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Study on Energy Productivity Ratio (EPR) on Pre-Factory Design of Glucose Syrup at Riau Indonesia

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Abstract. The aim of this investigation is to determine the performance of productivity and feasibility of the operation of glucose syrup plant based on Energy Productivity Ratio (EPR). EPR is expressed as the ratio of output to input energy and by-product. Glucose syrup plant is to process dregs of sago to become glucose product. The procedure starts from collecting data needed as input energy such as: dregs of sago prices, energy demand and the depreciation of the factory. The output energy and its by-product comprise the whole production process such as: glucose syrup price and the remaining product calcium chloride. Calculation the equal energy of glucose syrup is to analyze the value of Energy Productivity Ratio (R) based on processing capacity per year, the value of EPR was 2,19 and 4,47 (EPR > 1), which indicated that the processing dregs of sago to glucose syrup is reasonable to be operated based on the energy productivity.

1. Introduction

Glucose syrup is sweetener for food and drink, with no smelt, colorless but has high sweetness and better than other artificial sweetener. Glucose syrup could be generated from starches through hydrolysis of polysaccharides or disaccharide, using acid or enzyme. Generally Glucose syrup is used in the industry of food and drink, especially in industry of candy, jam and fruit cans [1].

Indonesia has produced a lot of glucose syrup. However, the development of food industry and pharmacy also increasingly fast, so it will need a lot of glucose which affect the production of glucose syrup. The increasing need of glucose syrup is not equal with the production of glucose syrup. To fulfill the needs for glucose syrup, the government still imports glucose syrup in large scale from various countries in the world, as seen in Table 1 [2].

Table 1. Import of Glucose Syrup in Indonesia

Year	Import (Kg)	Year Import (Kg)
2007	19.255.786	10.444.137
2008	22.084.916	14.495.464
2009	21.493.293	12.604.448
2010	18.172.955	14.867.472
2011	21.360.492	15.052.777

Import of glucose syrup in Indonesia for the following years, can be predicted with regression analysis of the data from Table 1, in order to estimate production capacity that factory will established. Results of the analysis could be seen in Table 2.

Table 2. Estimation of Glucose Syrup Import in Indonesia Using Regression Analysis

Year	Import (Kg)
2018	20.741.194
2019	20.770.940
2020	20.800.685
2021	20.830.430
2022	20.860.175

Based from the potential of establishment of factories glucose syrup is still high then it is required to calculate the energy productivity ratio (EPR). The energy efficiency is commonly defined by the ratio between outputs in physical units converted to energy and information on the energy input content [3,4]. EPR is used as indicator for analyzing the performance and productivity of the processing glucose syrup that will be established in Riau, Indonesia, especially in the usage of electricity that resulted on minimizing production cost and improving profit of the company.

The purpose of this paper is to give information to improve analysis of performance, productivity and feasibility operation based on energy productivity ratio in pre-factory design of glucose syrup at Riau, Indonesia.

2. Methodology

In conducting the required data has been collected, searching for equal energy of dregs sago and glucose syrup in calculating the value of energy productivity ratio (EPR) based on ton/year. The EPR of a product can be defined as the ratio of primary product energy plus its by-product energy compared to the total energy of raw materials, electricity-power and other energy used and the processing tool depreciation. The calculation is based on the production capacity per year [4,5].

Ratio energy from ingredients biofuel can be applied as ratio of non-renewable energy that be used on the value of energy production from fuel and some utility product side, if energy output : energy input is bigger than one (EPR> 1) then the production of the renewable fuel or a product could be continued but if the ratio energy is smaller than one (EPR< 1) then production of the product resulted in net loss, and declared as not defined source of renewable energy or the product [6].

To calculate EPR, the equations that be used are [4,5,7]

$$\mathbf{EPR} = \frac{Q_{out}}{Q_{in}} \quad (1)$$

$$\mathbf{EPR} = \frac{Q_{out}}{Q_{in} - Q_{out\,(side\ product)}} \quad (2)$$

For based price of 1 liter diesel is Rp. 8000 (Pertamina cost) with equal energy is 42.96 MJ/kg [8,9].

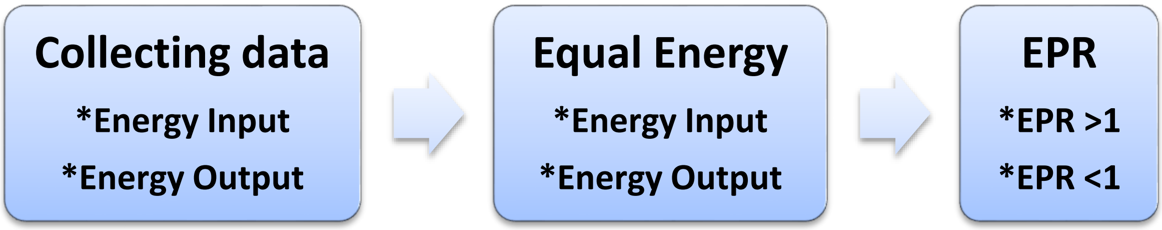

Figure 1. Investigation steps: collecting data, equal energy quantity and EPR calculation [5,7]

3. Results and Discussion

To calculate EPR, it is needed the equal energy input and output data. Equal energy was counted based on 1 liter of biofuel energy at Rp.8000 (Pertamina cost) with 42.96 MJ/ kg energy [8,9]. Input energy is consisted of equal energy dregs of sago, electricity energy and equal energy from equipment depreciation. Mean while in output energy consisted of equal energy of glucose and calcium chloride. Following is the calculation of equal energy input and output at pre-factory glucose syrup processing:
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3.1 Input Energy

Following is the data used in calculating the equal input energy:

- Working time per yearis 330 days
- Raw material dregs sago that be used per year is 24.122 ton
- Priceof ingredients raw and utilities per year is Rp. 119.415.236.040
- Fixed investation is Rp. 81.453.745.222
- Maintainance and marketing is Rp. 19.902.539.340
- Other Variables is Rp. 995.126.967

After finding price of input then next is to calculate equal energy by dividing each price of input with an energy base from 1 liter of diesel.

- Equal energy from raw material and utilities:

  $$\text{Energy} = \frac{119.415.236.040}{8000} \text{ x } 42{,}96 \text{ MJ/kg}$$

  Energy= 14.926.904,5 MJ/kg

  Energy = 14.926.904.500 MJ/ton
- Equal energy from fixed investation

  $$\text{Energy} = \frac{81.453.745.222}{8000} \text{ x } 42{,}96 \text{ MJ/kg}$$

  Energy = 437.406.611.842 MJ/ton
- Equal energy from maintainance and marketing

  $$\text{Energy} = \frac{19.902.539.340}{8000} \text{ x } 42{,}96 \text{ MJ/kg}$$

  Energy =109.346.453.673 MJ/ton
- Equal energy from the other variable

  $$\text{Energy} = \frac{995.126.967}{8000} \text{ x } 42{,}96 \text{ MJ/kg}$$

  Energy = 124.390.870 MJ/ton

Table 3. Input Energy of Producing Glucose Syrup

Types of Input Energy	**Equal of Input Energy (MJ/ton)**
Energy Raw material and utilites	14.926.904.500
Energy from Fixed Investation	437.406.611.842
Energy of Maintainance and Markting	109.346.453.673
Energy of Other Variables	124.390.870
Total	561.822.360.886

From the calculation result above it is obtained that equal total input energy equal to 561.822.360.886 MJ/ton (Table 3).

3.2 Output Energy

The data is then used to calculate equal output energy:

- Glucose Syrup that be produced per year is 21.000 ton
- Calcium Chloride that be produced per year is 15.683 ton
- Priceof Glucose Syrup sale per year is Rp. 229.090.946.721
- Priceof Calcium Chloride sale per year is Rp. 52.142.469.598

After finding each price from output then next is to calculate equal energy by deviding price of each output with the energy base from 1 liter of diesel.

- The energy generated by the glucose syrup:

  $$\text{Energy} = \frac{229.090.946.721}{8000} \times 42{,}96 \text{ MJ/kg}$$

  Energy = 1.230.218.383.890 MJ/ton
- Energy generated by Calcium Chloride:

  $$\text{Energy} = \frac{52.142.469.598}{8000} \times 42{,}96 \text{ MJ/kg}$$

  Energy =280.005.061.740 MJ/ton

Table 4. Output Energy of Producing Glucose Syrup

Types of Output Energy	**Equal of Output Energy(MJ/ton)**
GlucoseSyrupEnergy	1.230.218.383.890
CalciumChloride Energy	280.005.061.740
Total	1.510.223.445.633

From the calculation result above it is obtained equal that total input energy equal to 1.510.223.445.633 MJ/ton (Table 4).

Having obtained equal input and output energy, then will calculate EPR (energy productivity ratio) to input and EPR to input – by product:

$$\text{EPR} = \frac{\text{Output Product}}{\text{Input}}$$

$$\text{EPR} = \frac{1.230.218.383.890}{561.822.360.886}$$

EPR = 2,19

$$\text{EPR} = \frac{\text{Output Product}}{\text{Input} - \text{by product}}$$

$$\text{EPR} = \frac{1.230.218.383.890}{561.822.360.886 - 280.005.061.740}$$

EPR = 4,47

Based on the theory, the value of EPR that be obtained already corresponding with theory in which the value of EPR > 1 can be concluded that pre design factory processing glucose syrup in Riau, Indonesia is feasible to be operated because it gives profit to th ecompany.

4. Conclusions

The value result of energy productivity ratio (EPR) in this study is > than 1. Base on input to input and input to output plus by product the EPR was 2,19 and 4,47 respectively. Base on the value of the EPRs show that processing glucose syrup in this pre-factory design is feasible to be operated because it gives profit to company.

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