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MORALITY BEFORE KNOWLEDGE

The potential of circular economy in the oil palm plantation to industry

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ABSTRACT
Palm oil has become a crucial commodity because it has a high gross domestic product. The issue of the environmental effect of palm oil is still debated. On the other hand, desire become an essential aspect _ Because the production of agriculture No only For the moment but continues in the future. Studying and developing Stay About Palm is very important For knowing where Stay has been implemented. This study reviews the potency of palm oil through an analyzer potency of economy circular from cultivation to palm oil industry. The technique of deep data collection was used in writing the review. The document has been analyzed through a literature review to summarize the potential economic circular on the plantation and palm oil industry. Data search is not only limited to one country; paper from many countries has been reviewed. Studies This discusses the issue of palm oil getting its negative response and positive from various countries. However, findings show palm oil are very needed by humans. In context, waste produced _ by plantation and the palm oil industry study shows all waste can managed And converted to become something valuable. The circular economy is appropriate for increasing energy renewal in palm oil and ensuring a closed system. Management of good waste _ gives a mark plus economy from waste of palm oil so that palm oil can be sustainable in a way economy and environment.

KEYWORDS: circular economy; closed system; green technology; sustainability; waste management

1. Introduction

Palm oil is a essential crop commodity in Indonesia.. Based on data reported by Indexmundi (2022), the amount of palm oil production in Indonesia in 2021 was 44.5 million tonnes, and based on data from the National Central Bureau of Statistics (2020), the total area of Indonesia's palm oil in 2020 was 14.59 million hectares (ha). The palm oil industry produces waste on a large scale in the form of solid and liquid waste, which is the primary source of pollution and significantly impacts environmental sustainability (Ali et al., 2015). The solid waste produced can be empty bunches, shells, and fibers, while the liquid waste is in the form of high levels of organic materials.

Processing 1 ton of fresh fruit bunches from palm oil generates up to 23% (or 230 kg) solid waste in empty palm fruit bunches (EPFB), 6.5% (or 65 kilogram) shell debris, and wet

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decanter solid (mud). Palm oil 4% or 40 kg, fiber 13% or 130 kg (Kamal 2015), and liquid waste/Palm Oil Mill Effluent as much as 50% (Susanto et al. 2017). Waste of empty palm fruit bunches is a relatively large amount of solid waste of the four solid wastes, but its use is still limited. It is only burned, and some spread on empty land as mulch or fertilizer around the factory (Erivianto et al., 2016). So the best treatment is if the waste is processed into an energy source (Saragih et al., 2020).

Renewable energy includes biogas, biomass, and bioethanol (Fatichuddin and Nazaruddin, 2016). According to Anam and Mahmudsyah (2013), one potential source is solid waste biomass energy from palm oil, which has a reasonably high heat content. It can be processed into briquettes as fuel for biomass power plants or as a fuel substitute for kerosene. The calorific value of shell 3,893 kcal/kg or 16,304 kJ/kg (wet), EPFB waste is 3,498 kcal/kg or 14,650 kJ/kg (30% water content after compression), and fiber 3,068 kcal/kg or 12,849 kJ/kg and briquettes from empty palm fruit bunches is 7,490 kcal/kg or 31,368 kJ/kg, so it has the potential to produce electric power (Erivianto et al., 2016).

Utilization of palm oil waste into electrical energy Close System supports the Indonesian Sustainability Palm Oil (ISPO) policy, following Minister of Agriculture Regulation Number 19 of 2011 concerning Guidelines for Indonesian Sustainable Palm Oil Plantations, which, until now, the latest regulations regarding ISPO have been stipulated through Minister of Agriculture Regulation Number 38 of 2020 concerning Implementation of Indonesian Sustainable Palm Oil Plantation Certification. ISPO is a palm oil plantation business system with economic, socio-cultural, and environmentally friendly values based on statutory regulations. One of the principles contained in ISPO is managing the environment, natural resources, and biodiversity by applying waste utilization criteria.

Efforts to overcome the problem of palm oil industrial waste into a form that is useful and has economic value have been reported in previous research, namely the utilization of this waste in the pavement industry as sustainable materials. A total 40%–60% Palm Oil Clinker (POC) can be used to fine aggregate for optimal performance, while 0–100% Palm Kernel Shell (PKS) can be used to replace coarse aggregate. In addition, 50%–80% Palm Oil Fuel Ash (POFA) or POC fine (POCF) can be used as a filler replacement, 5%–8% POCF or POFA as a bitumen modifier, and 0.3% POF as a stabilizing additive. Furthermore, the study demonstrates that the safety of utilizing wastes with more than 50% CO_2 emissions can be curtailed with minimal heavy metal leaching and radioactivity levels (Yaro et al., 2022).

Other research on the use of palm oil industry waste to support the concept of a circular economy has been carried out by Davies et al. (2022) which uses palm oil mill effluent (POME) waste as biodiesel. POME is a waste product from the extraction process of palm oil, POME treatment is difficult and can cause significant environmental pollution if discharged directly into watercourses. Fatty acids (FAs) present in POME were extracted and subsequently esterified in situ to FA methyl esters (FAME) suitable for use as biodiesel. The simultaneous extraction and esterification result in an 89% yield of biodiesel from the available FAs in the POME solids.

The other research of the application of circular economy to the palm oil industry in Malaysia show that the circular economy model has the potential to reduce 39.292% of the imported steam and 13.469% of the imported electricity, while being 0.642% lower in terms of the gross profit (Yeo et al., 2020). Based on various data descriptions, it indicates that research regarding the management of palm oil waste from both plantations and factories has been researched and product innovations are being sought to increase its value or use. However, from this description there is still minimal comprehensive research from cultivation - post-harvest - to becoming a product from the factory. This article fills the gap to comprehensively complete palm oil waste management from a circular economy perspective. A circular economy is essential to achieving environmental, economic and social balance. Therefore, it is crucial to design a palm oil solid waste processing process to produce alternative energy by implementing a "Circular Economy" to increase energy for the palm oil industry in a closed system and increase the economic value of palm oil waste. To learn about the circular economic system in oil palm plantations to develop palm oil greentech in Indonesia more widely.

2. Methods

This study consists of several stages of writing to search information and data regarding potency economy circular on plantation and industry of palm oil. The stages for this study are observing problems from the cultivation-processing-marketing product of palm oil and analyzing potency national and international from the waste of palm oil. Technique analysis document through a literature review to support the hypotheses and findings by analysis document and data from source relevant the for invite conclusion, conclusion results and give suggestion. The purpose of a literature review is to understand the extent of existing knowledge, identify research gaps, and provide a theoretical basis for the research to be conducted (Snyder, 2019). The way to collect data is from various sources, reputable journals, and literature supporting electronic secondary data. The synthesis step consists of extracting and classifying relevant data from the selected journals to obtain information and conclusions. The data extraction process consists of identifying and extracting relevant data from the papers selected for use. The analysis phase is used to evaluate and extract information that concludes a conclusion (Mangista et al., 2020).

3. Results and Discussion

3.1 Rejection of Indonesian Palm Oil Exports by the European Union

In the coming decade, Indonesia will continue to endure discrimination against palm oil goods in the European Union (EU). The EU's dark campaign against palm oil presents a difficult problem. The majority of Europeans have a negative perception of palm oil. The oil palm problem is driven not just by deforestation but also by harmful ideas about health and social repercussions (Suwarno, 2019). Efforts to ban palm oil imports have taken different forms, including dark campaigns, increased fees on palm oil imports, and even declaring that palm oil is no longer a raw material for biofuel (Pradhana, 2020).

As part of its efforts to reduce greenhouse gas emissions from fossil fuels, the European Union (EU) established the Renewable Energy Directive (RED) in 2009, which set a target of 10% renewable transportation fuel in EU Member States by 2020. Most oil imports from EU palm oil is used as a biodiesel feedstock to meet this goal. However, research shows that when forests are cleared for plantations, palm oil-based biodiesel causes more greenhouse gas emissions than fossil fuels. The EU's response to this was to revise RED to RED II in 2018 to respond to this. As a result, while biofuels derived from crops with a high risk of deforestation, such as palm oil, would not be prohibited, it will be excluded from consideration beginning in 2030 (Russell, 2020).

The EU assumes that palm oil production currently conflicts with the EU's vision of sustainable and progressive development. The EU Parliament considers that in overcoming the impact of palm oil production that does not meet sustainable principles, especially those entering the EU market, steps must be taken to empower the use of palm oil and gradually reduce imports. So, the suspension will be phased out gradually, starting from 2019 to 2021. The resolution states that the European Union will reduce imports and stop using palm oil from palm oil-producing countries. Indonesia was specifically and several times mentioned as an actor in deforestation in the resolution (Pradhana, 2020).

In 1990, 74% of Indonesia's palm oil was exported to the European Union. This figure decreased drastically to 26% in 2000 and decreased further in 2010. This is the impact of the new EU regulations, which limit palm oil imports from Indonesia. Starting in 2000, the dominance of Indian palm oil exports shifted to Asian countries such as India and China.

Efforts to overcome the palm oil black campaign must be carried out with good strategy and planning. This planning necessitates connecting EU stakeholders through public diplomacy, business diplomacy, lobbying, and economic diplomacy. Habibie (2016) states that the strategy used is the Green Marketing Strategy, which includes marketing aspects of environmentally friendly products. Product standardization is needed to ensure the product is not harmful to health and the environment. Indonesia issued Indonesian Sustainable Palm Oil (ISPO) as a product standardization to guarantee environmentally friendly products and as a promotional tool. The Indonesian government is also trying to refute the EU's black campaign by conducting various research, which proves that the EU proves several facts and the EU is only highlighting Indonesia's mistakes in becoming an instrument of protectionism. If the results of this research are satisfactory and can be accounted for, then Indonesia has the power to bring this problem into international law (Sally, 2016).

3.2 Palm Oil Green Technology (Greentech)

Greentech is an effort to keep life on Earth sustainable or desirable. Sustainability is described as providing for society's requirements in the future without depleting natural resources and meeting present demands without jeopardizing future generations' ability to fulfill their own needs. Green technology can also be made through the creation and use of products, equipment, and systems used to conserve the environment and natural resources, hence minimizing and reducing the negative impact of human activities on the environment. Green technology will be considered the objective of human life in the future since humans cannot continue to utilize technology that has a harmful influence on the environment and all forms of life that rely on the environment. As humans, all of the parties must always safeguard the world from harm and devastation. Green technology seeks to discover and create methods of providing for humanity that do not harm the environment or deplete natural resources on the globe. The trash recycling process is one example of an alternative to traditional technology used to apply green technology. This initiative has the potential to drastically minimize negative environmental impacts, specifically the quantity of trash and pollution produced by human activities.

Indonesia supports the world's commitment to maximizing environmentally friendly energy in facing the energy transition era green. Various steps have been taken for the energy transition, including developing B-30 to D-100 and using environmentally friendly technology for the transportation and industrial sectors. Business entities that deal with fossil energy are also asked to make careful plans to face this transition era, using green and clean energy technology.

The key to all these things is to continue working optimally using green technology so that the products produced are environmentally friendly and support achieving the primary goal of reducing carbon emissions. As the manager of upstream oil and gas businesses, oil and gas has made plans to reduce carbon emissions from upstream oil and gas activities. At COP26 in Glasgow in early November, Carbon Capture Utilization and Storage technology was also discussed, which is relevant to the oil and gas industry. Apart from that, the use of technology Green has also become part of the program that the Government will implement, especially in National Strategic Projects.

An essential point in the energy transition is expanding the use of renewable energy. In line with this, the Government also continues to pay attention to energy adequacy to support various economic activities that require a smooth supply of oil and natural gas as energy sources and raw materials. Gas as an energy source with relatively low emissions will play a significant role, replacing other fossil energy sources considered more environmentally unfriendly, such as coal. For this reason, thorough preparations must be made to guarantee the energy adequacy that Indonesia needs to support economic growth.

The upstream oil and gas industry still creates a multiplier effect for other supporting industries. Last year, the Ministry of Energy and Mineral Resources established a competitive gas price policy for specific industries so that many downstream industries can develop even more rapidly. The Government also continues to be committed to supporting the achievement of long-term targets for the upstream oil and gas industry, significantly to maximize production of oil and gas. The Government has provided space to increase investment, including through some incentives for the upstream oil and gas industry and simplifying licensing for ease of doing business. For this reason, building infrastructure to support green technology activities is necessary. Strong collaboration is also needed between ministries and institutions and all stakeholders involved.

3.3 Main Products

3.3.1 Crude Palm Oil (CPO)

Indonesia is the world's largest producer of palm oil. The positive outlook for palm oil in the global vegetable oil trade has prompted the Indonesian government to expand palm oil planting lands in each province. The area of oil palm plantations in Indonesia reached 7.51 million hectares in 2009, producing 18.64 million tons of CPO or the equivalent of 84.73 million tons of fresh fruit bunches (FFB) (Agricultural Data and Information Center, 2010). The Central Statistics Agency (BPS) data shows that Indonesia's crude palm oil (CPO) production reached 44.76 million tons in 2020. This amount was generated from a producing land area (TM) of 11.99 million ha.

The problem that arises from the palm oil industry is the abundance of PKS waste. Each PKS with a 60 tons/hour capacity can process up to 1000 tons of FFB daily (Darnoko & Sutarta, 2006). CPO comes from the fresh fruit of palm oil obtained by extracting the palm fruit. Palm oil production worldwide is used to meet consumption needs and has been further processed into a friendly alternative fuel environment for automobiles called biodiesel. Research Center Palm Oil has successfully developed palm biodiesel from crude palm oil (CPO). Research institutions and Government State-Owned Enterprises have also carried out similar activities (processing continued from palm oil / CPO).

All components of palm fruit can be utilized optimally. Palm fruit has pulp and palm kernels, where palm flesh can be processed into CPO, while palm fruit is processed into palm kernel oil (KPO). CPO extraction averages 20%, while KPO is 2.5%. Meanwhile, palm kernel shells can be used as fuel for steam boilers. Palm oil is used for food and industry through refining, clarifying, and deodorizing processes. Apart from that, CPO can be broken down to produce solid palm oil (RBD Stearin) and liquid palm oil (RBD Olein).

Palm oil is widely used as a food raw material. Food ingredients from palm oil include cooking oil, margarine, vegetable fats for milk and ice cream, and many others. As a food ingredient, palm oil has two quality aspects. Aspect The first quality is related to the content and quality of free fatty acids (FFA) and the moisture and dirt content contained—palm oil. The second aspect of quality relates to the product's aroma, taste, clarity, and purity. Palm oil prime quality contains no more than two percent fatty acids (FFA). As for standard quality export, Palm oil contains no more than five percent free fatty acids (Semangun et al., 2005 in Hagi et al., 2012).

CPO (Crude Palm Oil) or crude palm oil is a vegetable oil obtained from the mesocarp of the fruit of the oil palm tree. Further processing of CPO will produce palm oil, which can be consumed and used for various other applications. Palm oil fruit consists of the outer layer (exocarp), fruit pulp, which contains oil in a fiber matrix (mesocarp), the middle layer of the fruit (endocarp), and the kernel, which also contains oil and will produce Crude Palm Kernel Oil (CPKO) (Poku, 2002).

Palm oil is rich in rubberenoids (pigments found in many plants and animals), which give a reddish color, and most of its components are glycerides (saturated palmic fatty acids). The palm oil processing process continues to develop in the face of various obstacles in processing, especially in terms of expensive equipment, workers' wages, production stability, production security, safety, and handling of waste in the environment. The process consists of 1) Sorting Palm Fruit; at this stage, the fruit will be checked for quality and ripeness. The harvest maturity criterion is essential because it shows the yield of oil and fatty acids in the fruit. 2) The sterilization process uses hot air at a temperature of 120-140°C and steam at a pressure of 2.5 atm, separating the fibers to be easily separated in the following process. In addition, heat will denature the proteins of the oil-carrying cells so that they effortlessly combine and flow when exposed to pressure. When exposed to pressurized steam, the air content will break the chemical bonds in the sap. Sap can cause foam accumulation during frying. This process will also hydrolyze the starch (Poku, 2012). 3) The oil extraction begins with stripping the palm bunches from the palm fruit using a rotary drum. This is then followed by digestion (crushing) to break down the oil-carrying cells in the digestive system. Digesters usually use cylindrical vessels with steam heating equipped with stirrers. This mixer will destroy the exocarp layer of the palm fruit (Poku, 2012). There are two methods for extracting oil from materials from the digester: mechanically (dry method) and using hot air to extract oil (wet method). Mechanically, you can use hydraulic or screw presses (Poku, 2012). 4) The refining process will break down the oil from impurities. The output mixture from a screw press machine contains oil, air, fiber, and non-oil solids. This non-oil solid is very thick, so hot air is added during refining. This addition of water will cause the solids to settle at the bottom of the tank and form a separate layer of water-soluble solids and a mixture of liquids (oil and air) (Poku 2002). The percentages are not always exact for each component, depending on the air added. Settling tank feed contains 66% oil, 24% air, and 10% NO. However, some surveys show that air content can reach 50% (Corley & Tinker, 2016). The mixture will be put into a screen filter to filter the fibers, heated for 1-2 hours, and left to rest with the help of gravity in the settling tank. Components with a smaller density, mainly oil, will be in the top layer. Meanwhile, lower-density components will be in the lowest layer (Poku, 2012). Next, a centrifugation machine will purify the CPO from dissolved solids that may still be contained in the mixture.

Palm oil is crude palm oil that has gone through a further refining process to become palm oil with low phospholipids and free fatty acids. Apart from that, the color is no longer reddish-orange and has no taste. The purification process includes sap removal (degumming), deoxidification, decolorization, and odor removal.

3.3.2 Palm Kernel Oil (PKO)

Indonesia and Malaysia are the leading producers of PKO (Palm Kernel Oil), while the Philippines and Indonesia are the leading producers of CPO. PKO is a by-product of palm oil obtained from the kernel of the palm fruit after pressing the mesocarp with the physical characteristics of a yellowish-white oil with a free fatty acid content of around 5%. PKO is semi-solid at room temperature, more saturated than palm oil, but equivalent to palm oil. Palm kernel contains 45-50% PKO in wet form. Methods for extracting PKO from palm kernel include screw pressing, direct dissolution, and pre-pressing, followed by solvent dissolution. PKO contains higher oleic acid than coconut oil. PKO is suitable for hydrogenation (hardening) for producing specialty oils with different melting points and end-use hardness (Hossain, 2013).

Triacylglycerol (TAG) accounts for approximately 95% of PKO. Free acids, monoacylglycerols, diacylglycerols, phospholipids, free and acylated sterols, tocols, and hydrocarbons such as alkanes, squalene, and carotene are the minor components. In PKO, C36 is the most prevalent TAG. It has a high concentration of soluble acids and a stable melting profile, making it appropriate for confectionery and other specialized fats. Palm kernel oil is produced via cracking, crushing, pressing, and sedimentation of palm kernel. Palm kernel has great potential as an oil and protein source.

The conditions of kernel storage and transportation are critical because they affect kernel quality. To avoid mold formation and a quick increase in FFA during storage and shipping, the optimal kernel moisture level should be no more than 7%. When evaluated with the naked eye, palm kernels must be devoid of musty, rancid aromas and foreign objects such as insects or fungal illnesses, according to Malaysian guidelines. Oil, carbs, protein, crude fiber, moisture, and ash are all found in kernels. PKO is extracted from kernels either mechanically or by dissolving.

Palm kernel extraction is entirely comprised of many national and international stakeholders along the value chain. PKO can be used as biodiesel by transesterifying PKO with ethanol using a potassium hydroxide (KOH) catalyst. According to research by Alamu et al. (2008), Nigerian PKO biodiesel provides promising results as a substitute for native diesel fuel. The fuel properties follow previous work and the limits of International biodiesel standards. Ethanol-PKO ratios 0.1, 0.125, 0.15, 0.175, 0.2, 0.225, and 0.25 biodiesel yields r 29.5%, 54%, 75%, 89%, 96%, 93.5%, and 87.2% were obtained in the reaction Typical transesterification at a temperature of 60 0 C, with a duration of 120 minutes with 1.0% KOH.

As a byproduct, PKO can be converted into PKC (Palm Kernel Cake), which is high in fiber. PKC has the potential to be a dietary ingredient because it is high in fiber and helpful to human health, including lowering the risk of cancer, blood sugar, and cholesterol levels, aiding in weight loss, and decreasing constipation. PKO is extracted using SC CO2, which extracts the oil and uses it as a source of fiber and nutrients for human use and animal feed. The best extraction conditions are 44.6 MPa and 600C for 50 minutes, with an oil yield of 49.2%. SC CO2 is a powerful method for creating high-quality palm kernel meal, which has the potential to be used as a source of protein and fiber (Hossain et al., 2016).

PKO can be extracted from a palm kernel using mechanical pressing or a hexane solution. According to PKO, almost 230 million tons of crude oil are produced globally, accounting for around 3.5% of total production. PKO represents 8% of output, 3% of consumption, and 16% of exports on average. PKO is more expensive than CPO. Because it contains more glycerides than palm oil, PKO may be converted into biodiesel biofuel. As a result, this biodiesel has the potential to replace Jet Fuel A1 in aviation fuel blends. (Betancourt et al., 2020).

3.4 Secondary Product

3.4.1 Palm Oil Empty Bunches (EPFB)

So far, the use of empty oil palm fruit bunches is minimal, namely open dumping and burning in incinerators. EPFB in Indonesia is palm oil mill waste, which is very abundant. However, most palm oil mills (PKS) and communities in Indonesia have yet to utilize this waste optimally. So, there is a need to develop green technology to support the implementation of a circular economy to achieve sustainable development with a focus on synergizing economic growth by utilizing waste utilization and environmental protection (Kasztelan, 2017). Some by-products from the use of EPFB are as follows:

1. TTKS as an Organic Fertilizer
   EFB composting is first done by chopping and disassembling it using a chopping machine into fibers, processing and mixing it with EM4 bioactivator liquid. However, composting continues to be relatively slow because the EFB fibers are numerous and complex. There are many ways to process EFB into compost, apart from using EM4 but still referring to the quality of the compost, speeding up the fiber degradation process, and enriching the EFB fiber material so that it becomes compost that can provide a variety of and relatively high levels of nutrients. Analysis of nitrogen (N) and phosphorus (P) levels obtained from EPFB organic fertilizer waste obtained average values in percent (%). The average value of nitrogen (N) content is 2.033%, and the average value of phosphorus (P) content is 0.107% (Kavitha et al., 2013).
   Research on making compost from EPFB to reduce material has been carried out by Satria (2016), Warsito et al . (2016) stated that making TKSS into compost is often hampered by the fact that many EPFB materials do not break easily between fibers and are hard enough to rot so that the C/N ratio of materials that have become compost is still relatively high. The optimal composting process ideally has a C/N ratio < 25 with 60% humidity and a temperature of 30-60 0 C (Veronika et al., 2019). According to Syahwan (2010), cooking EFB into compost requires quite a long process (around 13 weeks), and it would be ideal to use a decomposer from sludge or other materials. This constraint is very natural because EFB fibers contain a lot of cellulose, lignin, hemicellulose, and holocellulose (Anugrah et al., 2020).
2. EPFB as a Basic Material for Making Pellets

Biomass plays a vital role in providing renewable energy in Indonesia. Biomass can be considered an attractive solution and an essential component in diversifying energy sources because it is relatively cheap (mainly when derived from agricultural waste or wood) and widely available (Szwaja et al., 2019). The fulfillment of energy from biomass in Indonesia shows quite significant amounts. One of the abundant biomass wastes in Indonesia is palm oil, including EPFB. So, it can be used as an essential ingredient for renewable energy sources in the form of pellets.

Pellet biomass is a renewable and solid green fuel, meaning pellets are a carbon-neutral energy source. Handling during combustion is more accessible and cleaner, so it is exciting to use. In line with research by Hidayat et al. (2020), the quality of oil palm empty bunches (EPFB) pellets can be improved through torrefaction with a Counter-Flow Multi Baffle (COMB) reactor. Torrefaction EFB pellets are more suitable than raw biomass in terms of physical-chemical properties and calorific value. Torrefaction pellets are hydrophobic, so that they can be stored for a longer time. The calorific value of torrefaction pellets increased by around 13.15% from 15.82 MJ/kg to 17.90 MJ/kg. The ash content of torrefaction pellets is still high (13.49%), exceeding the Indonesian National Standard limit, so its use as fuel is still limited to small-scale industries.

3. EPFB as a Basic Material for Carbon Paper

   EPFB is a complex organic material that is rich in carbon elements. This carbon content can be used for various applications, including charcoal/activated carbon and conductive carbon paper. According to the research results of Destyorini et al. (2018), the carbonization process of empty oil palm bunch fiber (EPFB) in an inert gas atmosphere up to a temperature of 1300 0 C can produce relatively conductive carbon powder with an electrical conductivity value of ± (7.97-8.03) S/cm. Using carbon powder from EPFB fiber was successfully made using simple casting technology and produced a paper with dimensions of ± (10x10) cm and a thickness of ± (0.1-0.2) mm. The most conductive carbon paper is produced from carbon. EPFB 1300 0 C with an electrical conductivity value of carbon paper (2.34-2.40)x10 -1 S/cm. Conductive carbon paper (CCP) uses composite technology, charcoal/carbon EPFB powder (200 mesh), polymer, and solvent. The polymers used are Ethylene vinyl acetate (EVA) and Polyethylene glycol (PEG), while the solvent used is Xylen.

4. EPFB as Briquettes

   Briquettes are a form of biomass made from organic materials and used as alternative fuel. In making briquettes, the pyrolysis process and the adhesive used in molding the briquettes are the most critical factors because this will affect the quality of the briquettes produced. Using empty palm fruit bunches as an energy source in the form of charcoal briquettes will not only save money but will also improve the environment. As a lignocellulosic biomass, EFB can be converted into charcoal in a relatively easy procedure. Apart from that, the ash content produced by EPFB is also shallow, so it is hoped that if it is made into briquettes, the ash produced will be less and will not pollute the environment.

   Putra et al. (2013) stated that using 80% rice waste adhesive in making briquettes obtained the fastest burning rate obtained in briquettes with 80% adhesive with a calorific value of 5414.31 cal/g. The slow-burning rate was found in briquettes with 60% adhesive, namely 0.0476 g/s, even though it had the highest heating value of 5914.81 cal/g.

5. EPFB as a mixture for making helmets

   The use of EFB as a reinforced biocomposite has superior impact strength and is able to withstand impact energy. Furthermore, he said, the results of this research were applied to a diversified product in the form of a biocomposite helmet. Biocomposite helmets are environmentally friendly helmets and are the first innovation in Indonesia. Helmets produced by PT IMM were then tested to SNI standards and obtained excellent results. This helmet is a superior product from PT IMM with the name GC Helm, an abbreviation for Green Composite Helmet.

3.4.2 Midribs and Leaf Veins

Palm oil leaf sheath waste produced in Indonesia is increasing in line with the increasing growth of oil palm plantations. Every year, one oil palm tree can produce 22-26 oil palm fronds weighing 4-6 kg/frond (Ariyanti et al., 2017). Handling of oil palm leaf midrib waste is generally limited to collecting and then stacking it between oil palm plants. If palm leaf frond waste is not handled correctly, it can become a health and environmental problem around the plantation, such as becoming a nest for disease and pests. Apart from that, in realizing a circular economy, efforts are needed to handle waste in oil palm plantations, including oil palm leaf sheath waste, so it has valuable economic value. Here are several ways to use oil palm leaf midribs, namely:

1. Compost
   Palm leaf frond waste contains high levels of lignin and cellulose, so decomposing completely takes quite a long time. In order to speed up decomposition, it is necessary to treat waste by composting. Composting uses a decomposer to speed up the decomposition of waste so that the compost can be ready in a short time. Research on using palm oil waste in organic fertilizer has been carried out previously. The composting process is done by adding compost catalyst material and chopping palm leaves (2 cm, 4 cm, 6 cm) (Bulan et al., 2016).
   Meanwhile, the use of the EM4 bioactivator has also been carried out and produces compost that can be applied to plants (Daryono and Alkas, 2017). Palm leaf frond waste as compost can increase soil fertility. Compost from palm frond waste can be returned to the plantation as a form of sustainable agriculture.
2. Bioenergy
   One of the developments of energy sources that can be carried out as an alternative to overcome the energy crisis is the creation of bio-pellet energy sources. Wood powder with coconut frond powder can be used as raw material for bio pellets whose quality meets American standards (PFI) (Syamsudin et al., 2022). Palm leaf midrib and shell waste can be excellent and cost-effective precursors for making activated carbon. They produce good charge-carrying capacity, making it suitable as a material for supercapacitor carbon electrodes (Nasir, 2018).
3. Feed
   The conversion of palm leaf frond waste into animal feed is carried out using methods to produce Feed that meets standards. Processing through feed technology, one of which is fermentation using the microorganism Trichoderma sp. to increase protein by 5.35% compared to without microorganisms, the digestibility and nutritional value of the feed increases (Rizali et al., 2018). Midribs and leaves can be used as cattle feed to replace grass as a forage source because they have pretty high crude fiber (SK) with high lignin content, namely 17.4% and 27.6% (Pranata and Arico, 2019)
4. Sticks and Creative Crafts
   Palm leaf fronds consist of palm leaves, sticks (leaf bones), and wood fronds. Efforts to handle this waste can be made by separating the leaves and bones so that they produce sticks. More leaf waste can be used, while palm tree sticks can be collected and made into brooms. Apart from that, efforts to utilize palm leaf fronds create economic value through woven palm leaf fronds by making plates, bags, and other crafts.

3.4.3 Palm Shell

Palm shells are a solid waste by-product from palm oil processing. Palm oil shell ash contains mainly SiO_2 (Hutahaean, 2013). Efforts to use less effective palm shells can produce residues that are not utilized and have unfavorable impacts. Therefore, steps must be taken to utilize this waste in materials with higher economic value. Several efforts have been made to utilize palm shells as raw materials for making activated charcoal, diesel fuel, and paving materials.

1. Activated Charcoal Raw Material
   Palm shells can be used as raw material for activated charcoal. Activated charcoal is carbon that has been activated so that the pores are open, resulting in greater absorption capacity than ordinary charcoal. Activated charcoal is amorphous carbon, which partly consists of free carbon, which has an internal surface, so it has good adsorption capacity. The charcoal produced from palm oil shells is of high quality. The palm shells contain lignocellulosic substances. Another advantage highlighted by palm charcoal is its weight, which can reach 1.4 grams/ml. The heat energy from burning charcoal is more significant, namely 20,093 kJ/Kg (Donda et al., 2018). This very striking difference will be very significant compared to charcoal made from wood or ordinary palm oil shells. One of the friendly alternatives to heat energy. There are many uses for activated charcoal in the industrial sector, including as a desulfurizer in gas purification and LNG processing, as an aid to the filtering process, and so on (Kurniati, 2017).
2. Diesel Fuel
   The process of making oil from palm oil shells using pyrolysis. Using palm shell pyrolysis oil as a mixture of diesel fuel, the diesel had no problems and could ignite well in the tests carried out. A mixture of palm shell oil and diesel fuel has good performance and is proven to make diesel fuel burn longer than pure diesel fuel. If you want high rpm, use a fuel volume percentage of 10% palm shell oil and 90% diesel. The most economical fuel consumption uses a fuel volume percentage of 50% palm shell oil and 50% diesel (Nugroho, 2019).
3. Road Paving Materials
   Road pavement materials, such as palm oil industry processing waste, can be used from waste. Based on research by Munawarah et al. (2019), The substance utilized as a filler substitute is palm oil shell ash, which is an alternative to palm oil processing industry waste because palm shell waste usage in various CPO oil processing industries has not been maximized. Palm oil shells have a very thick and hard skin structure and contain a lot of grit (SiO2). Silica dioxide can increase the compressive strength of the asphalt mixture because it can reduce shrinkage and increase resistance to cracking (Siregar, 2012). Marshall test results for the AC-WC mixture with variations of palm shell ash of 0%, 25%, 50%, 75%, and 100% all meet the requirements as filler material in the AC-WC layer. AC-WC (Wearing Course) is the top layer of pavement that functions as a wear layer. Filler materials are essential in modifying the gradation of fine aggregate in the asphalt mixture so that the density increases.

3.4.4 CPO Dregs (Mesocarp Fiber/ Cake fiber)

Fuel derived from petroleum is a non-renewable fossil energy source, so the price tends to be expensive because there is no balance between demand and supply (Ni'mah 2014). Limited fossil energy sources cause the need to develop renewable energy and energy conservation. Processing palm oil or crude palm oil (CPO), the CPO-producing industry produces waste, including palm fiber waste (fiber cake). By looking at the potential that might be produced from palm fiber cake (fiber cake) originating from the CPO processing industry, there is one part, namely in the form of palm fiber, which some people consider to have no use value which can be used as the main ingredient for making alternative fuels such as biodiesel and bioethanol.

1. Biodiesel
   Biodiesel is a fuel from vegetable oils such as palm and castor oil. The by-product of CPO processing is fresh palm dregs (fibers) containing oil which still has a free fatty

acid (ALB) content of <5%, namely a level of 1.7664% so that it can be processed into Biodiesel through an in situ transesterification process. The process of making this Biodiesel using a NaOH catalyst at a temperature of 55 o C and a time of 4 hours produces Biodiesel that complies with Indonesian National Standards with a yield value of 35.89%, density of 0.8647 gr/ml, viscosity of 5.1064 cSt, number acid 0.449 mg.KOH/gr, calorific value 9,445.897 Cal/gr, and flash point 138 o C (Prasetyo, 2014).

2. Bioethanol

   In general, ethanol is produced by fermentation with the help of microorganisms. Therefore, it is often referred to as Bioethanol. One alternative energy that is relatively cheap in production and relatively environmentally friendly is the development of Bioethanol from agricultural waste (biomass), which contains a lot of lignocellulose, such as palm fiber waste (Hermiati et al., 2010). Ethanol or ethyl alcohol C2H5OH is a colorless liquid with characteristics including being flammable, soluble in air, biodegradable, and non-carcinogenic (Kusnadi, 2009).

   Making Bioethanol is carried out using several main processes, namely pretreatment (delignification) with a solvent, namely with acid at a temperature of 120 °C, which will produce an ethanol content of 7.03% (v/v) and produce a sugar content of 9.69% (v/v), hydrolysis with acid (H2SO4). Neutralization with NaOH and fermentation process with tape yeast. Meanwhile, measure ethanol content using the Gas Chromatography (GC) method and characterization of fibers using the SEM (Scanning Electron Microscope) and XRD (X-ray diffraction) methods.

3.4.5 Palm Oil Mill Effluent (POME) as Liquid Waste and Biogas

One of the wastes produced by Palm Oil Factories is POME (Palm Oil Mill Effluent). POME is one of the leading wastes from the palm oil industry, which has the potential for environmental pollution, which causes the most problems among other factory wastes. POME thrown directly into rivers can cause the death of aquatic biota, while POME thrown directly into the soil causes the population of microorganisms in the soil to decrease. The oil extraction does not use chemicals, so POME is not toxic but can pollute the environment.

The problem with processing POME with an open system is that it causes unpleasant odors, contaminated soil around the pond area, and the relatively large number of processing ponds, which is no longer considered economical in terms of space, time, and cost. So far, after being processed, POME is thrown into the river. Even though POME can be processed into the following products:

1. Organic fertilizer

   POME contains nutrients that plants need, such as N, P, K, and Mg, so that it can be used as fertilizer. However, POME cannot be directly used as an organic fertilizer because it can reduce environmental quality. Using POME as fertilizer in plantation areas can reduce the rate of liquid waste disposal, reduce waste processing costs, and improve soil fertility.

2. Biopower

   Indonesia is developing the use of POME palm oil waste, which is converted into biopower. Biopower is electricity produced through burning biomass raw materials (in the form of plants or animal waste), which is used to heat boilers to produce high pressure and ultimately move electricity producers (Dharmawan, 2016). Using palm oil waste to generate biopower is one of the activities that contribute to environmentally friendly development and a green economy. It has the potential to replace household energy needs, which are primarily reliant on fossil fuels. Sudaryanti (2017) states that the average total electricity produced from POME is 9,885,419 kW/year, equivalent to 1,760 kW/hour.

3. Biogas

   Biogas is a flammable gas produced from the anaerobic bacteria' fermentation (decay) process of organic materials. POME management using only open ponds is rarely implemented because methane gas is directly released into the atmosphere, making it less environmentally friendly. New POME processing technology, including membranes. This methane gas capture technology is carried out by making a tank (biogas reactor) covering the waste pond's surface using a cover/ membrane made from a parachute (covered lagoon). Biogas from POME can be used for various purposes, including household stoves, lighting, air heaters, and dryers, and to drive combustion motors/turbines (Pasaribu and Kusdiyantini, 2021). The influence of minimum and maximum COD influences methane gas (CH4) conversion and power conversion. POME containing low amounts of COD will produce less biogas than COD produced by high levels of COD. This is akin to methane-producing microorganisms getting more nutrition from POME, which has high COD levels. Similarly, if the amount of methane gas produced increases, so will the amount of electricity produced (Mirandaulia et al., 2019).

4. Conclusions

The conclusion that can be obtained from this paper is that green technology (Greentech) for palm oil is an effort to preserve life on earth due to the continued development of the palm oil industry today. Implementing a "Circular Economy" helps increase energy for the palm oil industry in the Close System and increases the economic value of palm oil waste. The palm oil industry produces main products and by-products. Crude Palm Oil (CPO) and Palm Kernel Oil (PKO) are the main products. Utilization of by-products in the form of materials that can be reprocessed, such as EFB, into organic fertilizer, pellets, carbon paper, briquettes, and helmets. Palm oil leaf midribs and bones become compost, bioenergy, feed, and craft products. Palm oil shells become activated charcoal, diesel fuel, and road pavers. CPO pulp (mesocarp fiber/ fiber cake) becomes biogas and bioethanol. POME becomes organic fertilizer, biopower, and biogas.

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