Engineering and Technology Challenges of The Energy Usage: An Estimation for Agro-Industrial In Indonesia

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Engineering and Technology Challenges of The Energy Usage: An Estimation for Agro-Industrial In Indonesia

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Abstract. Agro industry is one of strategic industry that supported by a potencial resources from agriculture, fisheries/marine, livestock, farm, and forestry sectors. Energy supply with affordable prices are factors of the agro industry sustainability. The purpose of this study is to ensure the availability of energy in the agriculture industries, the pulp & paper industries, the sugar industries from sugar cane, and the fish canning industries. The stages consist of identifying the needs and availability of raw materials, energy, and formulating the recommendations. A literature study from relevant sources and analysis of efficiency of energy is used to improve the industry competitiveness by using Net Energy Ratio (NER) calculation. Around 38% of the agro industries energy needs are from by-product's biomass. Biomass fuels that usually using by agro industries are palm shells, wood chips, bagasse, black liquor, or depending on the by-products. Aggregately, agro industries energy needs (2017) amounted to 15,711 million TOE. Based on the capacity, the final energy needs of selected agro industries amounted to 25,818 millions TOE that equivalent to 11% from the national final energy demand of 238.8 millions TOE and 30% of the final industrial sector energy needs of 87 millions TOE in 2025.

1. Introduction

The Agro industry is a strategic industry and it is supported by potential resources from farming, fishery/marine, cattle, plantation and forestry. The contribution of the Agro industry toward the PDB of non-oil and gas industry in 2016 is as much as 46.95%, which is the highest compared to other processing industries. The government, the ministry of industry in this case, has responsibility to improve the contribution and growth of the non-oil and gas manufacturing industry for the growth of national economy.

According to the data of Directorate General of Renewable New Energy and Energy Conservation, which is part of the Ministry of Energy and Mineral Resources (ESDM), in the last few years, the growth of the consumption of energy in Indonesia has reached 7% per year. This number is above the growth of the world energy consumption, which is 2.6% per year. The industry sector plays a big part on the high growth, with on average 2.7% increase of energy necessity per year, between 2011-2035. With the demand of energy consumption increasing each year for Industry sector in Indonesia, the number which was 39% in 2010 is projected will jump to 44% by 2030 [1].

In relation to this matter, to push the growth of national economy, the Agro industry is needed to be supported of its growth and roles. For the continuation, it needs to have a form of guarantee for enough supply of raw materials and energy. Some of the strategic Agro industry, such as palm oil, pulp & paper, sugar cane, and canned fish, is expected to be improved of its work and process, in relation with the huge potential of Indonesia natural resources and its potential on the national and global market.

However, it is also needed to be understood that along with the growth of the industry sector, it is also necessary for the improvement of resources and energy. In relation with this increase, a full attention on the availability of the resources and energy in affordable prices is required. One of the supports, aside from guaranteeing the availability and prices, is to have the capacity and productivity according to the necessity and quality of an internationally standard product.

The purpose of this activity is to make sure that the availability of energy for agro industry, for the likes of palm oil, pulp & paper, sugar cane, and canned fish. The activities, in details, are as following: 1) To identify the necessity and availability of real energy in Agro industry sector; 2) To identify the challenges related with the fulfillment of the energy necessity in the Agro industry sector.

Hopefully, the result of this identification can be useful to increase the competitiveness of this country's industry, whether it is for facing the intensified global market and of course the local as well.

2. Methodology

In conducting this research, the method of mass and energy balance modelling was used in 3 stages, which are: (1) Stage of identification of necessity and availability of energy, and (2) Stage of formulating the recommendation, in order to face energy fulfillment in relation to the challenges in the Agro industy sector.

Identification stage was done with literature study and data-information gathering from reliable sources. The model of mass and energy balance of the agro industry process was gained through the identification compartment that is related with the production process, the equation of mass balance to determine the input of raw material and supporting matter, as well as the output in form of products and side result between compartment. The balance of mass and energy model is an illustration of the flow of mass and energy in the process of Agro industry. The modeling of the balance of mass and energy uses approach of linier counting based on available data. The approach itself was used to find the critical factor and optimal solution of a relevant mass output with using quantitative model to support decision making. The modeling will result on the ratio (coefficient efficiency) and static variable by using the principality of linear equation.

The analysis stage was done with the approach of the efficiency analysis of the materials and energy to improve its competitiveness. If the produced energy is bigger or equal with the factory necessity, then the factory has the potential for a self-sustaining and efficient energy. The energy efficiency based on the energy is calculated using Net Energy Ratio (NER) [2]. The next stage was the formulation of the recommendation to face the challenges related with the fulfilment of the energy necessity in the Agro industry sector. This was done with expectation that the result of this identification could be useful to increase the competitiveness of the local industry, whether to face the intensifying global trade and of course to fulfill the local demand. The formulation of the recommendation involves aspects of necessity and availability of the Agro industry energy in order to guarantee the supply of the energy resources in competitive prices.

a. Balance of Energy Value

1) The fuel from many sources have different calorie number. The calculation of the amount of the proportion of each component used weight average.

$$Weight\ average = \frac{\sum_i (CVi\ x\ Quantityi)}{\sum_i (Quantityi)} \qquad \begin{array}{c} \boldsymbol{CV{:}Calorific\ Value\ (e.g.\frac{kJ}{m3})} \\ \boldsymbol{Quantity{:}Physical\ quantity\ (e.g.m3)} \end{array}$$

2) The Percentage of the Energy Necessity per Production [4]

$$\text{Energy Necessity (\%)} = \frac{\boldsymbol{Fuel\ Energy\ (J)}}{\boldsymbol{Total\ Energy\ (J)}} \text{ x } 100$$

3) Fuel Energy [5]

Fuel Energy (J) = ∑BBi (one unit) x FKi (J/one unit)
BB = Volume or mass of the fuel being used (per one unit)
FK = Fuel conversion factor (J/per one unit)

b. Energy Conversion Factor
Conversion factor is used to convert the quantity of the fuel between natural unit (mass or volume) with the energy unit (energy content). The energy conversion factor that was used for the calculation of this research can be seen on Table 1.

The first step to make the mass balance model was to identify the compartment process of the Agro industry production. The equation of mass equilibrium is to determine the input of raw material and additional material, as well as the output between compartments. The equilibrium model was developed into two stages, which is the simple model and complex one. The simple model was built with assumption that the production system of Agro industry is a single compartment made of input and output in the form of product and co-product. The complex model was built according to the stages of the production process of the Agro industry.

Tabel 1. Energy Conversion[6]

Fuel	Unit	Value
Diesel	MJ/L	35.9
Diesel	MJ/kg	42.9
Coal	MJ/m^3	34,797.30
Coal	MJ/kg	25.75
LPG	MJ/L	24.5
LPG	MJ/kg	46
Natural Gas	MJ/m^3	35.14
Natural Gas	MJ/kg	45.75
Electricity	MJ/kWh	3.6
Biomass	MJ/ton	7,500
Steam	MJ/ton	2,700

The mass equilibrium of the Agro industry production model is gained through compartment identification and the equation of mass equilibrium, which is to determine the input of the raw material and additional material, along with the output between compartment. Simple model assumed that all steps in the process is done in one compartment (Figure 1).

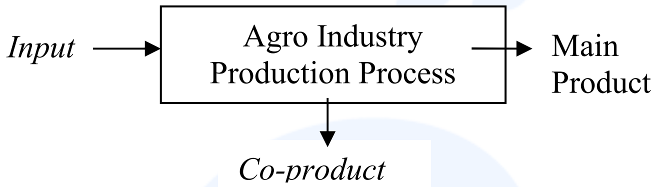

Figure 1. Simple mass equilibrium model[7]

The mass equilibrium would be achieved if the input is the same as the output (product and co-product). The process efficiency was expected to be close to 100%, where all the raw material content is the component of the product that can be converted into renewable-reusable product. The general equation of mass equilibrium with assumption that the side result is waste that can be repurposed:

$$\text{Input (I)} = \text{Product (P)} + \text{Side Result (C)}$$ [8]

The modelling of mass and energy equilibrium using linear calculation approach based on available data.

$E_n = n \times CV$

Where:

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En = Energy
n = Inventory Volume
CV = Calorific Value (energy conversion value)

National Energy Necerssity
1. Energy necessity per ton product (J):

$$ENP\left(\frac{J}{ton}\right) = \frac{Total\ energy\ production\ in\ industry\ (J)}{Total\ Production\ in\ Industry\ (ton)}$$

ENP = necessity per ton product (J/ton)
Total energy production in industry (J)
Total Production in Industry (ton)

2. National Energy Necerssity:
NEN (J) = TNP (ton) x ENP (J/ton)
NEN = National Energy Necerssity (J)
TNP = Total National Production (ton)
ENP = Energy necessity per ton product (J/ton)

3. Result

a. Energy Provision

Industry sector is predicted to be still dominating in the matter of final energy consumption. Indonesia is currently growing to be a developed country, which is indicated with the dominance of the industrial sector in supporting its economic activities. According to the BPPT at Outlook Energi Indonesia 2017, the segment of industrial sector final energy necessity would increase from 29% in 2015 into 43% (basic scenario) or 44% (high scenario) in 2050. The final energy consumption based on type for 2010-2015 was still dominated by Oil type fuel (gasoline, solar, diesel oil, kerosene, burning oil, avtur and avgas) reaching 25%, followed by natural gas (11%), electricity (11%), coal (6.2%) and LPG (4.8%).

1. The necessity for Agro industry energy

In general, the necessity of Agro industry energy is calculated by multiplying the number of productions with the necessity of energy in each Agro industry. The national production is based on the number of national production and installed capacity in 2015. The national production and installed capacity data were acquired from the Ministry of Industry. The calculated necessity for energy is direct energy.

2. The energy necessity based on the source

In this resulted, around 38% of the Agro industry energy necessity comes from biomass, which is produced by co-product of the Agro industry production. The biomass fuel that is used, such as palm oil shell, wood chip, sugar cane pulp, black liquor, all depends on the co-product of the Agro industry. The details of the Agro industry energy based on the energy source can be seen on Table 2. The energy consumption according to the fuel type in Agro industry is shown on Figure 2.

Table 2. The necessity of Agro industry energy based on the energy source

No	Fuel Type	Energy Necessity (one unit)			
		National Production		Installed Capacity	
		(One Unit Fuel)	(TJ)	(One Unit Fuel)	(TJ)
1	Solar (liter)	51,296,726.1	1,841.6	76,078,380.1	2,675.9
2	Natural Gas (m^3)	4,303,229,800.2	151,215.5	8,300,701,592.0	291,686.6
3	Electricity (GWh)	7,242.1	26,071.6	13,862.1	49,903.7
4	Coal (m^3)	9,387,536.0	199,485.1	14,981,452.7	318,355.8
5	Biomass		276,006.0		413,117.9
	Total		654,619.8		1,075,739.90

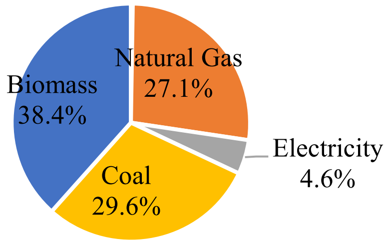

Figure 2. Energy consumption based on the energy type

The national production energy consumption and Agro industry installed capacity were chosen based on the type of fuel as shown on Table 3. The percentage of the chosen energy consumption of the Agro industry installed capacity toward the projection of availability of the national energy in 2025 is shown on Figure 3.

Table 3. Agro Industry Energy Consumption

No	Fuel Type	Energy Necessity (million TOE) National Production	Energy Necessity (million TOE) Installed Capacity	Energy Availability*) (million TOE)
1	Solar	0.044	0.064	110 **)
2	Natural Gas	3.629	7.0	62
3	Electricity	7.2 TWh	13.9 TWh	579 TWh
4	Coal	4.788	7.641	105
5	Biomass	6.624	9.915	52
Total (million TOE)		15.711	25.818	

*) Projection for 2020 [9]
**) Availability of fuel energy

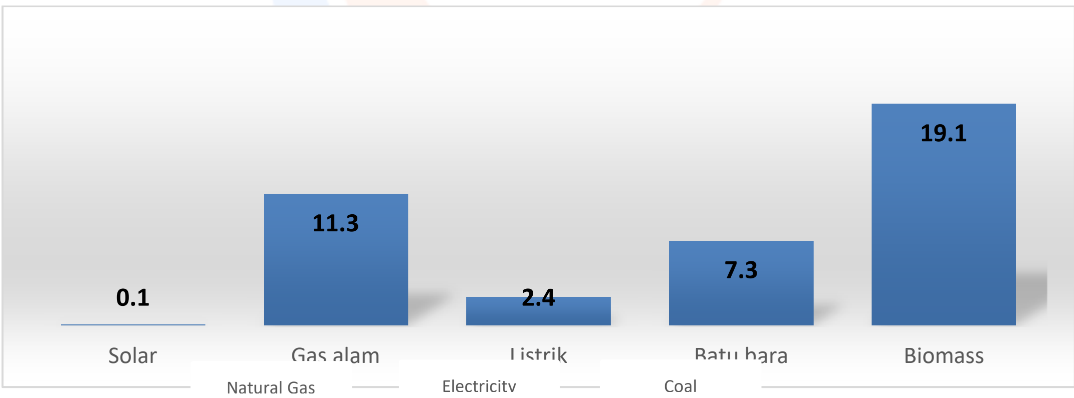

Figure 3. Percentage of the consumption of chosen agro industry installed capacity energy

The necessity of the chosen Agro industry energy for national production (2017) was as much as 15,711 million TOE. Based on the installed capacity. The necessity of chosen Agro industry final energy is as much as 25,818 million TOE, which is equal to 11% of the projected national energy necessity, which itself is 238.8 million TOE and 30% of the industry sector final energy necessity, equaling to 87 million TOE, in the year 2025. The necessity of Agro industry energy for national production without biomass was as much as 9 million TOE or 4.6% of the primary energy without biomass provision in 2015, equally as 195 million TOE. The installed capacity of chosen Agro industry energy without biomass necessity is as much as 16 million TOE, which is 4.8% of the projected energy availability in 2025, or equal as much as 332 million TOE.

3. Total Necessity of Agro Industry Energy

Aggregately, the energy necessity for industry is shown in the table as follow:

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Table 4. Energy necessity per ton of the chosen Agro industry product

No	Product	National Energy Necerssity (ton)	Industry installed capacity of energy necessity (TJ)	Energy Necessity: Solar		Natural Gas		Fuel		Electricity		Coal		Biomass	
				Kilo liter	TJ	m3	TJ	ton	TJ	GWh	TJ	m3	TJ	m3	TJ
1	Biodiesel	30,060,000	74,583.2	0.0	0.0	0.0	0.0	0.0	0.0	1,328.6	4,782.8	0.0	0	4,905,158.7	69,800.4
2	Pulp	11,049,000	407,577.3	34,971.3	1,255.5	530,758,431.8	18,650.9	22,787,678.6	265,476.5	0.0	0.0	5,750,330.1	122,194.5	0	0
3	Paper	23,162,275	376,523.4	21,716.1	779.6	6,510,329,212.5	228,773.0	0.0	0.0	5,994.6	21,580.7	5,900,711.5	125,390.1	0	0
4	Edible Oil and Margarine	26,000,000	58,426.1	2,347.8	84.2	0.0	0.0	0.0	0.0	2,837.6	10,215.2	2,264,780.9	48,126.6	0	0
5	Coffee Powder	238,702.5	500.8	231.9	8.3	10,142,142.1	356.4	0.0	0.0	37.8	136.1	0.0	0.0	0	0
6	Coffee Mix	63,452.6	1,170.7	278.5	10.0	8,504,436.9	298.8	86,504.3	648.8	59.2	213.1	0.0	0.0	0	0
7	Cocoa	891,124	4,231.2	0.0	0.0	79,229,779.1	2,784.1	0.0	0.0	401.9	1,447.0	0.0	0.0	0	0
8	Milk Powder	6,279,433	45,647.0	5,465.7	196.2	1,064,574,689.7	37,409.2	0.0	0.0	2,233.8	8,041.7	0.0	0.0	0	0
9	White Crystal Sugar	3,000,000	77,247.5	1,539.9	55.3	0.000	0.000	10,292,294.7	77,192.2	0.0	0.0	0.0	0.0	0	0
10	Refined Sugar	5,016,000	24,081.5	1,993.6	71.6	0.0	0.0	0.0	0.0	379.3	1,365.3	1,065,630.3	22,644.6	0	0
11	Animal feed	24,000,000	5,806.6	7,533.6	270.5	97,162,899.9	3,414.3	0.0	0.0	589.4	2,121.8	0.0	0.0	0	0
	Total		1,075,795.2	76,078.4	2,731.2	8,300,701,592.0	291,686.6	33,166,477.7	343,317.5	13,862.1	49,903.7	14,981,452.7	318,355.9	4,905,158.7	69,800.4

4. Conclusion

Based on the total energy that is needed, there for the processing of biodiesel took 2.5 GJ energy per ton biodiesel. The energy necessity for processing cooking oil and margarine is 2.25 GJ per ton cooking oil or margarine. The energy necessity on the pulp processing is 36.9 GJ per ton pulp, meanwhile in the paper processing factory, it is 16.3 GJ/ton. The total energy use for the whole process in coffee processing factory is 18.5 GJ/ton coffee mix. As for powdered coffee processing industry, it needs energy as much as 2.1 GJ/ton powdered coffee. The energy necessity per ton product for the cacao processing industry is as much as 4,748.1 MJ/ton cacao powder. The energy necessity in the processing of powdered milk is 7.3 GJ per ton powdered milk. The energy necessity per ton product of rock sugar processing is as much as 25.8 GJ. The energy necessity per ton product that is produced in the processing of the granulated sugar is as much as 4.8 GJ/ton of granulated sugar. Based on the total of weft production that is produced at the cattle weft processing and the total energy that is used at the cattle weft factory, then it can be obtained the energy necessity per ton cattle weft product, which is as big as 241.9 MJ/ton cattle weft. Aggregately, the energy necessity of the selected Agro industry as much as (2017) 15,711 million TOE. Based on the installed capacity, the final energy necessity of the selected Agro industry is as big as 25,818 million TOE, equal to 11% of the projected nationally final necessity energy as much as 238.8 million TOE and 30% of the final energy necessity of the industry sector as much as 87 million TOE in 2025.

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