Determining transparency on material and energy flow in Palm Oil industry

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Abstract. Palm oil is a strategic commodity for Indonesia because of its large role in economic and social development. Strengthening the development of a sustainable palm oil industry must refer to increasing responsibility and efficient use of resources towards a sustainable palm oil industry, credible, and transparent. This study describes the role of material and energy flows as the basis for resource use in the production of crude palm oil (CPO). Oil palm plantations and processing have tried to implement zero emission to increase competitiveness and reduce the risk of environmental damage. Data sources, quality, and uncertainty. Developing material and energy flow analysis shows evaluations in human resources, applying technology, reducing emissions, and energy efficiency are issues of relevant resources. It is important to justify and analyze critical industrial systems in reducing material waste. Derivative policy implications for production and consumption processes must be applied based on industrial output.

1. Introduction

The palm oil industry is one of the largest producers of foreign exchange earnings in Indonesia, after contributing 2.46 percent to the country's gross domestic product in 2017. Indonesia is the largest commodity producer in the world with a total output of 42 million metric tons [1]. Palm oil production must be developed continuously because it can be very beneficial to the community and the environment, while also contributing to state revenues. The income generated through palm oil production - from upstream to downstream - has increased the welfare of the Indonesian people [1, 2]. The palm oil supply chain plays an important role in the sustainability of activities and the achievement of production targets [2, 4]. Information transparency is needed to fulfill the traceability system in accordance with applicable policies. Companies need to provide guidance to suppliers to ensure the clarity of the products they produce [3]. Some oil palm businesses have not fully provided transparent information on their activities and achievements. In addition to awareness factors, lack of knowledge and assistance is the reason. Transparency of information from products plays an important role as a form of guarantee and quality management [3, 4].

Material and energy flow analysis (MEFA) provides a transparent picture of the palm oil industry. The preparation of material and energy flow diagrams is intended for the use of renewable energy in manufacturing processing of fresh fruit bunches and the utilization of outputs that have the potential as an energy source [5]. Furthermore, identification of location problems is done to predict the impact of reducing energy consumption and environmental loads [6]. The government through the Ministry of
Environment and Forestry has set waste quality standards and environmental protection compliance programs in the palm oil industry (PROPER) [7]. However, no oil palm industry has been able to reach the highest level of the program. Increased production of plantations and processing of oil palm produces solid, liquid and gas waste. Liquid waste in the form of palm oil mill effluent (POME) is the most produced and requires very complex handling and high costs [8]. The handling of existing wastewater still does not meet the environmental balance standards because the processing is only still using open storage ponds so that the methane gas formed in liquid waste will be released and wasted into the atmosphere resulting in global warming [7, 8]. In 2030, it is estimated that there will be a production of 54 million tons of EFB, 31 million tons of MF, 15 million tons of PKS, 130 million tons of palm oil, 115 million tons of palm oil, and 59.7 million tons of palm oil. Further research and technological development needs to be done to increase the added value of palm oil waste biomass [2]. POME actually has potential as a biomass energy material because of the content of microorganisms that are capable of producing methane if it is managed properly. Increasing pressure on the palm oil industry due to the environmental impacts it causes. The level of losses of material and energy materials with high input and output of the oil palm industry is a contributor to waste and the largest emissions to the environment [9].

Material inventory and energy are used as the basis for the preparation of material flow models and simulations of each process connected with the use of material or energy [10]. The constraints to implementation are the lack of a strong national database system on emissions, standards for resource use and effective waste management. Potential waste models are arranged based on the ratio of inputs and outputs to savings in accordance with the ability of the company.

2. Material and Method
The research was carried out through field observations, industry discussions with the company, and the government. Mass balance, energy balance, and output in the form of waste are used to identify the consumption of raw materials, fossil energy materials, fuel biomass energy materials (fiber and leather) (tons / hour) and the amount of electricity produced (KWh) obtained from the company [10]. Secondary data is obtained from literature studies through journals, textbooks, and others. Activities related to process and non-process are traced and calculated to identify as the basis for determining the main greenhouse gas emissions (CH4, N2O and CO2) [9]. To identify the input component activities outside the system is ignored. Data were analyzed for life cycle values using spreadsheets (Ms.Excel, OpenLCA, and AgroFootprint 4.0) [11].

3. Results and Discussion
The Indonesian palm oil industry seeks to achieve a holistic balance between the social, environmental and economic needs of the country and society by addressing the needs for community development, conservation and environmental management, and ensuring increased oil palm industry responsibility, efficiency and sustainability. In principle, coconut processing is a process of extracting CPO mechanically from oil palm fresh fruit bunches (FFB) followed by a refining process. Overall the process consists of several stages of the process that run continuously and are related to each other failure in one process stage will have a direct effect on the next process (Figure 1) [9, 12]. Therefore, every stage of the process must be able to run smoothly in accordance with existing provisions.
Energy from the boiler is flowed to the turbine for 24 hours except during maintenance and repairs. With an average processing capacity of 30 tons of FFB per hour the company has an installed capacity of around 42.5 tons / hour. The use of resources will produce air emissions (CO₂, CH₄ and particulates) obtained from energy generation systems in the factory. Vapor pressure and vapor volume (tons / hour) generated from boilers and electricity generated (KWh) through generators. The company is trying to make improvements over the period 2015-2018. The functional unit (FU) used is 1 ton of fresh fruit bunches (FFB), the average yield of palm oil mills is shown in Figure 2. Analysis of material flow and energy occurs in the treatment system on a calculation basis in a capacity of 30 tons FFB / hour. Efficiency as a comparison of the number of products with incoming material.
Figure 2. Mass balance of CPO processes

Table 1. Material flow quantity palm oil processing

| Process                  | Material                        | Input          | Output                      |
|--------------------------|---------------------------------|----------------|-----------------------------|
| Palm Oil Mills           |                                 |                |                             |
| Boiler                   | Feed water                      | 15-25 ton/hour | High pressure steam         |
|                          | Palm pressed fibre (PPF)        | 4.5-7.5 ton/hour | Boiler ash                  |
|                          | Palm kernel shell (PKS)         | 2-3.25 ton/hour |                             |
| Steam turbine            | High pressure steam             | 15-23 ton/hour | Low pressure steam          |
| Grading                  | Fresh fruit bunch               | 35-56 ton/hour | Fresh fruit bunch           |
| Sterilization            | Fresh fruit bunch               | 35-56 ton/hour | Sterilized fruit bunch      |
|                          |                                 |                | Palm oil mill effluent (POME)| 8-17 ton/hour |
| Thressing                | Sterilized fruit bunch          | 25-35 ton/hour | Sterilized fruitlet         |
|                          | Empty fruit bunch               | 31-50 ton/hour |                             |
| Digestion                | Sterilized fruitlet             | 24-38 ton/hour | Digested fruitlet           |
|                          | Low pressure steam              | 4-6 ton/hour   |                             |
| Oil pressing screw       | Empty fruit bunch               | 8-12 ton/hour  | Pressed liquid              |
| Pressing (double screw)  |                                 |                | Pressed empty fruit bunch   |
|                          |                                 |                | 10-16 ton/hour              |
| Nut separation           | Pressed cake                    | 10-16 ton/hour | Palm nut                    |
| Nut cracking             | Palm nut                        | 6-9 ton/hour   | Cracked nut (Wet kernel)    |
| Kernel separation        | Cracked nut                     | 6-8.5 ton/hour | Palm kernel shell (PKS)     |
| Kernel drying            | Wet kernel                      | 6-9 ton/hour   |                             |

Note: The table shows the material flow quantity for various processing stages in palm oil mills. The input and output quantities are given in range values for each material, and the units are ton/hour unless otherwise specified.
Table 1 shows the material flow for the palm oil industry production and consumption process. The ability of each stage to be the basis for calculating material flow between units of processing fresh fruit bunches shows that for the production of 205 kg CPO (FU), the sterilization and pressing process consumes the largest amount of energy (in the form of steam). The sterilization process has the largest water use capacity in the amount of 15-23 tons. The choice of technology such as vertical sterilization is expected to reduce energy and water consumption gradually. Estimates of the amount of liquid waste and oil lost during the sterilization process are expected to have an accuracy of more than 80%. Improvements in the sterilization section also affect the largest amount of energy supply in palm oil processing.

4. Conclusion
The results of mass and energy flow analysis show the process of sterilizing high levels of raw material consumption and energy so that it has an impact on the environment. Managing information on material and energy flows transparently needs to be done on the basis of evaluation and improvement in the use of materials, energy materials and water. The application of vertical sterilization technology is expected to increase the most efficient and environmentally friendly CPO production.

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