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Study on Energy Productivity Ratio (EPR) at palm kernel oil processing factory: case study on PT-X at Sumatera Utara Plantation

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Abstract. The purpose of this study was to determine the performance, productivity and feasibility of the operation of palm kernel processing plant based on Energy Productivity Ratio (EPR). EPR is expressed as the ratio of output to input energy and by-product. Palm Kernel plan is process in palm kernel to become palm kernel oil. The procedure started from collecting data needed as energy input such as: palm kernel prices, energy demand and depreciation of the factory. The energy output and its by-product comprise the whole production price such as: palm kernel oil price and the remaining products such as shells and pulp price. Calculation the equality of energy of palm kernel oil is to analyze the value of Energy Productivity Ratio (EPR) bases on processing capacity per year. The investigation has been done in Kernel Oil Processing Plant PT-X at Sumatera Utara plantation. The value of EPR was 1.54 (EPR > 1), which indicated that the processing of palm kernel into palm kernel oil is feasible to be operated based on the energy productivity.

1. Introduction

Palm kernel oil (PKO) is one of the oil produced by oil palm crop beside CPO products. The palm kernel oil is derived from the seeds inside the palm fruit called palm kernel. Usually, PKO is more widely used for oleo chemical industry [1].

In Sumatera Utara plantations there are a number of companies produce palm kernel oil (PKO) and crude palm oil (CPO). One of the companies that produce palm kernel oil was taken as sample to get the data for this study. Palm kernel is processed at palm kernel processing plant to produce palm kernel oil as main product and palm oil cake as by product [2]. The raw material of palm kernel is obtained as by product of palm oil processing plants of one state factory (PT-X) and some private companies in Sumatera Utara area.

Productivity is defined as the relationship between input and output of a production system. This relationship is often more commonly expressed as the ratio of what is produced (output) to the total resources used (input) or simply the ratio of output divided by input [3,4]. Productivity is one factor that is important in influencing the performance of a company. The EPR formulation is as shows in equation 1.

$$\text{EPR} = \frac{\text{Output Energy}}{\text{Input Energy} - \text{Output Energy of side products}} \quad (1)$$

The PT-X Company is used as a sample to get data to calculate the value of EPR. The company processes palm kernel into palm kernel oil. The target data required is all the energy used in doing the processing activities to produce palm kernel oil and its by-products. The results of this EPR calculation can be used as one of the indicators to analyze the performance and productivity of the plant. Certainly this analysis can be used to improve for example in the use of electrical energy as an input during the process and take advantage of by-products in the output. This will certainly increase the company's profit.

The purpose of this study is as information to assist in analyzing the performance, productivity and feasibility of the operation of a factory based on the assessment of the value of Energy Productivity Ratio (EPR) at PT X Plantation Processing Factory in Sumatera Utara plantation area.

2. Methodology

The methodology is first to collect the required data. The data is then calculated the equal energy for each input and energy output in the processing of palm kernel into palm kernel oil. Then calculated Energy Productivity Ratio (EPR) on a ton / year basis. The stages are as shown in Figure 1

The EPR of a product can be defined as the ratio of primary product energy plus its by-product energy in comparing to the total energy of raw materials, electricity and others energy used and the tools process depreciation. The calculation is based on the product capacity per year.

Calculation result of the energy input: energy output and if the energy ratio of $1 > 1$ then the product production can be continued. Whereas if the energy ratio of $1 < 1$ then the production of renewable fuel product become a loss and can be declared as not a feasible source of renewable energy in an energy review [5]. Calculation of equal energy, for value of unit of rupiah price used base of 1 liter diesel with price Rp. 5650 [7] with energy equal to 42.96 MJ/kg [8].

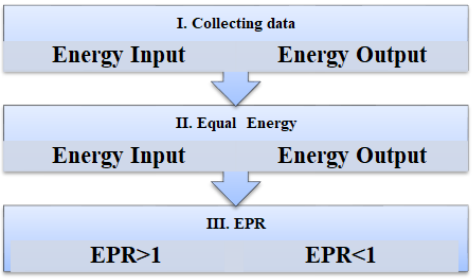

Figure 1. Research steps: collecting data, equal energy quantity and EPR calculation

3. Results and Discussion

Energy input which consists of equal energy from palm kernel prices, electrical energy requirements in the processing and equal energy from the equipment depreciation. For energy output is extracted from equal energy selling price of palm kernel oil and the rest is shell and pulp core [9].

The following is the calculation of equal energy input and output at the palm kernel processing plant: The following data is used to find equal energy input with working time per year 300 days.

Table 1. The information on energy input in producing Palm Kernel Oil

No	The input resource	The Price or Energy Used
1	Price of palm kernel 120.000 tons	Rp, 487,920,000,000
2	Annual electricity usage	14,400,000 kWh
3	Depreciation of equipment	Rp, 765,400,348

The raw material of palm kernel that enter annually 120,000 tons, and the investment cost of factory is Rp. 64,958,402,381. The data from Table 1 to obtain the price of each of the input then was

calculated for equal energy by dividing the price of each input with the energy base of 1 liter diesel (42.96 MJ/kg) [8].

- Equal energy from palm kernel is for total 120.000 ton per year:

$$Energy = \frac{\text{Rp. } 487.920.000.000}{\text{Rp. } 5650} x\ 42.96\ MJ/kg$$
$$Energy = 3{,}709{,}919{,}150{,}442\ MJ/kg$$
$$Energy = 3{,}709{,}919{,}150{,}442\ MJ/ton$$

- Electrical energy used per year:

14,400,000 kWh x 3.6 MJ = 51,840,000 MJ

- Equal energy from depreciation:

$$Energy = \frac{\text{Rp. } 765400348}{\text{Rp. } 5650} x\ 42.96\ MJ/kg$$
$$Energy = 5{,}819{,}752{,}026.5628\ MJ/ton$$

Table 2. The equal energy input in producing Palm Kernel Oil

No	The input resource	The Equal Energy (MJ/Year)
1	Energy of palm kernel	3,709,919,150,442
2	Annual electricity usage	51,840,000
3	Depreciation of equipment	5,819,752,026
	Total	3,715,790,742,468

From the above calculation the total input energy equal to 3,715,790,742,468.9 MJ/ year. The following data is used to find equal energy output. The raw material of palm kernel seeds per year is 120000 tons with the percent of palm kernel oil yield 43% is 51600 tons. The palm kernel shell is 68400 tons. The kernel pulp is used as fertilizer in self-plantation.

Table 3. The information on energy output in producing Palm Kernel Oil

No	The output resource	The Price
1	Palm kernel oil (51600 tons)	Rp 604,088,424,000
2	Palm kernel shell (68400 tons)	Rp95,760,000,000

The output energy data obtained is continued by calculating equal energy. The basis for determining equal energy is from the energy price of 1 liter of diesel oil.

The energy produced by palm kernel oil is:

$$Energy = \frac{604088424000}{5650} x\ 42{,}96\ MJ/kg$$
$$Energy = 4{,}593{,}210{,}388.5026\ MJ/kg$$
$$Energy = 4{,}593{,}210{,}388.502{,}6\ \ MJ/ton$$

The energy generated by palm kernel shell is:

$$Energy = \frac{95{,}760{,}000{,}000}{5650} x\ 42.96\ MJ/kg$$
$$Energy = 728{,}114{,}973{,}45132\ MJ/kg$$
$$Energy = 728{,}114{,}973{,}451.32\ MJ/ton$$

Table 4, The equal energy output in producing Palm Kernel Oil

No	The output resource	The Equal Energy (MJ/Year)
1	Energy of palm kernel	4,593,210,388,502.6
2	Energy of palm kernel shell	728,114,973,451.32
	Total	5,321,325,361,953.9

From the above calculation results obtained the total output energy equal to 5,321,325,361,953.9 MJ / ton,

Once in can equalize the input and output energy, the next will be calculating the EPR (Energy Productivity Ratio),

$$EPR=\frac{Output\ product}{(Input-by\ product)}$$

$$EPR=\frac{4,593,210,388,502.6}{(3,715,790,742,468.9-728,114,973,451.32)}$$

$$EPR=\frac{4,593,210,388,502.6}{2,987,675,769,017.5}$$

$$EPR=1.54$$

Energy value productivity ratio obtained from the calculation > 1, This indicates that the output energy requirement is greater than the input in the PT-X plant, In accordance with theory then EPR indicates that this factory provides benefits to the company, From the results of calculations performed, it obtained the EPR value of 1,54, The results of this EPR value included in the low EPR category is due to the use of electricity input energy during the process of inefficient processing, which amounted to 51,84 million MJ / ton per year, However, improved EPR can be performed even better by increasing the efficiency of the use of electricity needs in the processing, In addition, by calculating the pulp from the palm kernel as a fertilizer with a certain sale value as output energy of side product was ignored in this calculation, because it is used as fertilizer by the company itself, This study can be concluded that the processing of palm kernel PT-X into palm kernel oil meets the feasibility of production and can provide benefits to the company,

4, Conclusions

The value of EPR obtained is 1.54, These results indicate that the processing of palm kernel PT-X into palm kernel oil is still feasible to operate, This indicates that the value of EPR is higher than 1 that can still provide benefits to the company, In the processing of palm kernel into palm kernel oil, electrical energy consumption is still less efficient, The value of the pulp from the rest of the palm kernel is still negligible in the value of its output energy equivalent,

Acknowledgment

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