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

B Haryanto, H Harahap, R Tambun, R Hasibuan, P Suherman, Kelvin, D Haryanto, J Wijaya
Department of Chemical Engineering, Engineering Faculty, Universitas Sumatera Utara, Jalan Dr. T. Mansur No. 9, Padang Bulan, Medan, Indonesia
E-mail: bode.haryanto@usu.ac.id

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].

| 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 in 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]

$$\text{EPR} = \frac{Q_{\text{out}}}{Q_{\text{in}}}$$  \hspace{1cm} (1)

$$\text{EPR} = \frac{Q_{\text{out}}}{Q_{\text{in}} - Q_{\text{out}} \text{ (side product)}}$$  \hspace{1cm} (2)

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

3.1 Input Energy

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

- Working time per year is 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 investment 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:
  \[
  \text{Energy} = \frac{119.415.236.040}{8000} \times 42.96 \text{ MJ/kg} \\
  \text{Energy} = 14.926.904.5 \text{ MJ/kg} \\
  \text{Energy} = 14.926.904.500 \text{ MJ/ton}
  \]

- Equal energy from fixed investment
  \[
  \text{Energy} = \frac{81.453.745.222}{8000} \times 42.96 \text{ MJ/kg} \\
  \text{Energy} = 437.406.611.842 \text{ MJ/ton}
  \]

- Equal energy from maintainance and marketing
  \[
  \text{Energy} = \frac{19.902.539.340}{8000} \times 42.96 \text{ MJ/kg} \\
  \text{Energy} = 109.346.453.673 \text{ MJ/ton}
  \]

- Equal energy from the other variable
  \[
  \text{Energy} = \frac{995.126.967}{8000} \times 42.96 \text{ MJ/kg} \\
  \text{Energy} = 124.390.870 \text{ MJ/ton}
  \]
Table 3. Input Energy of Producing Glucose Syrup

| Types of Input Energy                          | Equal of Input Energy (MJ/ton) |
|------------------------------------------------|-------------------------------|
| Energy Raw material and utilities              | 14.926.904.500                |
| Energy from Fixed Investation                  | 437.406.611.842               |
| Energy of Maintainance and Marketing           | 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
- Price of Glucose Syrup sale per year is Rp. 229,090,946.721
- Price of 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 dividing price of each output with the energy base from 1 liter of diesel.
- The energy generated by the glucose syrup:
  \[ \text{Energy} = \frac{229,090,946.721}{8000} \times 42.96 \text{ MJ/kg} \]
  \[ \text{Energy} = 1,230,218,383.890 \text{ MJ/ton} \]
- Energy generated by Calcium Chloride:
  \[ \text{Energy} = \frac{52,142,469.598}{8000} \times 42.96 \text{ MJ/kg} \]
  \[ \text{Energy} = 280,005,061.740 \text{ MJ/ton} \]

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:

\[ \text{EPR} = \frac{\text{Output Product}}{\text{Input}} \]

\[ \text{EPR} = \frac{1,230,218,383.890}{561,822,360.886} \]

\[ \text{EPR} = 2.19 \]
EPR = \frac{\text{Output Product}}{\text{Input-by product}}

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 the company.

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.

ACKNOWLEDGMENT
The authors wish to express sincere gratitude to Professor Robison Tarigan to help and for providing comments on this manuscript.

References
[1] Yusrin Y, Ana Hidayati and Mukaromah M, 2010 Proses Hidrolisis Onggok dengan Variasi Asam pada Pembuatan Ethanol. Prosiding Seminar Nasional UNIMUS p 20
[2] Kemenperin, 2012 Data Statistik Ketahanan Pangan Perdagangan Luar Negeri Impor Indonesia. Biro Pusat Statistik. access on November 15 2017
[3] Blancard Stephand and Elsa Martin, 2012 Energi Efficiency Measurement In Agriculture With Imprecise Energy Content Information. UMR 1041 INRA-AGROSUP.
[4] Haryanto B, 2000 Studi Neraca Energi Pembuatan Biodiesel dari Minyak Sawit. Magister Thesis ITB Bandung Indonesia
[5] Haryanto B, Rina Br. B, Situmeang EM, Christina EP, and Pandiangan F, 2018 Study on Energi Productivity Rasio (EPR) at Palm Kernel Oil Processing Factory: Case Study on PT-X at Sumatera Utara Plantation. IOP Conference Series Materials Science and Engineering vol 309 (1) 012043
[6] Batchelor Sheila E, Elaine J Booth and Kerr C Walker, 1995 Energy Analysis of Rape Methyl Rester (RME) Production from Winter Oilseed Rape. Industrial Crops and Products an International Journal vol 3 (4) p 193
[7] B Haryanto, E B B Tarigan, Rina Br. B, JI Tarigan and P Ginting, 2018 Utilization of The Sand from Mount Sinabung Eruption as Material for Planting Media. Proceeding Series, Advances in Economics, Business and Management Research vol 46 p 105
[8] Pertamina, 2018 Harga Bahan Bakar Minyak Access on June 6 2018
[9] Daniel Felten, Norbert Froba, Jerome Fries and Christoph Emmerling, 2013 Energy Balances and Greenhouse Gas-Mitigation Potentials of Bioenergy Cropping Systems (Miscanthus, Rapeseed and maize) Based on farming Conditions in Western Germany. Renewable Energy vol 55 p160