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Biodisel Production Cost Assessment from Different Palm Oil Raw Material as Feedstock

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Abstract
Biodiesel production system in Indonesia shows its volatility as Indicated by the fact that some biodiesel industries ceased their production activities because unreasonable high production costs due to the fluctuating selling price. The purpose of this study was to analyze and get the production cost to obtain the selling price policy based approach in biodiesel production system. Production cost structure is determined from various raw materials and the process technology used. The raw material specifications vary from different palm oil based products with different free fatty acids (FFA) that could be produced as biodiesel. There are CPO and refined oil. Grand InzioTechnology is one of the established technology chosen because of it's ability to process all raw materials with various FFA content. According to the cost analysis, it shows that variable costs contribute higher component that constitutes the production costs. According to the production costs without considering the raw material price, the biodiesel production cost from CPO is Rp1,115 per liter, RBDPO Rp 963 per liter, RBD olein Rp 965 per liter, RBD stearin Rp 950 per liter and PFAD Rp 1.130 per liter. The minimum selling price is RBD PFAD by Rp 9.414 per liter.
Keywords: Palm Oil, Production Cost, Biodiesel, Selling Price

1. Introduction

Biodiesel is an environmentally friendly renewable energy source, and can reduce the fossil energy consumption of whichthe supply is predicted to decreasing. Biodiesel is mono-alkyl esters of long chain fatty acid derived from vegetable oils and animal fats (Sanjid et.al, 2013, Melero et.al, 2014) of which the specification is in accordance with ASTM D6751 and Indonesian National Standard (SNI) 7182:2012 and can used in diesel engines. Biodiesel is often also expressed as Fatty Acid Methyl Esters (FAME) or Fatty Acid Ethyl Esters (FAEE). The blending between biodiesel and diesel fuel is known as *biodiesel* fuel and the usage schemes are outlined in government policy that biodiesel consumption needs are increasingly required (Energy and Mineral Resources [ESDM]2013).

One of prospective raw materials for producing biodiesel is the feedstock derived from palm oil (Hasan et al, 2012, Paryanto et.al, 2013). This is due to the availability of palm oil which is abundant in Indonesia. Oil World published Indonesian palm oil data for October 2013 to September 2014, the production was 30 million tons, exports was 20.9 tons and used for domestic consumption was 9.15 million tons, the consumption was in the form of oleochemicals, oleofood and biodiesel (Oil World 2014). Indonesia as the largest palm oil commodity-producing country in the world has the potential to develop palm oil-based biodiesel as biofuels (renewable energy) instead of fossil fuels (Hasan et al, 2012). However, the problems of high selling price makes biodiesel production in Indonesia unatteractive. In fact, from 25 producers having biofuels (BBN) permission, 13 producers have stopped the production (ESDM, 2013). While biodiesel need is increasing due to the government policy, blendingof 10% biodiesel into diesel fuel (*biodiesel*fuel). The blendingof 10% *biodiesel fuel* reduces diesel imports equal to 3.3 million kiloliters (USD 2.43 Billion) (ESDM,2014). On the other hand, the selling price of biodiesel is determined by Mean Oil Platts Singapore (MOPS) that is the price of diesel in the Singapore market, until now the selling price of biodiesel is always higher than the price of MOPS, therefore, the selling price of biodiesel from producers cannot compete with fossil oil subsidized by the government.

The high selling price of biodiesel production costs are due to the high cost of production of biodiesel. The government currently has subsidized biodiesel, but still not able to develop biodiesel production in Indonesia so that it is necessary to determine the minimum selling price of biodiesel that can be used as a reference in the provision of incentives and other policies in determining the price of biodiesel in Indonesia.

According to these problems, this research aims to obtain biodiesel production costs based on variations in raw materials and production process technology. Biodiesel raw material considered in this study are *Crude Palm Oil* (CPO), *Refined Bleached Deodorized Palm Oil* (RBDPO), *Refined Bleached Deodorized Olein* (RBD Olein), *Refined Bleached Deodorized Palm Stearin* (RBD Stearin), and *Palm Fatty Acid Destilled* (PFAD). The production costs will be used as the basis of determining the biodiesel selling price of each raw material, so it can be determined the lowest selling price of palm oil-based biodiesel in Indonesia.

2. Method

The framework to answer each of those objectives is illustrated in Figure 1:

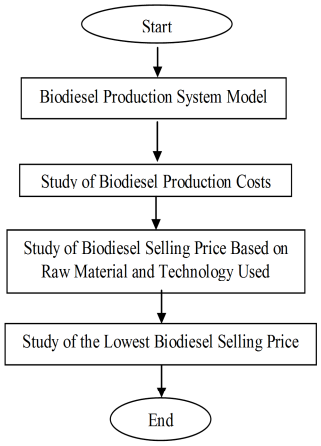

Figure 1. Research Framework

2.1 Study of Biodiesel Production Costs

This study used biodiesel production system model approach to obtain biodiesel production costs. The biodiesel production system model refers to the research results of palm oil-based biodiesel production system model (Sembiring, 2014). This system model analyzes the components of production cost of raw material variations and biodiesel production process technology. Biodiesel process technology approach used Grand Inizio technology. Biodiesel production system model according to grand inizio technology is described as follows:

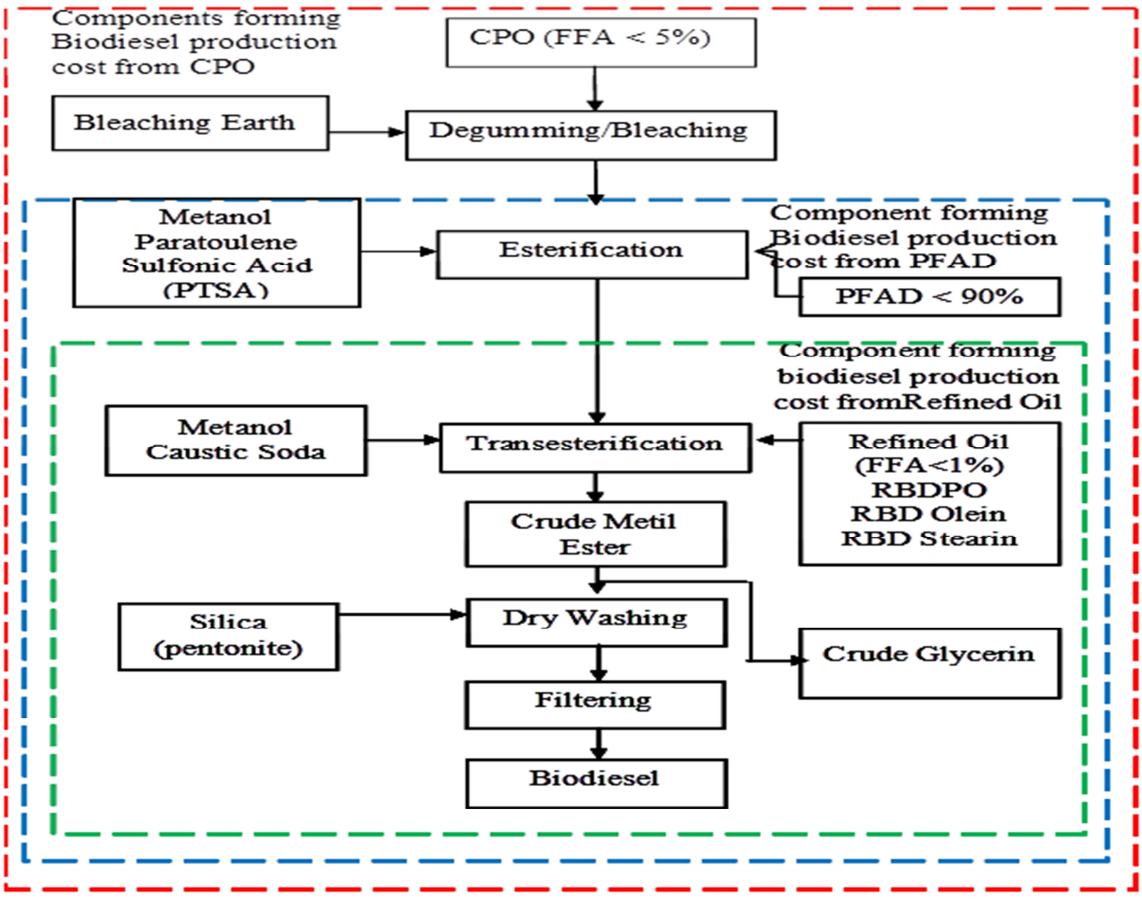

Figure 2.Model of palm oil-based biodiesel production system (Sembiring 2014)

The model of biodiesel production system in Figure 2 describes the biodiesel production process and its raw materials and production cost components requirements. CPO (FFA levels <5%) is through all the stages of the production process of Grand Inizio technology. Thus, the forming part of production cost is the price of CPO raw material coupled with the overall cost of Grand Iniziobiodiesel process. Palm Fatty Acid Distillate (PFAD) is not through the process of Degumming / Bleaching due to the absence of impurities. Based on the fact, the forming component of PFAD biodiesel production costis PFAD raw material costs plus the production process cost reduced by degumming process in the Grand Inizio technology. Refined Oil as RBDPO, RBD Olein, and RBD stearin have FFA levels <1% and do not have impurities that Refined Oil is not through the process of Degumming / Bleaching and Esterification thus the forming component of Refined Oil production cost is the cost of raw materials plus the cost of production costs reduced by Degumming and esterification process costs in Grand Inizio technology. Thus, the biodiesel production cost structure of all raw materials considered are shown ini Table 1.

Table 1 Structure to determine biodiesel price

Production Cost Components	Types of Cost	Calculation
OSBL	Maintenance costs of raw materials and products	15% of maintenance cost
ISBL	Cost of raw material	Based on the market price of palm oil
	Cost of Utility	Based on steam and electricity prices
	Cost of auxiliary materials	Based on the market price of methanol, *Paratoulene Sulfonic Acid, Caustic Soda*, Silica
Maintenance	Engine maintenance cost	2-20% of machine investment cost
Insurance	Insurance cost	1% of total investment cost
Labor	Labor cost	The amount is based on machinery and equipment as well as Regional Minimum Wage (UMR)
Public Administration		20-30% of operation labor
Depreciation		10% of machine investment cost
Marketing and Distribution		2% of total production cost
Tax		2% of total investment cost

Source: Sembiring 2014 (being published)

The need for raw materials and auxiliary materials in Grand Inizio technology is shown in the following mass balance (capacity of 1000 kg of raw material)

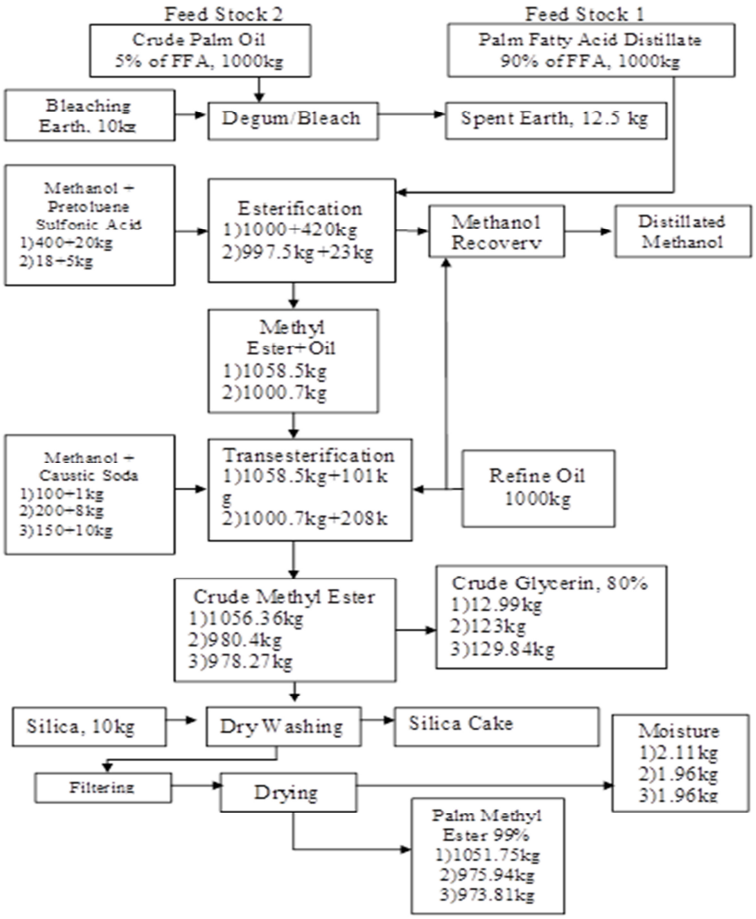

Figure 3. The mass balance of biodiesel production process technology (Grand Inizio) made from palm oil feedstock (basis of 1000 kg of raw material)

2.2 Study of Biodiesel Selling Price

The selling price of biodiesel was obtained from the total cost component of biodiesel production cost structure. The cost components included fixed cost and variable cost and profits earned from by product of biodiesel processing, that is glycerol.

The production cost was obtained based on heuristic approach calculation (Coelho et.al, 2014). The selling price of biodiesel was obtained based on production costs, 10 percent profits and 10 percent VAT of the production cost. The production cost was divided into two, namely the price of raw materials and if the process cost/ biodiesel process.

Production cost componentwas identified from previous biodiesel production process technology. The components of production costs consist of Inside Battery Limit (ISBL) cost, Outside Battery Limit (OSBL) and general cost, of which the raw material variation differences lead to differences in the flow of the production process which results in different production cost components mainly on the production cost (raw material prices, utility cost and auxiliary material cost).

The calculation of ISBL scope production cost uses heurisitic technique formulated as follows:

$$BP_i(ISBL) = \{(F_i x\ PF_i) + (Me_i\ x\ PMe) + (Cta_i\ x\ PCta_i) + (Ctb_i x\ PCtb_i) + (Ch_i\ xPCh_i) + (OS_i\ x\ POS_i) + (El_i\ x\ PEl) + (St_i x\ PSt)\}/yi$$

Where:

$BP_i(ISBL)$: Production cost of FAME per unit mass of FAME to feed i type
PF_i : Price of type feed i
SBL : Methanol price per unit mass
$PCta_i$: Acid catalyst price to feed i
$PCtb_i$: Base catalyst price to feed i
PCh_i : Chemical Price to feed i
POS_i : Other supplies prices to feed i
PEL : Electric energy price
PST : Steam price

Additional product and feedstock handling in OSBL
$BMFP_i\ (OSBL) = F_i\ (Elmf_i\ x\ PEl + Stmf_i\ x\ PSt) + BD_i\ (ElmBD\ x\ PEl + StmBD\ x\ PSt)$
Notation Meaning in OSBL model:
$BMFP_i$: Feedstock i and products maintanance costs.
$Elmf_i$: Electricity use per unit of feedstock imaintanance
$Stmf_i$: Use of steam for the maintanance per unit of feedstock i
ElmBD : Electricity use for biodiesel maintanance
StmBD : Use of steam for biodiesel maintanance

Total Production Cost
$TBP_i = BP_i\ (ISBL) + BMFP_i\ (OSBL) + BU - H_{Gliserol}$

Where:
TBP_i : Total production cost
$BP_i(ISBL)$: Production Cost of -i
$BMFP_i(OSBL)$: Costs of feedstock maintenance and -i product
BU : General Cost
$H_{gliserol}$: Glycerol Price

General cost component in determining the production cost:
BU = TK + ADM + PER + INS + DEP + PEM + TAX
Where:
TK : Fixed costs of labor
ADM : Public administration
PER : Engine maintenance costs
INS : Insurance
DEP : Depreciation
PEM : Marketing and distribution
TAX : Tax

The production cost is used to obtain the selling price of biodiesel.
Calculating the selling price is formulated as follows :
$HJ = BP_i + PPN_{10\%} + M_{10\%}$

Where:
HJ = selling price
BP_i = production cost
$PPN_{10\%}$ = value-added tax by 10%
$M_{10\%}$ = 10% margin

Basis of calculation used in the study of biodiesel selling price is 1000 kg of feedstock

3. Results and Discussion

3.1 Study of Biodiesel Production Costs

The production cost of biodiesel is built based on OSBL, ISBL and general costs. These three costs are influenced by total investment of biodiesel plant establishment. Investment costs include direct cost (machinery, piping, electrical, building, instrumentation and control, yard improvements, service faclilites, land), Indirect Cost (engineering and supervision, expansion and construction, contractor and contingency costs) (Carberry et.al, 2007). Based on the model of palm oil-based biodiesel production system (Sembiring, 2014) it is known that the equipment needs for each category of raw materials has differences. The difference occurs because the raw materials with FFA content of 1-5% or more as the raw material of the first and third types and requires a preliminary process and requires more extra costs. Based on the calculations in Table 2, it shows that the fixed investment cost of the biodiesel industry with raw material category of the first type requires the highest costs followed by raw material of the third type. In the second types of raw material, the industrial investment costhas the lowest cost among the others.

CPO fuel requires a longer production process begins with the processes of purification and washing to remove impurities. The addition of process stage adds the equipment needs thus increasing the cost of investment in equipment. In the second and third categories of raw materials do not require the stage because the two raw materials are obtained from the results of processing / refining of CPO.

Production cost component is identified from previous biodiesel production process technology (Figure 2 and 3). Components of production cost consist of fixed cost and variable cost, of which the raw material variations differences lead to differences in the flow of the production process which results in different component of production cost, especially in variable cost (raw material price, utility cost, and auxiliary materials cost).

Table 2 Fixed Investment Costs for each Raw Material Category (base of 1000 kg of raw material)

Fixed capital Investment	Non Refined (CPO)	Refined (RBDPO, Olein, Stearin)	Refined (PFAD)
Total direct Cost	485,238,743.65	385,278,739.71	477,860,225.02
Total Indirect Cost	117,160,260.04	93,025,047.82	115,378,726.36
Total capital Investment	602,399,003.68	478,303,787.53	593,238,951.38

The different stages of production process affect the production cost of each category of raw material. On the same number of raw material needs, CPO raw material needs more additional material as shown in Table 3. The needs for such additional materiasl are bleaching earth at the stage of purification and degumming processes to remove impurities. The number of bleaching earth refers to the mass balance of biodiesel production process in the first category raw material, that is Figure 2. The amount of costs for raw material and other cost components can be seen in Table 3.

Table 3 Production Cost for each Raw Material Category (basis of 1000 kg of raw material)

Komponen biaya	Bahan Baku				
	CPO	RBDPO	RBD Olein	RBD Stearin	PFAD
OSBL	303	330	334	308	280
General Costs					
Labor	6389	6389	6389	6389	6389
Depretiation	40 159	31 887	31 887	31 887	39 549
Tax	54 215	43047	43 047	43 047	53 391
Insurance	4015	3189	3189	3189	3594
General public	1278	1278	1278	1278	1278
Marketing and distribution	181990	197941	200374	184541	167795
Maintenance	161	128	128	128	158
Total General Cost	288207	283859	286292	270459	272156
ISBL					
Utilitas	219504	107179	107109	107179	174090
Bahan Penolong	666800	572000	572000	572000	851600
Total ISBL	958304	679179	679179	679179	1025690
By-Product cost (Glyserol)	59040	62323	62323	62323	6235
Total costs	1115777	963368	965804	949945	1298485

The total production cost is reduced by by-products price produced, that is glycerol. The following is the selling prices generated for the case study of raw material prices in 2013.

3.2 Study of Biodiesel Selling Price

The proportion of production costs in biodiesel production process is produced from raw material cost component. The *fluctuating* palm oil price significantly affects the production cost. This has led to the uncertainty of biodiesel production cost per year. Contribution of the raw material cost needs on the total production cost varies between 75.90%. PFAD raw material has the lowest contribution equal to 75.40% of the total production cost, CPO by 88.57%, RBD Stearin by 89.92%, RBDPO by 90.02%, and RBD olein by 90.13%. This study uses a case study in raw material prices in 2013 to get the lowest selling price of each biodiesel raw material.

Table 4. Case study of biodiesel selling price calculation in 2013

Raw Material	Raw Material Price (Rp/ Kg)	Process Cost (Rp/ Kg)	Margin (10%)	VAT (10%)	Selling Price (Rp/ Kg)	Selling Price (Rp/ liter)
CPO	8,107	1,115	931	1,024	11.272	10,145
RBDPO	9,132	963	1,019	1,121	12,339	11,105
Palm Olein	9,254	965	1,032	1,135	12,490	11,241
Palm Stearin	8,462	950	950	1,045	11,503	10,353
PFAD	7,259	1.310	8564	951	10.460	9.414

Source: Results of calculation
Remark: Assumed dollar exchange rate is Rp 12,000
The density of biodiesel = 0.876

Based on the calculation of production cost for each raw material in Tables 3 and 4, PFAD raw material hascost needs for additional materials higher followed by raw material of CPO. Although the stages of PFAD production process is shorter than CPO, it has higher additional material cost because in the production process it is required methanol four times more. This additional material significantly influences process cost, so PFAD has the highest cost.

Case study of raw material prices in 2013 conducted with the best process condition for each biodiesel raw material produces the lowest price of Rp 9.414 per liter so that it can be used as a reference in the provision of incentive and other policies in determining the price of biodiesel in Indonesia.

4. Conclusion and Suggestion

Conclusions

Biodiesel products process cost with *palm fatty acid distilate* (PFAD) raw material has the highest value compared to other types of raw material reaching two times more, that is equal to Rp 1,298. The component contributing the highest process cost is methanol catalyst cost.

Based on the case study of biodiesel raw material in 2013, PFAD is biodiesel raw material with the lowest production cost compared to other raw materials amounted to Rp. 9.414 per liter. Thus,the lowest price produced can be made as reference for the provision of incentive and other policies in determining the price of biodiesel in Indonesia.

Suggestions

Raw material price fluctuations may significantly affect the production cost and selling price of biodiesel. It is needed further study on the lowest and highest prices of the respective raw materials from 2006 (the year when biodiesel began to develop). The lowest and highest prices during the last eight years can be used as the basis of determining the maximum amount of subsidy to be provided by the government. In addition, it is required study on the application of incentive provision policy and other policies in determining the price of biodiesel in Indonesia.

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