Production of Microalgae and Oil Palm Based Biodiesel: A Case Study Implementation of Extended Life Cycle Analysis in Indonesia

Arif Dwi Santoso, Rahmania Admirasari, Joko Prayitno Susanto, Nawa Suwedi, Joko Prayitno, Devitra Saka Rani and Yudhi Soetrisno Garno

July 28, 2020

Production of Microalgae and Oil Palm Based Biodiesel: A Case Study Implementation of Extended Life Cycle Analysis in Indonesia

Arif Dwi Santoso[1§]*, Rahmania Admirasari[1§], Joko Prayitno Susanto[1§], Nawa Suwedi[1§], Joko Prayitno[1§], Devitra Saka Rani[2§] , Yudhi Soetrisno Garno[1§]

[1]Center for Environmental Technology, Agency for the Assessment and Application of Technology (BPPT), Jakarta, Indonesia

[2]R&D Centre for Oil and Gas Technology (LEMIGAS), Ministry of Energy and Mineral Resources, Indonesia

*arif.dwi@bppt.go.id

[§]These authors contributed equally to this work

Abstract. This paper will introduce a research regarding microalgae biomass as an environmentally and sustainably alternative biodiesel raw material. The purpose of the research is to compare all production cost variables between microalgae and oil palm biodiesel using production process cycle analysis system of extended life cycle analysis (extended LCA). The use of extended LCA system could possibly accommodate all environmental commodity variables on biodiesel production so that the potential microalgae biomass which is a renewable, low land use and environmentally sustainable product could be promoted. Values of environmental commodity variables are estimated by employing a willingness to pay (WTP) approach that is referred to the calculation of Environmental Priority Strategy (EPS) Software. The result research shows that there is an increase of biodiesel production cost of microalgae and oil palm after the inclusion of their externality variables cost. The biggest biodiesel production cost comes from the stage of fresh fruit bunch biomass production of palm that reaches 49% - 64% of the total cost production. Extended LCA analysis concludes that the increase of microalgae and palm biodiesel production cost is about 3% and 18%; respectively. From profitability analysis indicates that biomass input for the production of biodiesel from microalgae is more environmentally sustainable than from oil palm because both technical and non-technical constraints during microalgae biomass production are easier to be taken care. In addition, it is predicted that microalgae will have a significant contribution in the green house gases (GHGs) mitigation by replacing fossil fuel in the future through its role as a biodiesel.

Keywords: microalgae, palm oil, biodiesel, environmental commodity, extended life cycle analysis (extended LCA)

1. **Introduction**

Indonesia is predicted to face a national energy crisis in the future. This is due to the imbalance between energy production and consumption, particularly for domestic oil fuel. Since 2003, Indonesia oil production has no longer been able to support its national energy demand that has steadily been increasing. The energy crisis is more severe due to the high contribution (almost 90%) of the three major non-renewable fossil fuels, namely coal, petroleum, and natural gas. Whereas renewable non fossil fuels such as solar, wind, geothermal and biofuel have not undergone significant development.

An effort to reduce energy dependence on fossil fuel is to find an alternative and renewable energy sources like biodiesel from palm oil, corn, jatropha and other crops [1]. For that, Indonesian government has implemented oil to LPG conversion program as well as promoted energy diversification program of non-fossil fuel through Presidential Decree No. 5/ 2006. This Presidential Decree target is to use alternative and renewable energy resources such as biofuel (bioethanol, biodiesel) as much as 5% of the total energy mix by 2025. Biodiesel in Indonesia is generally produced from oil palm (crude palm oil or CPO) while bioethanol is derived from the molasses, corn, cassava and others.

Indonesian biofuel producers association declares that the total annual production of biodiesel and bioethanol increased from 0.65 million litters and 0.194 million litters in 2011 to 0.7 million litters and

0.2 million litters in 2012, respectively. However, this biofuel production is still far from the target mandated by the Presidential Decree that is 4.52 million litters for biodiesel and 2.78 million litters for bioethanol annually between 2011 and 2015 [2].

Some efforts to lead the way and to promote biodiesel for vehicle, a mixture between crude palm oil (CPO) and diesel fuel, has been done but its amount is still very limited. If a mixture quantity of CPO in diesel fuel is lifted up it could alertly affect CPO supply for cooking oil. Another obstacle that has not been solved is the structure of production cost. It is determined by small production scale, unconsolidated market structure, limitations of infrastructure for processing, distribution, transportation of biomass, method of growing crops, supply of water, seeds, and fertilizer, conservation of biodiversity, as well as networking in logistics and distribution system.

Beside the above technical constraints, effort on the conversion of biofuel raises different opinions among researchers and environmental observers in terms of its contribution on the increase of greenhouse gases resulting from land use changes [1],[3] threaten food supply [1], and increased forest and biological diversity degradation [4]. Therefore, biomass from algæ will get first priority to be used as biodiesel. The advantage of algal biomass is due to its status as a renewable energy source [5] and its ability to reduce CO_2 emission. During photosynthesis, algæ utilize solar energy to convert CO_2 into carbohydrates, fats and proteins with productivity are much higher than that of land plants [6]. Algæ also have a double time growth of around 3.5 hours, require less water in their growth and have capability to produce biodiesel raw material of 15-300 times faster than that of land plant [7]. High algae productivity as a source of biodiesel raw material has attracted researchers and business people. Research on algae production and utilization at laboratory and pilot project scales has many been done. Business on algal biomass production as well as its conversion to useful product such as biodiesel, feed and food supplement has also been initiated.

Process handling from refining and selecting species, biomass production till harvesting have been mastered however their application at the real commercial scale still needs some forward steps. Moreover, biofuel refinery from algal biomass is still being debated in terms of economic and ecological advantages. However, it is necessary to estimate the cost composition of biodiesel production from microalgae and oil palm biomass in order to compare each other. Estimated biodiesel production costs are based on the real production cost and the cost when its environmental commodities are taken into account. In addition comparing production cost, it is also discuss profitability analysis of biodiesel compared to that of fossil diesel oil.

2. Methodology

2.1 *Life cycle costing*

Analysis of life cycle costing (LCC) is an economic analysis method to determine production cost gained by production process of goods. It consists of processes of the raw materials supply selection, production equipment installation, operational activities, instrument maintenance, and end product utilization [8]. In this research, all expenses incurred from palm oil and algal oil production are based on cost component of biodiesel production system that includes 3 (three) stages: (a) production of fresh fruit bunch or microalgae biomass, (b) production of crude palm oil (CPO) or algal oil, and (c) production of biodiesel.

All production costs at any stage of the process are inventoried based on the raw material used, energy used and energy generated. To have relatively representative information on economic scale, data of oil palm biodiesel production are taken from 35 palm plantations that have more than 10,000 ha of land with the productive life time between 15 and 25 years. While data of algae based biodiesel production is taken from 40 algal biodiesel production activities with the biomass production capacity of about 10-15 tons per ha year. Comparison of cost components between biodiesel from crude palm oil and that from algal oil is based on the biodiesel market price of Indonesia. The functional unit used in this calculation is based on one liter of biodiesel. This unit will become a reference of all data inputs used.

2.2 *Determination of Externality Variable Values*

Externality variable values consist of costs and benefits arising from biodiesel production processes in the form of land value, social conflict cost and environmental cost. The value of land used for cultivation of both oil palm and microalgae is calculated based on market price approach [9]. This research uses two types of land values; the first is land value based on productivity and the second one is based on the ecological cost. Land value based productivity is calculated using formula introduced by Cahyono *et al*. (2009) [10]:

$$V_p = \sum(P_{pi} . h_{pi}) \text{ ....(1)}$$

Where;
V_p : land economic value (IDR/ha -year);
P_{pi} : productivity of agricultural land for plant type i (ton/ha-year); and
h_{pi} : price of food product for plant type i (IDR/ton).

The cultivation of microalgae and oil palm uses forest land that is calculated using the following equation:

$$V_r = P_h . h_k \text{ ....(2)}$$

Where:
V_r : forest land economic value (IDR/ha- year);
P_h : productivity of forest logging (m^3/ha-year); and
h_k : market price of logging (IDR/m^3).

Calculation of land value including the value of ecological functions of land that is obtained from [11] and [12] and adjusted to the condition at which the data is taken, is given in Table 1.

Table 1. Values of land based on the substitution of the ecological functions (IDR/ha)

Parameter of ecological function	IDR/ha
Product of wood	956,015
Weed and pest control	271,315
Water conservation control	545,629
Erosion control	969,673
Top soil formation	109,259
Cycle of humus	1,092,589
Waste processing	1,024,302
Biodiversity	1,273.323
Others	99.024
Total (IDR/ha)	6,341,129

Source: Adapted from Ruitenbeek, 1999; Constanza *et al*.,1997.

Social costs are expenses incurred due to social problems such as land conflict as a result of biodiesel production. Value of social cost is estimated to about 0.05% [13] and 0.01% [14] of total investment for oil palm, and for microalgae respectively. Environmental cost is estimated based on the cost of air pollution emitting during the production of biodiesel. Emission value as an environmental commodity that is intangible one is approached with transfer benefit method. Then, for having benefit value from this benefit transfer method, it is used a general approach of "willingness to pay, abbreviated as WTP" [15]. In this research it uses economic value of environmental commodity calculated by software of environmental priority strategy (EPS) 2000 version designed by the Centre for the Environmental Assessment of Product and Material Systems (CPM), Sweden. The environmental commodity calculated by EPS software is then approached with elasticity of paying ability from country or location of application [16], [17]. The adjustment of that environmental commodity value to the value of Indonesia is found based on the comparative value of income per capita of Sweden to Indonesia (Table 2).

Table 2. Value of environmental commodity based on combustion of 1 liter biodiesel, Indonesia

Environmental commodity category	Unit	IDR /unit
CO_2	Kg CO_2	110.35
CH_4	Kg CH_4	2,779.13
N_2O	Kg N_2O	39,132.61
CO	Kg CO	337.17
NO_x	Kg NO_x	2,176.30
SO_2	Kg SO_2	3,341.09
VOC	Kg VOC	2,186.52
PM_{10}	Kg PM_{10}	36,782.62

*Based on conversion of Indonesian Rupiah Currency of 9.200 IDR per EUR and Restianti, 2012 [18].

WTP for Indonesia (WTP_{Ina}) is estimated from WTP_{EU} that is multiplied by the value of ratio between GDP_{Ina} dan GDP_{EU}, as follows:

$$WTP_{Ina} = \frac{WTP_{EU} x\, GDP_{Ina}}{GDP_{EU}} \quad \dots\dots\dots(3)$$

Where,
GDP_{Ina} : US$ 3.716 (UNDP, 2011),
GDP_{EU} : US$ 32.700 (Silalertruksa, 2012),
WTP_{Ina} : WTP Indonesia
WTP_{EU} : WTP Europe.

3. Production of Biodiesel

3.1. *Production of Biodiesel from Palm Oil*

Production of biodiesel from palm oil consists of several stages: palm tree cultivation, CPO production and biodiesel production. The whole system of biodiesel production from palm oil is described in detail below and also as shown in Figure 1.

(1) Palm tree cultivation. This activity consists of growth and enlargement of seed palm trees at estate land. Materials and energy utilized at this stage of plantation are fuel, fertilizer, herbicide/ pesticide chemicals, water, and palm seeds. The output of this activity is product of fresh fruit bunch (FFB) as well as emitted gaseous pollutants derived from the use of fertilizer, chemicals and farm machine.

(2) CPO production. This stage activity consists of:

- Harvesting of FFB;
- Cooking and sterilization of FFB;
- Separation of empty fruit bunches (EFB) from FFB, and it is then used as fuel;
- Extraction of crude oil;
- Separation of decanter cake;
- Separation of fiber; and
- Extraction of kernel for production of palm kernel oil (PKO) and palm kernel extract (PKE)

(3) Biodiesel production. CPO is transesterificated with the help of catalysts of sodium hydroxide (NaOH) and methanol. Process inputs are CPO, water, electricity and catalyst. While the outputs are methyl ester (biodiesel), glycerol and liquid waste.

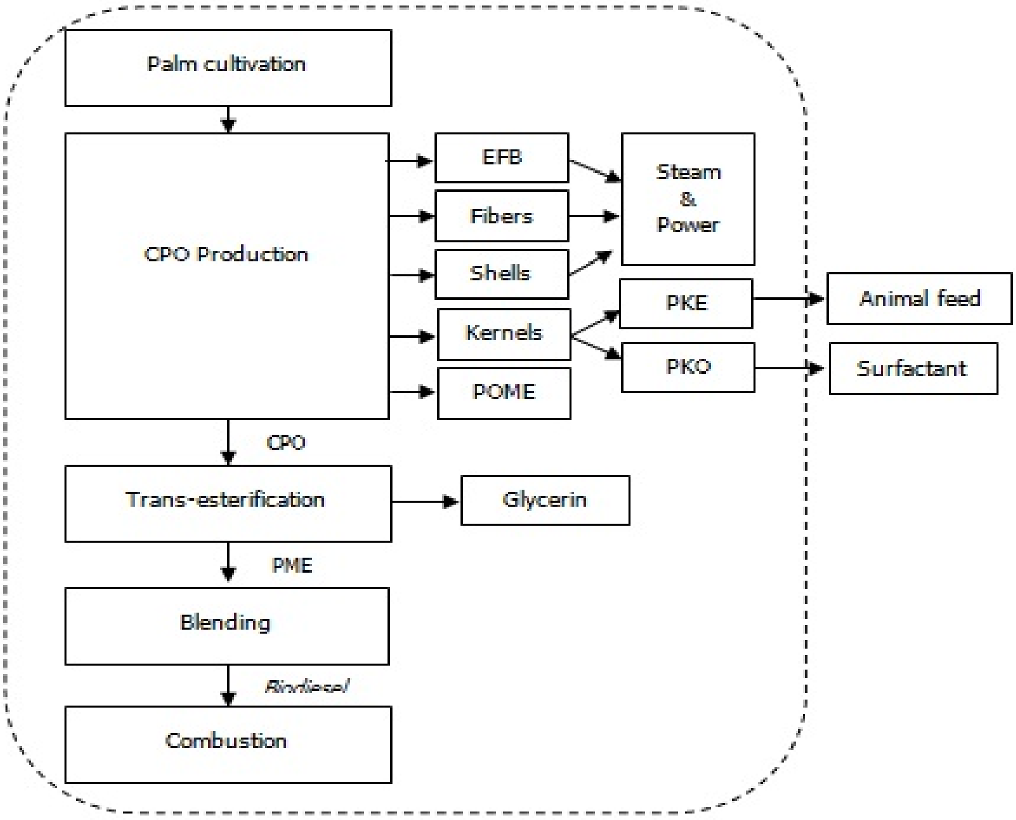

Figure 1. Schematic production of biodiesel from oil palm

3.2. *Production of Biodiesel from Microalgae Oil*

Production of biodiesel from microalgae oil also composes three stages: cultivation of microalgae in the photo bioreactor or pond, production of algal oil, and production of biodiesel. A whole system of biodiesel production from algae is shown in Figure 2. At the cultivation stage, the important activities are the cultivation of algae in PBR or pond and the process of harvesting. It is required to have skilled persons to control the amount of nutrients and maintain the media to be always in right concentration for the optimum algae growth. While on harvesting stage the optimum operation of the harvester is necessary to minimize the use of energy.

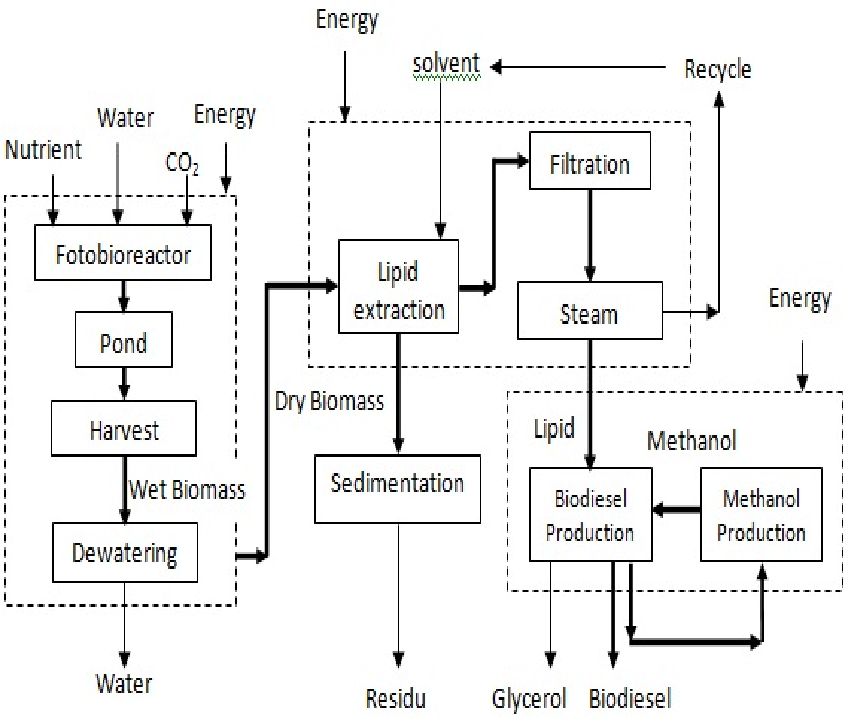

Figure 2. Schematic production of biodiesel from algae

Production of lipid and biodiesel from algae are relatively similar to the production of CPO and biodiesel from palm oil. The only different is on the process of sonification that is a breaking up of algal cell wall. This process consumes much energy and catalyst solution that will increase the cost of the total operation.

4. Result and Discussion

4.1. *Determination of LCC*

Determination of the life cycle costing (LCC) of biodiesel production involves all expenses incurred in the production of biodiesel based palm oil and algæ as shown in the respective Figure 1 and Figure 2. The production cost at any stage is detailed in Table 3.

Based on comparison of those biodiesel production costs it can be found the important results as follows.

1. The largest component cost is due to the production of biomass (CPO or algal oil) that reaches 49.03 % of the total cost for palm tree based biodiesel and 64.08 % of total cost for microalgae based biodiesel. This information will give attention to biofuel observers that for reducing biodiesel price to reach economical cost it should lower production cost of both algae and oil palm. Cost-saving biomass production is done primary through the improved efficiency of land preparation for palm tree and reactor/pond development for algae, as well as the improved efficiency of palm trees and microalgae culture.
2. An addition effort to reduce biomass production cost is to improve efficiency in the harvesting process of algæ and saving electricity used in the cultivation.

Table 3. Composition of production cost and externality cost at 1 litter biodiesel derived from microalgae and palm tree.

Process/Material	Cost @ 1 Litter of Biodiesel		
	Unit	Algae	Palm
1. Cultivation	IDR	5,955	4,680
	%	64.08	49.03
a. Preparation of land/reactor	IDR	1,367	3,023
b. Fertilizer	IDR	778	330
c. Other material	IDR	27	353
d. Harvest	IDR	3,783	974
2. Production of oil	IDR	1,683	1,445
	%	18.45	15.14
a. Methanol	IDR	851	667
b. Other materials	IDR	163	330
c. Electricity	IDR	453	236
d. Heat energy	IDR	217	212
3. Production of biodiesel	IDR	1,095	997
	%	11.78	10.45
a. Methanol	IDR	480	393
b. Other materials	IDR	63	188
c. Electricity	IDR	416	283
d. Heat energy	IDR	136	133
4. Others	IDR	317	730
	%	3.41	7.65
a. Tax and others	IDR	190	393
b. Man power	IDR	127	338
5. Externalities	IDR	242.29	1,692.55
	%	2.61	17.73
a. Land value	IDR	309	961
b. Environmental cost	IDR	197	196
c. Social cost	IDR	2	125
Total cost	IDR	9,292.29	9,545.55
	%	100	100

3. Externalities production cost of microalgae based biodiesel is approximately 2.6 % of the total cost which is lower than that of oil palm based biodiesel (about 17.7 %). This information can also be a good consideration for energy policy makers in Indonesia. If CPO is chosen as biodiesel material then it will bring the consequence of increasing environmental burden in the form of pollution produced as much as 17.7 % of the total cost.
4. For productions of microalgae based biodiesel much chemicals are used such as for esterification process, sterilization and fertilization. The use of these chemicals must be watched out because they potentially pollute environment if they are not treated before disposing or reusing them.

4.2. *Determination of Externalities Costs*

Calculated externality cost that is included as production cost of biodiesel consists of three different costs: land use cost (land value), environmental cost and social cost. Contribution of externality cost to total production cost of both palm and microalgae based biodiesel is presented in Figure 3.

The calculation is based on one litter of biodiesel at the commercial scale. If the fuel production cost is computed without considering externality cost the production cost of biodiesel from fossil fuel, microalgae and oil palm are about IDR 6,992, IDR 9,050 and IDR 7,903. Based on the only biodiesel production price, the biodiesel based microalgae cost is the highest and does not meet the local biodiesel market price that is IDR 8,500.

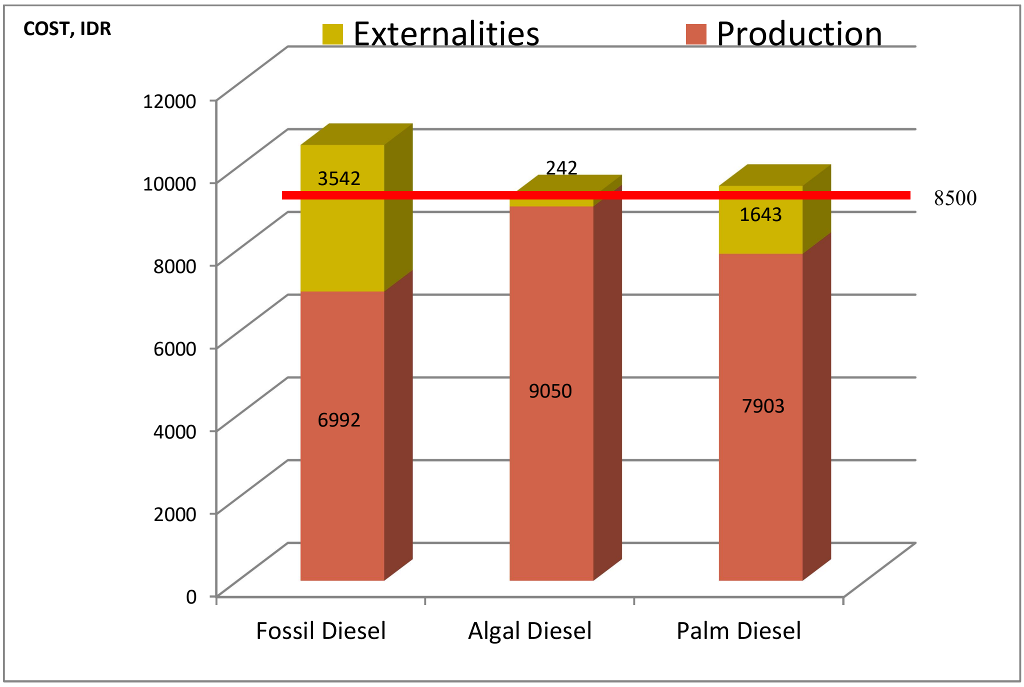

Figure 3. Comparison of externality cost to total production cost per kg of palm and algae based biodiesel.

If the externality cost that is land, environment and social cost is charged into the structure of production cost the potency of microalgae to be candidate of biodiesel will be better. Additional charge of this externality cost will affect the total biodiesel production cost. For diesel production with inclusion of externality cost increase the total production cost of fossil based diesel fuel by 33.6%, palm based biodiesel by 18% and algae based biodiesel by only 3%.

From data analysis shown above also shows that every biodiesel production from microalgae biomass causes environmental burden of about 3 % while from palm oil based biodiesel contributes it by 18 %. Environmental burden mentioned here is represented by the cost dedicated for environment recovery as a result of this product that must actually be paid by consumers. In fact, this cost is not currently included into market price of the product.

The average consumption of palm based biodiesel in Indonesian reaches 600,000 kilo litters per year [19] resulting environmental cost around IDR 2.1 trillion per year. Comparison of externality cost of microalgae based biodiesel that is about six times smaller than that of palm based biodiesel will be a main consideration to select biomass sources of biodiesel.

4.3. *Profitability of Microalgae and Palm Oil Based Biodiesel*

In an effort to see production profitability in market, the price of biodiesel is compared with fuel oil price with addition of production cost of US$ 15 per barrel [20]. Figure 4 shows the competitiveness of palm oil and microalgae based biodiesels compared with fossil diesel fuel of three different crude oil prices. At the crude oil price about US$ 80 per barrel, both palm oil and algae based biodiesel could not compete with the fossil diesel fuel, except they receive government's subsidies. Conversion of fossil diesel fuel to biodiesel will be profitable if the crude oil price is above 100 US$/barrel. In competitiveness of biodiesel is influenced by two factors: high production cost of CPO/ algal oil that causes total production costs and global crude oil price condition. The world crude oil price could be a key factor for the government or decision makers in setting policy of fossil fuel conversion into biodiesel.

If the price of CPO and algal oil is below IDR 6,000 / kg and global crude oil price is above 100 US$/ barrel, the fuel conversion program of fossil diesel to biodiesel will be feasible to implement. Externality variables could be key factors to save the environment so they need to be used as determining factors in each decision made by the government in exploiting natural resources. To include externality variables into production cost and energy balance calculation of biodiesel production, they must be valued according to the market price and then integrated into the calculation formula.

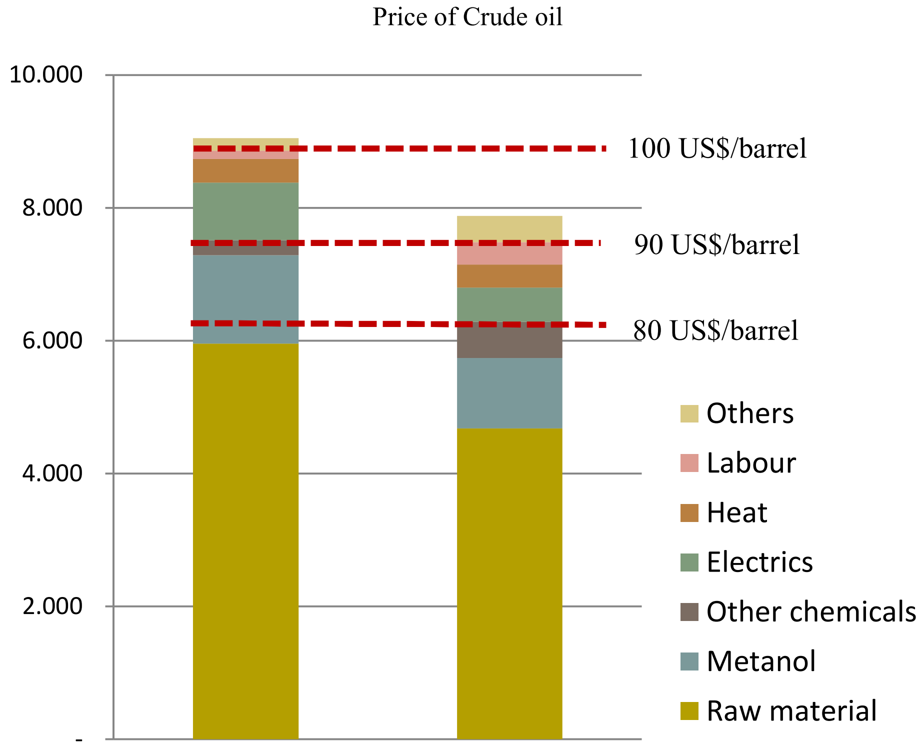

Figure 4. Cost of algae and palm oil based biodiesel production at different price of crude oil (IDR/liter)

The internalization of the externality variables of biodiesel production will change the total production cost of algae and palm oil biodiesel. Addition of externality costs of algae and palm oil based biodiesel increases their total production costs by 3% and 18%, respectively. Total production cost of biodiesel by adding externality costs is however still not enough for biodiesel to be competitive to fossil diesel fuel. To encourage the implementation of oil conversion program to biodiesel, the government therefore needs to provide the subsidy. In term of sustainability, biodiesel is much better than fossil diesel fuel. Between algae and palm oil based biodiesel, algae based biodiesel is however more sustainable. Besides, palm biomass is often restricted due to the limitation availability of land, social conflict and environmental burden as well as it could potentially compete with the use of CPO for cooking oil and food [21].

On the other hand, production of algae has a great potential to be further developed. Unlike palm oil, algae production is not restricted by land availability, social conflict and food competition. The conversion efficiency of algal biomass to alga oil is still possible to be increased and improved [6]. Another advantage of algae biomass is its role in mitigating greenhouse gases, especially CO_2 much higher than that of palm tree [21].

5. Conclusions

Life Cycle Costing Analysis applied by adding externality variables can give detail information on the production cost composition of algae based biodiesel to that of palm oil based biodiesel and to fossil diesel fuel. Production cost of biodiesel is mainly used to produce algal oil for the algae and CPO for palm which reaches up to 64.08 % and 49.03 % of the total biodiesel production cost; respectively.

This information can be a good lesson for biodiesel players how to reduce cost of biodiesel production that is by concentrating in reducing the cost of algal oil and CPO production. Profitability analysis of biodiesel production shows that efforts to convert fossil oil to biodiesel will be effective if there is subsidy given by the government and if the crude oil price is above US$ 100. Externality variables contribute to influence total production cost of biodiesel up to 18 % with three highest cost components of land use, oil utilization and social conflict. Algae culture for production of biodiesel is environmentally safer and more sustainable than that of palm tree. It is because technical and non-technical constraints on production of algal biomass are easier to be handled. Besides, there is excellent role of microalgae that is its ability to efficiently absorb and convert the GHG of CO_2 to its biomass through photosynthesis.

Acknowledgement

Special thank is directed to Ministry of Research and Technology, Republic of Indonesia who has provided funding for this research. Thank lots to Prof. Kardono, Prof. Tresna P. Soemardi and Dr. Awal Subandar for advising and supervising our manuscript.

References

[1] Halim R, Danquah M K, Webley P A. Oil extraction from microalgae for biodiesel production, *Biores Technol* . 2011, 102: 178-185.

[2] Ministry of Energy and Mineral Resources (MoEMR) of Indonesia, "Handbook of Energy and Economic Statistic of Indonesia 2012", Center for Data and Information on Energy and Mineral Resources, Jakarta, 2012, PP. 4-21.

[3] Demirbas A, Demirbas M F, Importance of Algal Oil as a source of biodiesel, *Energy Convers Manage*. 2011,52:163-170.

[4] Khoo HH, Tan RBH, Tan ZH, GHG intensities from the life cycle of conventional fuel and biofuels, *Air Pollution* .2009, 17:329- 340.

[5] Jorquera O, Kiperstok A, Sales EA, Embirucu M, Ghirardi ML, Comparative energy life-cycle analyses of microalgal biomass production in open ponds and photobioreactors, *Bioresour Technol* .2010, 101:1406–1413.

[6] Scott SA, Davey MP, Dennis JS, Horst I, Howe CJ, Lea-Smith D J, Smith AG, Biodiesel from algae: challenges and prospects, *Current Opinion in Biotecnology* . 2010, 21:227–286.

[7] Chisti Y, Biodiesel from microalgae, *Biotechnol Adv*. 2007, 25:294–306.

[8] Lora EES, Palacio JCE, Rocha MH, Renó MLG, Venturini OJ, Del Olmo OA, Issues to consider, existing tools and constraints in biofuels sustainability assessments, *Energy*. 2011, 36: 2097-2110.

[9] Suparmoko M, "Panduan dan Analisis Valuasi Ekonomi Sumber Daya Alam dan Lingkungan: Konsep, metode perhitungan dan aplikasi", 2009, BPFE, Edisi pertama cetakan kedua, Yogyakarta.

[10] Cahyono SA, Hariyadi B, Yuliantoro D, "Nilai Guna Tak Langsung Pengelolaan DAS Grindulu (Indirect Value of Grindulu Watershed Management) ", 2009, Proceeding of R&D result, Forestry Research Center, Solo, Indonesia.

[11] Ruitenbeek J, *Indonesia's Fires and Haze: the cost of catastrophe,* (1999) Institute of Southeast Asian Studies Singapore.

[12] Constanza R, Arge R, Groot R, Farber S, Hannon B, Limburg K, O'neill R, The Value of the World's Ecosystem Services and Natural Capital, *Nature*. 1997, 387: 253-259.

[13] Manurung EGT, "*Analisis Valuasi Ekonomi Investasi Perkebunan Sawit*", Nature Resources Mana gement Program, 2001, PP. 5-10.

[14] Nguyen TLT, Gheewala SH, Fossil Energy Environmental and Cost Performance of Ethanol in Thailand *J. Clean Prod.*2008,16: 1814-1821.

[15] Wilson AM, Hoehn JP, Valuing environ mental good and service using benefit transfer: the state of the art and science. *Ecol. Econ.* 2006, 60:335-342.

[16] Nguyen TLT, Gheewala SH, Bonnet S, Life Cycle Cost Analysis of Fuel Ethanol Produced from Cassava in Thailand, *Int. J. Life Cycle Assess*. 2008, 13:564-573.

[17] Conner DO, Estimating ancillary benefits of climate policy using economy wide models: theory and application in developing countries (2001) OECD Development Centre Paris, France Paris.

[18] Restianti YY, Gheewala SH, Environmental and Life Cycle Cost Assessment of Cassava Ethanol in Indonesia, *Journal of Sustainable Energy and Environment*. 2012, 3:1-6.

[19] Hutapea M, Direktur Bioenergi, Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi, http://www. Indonesia finance today.com/read/35907/Konsumsi-*Biodiesel*-Nasional-Diprediksi-Tidak-Capai-Target (2012). *Downloaded* on 24 November 2012 at 17.00.

[20] Pradiptyo, Konsumsi BBM meningkat, subsidi membengak, http://www.antara news. com /berita/307671/pengamat-konsumsi-bbm-meningkat-subsidi-membengkak 29 Mei2014 8.15 WIB (2012)