

# A REVIEW OF BIODIESEL DEVELOPMENT IN INDONESIA: CURRENT STATUS, FUTURE POTENTIAL AND ITS IMPACT ON THE ENVIRONMENT

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## ABSTRACT

Indonesian government issued National Energy Policy in 2006 that will reduce role of fossil fuels and increase role of renewable energy in 2025 as a target year. Bio-fuels are one of the renewable energy focuses in Indonesia. In 2009, biodiesel production capacity was 1.12 tons per year and expected to rise every year. Target of biodiesel usage increases gradually from B-10 in 2006-2010, B-15 in 2011-2016 and B-20 in 2016-2025. The policy and its target are set by the government to diversification energy source, to boost economic growth (especially regional development and creation of employment) and to reduce greenhouse gas emissions. Currently the main feedstock of biodiesel in Indonesia is derived from palm oil. Some concerns arise related to palm oil biodiesel such as competition between food versus energy and environmental issue in particular replacing forest to oil palm plantations and biodiversity loss. Therefore, development of biodiesel feedstock from non-edible crops and can be grown in non-arable land are very important for future biodiesel development in order to eliminate competition with food and prevent deforestation and biodiversity loss.

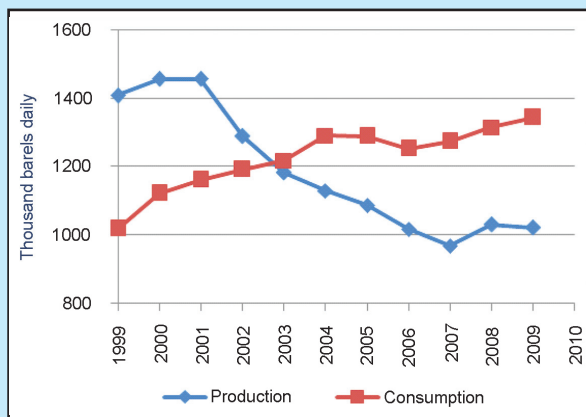
**Keywords:** biodiesel, renewable energy, future potential, enviromental

## I. INTRODUCTION

The role of renewable energy has increased rapidly in recent years because world crude oil prices are fluctuating and increasing significantly for the past few years. Furthermore, climate change issues also could trigger acceleration the use of renewable energy. Indonesia, as one of the most populous countries in the world, faces many challenges in the energy sector since energy consumption rise significantly in line with economic and population growth. On the other hand, oil production in Indonesia decreased considerably since 2001 (Figure 1) while its reserves per production will be exhausted in 24 years as shown in Table 1 (ERIA 2010; IEA 2008). This condition made Indonesian position reverse from oil exporter country to oil importer country since 2003.

To cope with increasing energy demand and to diversify energy sources, Indonesian government issued national energy policy in 2006. Figure 2 shows

national energy policy issued by Indonesian Government in 2006 which illustrate current energy mix and energy mix of 2025 with two scenarios, business as



**Figure 1**  
Comparison of oil production and consumption in Indonesia from 1999 to 2010 (Data adapted from BP Statistical Review of World Energy June 2010)

usual and optimizing energy management. Current energy mix shows that oil is a major energy resource with more than 50% energy share followed by gas and coal. According to business as usual (BAU) scenario, the use of oil will slightly down to 40% while role of renewable energy only 3% in total energy mix. By optimizing energy management scenario, it is expected that by 2025 the role of renewable energy in national energy mix will increase up to 17%. Geothermal and biofuels are the primary renewable energy focus in Indonesia with equal share 5% from total 17% target of renewable energy in 2025.

The goals of this review is review of current status of biodiesel in Indonesia, analyze how this condition will affect future development of biodiesel, evaluate impact of biodiesel development to the environment, social and economic.

## II. ADVANTAGES AND DISADVANTAGES OF BIODIESEL

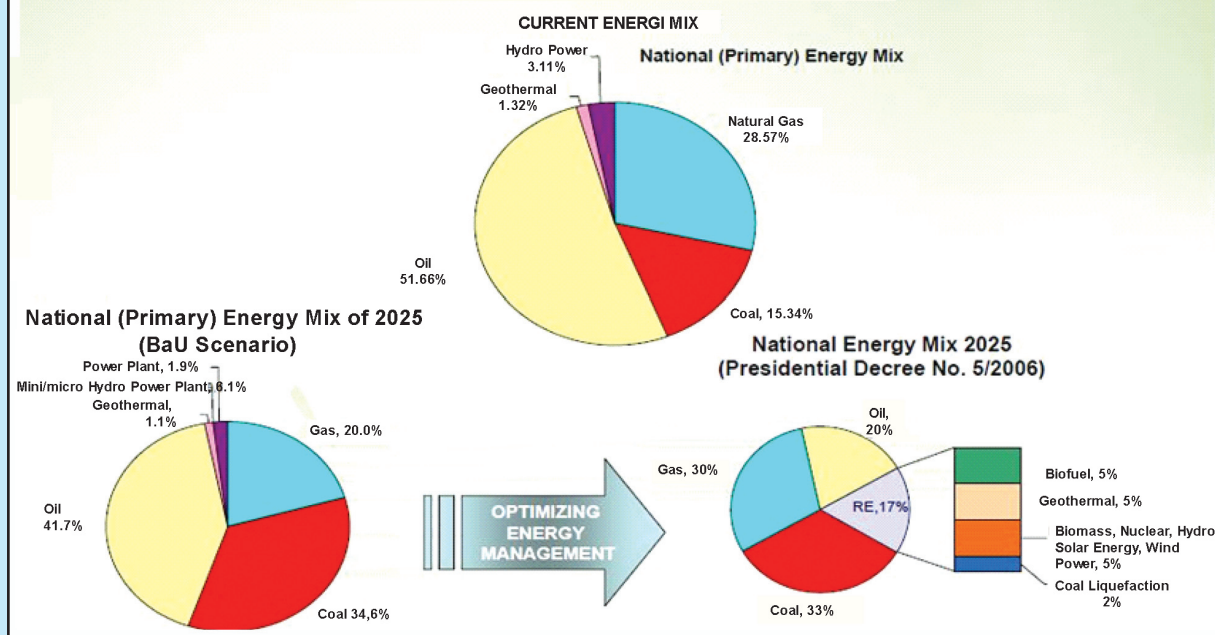
Biodiesel is very attractive to be developed because it has many advan-

tages both technical and non-technical. Technically, biodiesel has higher cetane number and better aromatic content, sulfur content and flash point compare to petroleum diesel. For this reason, biodiesel has a better engine compression compared to petroleum diesel. Diesel engine does not need to be modified when it uses biodiesel B-10 or B-20 as a fuel. In addition, biodiesel emits less pollutant compared to low sulphur diesel during the combustion process. This could be a solution to reducing the problem of urban pollution since gas emissions from the transportation sectors contribute a significant amount to the total gas emissions (O'Connel *et al.*, 2007). In

**Table 1**  
**Indonesian Fossil Energy Resources in 2007(IEA 2008)**

Fossil Energy	Resources	Reserves	Production	Reserves/ Production (years)
Oil (billion barrels)	55.6	8.4	0.348	24
Gas (TCF)	334.5	165	2.79	59
Coal (billion tonnes)	90.5	18.7	0.201	93

### NATIONAL ENERGY POLICY (PRESIDENTIAL DECREE NO. 5 YEAR 2006)



**Figure 2**  
**Indonesian Energy Policy (Legowo 2007)**

**Table 2**  
**Advantages and Disadvantages of Biodiesel**

Area	Advantages	Disadvantages
Technical	<ul style="list-style-type: none"> <li>- Higher cetane number</li> <li>- Better engine compression</li> <li>- Lower sulphur content</li> <li>- Reduce pollutant emissions such as PM and CO</li> </ul>	<ul style="list-style-type: none"> <li>- Moisture content problem</li> <li>- Glycerol content</li> <li>- Low energy density</li> <li>- Higher specific fuel consumption</li> <li>- Emit higher nitrogen oxide (NOx)</li> </ul>
Non-technical	<ul style="list-style-type: none"> <li>- Economic growth (regional development, creation of employment, reduce poverty)</li> <li>- Energy security (reduced imported fuels)</li> <li>- Environmental impacts (reduce GHG emissions)</li> </ul>	<ul style="list-style-type: none"> <li>- High cost (feedstock, capital and labor)</li> <li>- Competition with food</li> <li>- Deforestation</li> <li>- Loss in biodiversity</li> </ul>

non-technical area, biodiesel become more attractive because it has major benefits to economic impacts (regional development and creation of employment), environmental impacts (reduce GHG emissions) and energy security because it can reduce imported fuels (Demirbas 2009).

Even though biodiesel has many advantages over petroleum diesel, it has some drawbacks as well. Energy content of biodiesel is lower than petroleum diesel. As a result, specific fuel consumption for biodiesel is higher than petroleum diesel. Biodiesel also has to deal with the moisture content problem and low energy density that cause biodiesel to be less economical than petroleum diesel (O'Connel et al., 2007). In addition, the cost of biodiesel such as scale, process efficiency, feedstock costs, capital and labor costs is the major barrier to commercialization the product. Particularly, the cost of producing oil-seed-derived biodiesel is dominated by the cost of the oil and by competition from high-value uses like cooking (Demirbas 2009). Those benefits and drawbacks of biodiesel are summarized in Table 2.

### III. CURRENT STATUS OF BIODIESEL

Biodiesel feedstock in Indonesia is mainly palm oil. Indonesia is the largest producer of Crude Palm Oil (CPO) in the world and currently produces about 20 million tonnes of CPO from 7 million hectares

**Table 3**  
**Current Biodiesel Production Capacity**  
**(millions of tonnes per year) (Dillion et al., 2008)**

Biodiesel Production and Capacity	2008		2009		2010
	Capacity	Production	Capacity	Production	Capacity (estimation)
	1.59	0.72	2.52	1.12	4.12

**Table 4**  
**Plantations area of biodiesel sources**  
**in 2008 and planned by 2010**

Biodiesel Sources	2008	Planned by 2010	Total (million ha)
	(million ha)		
Oil Palm plantations	0.40	3.06	3.46
Jatropha plantations	0.15	1.5	1.69
Total	0.55	4.6	5.15

palm oil plantation. The area of palm oil plantation is expected to rise to 10 million hectares by 2015 (Waltermann and Streubel 2010). In 2008, 11 biodiesel facilities operated in Indonesia, producing about 725,000 tonnes and expected to increase every year as shown in Table 3 (Dillion et.al. 2008).

During 2008, oil palm plantations for biodiesel feedstocks were 400,000 hectares (6%) of land out of approximately 7 million hectares of total oil palm plantations. In 2010, the government planned to add 3.06 million hectares oil palm plantations and 1.5 million hectares plantations of oil palm and jatropha respectively as shown in Table 4. Nevertheless, there

were many biodiesel projects were halted in 2008 due to high price of crude palm oil. Therefore, it seems unlikely to have 10 folds plantations in two years time (Dillon *et al.*, 2008).

However, some concerns related to palm oil arise because of fuel versus food competition and deforestation. Hence, development of biodiesel feedstock from other crop such as jatropha is essential to address food security and environmental issues related to palm oil. Various research center and universities in Indonesia has already done many studies regarding technical and economic aspects of non-edible crops, (IEA 2008) which is very important for future biodiesel development in Indonesia.

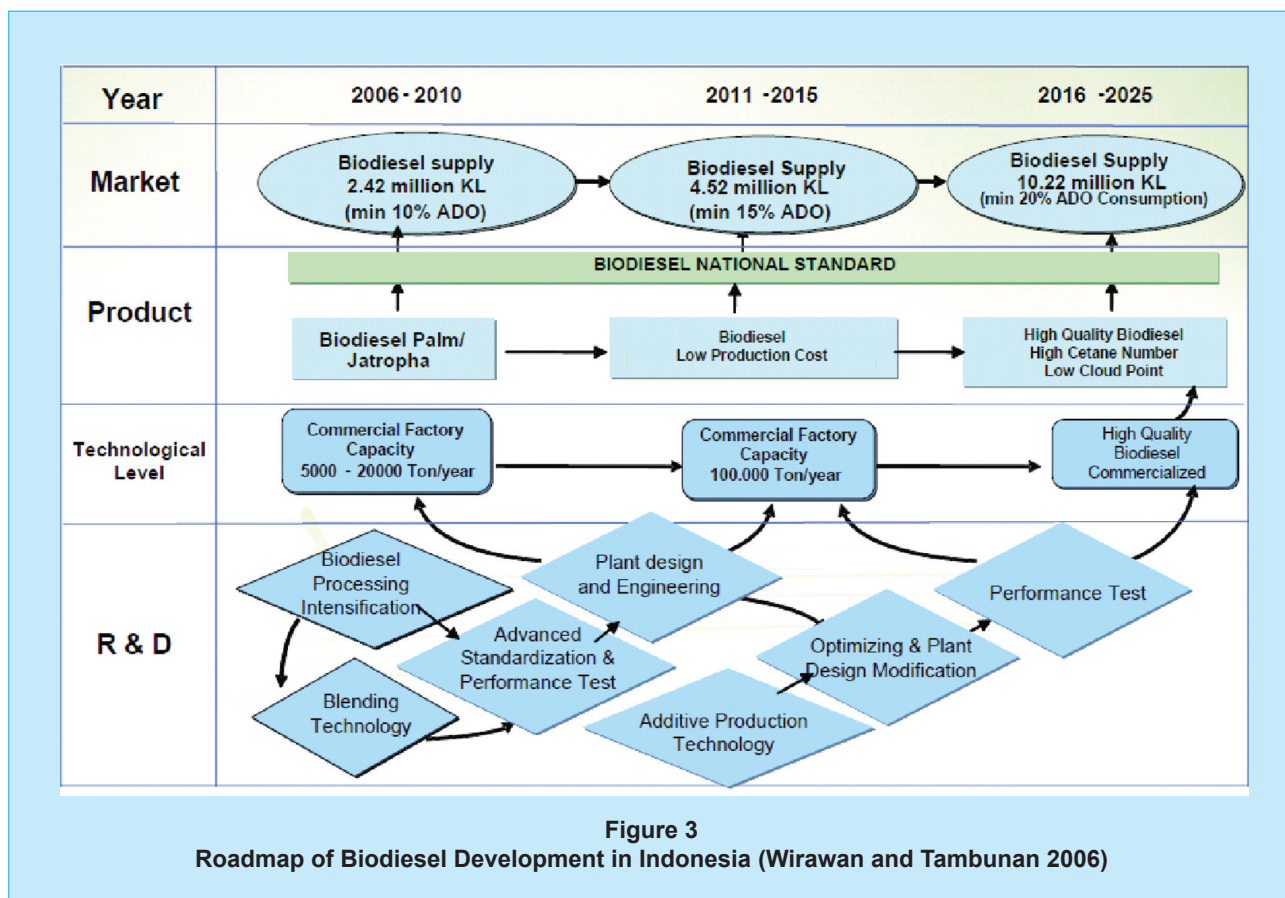
#### IV. FUTURE POTENTIAL OF BIODIESEL DEVELOPMENT IN INDONESIA

Further planning for expansion and biodiesel development has been formulated by Indonesian government through a roadmap for biodiesel development up to 2025 as illustrated in Figure 3.

The target is biodiesel supply will achieve 4.52 and 10.22 million kilolitres (million kL) in 2011–2015 and 2017–2025 respectively to substitute up to 20% of all diesel consumed. Currently, biodiesel supply is 2.42 million kL and expected to substitute 10% of diesel consumed (Wirawan and Tambunan 2006).

However, in 2010, the actual blending in the market of transport petroleum diesel is 2.5% biodiesel much lower than the original target (Dillon *et al.* 2008). To achieve mandatory targets as shown in the roadmap, 3.64 million hectares of land will be used in 2010 for oil palm plantations out of 5.25 million hectares of land allocated for biofuels crops. Ultimately, more than 7 million hectares of land in 2025 are required for plantations of all biofuels crops such as oil palm, jatropha, sugar cane and cassava (IEA 2008).

For future development, there are approximately 18 million hectares land excluding peatland, forests and other protected areas that suitable for oil palm plantations (Winrock International 2009). There are also approximately 15 million hectares of land throughout Indonesia that are suitable for jatropha plantation. However, there are many impediments to develop jatropha, such as lack of seeds and it is unproven commercially (Legowo 2007).





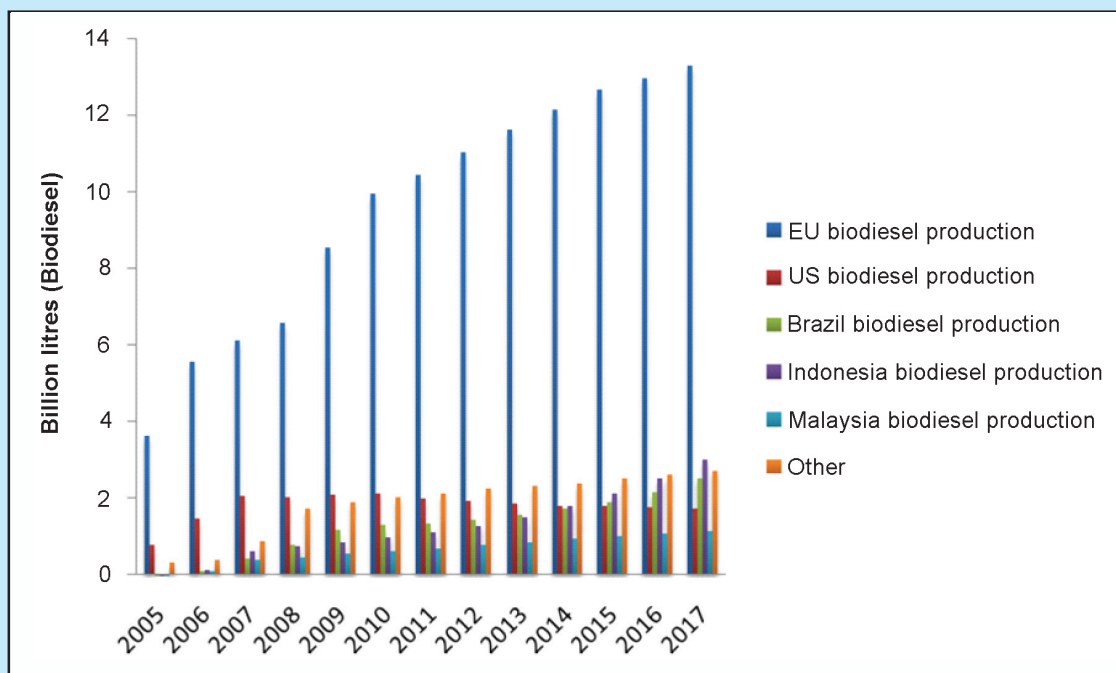


Figure 4  
World's Biodiesel Production (Jackson 2010)

There is also a prospect of exporting biodiesel product particularly with projection of the world's biodiesel production up to next 6 years as shown in Figure 4. Currently, the world's largest biodiesel production is predominantly from EU and the USA. For the next 6 years, it is predicted that EU still lead the market and Indonesia will be the second largest world biodiesel producer. To fulfill the mandate of biodiesel regulation, EU have to import their feedstock, it is projected that the import will be either from Indonesia or Malaysia. Hence, it is a big opportunity for Indonesia to export biodiesel products that fulfill the EU standard.

## V. IMPACT OF BIODIESEL DEVELOPMENT

### A. Environmental Impact

There are many both positive and negative impacts of biodiesel for the environment. Firstly, it is proven by laboratory and road test that biodiesel reduce pollutant emissions such as carbon monoxide, volatile organics and particulate matters (USAID

Asia 2009). The effectiveness of emissions reduction depends on the feedstock and blending composition. However, the usage of all types of biodiesel increases nitrogen oxides. Figure 5 shows an estimation of pollutant emissions changes for various biodiesel blends and feedstocks.

Other environmental impact of biodiesel development is mainly related to land use, land use change and forestry. Oil palm and jatropha give the most significant GHG savings when planted on degraded land without loss of natural vegetation. On the other hand, oil palm will produce 8 to 12 times GHG emissions in life-cycle analysis of palm biodiesel when cultivated by replacing forest as shown in Figure 6 (USAID Asia 2009). Another report from CSIRO in 2007 stated that palm oil biodiesel resulted in a saving in GHG emissions of 80% compare to petroleum diesel. On the other hand, when palm oil biodiesel is associated with replacing rainforest or peat swamp, they discovered the emissions are 8 to 21 times higher than petroleum diesel (Dillon *et al.*, 2008).

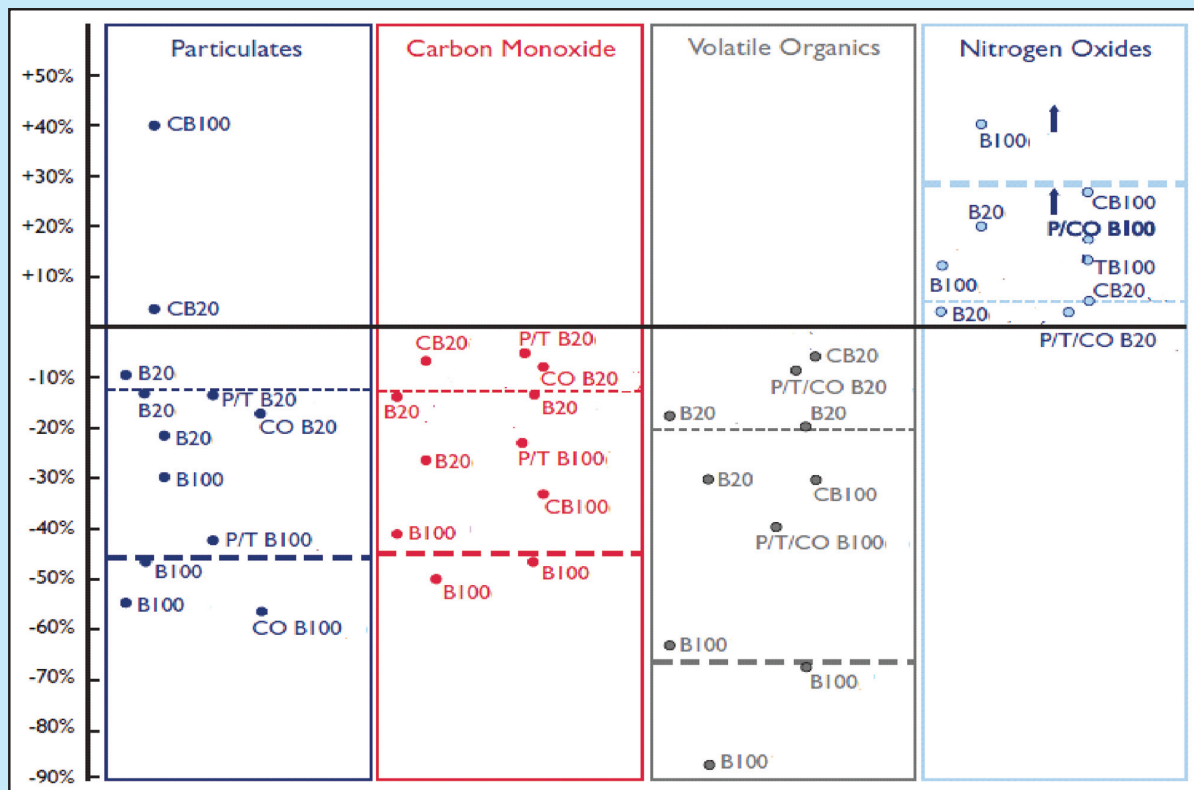
In contrast, another study shows different result. According to Yee, et al. (2009) effectiveness of oil palm plantations is similar to rainforest in term of carbon sinks areas of dry matter that provide to absorb GHGs from the atmosphere. The study (summarized in Table 5) stated that net assimilation of oil palm plantation (64.5 tonnes CO<sub>2</sub> per hectare per year) is slightly higher than net assimilation of rainforest (42.4 tonnes CO<sub>2</sub> per hectare per year).

Yet, it is debatable whether oil palm plantations cause deforestation in Indonesia or not. Koh *et al.* (2011) studied changes

in land usage especially in islands of Sumatra and Kalimantan, Indonesia. They pointed out that by the early 2000s, 90% of oil-palm plantation was

Parameter	Oil palm (plantation)	Rainforest
Gross assimilation (t CO <sub>2</sub> /ha/year)	161.0	163.5
Total respiration (t CO <sub>2</sub> /ha/year)	96.5	121.1
Net assimilation (t CO <sub>2</sub> /ha/year)	64.5	42.4
Leaf area index	5.6	7.3
Photosynthetic efficiency (%)	3.18	1.73
Radiation conversion efficiency (g/M)	1.68	0.86
Standing increment/year (t)	100	431
Biomass increment/year (t)	8.3	5.8
Dry matter production/year (t)	36.5	25.7

**Table 5**  
**Comparison of some physiological parameters of oil palm and tropical rainforest (Yee *et al.*, 2009)**



CB = Canola-based, P = Palm Oil, T = Tallow, CO = Cooking Oil

**Figure 5**  
**Estimated pollutant emissions changes for various biodiesel blends (USAID Asia 2009)**

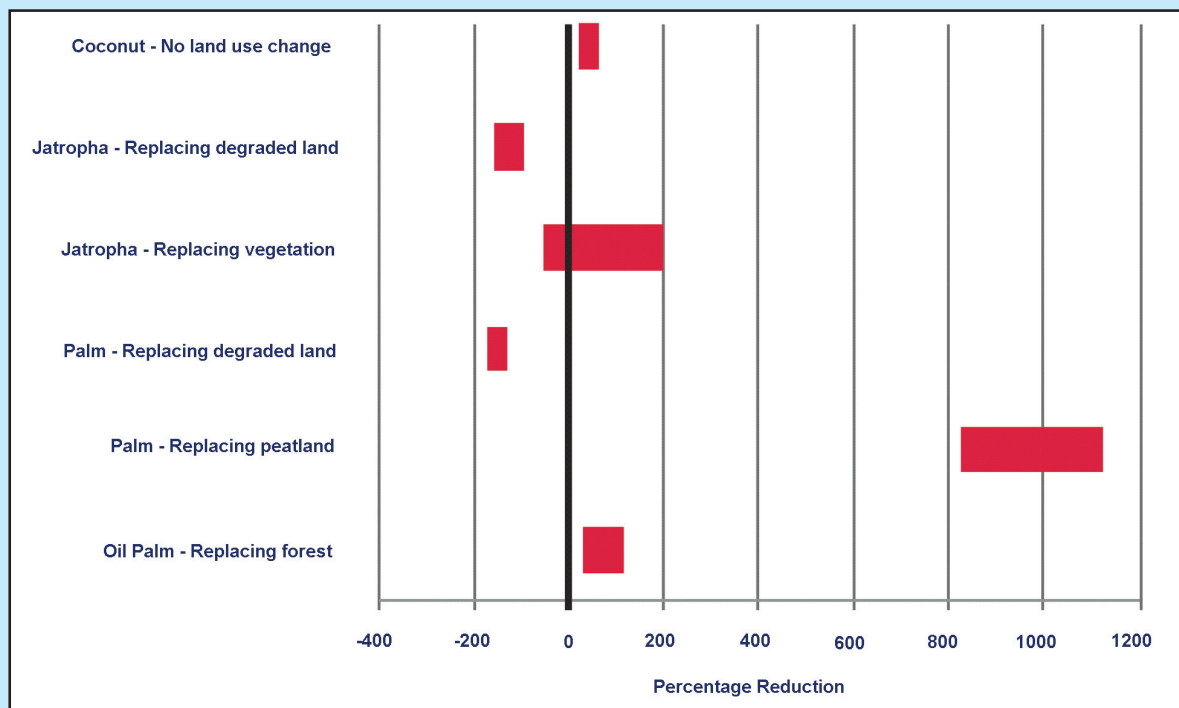


Figure 6  
Range of net GHG balances for biodiesel system (USAID Asia 2009)

in non-peat areas, only 6% of total peatlands had been cultivated with oil palm. Hence, it is evidence that oil palm plantation was not the main cause of deforestation in Indonesia.

It is important to compare the policy of renewable energy and its impact to the environment to another country that has a similar situation like Indonesia such as Brazil. Similar to Indonesia, Brazil is a developing country that has huge tropical rainforest and has already implemented biofuels for many years. Table 6 shows a comparison of Indonesia and Brazil in term of biodiesel policy and their efforts to prevent deforestation.

Nonetheless, there are many critiques from the NGO regarding moratorium issued by the Indonesian government. First, presidential instruction is not a very strong law instrument to prevent deforestation. Hence, there will be no strong law enforcement when illegal logging keep occurring in the forest. Second, according to Greenpeace, 40 million hectares of Indonesian forest are left open for deforestation under the moratorium because moratorium only covers peat land and primary forest. Whereas vast areas of sec-

ondary forest, still rich in biodiversity, important for local livelihoods and storing huge amounts of carbon, can still be logged and converted (Butler 2011).

### B. Impact on Biodiversity

Biodiversity is important because it provides benefits not only to local community (Indonesia) but also to the global community. Indonesian forests have approximately 25,000 flowering plants and high number of mammals, reptiles, amphibians and birds (Pagiola 2000). Impact of biofuels on biodiversity mainly associated with land use change from diverse rainforest to monoculture plantations (oil palm). Overall Southeast Asia, biodiversity is reduced by about 85% due to palm oil plantations compare to remain unchanged habitat (Fargione *et al.* 2010). Land use change from peat swamp forests to palm oil plantation considered as a reason to the local extinction of 1% biodiversity (4 species of forest-dwelling birds) in Borneo and 3.4% biodiversity in Sumatra (16 species of forest-dwelling birds) by early 2000s. Nowadays (10 years later), it is likely that biodiversity loss will much more higher than those numbers (Koh *et al.* 2011).

**Table 6**  
**Comparison of Indonesia and Brazil in term of biodiesel policy**  
**and their efforts to prevent deforestation**

Biodiesel	Indonesia	Brazil
Policy	National Energy Policy, Presidential Decree No. 5 Year 2006	Presidential Decree dated July 2, 2003
Implementation	Biodiesel Roadmap 2006-2010: 10% biodiesel blending in Automotive Diesel Oil (ADO) 2011-2015: min. B15 2016-2025: min. B20	Energy Matrix 2005-2008: optional use of B2 After 2008, B2 will be mandatory 2008-2013: blends up to 5% biodiesel After this period, B5 will be mandatory
Issue with deforestation	20 May 2011: The moratorium on permits for new concessions in primary rainforests and peatlands through a Presidential Instruction, No 10, 2011 "Suspension of Granting New Licenses and Improvement of Natural Primary Forest and Peatland Governance"  Aim: <ul style="list-style-type: none"> <li>To slow Indonesia's deforestation rate</li> <li>The suspension will cover 64 million ha of primary forest.</li> </ul> Indonesia agreed to establish the moratorium as part of its reducing emissions from deforestation and degradation (REDD+) agreement with Norway (2 years after Norway agreement with Brazil).	2008: plans to reduce deforestation by 70 percent from a 1996-2005 baseline  Target: Cut emissions from deforestation by 4.8 billion tonnes between 2006 and 2017  Reducing deforestation: <ul style="list-style-type: none"> <li>2006-2009 11,400 km<sup>2</sup> per year (2006-2008 averaged 12,500 km<sup>2</sup>)</li> <li>2010-2013: 7,980 km<sup>2</sup> per year</li> <li>2014-2017: 5,586 km<sup>2</sup> per year</li> </ul> REDD+ Agreement with Norway: Norway pledged \$1 billion to Brazil for reducing Amazon deforestation

Data adapted from: Butler 2009; Butler 2011; Daemeter 2011; Legowo 2007; Wirawan & Tambunan 2006; and Pousa et al. 2007

Other impact of palm oil expansion is a threat to endangered species such as orangutan, Sumatran tiger and Asian elephant. Those species needs forest cover for conservation. On the contrary, palm oil plantation cleared land. However, some conservation groups and oil palm industries have arranged the Roundtable of Sustainable Palm Oil (RSPO) to set up some standards for sustainable production for example using idle lands and improving yields to achieve an efficient supply-side (production) (Nantha and Tisdell 2009).

### C. Social and Economic Impact

Biodiesel development has an important role related to social and economic impacts particularly in regional development and creation of employment. The government of Indonesia set a target to create 3.5 million new plantations job in line with roadmap of biodiesel development that eventually will lead to a growth in agricultural sector and the rural economy. Additionally, it is likely to reduce

poverty and improve livelihoods in the rural areas (Dillon *et al.* 2010). On the other hand, there will be a concern on social impact regarding indigenous people in particular the land conflict between Palm Oil Company and people who live around the plantation area (USAID Asia 2009).

Another important economic impact of biodiesel development is its competition with food. Increased consumption of biodiesel intensifies demands for both food and fuel. In most cases biodiesel feedstocks are also food crops such as palm oil (or canola and soybean in other countries). As a result, it creates a conflict between food and energy supply (Pimentel *et al.* 2009). Accordingly, increasing palm oil production will boost the price of cooking oils as production changes to biodiesel feedstock. This happens because energy markets are large relative to agricultural markets (Datuk 2008). Thus, a small change in energy demand means a large change in demand for agricultural feedstocks, raising concerns about food prices and food security.



## VI. CONSTRAINTS FOR FUTURE BIODIESEL DEVELOPMENT

There are some constraints for future biodiesel development in Indonesia, i.e.:

### a. Uncertain implementation of biofuel policy in the future.

It is related to political condition especially after new election in 2014. There is no assurance that new elected government will continue the policy.

### b. Fossil fuel subsidies

Currently, Indonesian government subsidizes fossil fuel. It will make biodiesel more expensive to produce than fossil fuel and eventu-

ally make biodiesel not competitive. Hence, the government needs to subsidize biodiesel as well. The subsidy to support renewable energy development is a common practice in some countries such as Brazil where they produced ethanol from sugarcane. For many years subsidies were given by Brazilian government to establish ethanol industry (Dillon et al. 2008). As a result, today Brazil becomes one of the world market leaders in biofuels.

### c. Uncertainty of crude oil price and crude palm oil (CPO) price

Both crude oil and CPO prices are very volatile. Two graphs in Figure 7 show fluctuation

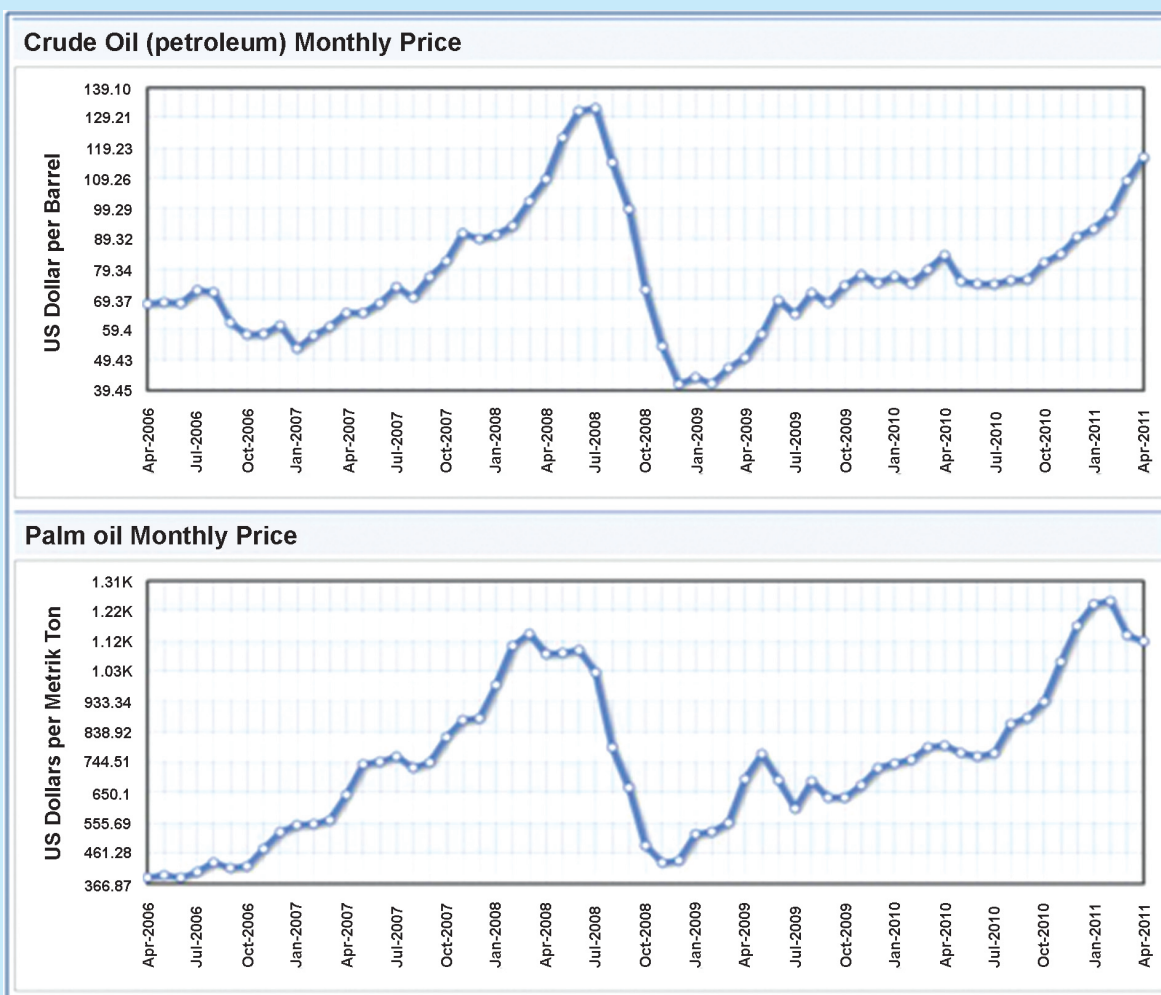


Figure 7  
Comparison of crude oil and CPO price from April 2006 to April 2011 (indexmundi.com 2011)

of crude oil and CPO price for the last five years. Generally, price of vegetable oil is more expensive than for diesel oil for the past 15 years (indexmundi.com 2011). It causes biodiesel more expensive to produce than fossil fuels.

#### d. Policy outside Indonesia

Since Indonesia intends to export its biodiesel product, policies outside Indonesia such as Roundtable Sustainable Palm Oil (RSPO) and EU Biofuels Import Restrictions will affect both Indonesian policies and products significantly. RSPO is a voluntary certification system to assure consumers that palm oil they buy derived from sustainable sources (Dillon et al. 2008). But RSPO is just like two sides of a coin. On one hand, it can reduce negative environmental impact and support sustainable development of palm oil industry. On the other hand, if the company fails to prove that their products are not from sustainable sources, they will not get a certificate, which require for export. Other regulatory standard is the European-based Roundtable on Sustainable Biofuels that is different from RSPO. The EU has mandated imports of biofuels products that demonstrate GHG savings of 45 percent or more compared to petroleum-based fuels. EU studies conclude that palm oil yields GHG reductions of less than 35 percent. Hence, EU Biofuels Import Restrictions will affect products of palm oil biodiesel from Indonesia. However, Malaysian Palm Oil Board ensures that palm oil biodiesel will reduce 50% of GHG emissions if it is produced sustainably (USAID Asia 2009). Thus, it is likely that Indonesia can overcome this restriction if intend to import biodiesel product in the future.

## VII. CONCLUSION

Indonesian Government has an impressive plan to develop biofuel, however it is required to have more comprehensive guidance to support current policy. Both policy and guidance are very important to support biodiesel development, which will increase economic growth through regional development and creation of employment that eventually will reduce poverty in Indonesia. Moreover, future biodiesel

development will be better if focus on feedstocks that do not compete with food production because currently biodiesel feedstock in Indonesia focus on palm oil. Another important consideration of biodiesel development is its impact on the environment. If managed imprudently, future expansion of biofuels production will lead to further loss of tropical forests which is eventually will increase GHG emissions and loss of valuable biodiversity.

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