. While the lowest capacity of solid palm waste production occurs in the West Kutai district.

However, if you see the results of the production of solid palm waste managed by Kutai East regency, Paser district and Kutai district of Kartanegara mostly produce the type of liquid waste (51.8%), empty Tandan (23.8%), serum (13.5%) palm shells (6.7%) and solid waste palm mud(4.1%). This shows that the production of liquid waste type is much carried out by several districts/cities in the Eastern Kalimantan Province as a power plant system.

Utilization of bioenergy products from palm waste to promote accelerated energy transition. According to (Hidayat & Amirta, 2011) the use of palm coconut solid waste as a bio-pellet raw material will also be highly strategic in providing environmentally friendly alternative energy, especially if linked to the efforts of the region and the country to play an active role in reducing global warming and climate change caused by emissions from fossil fuels.

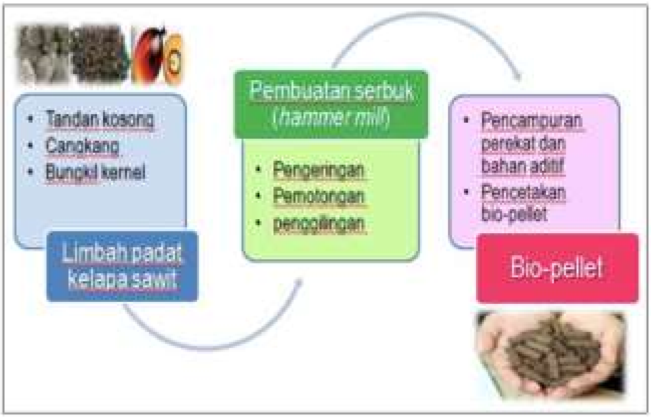

Fig. 6. Figure Flowchart of Bio-pellet Manufacturing Process. *Source: Palm Oil Waste Utilization Journal,(Hidayat & Amirta, 2011)*

The solid waste consists of empty thorns, shells and palm coconut sable. Despite having a fairly high heating value (12–16 MJ/kg), palm coconut solid waste has a low type weight (112–572 kg/m3) as well as an uneven size. Low density and uneven size are sometimes the cause of technical problems in energy conversion such as instability of combustion or failure in the gasification process. Densification can improve energy conversion efficiency and facilitate transportation. The use of fuel in a uniform form such as pellets, will facilitate the energy conversion tool combined with an automatic control system, so that the use of solid fuel will be pleasant use of gas or liquid fuel. Production of bio-pellets made of crude palm coconut waste consists of crushing and melting, mixing with binders, pressing and drying.

Bio-pellets are currently used for domestic/residential and industrial heating. For domestic use, its quality is strict especially on pollutants and emissions that are hazardous to health. Bio-pellet standards have been applied in several countries, such as: Önorm

M 7135 (Austria), DIN 51731 (Germany), EN 14961- 1 & 2:2011 (European area), Pellet Fuel Institute (USA) (Duca, 2014). The international standard on the classification of wooden bio-pellets has also been established, ISO 17225-2:2014. With the growing demand for biopellet, the diversification of biomass raw material sources will continue to increase. Agricultural waste, such as palm waste, can be an alternative source of bio-pellet raw materials. ISO 17225-6:2014 has established the classification of non-wood raw bio-pellets for domestic/residential heating. (ISO, 2014). For industry purposes, where emissions and pollution can be multiplied by the application of technologies that can process emission and pollutants, there is no standardization specifically regulating the content of bio-pellets sold on the market. For that, non-woody biomass raw pellets can be introduced for industrial needs. (Widjaya et al., 2018).

At the moment, palm waste is not much processed; although a small portion of the palm shell has been used for fuel in palm plants for energy production using boiler systems. Empty palm trees are only returned to the soil as organic material.

Using biomass power plants to accelerate the Energy Transition in Eastern Kalimantan. The biomass power plant (PLTBm) is a power plant that uses fuel from forest energy plants (HTE), garbage and organic waste. The Government encouraged the development of the PLTBm by issuing the Regulation of the Minister of ESDM No. 4 of 2020 on the second change to the Regulations of the Ministry of ES DMN No. 50 of 2017, which required cooperation with the local government to provide land as well as regulations on the price of long-term biomass fuels.

In the case of PLTBm development, the supply of biomass/biogas is required. Therefore, before the construction of a biomass plant, the supply of biomass fuel / biogas must be determined by the source of fuel and its long-term price.

In the early stages of this biomass/biogas PLT growth, PLN gives more opportunities to the private to establish cooperation with plant owners. In addition, another important thing in the processing of biomass/biogas energy into electricity is the understanding of the conversion technology, which is tailored to the type of biomassa / biogas to be used. Although a variety of technologies are available, in order to the maximum energy output of a plant-fuel, a good understanding of the biomasse/biogas type and type of technology is required.

Biomass/biogas PLT has an interesting opportunity to be built in isolated areas or small islands that are still dependent on PLTD. Thus, with the conditions of electricity demand in East Kalimantan, some areas despite being far from large plantations, sources of biomass/biogas fuel can be grown in the remote locations. Planting trees as a source of biomass or waste use in addition to being useful as an energy source, is also useful for improving the quality of land.

Co-firing biomass with coal on PLTU. Co-firing on PLTU coal is one of PLN's breakthrough programs in improving renewable energy mix that is carried out without requiring significant investment costs at the same time can be a waste management solution. PLTU's commercial co-fire implementation is based on co-firing testing that demonstrates technically viable results and does not interfere with the plant's operational reliability.

The number of PLTUs potentially to co-fire with a total capacity of up to 18,895 MW. If the entire PLTU unit has been operating commercially co-firing with a biomass percentage for PLTU PC type boilers of 6%, CFB 40% and Stoker 70%, then EBT production capacity from co-fireing of 2.7 GW which requires biomass up to 14 million tons per year (assumption CF 70%) can be obtained. This is supported by the presence of integrated regulation/policy, the formation of sustainable biomass supply, a business scheme and a well-running biomasse supply chain.

In order to the EBT energy mix target of 23% by 2025, the co-firing program is one of the strategies for accelerating the increase in EBT mix. For this, support from governments and other stakeholders is needed to be able to maintain the long-term sustainability of biomass supply and can provide competitive biomass prices, so that it does not affect the increase in electricity BPP.

The roadmap of co-firing implementation is shown in Figure IV.9, with initial estimates of biomass needs around 9 million tons and will continue to increase. In order to the renewable energy mix target of 23% by 2025, the co-firing program is one of the strategies for accelerating the increase in EBT mix. For this, support from governments and other stakeholders is needed to be able to maintain the long-term sustainability of biomass supply and can provide competitive biomass prices, so that it does not affect the increase in electricity BPP.

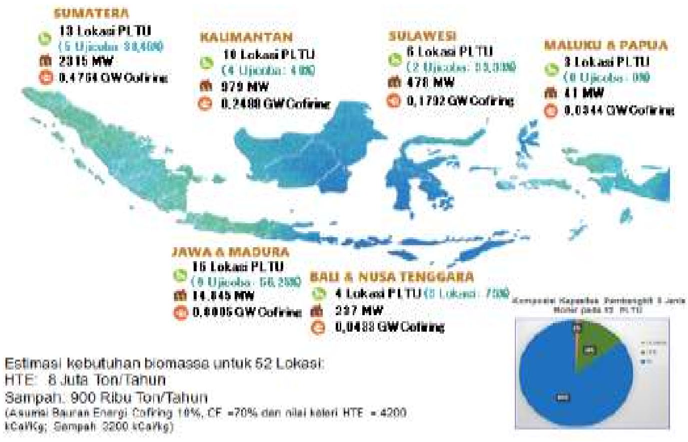

Fig. 7. Gambar IV. 1 Peta Sebaran Lokasi Co-Firing (Source : RUPL PT PLN 2021 – 2030)

Electricity supply plans for the new capital of the country. In the RUPTL document PLN Year 2021 – 2030 explained that in addition to supporting the government program for the development of the Area, PLN also supported the plan for the transfer of the capital of the country (IKN) to the island of Kalimantan announced by the president in 2019. The move began in 2024 and is expected to be completed in 2029. The initial initiation of the location is in some of the northern districts of the paser penajam and some in the county of the cartanegara. Until now, the master plan of the capital is being prepared by Bappenas. The government aims at the master plan for the construction of a new capital in East Kalimantan will be completed by the end of 2020.

For the zoning plan and the stage of construction of the new capital of the country submitted by Bappenas is divided into 3 major stages as follows:

- The first phase is the construction of the Central Government Area in 2021-2024.
- The second phase is the construction of the State Capital Area for the years 2025-2029.
- The third phase is the construction of the expansion of the Capital Area of the country in 2030-2045.

The estimated electricity needs of IKN are more than 900 MVA which will be gradually prepared by PLN. For these needs, additional infrastructure will be built, both power plant, transmission and adequate GI. Government policy to supply ICT electricity needs from new renewable energy sources, driving the development of EBT in particular PLTA in the Northern and Eastern Kalimantan provinces. The PLTA will be channeled via SUTET and GITET 500 kV. The construction of SUTET and GITET is in line with the master plan of the Kalimantan island, where the entire province on the island is interconnected by a backbone of 500 Kv.

PESTLE model analysis on the application of bioenergy and circular bioeconomy in driving energy transition

Political Factor

- The Long-Term Regional Development Plan (RPJPD) of East Kalimantan Province 2005-2025 includes programmes in the sector of energy conservation, job creation, poverty reduction, empowerment of small and medium-sized enterprises, as well as empowering inland/border communities.
- Construction of bioenergy power plants, including biomass, biogas and waste generation plants: According to RUEN 2025, it is expected to reach 5.5 GW. Based on the Green RUPTL 2021 – 2030: 590,3 MW (reduced GRK emissions of 4.61 million tons of CO2e). Based on the scenario NZE 2060 is expected to reach 37 GW.
- Indonesia has a new and renewable energy (EBT) target of 23% in its national energy mix by 2025. This policy, coupled with Indonesia's commitment to reduce emissions

by 29% by 2030, is a clear effort towards a cleaner and more sustainable energy system.

Economic Factor

- Price: There is no guarantee of the price certainty of bioenergy because it is heavily influenced by the price of raw materials which constitute 60% of the component of production cost.
- Financing and Investment: Banks are less interested in funding. The initial cost of investment for the implementation of bioenergy technology is still estimated to be high, resulting in the cost of producing energy from bio-energy sources being relatively high so that it is not able to compete with conventional energy that is still subsidized.
- The need to create a bioenergy business model from the top to the bottom, off-taker guarantees and reliable distribution.
- Difficulty obtaining loans (with low interest rates) because they are considered to be high-risk and less profitable.

Social Factor

- Sustainable supply of raw materials and price stability of biomass Social Factor
- People are still more interested in using conventional energy (karena masih disubsidi).
- Public knowledge is still minimal about bioenergy and circular bioeconomy.
- There is a great opportunity for new jobs.

Technological Factor

- Technologies that have been proven and tested are still largely dependent on overseas
- Requires improved support infrastructure, especially for remote areas.
- Lack of research on bioenergy and circular bioeconomy.
- Potential existing data needs to be updated and need to make a potential mapping along with its development strategy.
- Lack of infrastructure support.

Environmental Factor

- There is no special land available for planting diversification of bioenergy raw materials.
- lack of guarantees of sustainable availability of raw materials for some bioenergy commodities.
- Environmental damage caused by untreated palm coconut waste.
- There is a conflict between the use of raw materials for bioenergy products with the satisfaction of food, feed and fertilizer needs.

5 Conclusion and Advices

5.1 Conclusions

East Kalimantan has an area of palm plantation of 368,504 Ha and produces 1,140 ha. It is 639 tons. According to GAPKI, to date, the productivity of palm coconut oil is the largest among other vegetable oils, that is, 4–5 tons per hectare, while rape oil is only 900 kg per hectar, sunflower oil is 700 kg per hektar, and soy oil is 500 kg per ha. However, on the operational palm plantation and processing of crude palm oil (CPO) always leaves biomass that is often also referred to as the waste of the palm industry. The existence of this biomass becomes a problem if the waste is only discarded or left alone and various negative issues about the palm coconut industry are always thrown away.

The use of palm coconut waste can be maximized with bioenergy and circular bioeconomy strategies. Circular bioeconomy is aimed at achieving sustainable development through high efficiency use and recycling of resources, and through the combination of environmental, economic and social goals while bioenergy from palm coconut waste can be exploited as an energy source that can support the acceleration of the Energy Transition in Eastern Kalimantan.

One of the products produced with the integration of Bioenergy and Circular Bioeconomy is BioPellet which can be used as a replacement for fossil energy sources such as petroleum or coal through the use of the CoFiring program against the already running PLTU.

5.2 Advice

1. In order for this research to continue to the next stage, further validation and verification of the data processed from these research results is necessary.
2. It requires the integration of cross-sectoral policies, as well as improved inter-agency coordination and synchronization of government programmes with the strategies outlined in this research.
3. Open cooperation with institutions – research institutes and universities of international level who have experience in bioenergy systems and circular bioeconomy.
4. Improve knowledge to the business actors of the palm coconut industry on Bioenergy and Bioeconomy.
5. The government makes fiscal and non-fiscal incentives policies for bioenergy producers.

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