Current Status of Bioenergy Development in Indonesia

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Abstract

Because of the effects of high petroleum and natural gas prices, Indonesia is implementing national policies and legislation to encourage bioenergy production as a means to achieve energy security and self-sufficiency and to reduce reliance on fossil fuel reserves. The growing national and international demand of bioenergy is particular interest to developing countries like Indonesia for seeking opportunities on economic growth and trade. Indonesia has a comparative advantage for bioenergy production because of greater availability of land, favorable climatic conditions for agriculture and lower labor costs. However, Indonesia faces socio-economic and environmental implications affecting the potential to benefit from the increased local and global demand of bioenergy. The interrelationship between land uses and the competing needs of energy and food security is a key issue in the bioenergy that should be considered. In addition, the effects of large-scale bioenergy production on global commodity prices are a significant trade concern. Bioenergy production may also entail harmful environmental effects such as deforestation and loss of biodiversity. Regulation is required to reduce the negative impacts of large-scale production, as well as to ensure that the most cost-effective and highest-energy conversion technologies are used. Given the opportunities and risks, criteria for the sustainable development of the bioenergy industry should be clearly established in both international and national regulatory frameworks.

Keywords: energy, bioenergy, alternative energy, renewable, sustainable development

I. Introduction

Indonesia derives the vast majority of its energy consumption from fossil fuels. From the 95% of fossil fuels energy consumption, the fossil oils consumption is 52%. Almost half of the fossil oil is supplied by subsidy. However, since 30 September 2005, the government has reduced the subsidy by increasing the price of fossil oil ranging from 188% up to 286%.

Indonesia, as an oil producer, holds proven oil reserves as 4.7 billion barrels. However, as the oil demand is increased, Indonesia has become a net oil importer since 2004 as described in Figure 1. Indonesian crude oil production averaged 944,000 barrels per day (bbl/d)**,** down from the 2004 average of 967,000 bbl/d and continuing the decline of the past several years. The decline is due mainly to the natural fall off of aging oil fields, a lack of new investment in exploration and development, partially due to regulatory difficulty.

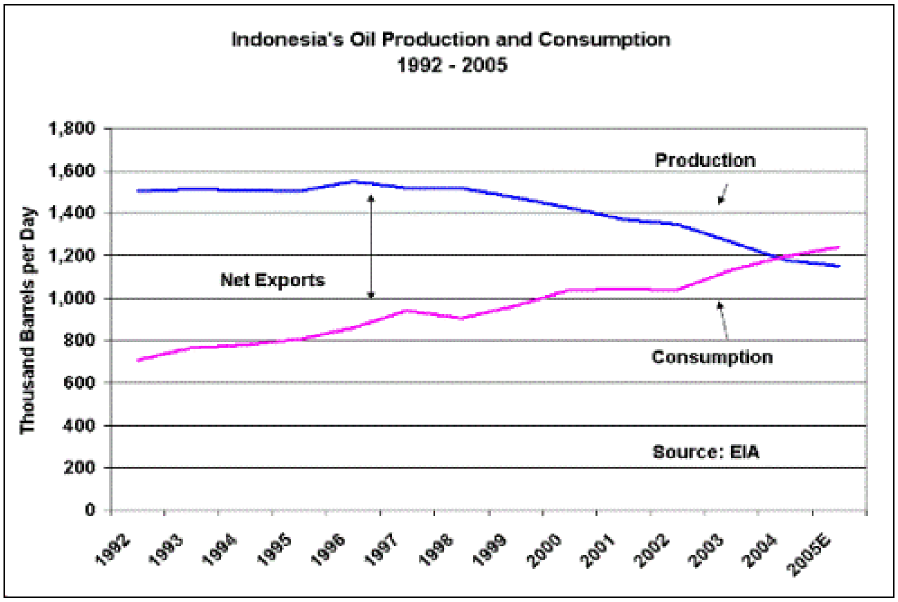


Figure1. Oil production and consumption of Indonesia 1992-2005(Source EIA)

In addition to fossil energy sources, Indonesia is blessed with relatively abundant potential of renewable energy, according to the data, geothermal potential is about 20 thousand MW, hydro power is about 75 thousand MW, biomass is around 50 GW, solar energy is about 1203 TW and 9287 MW for wind energy. However, the utilization of renewable energy in Indonesia is still very low compare to its huge potential.

The energy utilization is always linked to the emission generation. Fossil energy sources are the major contributors to greenhouse gases (GHGs) emission and climate change. The studied showed around 60% of GHGs emission come from fossil energy utilization. In order to minimize the global warming as a result of the increase of GHGs emission, Indonesia look into the use of clean energy such as renewable energy sources and clean fossil fuel. One of the barriers in developing renewable energy technology and clean energy technology is related to its high investment cost due to the most of the technologies are still imported. Therefore, research and development activities to produce locally proven technology with lower cost are very important.

The growing national and international demand of bioenergy is particular interest to developing countries like Indonesia for seeking opportunities on economic growth and trade. Indonesia has a comparative advantage for bioenergy production because of greater availability of land, favorable climatic conditions for agriculture and lower labor costs. However, Indonesia faces socio-economic and environmental implications affecting the potential to benefit from the increased local and global demand of bioenergy. The interrelationship between land uses and the competing needs of energy and food security is a key issue that should be considered. Such kind issues directed the Government of Indonesia to make regulation for bioenergy development.

II. Policy and Program of Bioenergy in Indonesia

2.1. National Policy on Bioenergy

Indonesia is the world's second largest palm oil producer after Malaysia, but it was not until after global fuel prices soared and Indonesia became a net fuel importer that the Indonesian Government began to actively pursue alternative energy industries, including biofuels produced from palm oil. The government reduced and then eliminated fuel price subsidies in 2005, allowing the biofuel industry to become economically viable. Since then, the government has enacted legislation to encourage the use of biofuels, including Presidential Regulation No. 5/2006, Presidential Instruction No. 1/2006 and Presidential Decree No. 10/2006 (ESDM; 2006; Sudradjad,2006).

In 2005, the Minister of Energy and Mineral Resources issued a National Energy Management Blueprint (NEMB) in support of the National Energy Policy (NEP). Article 4 of the NEMB establishes national strategies for the management and use of energy resources including a roadmap for each alternative energy sector. It provides a target for biodiesel use of 1.5 million kilolitres in 2010 (10% of national transportation diesel oil consumption) and targets an increase of up to 6.4 million kilolitres in 2025 (20% of national transportation diesel oil consumption, or 5% of total national diesel oil).

Presidential Regulation No. 5/2006 implements the NEMB. It states that the purpose of the NEP is to ensure a secure domestic energy supply and to encourage sustainable development. Article 2 establishes a target for biofuels to contribute at least 5% of the total national energy consumption by 2025. Presidential Instruction No. 1/2006 establishes the framework for coordination among ministries to promote the supply and use of biofuels. It designates ministries responsible for formulating and implementing policies, including incentives, tariffs and trading systems, as well as standards and procedures for cultivation methods, processing, quality testing, the supply and distribution of biofuels, the provision of land and the development of research and technology. Specific to agricultural production, articles 3 and 4 provide that the Ministry of Agriculture shall encourage the provision and development of bio-fuel plants including seeds and seedlings, whereas the Ministry of Forestry shall provide licenses regulating the use of unproductive lands for biofuel plantations.

Indonesia established biodiesel standard SNI 04-7182-2006 which was approved by the National Standardization Agency under on 22 February 2006. The biodiesel standard was formulated by taking into account similar standards already applied in other countries such as ASTM D6751 in the US and EN14214:2002 in the EU. On 17 March 2006, the Oil and Gas Directorate-General of the Department of Energy and Mineral Resources issued a decree regarding the quality and specification of two types of diesel oil. This decree regulates the use of fatty acid methyl ester up to the maximum of 10 percent of the volume of automotive diesel fuel with which it is to be blended. The biodiesel to be mixed has to meet the biodiesel standard SNI 04-7182-2006.

2.2. Village Self-Sufficiency Energy Program (Desa Mandiri Energi)

Indonesia is island country where many villages are isolated and remote. Forty five percent of them have minimum access to road, education, health, electricity and national distribution of fuel oil. The difficulty of transportation to remote locations causes some people in this country are not experiencing the highest allowable retail price (HET) of oil subsidy. Further, those in remote area are usually categorized below the poverty line. As an example, in Wamena Papua, the price of household kerosene is Rp 20.000/liter, while the highest allowable price for subsidized kerosene is Rp 2.300/liter. To overcome this problem, the government has developed a program of village self-sufficiency energy or ″Desa Mandiri Energy (DME) ″.

The DME program is a participatory rural approach program. There are several arrangements of DME program (*Tim Nasional Pengembangan BBN*, 2007):

1. The project of DME in the village has aims to open job opportunity, reduce poverty and produce biofuel.
2. The location could be placed at agricultural based, fisheries based or transmigration area
3. The plant is managed by local farmer corporation or small and medium scale of business
4. The central government and local government provide contribution for plantation (seed, mother stock seed, machineries etc) through government budget.
5. The location of DME is nominated by local government. However, it is still possible that the location of DME is nominated by entrepreneur, NGO or local people.

Because many villages are eligible for DME, the government performs this project gradually from 2007 to 2010. The funding contribution for DME project is as follow (Figure 2):

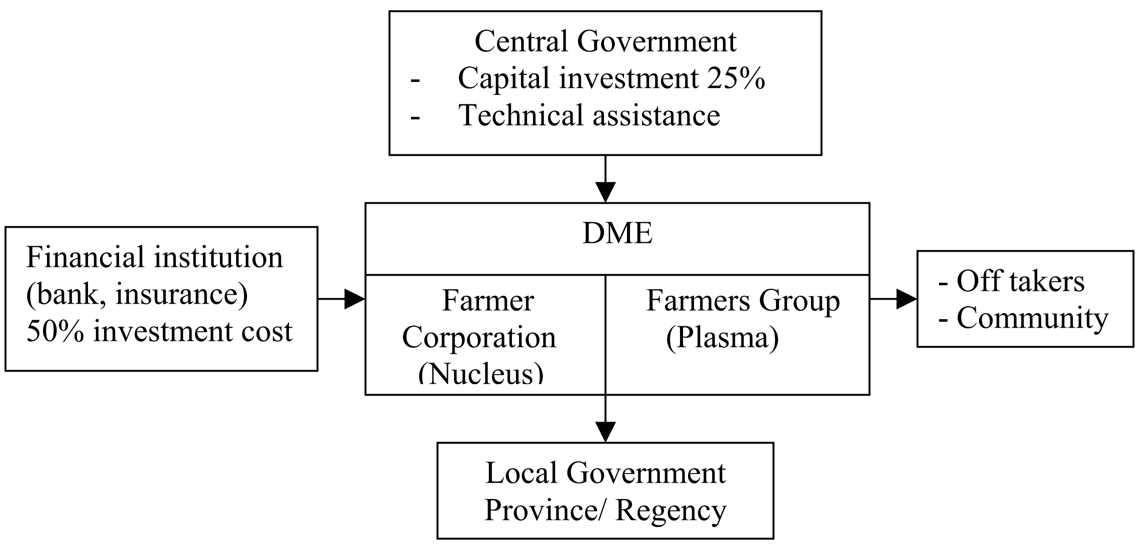
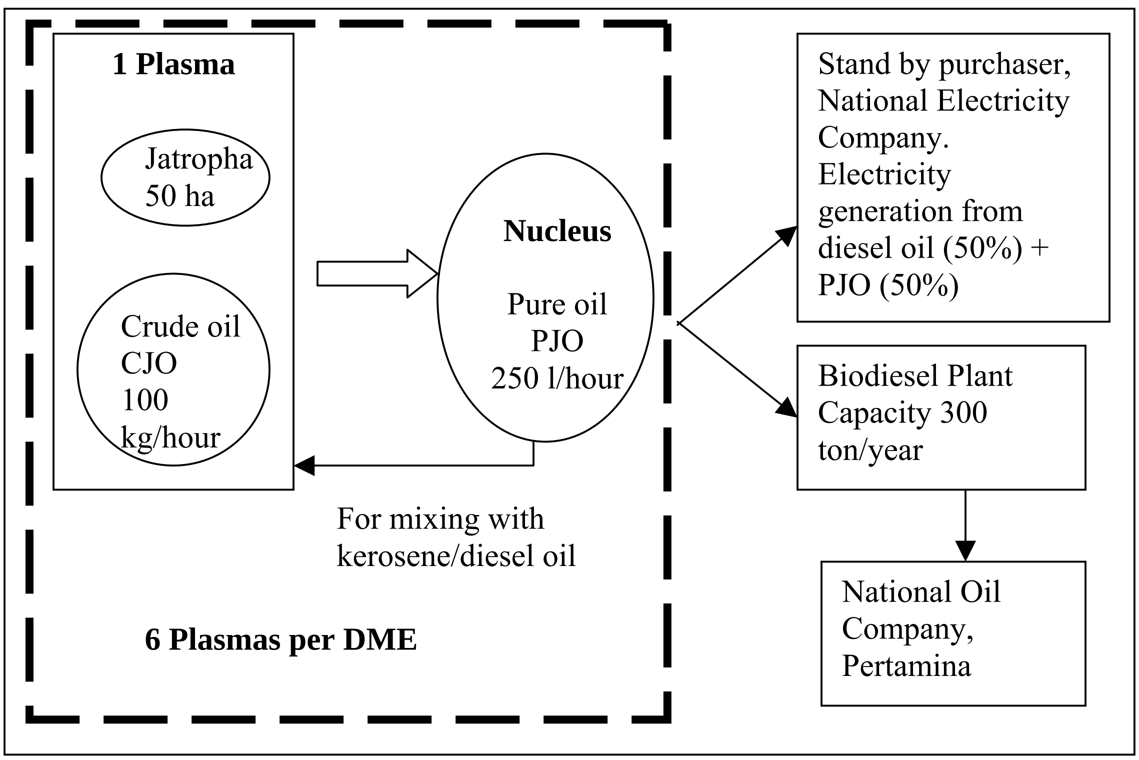


Figure 2. The scheme of DME funding

The DME is developed by the networking system of a nucleus and several plasmas (Figure 3). The nucleus could be the processing plant in a village scale while the plasma consists of farmers or farmers group who produce the feedstock. To be sustainable, it should be preceded by the feasibility assessment (technical, socioeconomical). In this feasibility assessment, it evaluates relation between the agro ecosystem and socio-economic feasibility. There are five models development of commodities based for DME such as *jatropha curcas*, palm oil, coconut, cassava and sugar cane. However, other potential commodities such as corn, sorghum, *arengga pinnata* are also accepted.

DME or special region for biofuel development is one of program to open job opportunity and eliminate poorness of society at isolated or remote villages by empowering the society to fulfill their energy need. DME program can exploit marginal land of 5 million hectares to produce several kind of biofuel feedstock and able to create job opportunity for 3–5 million people.

An example of networking between stakeholders in a DME based on *jatropha curcas* is as follow:



Remarks: Crude Jatropha Oil (CJO), Pure Jatropha Oil (PJO)

Figure 3. DME based on *jatropha curcas*

III. Research and Development

3.1. Biodiesel

In fact, the effort of biodiesel development in Indonesia has been made since more than ten years ago. However, the activity was not become priority due to the cheap oil price in the country. Research activity was limited only in laboratory scale and performance test. Several Indonesian research institutions have been pioneering worked on biodiesel development including LEMIGAS (Oil and Gas Technology), PPKS Medan (Indonesian Oil Palm Research Institute, Department of Agriculture), ITB (Bandung Institute of Technology), and BPPT (Agency for the Assessment and Application of Technology). By that time, biodiesel developments are mainly focused on production process technology, engineering, biodiesel property and performance test, standardization and promotion. To accelerate the information exchange among biodiesel stakeholders and to promote biodiesel development, a national forum for biodiesel called *Forum Biodiesel Indonesia* (FBI) was established in 2002. The forum members comprise of scientists from universities and research institutes, automotive industry associations, palm oil association, engineering industries, biodiesel producers, relevant government offices (Ministry of Transportation, Ministry of Energy and Mineral Resources, Ministry of Agriculture) and several non governmental organizations. The following are some activities of several research institutions that work on biodiesel.

• LEMIGAS (Oil and Gas Institute), in cooperation with Pertamina (a state own oil company), has tested biodiesel blended with automotive diesel oil (ADO) at a ratio of 30:70 for commercial diesel engine vehicle in 1996. The program was intended to support the national policy on energy conversion and diversification. This early research unfortunately showed that biodiesel gave negative impact on the engine performance despite of its positive results on the engine's emission. Currently, LEMIGAS specializes in the testing methods for biodiesel fuel properties.

• Ministry of Agriculture, Indonesian Center for Agricultural Engineering Research and Development (ICAERD) has worked on biodiesel for several years. ICAERD has been partly modified the seed oil extractor made by RRC for *jathropha* oil extractor. The capacity is 70-80 kg seed/hour. Depended on the seed quality, the oil extracted is on average 25% - 28% (Handaka and Hendriardi, 2005). PPKS Medan has also carried out research on biodiesel production from palm oil. In cooperation with ITB, they have conducted road test Java-Sumatra in 2004 which covered a total distance of 2,020 km (Reksowardojo, *et al*., 2005; Prastowo, 2006).

• ITB (Bandung Institute of Technology) has focused its research and development on macroeconomic studies of biodiesel, developing technology for jatropha oil extraction and its conversion to methyl ester. The institute is also focusing on standardization of fuels and on diesel engine test series. The pilot scale biodiesel plant with the capacity of 150 L product per batch was developed by ITB.

• Engineering Center–BPPT has been developing biodiesel since 2000 and the center has focused its work on the process technology and engineering of biodiesel production. The center uses various raw materials, such as various CPO grades, Palm Fatty Acid Distillate (PFAD) and Coconut Fatty Acid Distillate (CFAD). The property and performance tests of the biodiesel produced are carried out in Thermodynamics and Propulsion Engine Research Center (BTMP), another BPPT Laboratory, that focusing its work on diesel engine bench and non-stationary operation tests for performance and emissions of fuels include biodiesel. Until now, the Engineering Center–BPPT has constructed and been operating a pilot plant with daily capacity of 1.5 tons since 2003. In cooperation with the Riau Provincial Government, the Engineering Center–BPPT has completed the construction of a biodiesel plant with daily capacity of eight tons. The continuous system with three ton per day capacity plant now still under constructing at the Science and Technology Research Center in Serpong, Banten.

In addition to the development of biodiesel production, Engineering Center-BPPT has also carried out two road tests. The first one is the Java - Sumatra road test carried out in 2002, that covered a distance of 5,000 km. The second one is Java - Bali road test in 2004 that covered a total distance of 20,000 km. Both tests were carried out in cooperation with leading automotive companies in Indonesia. The first one was PT. Toyota Astra Motor that supplied the vehicle and emission testing facilities. In the second road test, PT. Pantja Motor worked actively in the vehicle performance test along with BTMP-BPPT while JIF – Japan Indonesia Science and Technology Forum, provided a sponsorship. As a promotion activity, Engineering Center-BPPT also conducted similar road test for the BPPT's 23 diesel buses for three months. The test has received a warm response from the bus drivers and the qualitative test has shown that the biodiesel is responsible for the reduction in the quality of engine exhaust; the engines noise were less and the acceleration was much better.

As a response to the government seriousness in supporting the biofuel development as a national priority program, a number research institution such as IPB (Bogor Institute of Agriculture, BPPT Biotechnology Center, Center for Plantation Research and Development, Ministry of Agriculture now have actively started on biodiesel development, especially in the field of farming technology. Several private and state companies such as PT. Energi AIternatif Indonesia, PT. Rekayasa Industri, PT.Eterindo Wahanatama, PT. Rajawali Nusantara Indonesia, etc, now have also actively started on biodiesel business.

The diesel oil consumption in Indonesia places the first rank compared to other sources of oils (Table 1). The diesel oil consumption is increased from 22 072 ML in 2000 to 27 466 ML in 2005. In 2006, the consumption is fall to 25 092 ML due to the increase of the selling price up to 205% (DESDM, 2007).

Table 1. Oils consumption of Indonesia year 2000-2006 (000 kL)

Oils	2000	2001	2002	2003	2004	2005	2006
Automotive diesel oil	22 072	23 357	24 276	24 046	26 488	27 466	25 092
Lighting kerosene	12 458	12 280	11 676	11 753	11 846	11 370	10 018
Premium gasoline	12 429	13 067	13 630	14 647	16 418	17 459	17 067

Source: DESDM, 2007

Diesel oil is used widely in transportation sector, industry and agricultural machineries. The program of biodiesel, B-5 (blending 5% biodiesel with diesel oil) has been introduced by government in 2006. At this moment, the B-10 has been applied, but only at several pump stations in Jakarta and Surabaya. However, the government has target to apply B-10 in more big cities at 2011-2015. Bio oil and biokerosene is also intended to apply as an alternative source of lighting kerosene and power station fuel oil. In 2015, it is planned that the O-10 (blending 10% bio-oil with lighting kerosene) will be applied as an alternative source of kerosene for household and O-50 (blending 50% bio-oil with fuel oil) will be applied for power generation of national electricity company (Timnas Energi, 2006).

The feedstock for bio-oil and biodiesel production has planned mainly from palm oil and jathropha curcas. However, other potential feedstock such as unused frying oil, rubber seed, coconut etc is also encouraged. As stated previously, the development is based on potency of specific location. For good standard quality of biodiesel, the national standard of biodiesel is issued as SNI Biodiesel No. 04-7182-2006.

Oil Palm

Indonesia is the second largest country of world palm oil producer. Palm oil and its derivatives have been used widely as edible oil, industrial material and export commodities as crude palm oil (CPO). For bio-oil production, it utilizes CPO and waste of palm oil industries. The process of transesterification is mainly used to convert the oil as FAME (fatty acid methyl ester). It may be the cheapest and viable technologies at the moment compared to other processes. In big scale, the alcohol (e.g. methanol) could be recovered for the next process of transesterification.

Pilot plant of biodiesel production from palm oil has been built for capacity up to 10 ton per day. Productions of biodiesel are supplied to *PT Pertamina*, the national company of oils and gas. Other outer investors are also interested to develop biodiesel production plant in Indonesia. However, the government still formulates the regulations. It is predicted that the investors may be dealing in mid 2008.

The barrier to expand the production of biodiesel feedstock from palm oil is that this commodity is used for other purposes. Therefore, it may have potential conflict as feedstock of energy, industry and food stock. However, recently, the expansion area of cultivation is growing vastly. If uncontrollable, it may impact on environment such as deforestation.

Jathropha curcas

Jathropa curcas is promoted as feedstock of bio-oil and biodiesel in Indonesia. It is not edible oil and not used for industry sector at present. Therefore, it will reduce the potential conflict of other uses on the outside of energy sector. *Jathropha curcas* is also growing well at wide range of soil textures such as soil with high mineral content, sandy soil or clay soil with good drainage. This plant is also appropriate for land conservation.

Jathropha curcas is a shrub plant. The fruit is kernel which contains 3 seed each. In mature seed, it contains 35-45% of oil. Some of the cultivars are known as non edible plant. Research also finds that oil contents of the cultivars are also varied. Compared with biodiesel from palm oil, the oil from *jathropha* has lower pour point ($-2.5^{o}C$); therefore it may use in some four seasons countries. In Indonesia, *Jathropha curcas* previously was used only for fence plant. After promoted as bio-oil feedstock, it is cultivated in farm as monoculture or hetero culture (Prastowo, 2006).

The pathway of the growth *jatropha curcas* is mainly for developing community self production of energy (DME) especially in rural area. It will further use as an alternative source of lighting kerosene, marine diesel oil or fuel oil. The plant of oil production is also encouraged only in small and medium scale with low to middle complexity of technology. The plant may process on average capacity of 0.5 - 1 ton seeds/per day. Typical process of oil extraction from *jatropha* seed is by mechanical extraction that is screw press or hydraulic press.

The barriers of application jathropha curcas as bio-oil at the moment are

- Kerosene is still subsidized up to 2007; the price of *jatropha* oil is not competitive with kerosene subsidized.
- The productivity of the plant is still low; therefore farmers are more interested to plant other crops such as corn.
- The best cultivar (high yield, high oil content, adaptable and tolerance) is still under investigation.
- The viscosity of *jatropha* oil is higher than lighting kerosene. Lighting the jatropha oil is not as easier as the household kerosene. The simple technologies are still under development. Whilst transesterification of *jatropha* oil in rural area may be difficult to perform, because it is not easy to find catalyst and alcohol in most of those places.
- In fact, at present, people in rural area not only use kerosene for cooking but also get used to cook with firewood, coconut husk and charcoal. The *jatropha* oil may be used only for lighting in places at no electricity.

Other sources of feedstock

Other sources of feedstock bio-oil that are in research and development stage are coconut, rubber seed, cotton seed, rice bran and unused frying oil. All of them will be used for specific location based on typical local commodities available. For unused frying oil transesterification is applied in big cities. Local government of Bogor city has initiated to collect unused frying oil from restaurants and use as biodiesel for city circle bus *TransPakuan*.

3.2. Bioethanol

Bioethanol can be produced by converting the starch content of biomass feed stocks (e.g. cassava, corn, potatoes, beets, sugarcane, and wheat) into alcohol. The fermentation process is essentially the same process used to make alcoholic beverages. Yeast and heat are used to break down complex sugars into more simple sugars, creating bioethanol. There is a relatively new process to produce bioethanol which utilizes the cellulose portion of biomass feed stocks like trees, grasses and agricultural wastes. Cellulose is another form of carbohydrate and can be broken down into more simple sugars. This process is relatively new and is not yet commercially available, but potentially can use a much wider variety of abundant, inexpensive feed stocks.

The production of bioethanol by fermentation involves four major steps: (a) grow, harvest and delivery of raw material to an alcohol plant; (b) pre-treatment or conversion of the raw material to a substrate suitable for fermentation to bioethanol; (c) fermentation of the substrate to alcohol, and purification by distillation; and (d) treatment of the fermentation residue to reduce pollution and to recover by-products.

Fermentation technology and efficiency has improved rapidly in the past decade and is undergoing a series of technical innovations aimed at using new alternative materials and reducing costs. BPPT has been involved in the technological assessment since 1983 supported by bioethanol pilot plant facilities located in Lampung. The many and varied raw materials for bioethanol production can be conveniently classified into three types: (a) sugar from sugarcane, sugar beet and fruit, which may be converted to bioethanol directly; (b) starches from grain and root crops, which must first be hydrolyzed to fermentable sugars by the action of enzymes; and (c) cellulose from wood, agricultural wastes, which must be converted to sugars using either acid or enzymatic hydrolysis.

Bioethanol can be used as a liquid fuel in internal spark ignition combustion engines either purely or blended with petroleum. Therefore, they have the potential to change and/or enhance the supply and use of fuel (especially for transport) in Indonesia. There are many widely-available raw materials from which bioethanol can be produced, using already improved and demonstrated existing technologies. Bioethanol has favorable combustion characteristics, less pollutant emitted and high octane-rated performance.

Premium gasoline is mainly used for transportation sector. The national consumption of gasoline is the second highest after Automotive Diesel Oil (ADO). It is predicted that the growth consumption is 7% and by 2009, the needs will be 21 millions kL. Road map of biofuel development in Indonesia declares that bio-ethanol will be blended with gasoline gradually from E-5 to E-15 in 2015 for non Flexible Fuel Vehicle (FFV) while for FFV up to 40%. Based on those assumptions, prediction of bioethanol consumption in Indonesia is as shown in Table 2.

Table 2. Prediction of bioethanol consumption (millions kL) year 2006-1010

Year	Bioethanol consumption (millions kL)
2006	1.71
2007	1.75
2008	1.78
2009	1.82
2010	1.85

Source : Prihandana *et al.*, 2007

The feedstock of bioethanol in Indonesia is planned mainly from sugarcane and cassava. However, it was found that other sources potential as a bioethanol feedstock in Indonesia (Table 3).

Table 3. Potential sources of bio-ethanol feedstock (Prihandana, *et al.*, 2007)

	Yield	Ethanol (l/Ha/year)
- Corn	1– 6 Ton/Ha/year	400 – 2500
- Cassava	10 – 50 Ton/Ha/year	2 000– 7 000
- Sugarcane	40 – 120 Ton/Ha/year	3 000 – 8 500
- Sweet potato	10 – 40 Ton/Ha/year	1 200 – 5 000
- Sorghum	3 – 12 Ton/Ha/year	1 500 – 5 000
- Sweet sorghum	20 – 60 Ton/Ha/year	2 000 – 6 000
- *Arrenga Pinnata*	0.6 – 1.2 million liter/ha/year	40 000 liter/ha/year
- Molasses	2000 liter/ha/year	500 liter/ha/year

Table 3 shows that *arrenga pinnata* has the highest production of ethanol. However, the ecosystem of this plant is limited. Sugarcane and cassava is the second and third highest ethanol production. Although those are also used for food stock, the area extensions of the plantations are promising. Research and development are also still working on the high productivity yield and high starch content. Therefore, the government focuses on the development of sugarcane and cassava as the feedstock. Sweet sorghum may have potential feedstock of national bio-ethanol in the near future.

At present, Indonesia has 11 bio-ethanol manufacturers. All of them are big scale with production capacity ranging from 3.6 millions l/year to 50 millions l/year. The expansion of big capacity manufacturers will produce totally 940 million liter/year in 2010. Production of bio-ethanol 95% are mainly for industrial supplying. Since 2006, only a manufacturer, PT Molindo Raya, has produced fuel grade bio-ethanol 99.5%. It is said that converting 95% bio-ethanol to fuel grade requires high investment cost Rp 5-7.5 trillions, capacity 7 millions l/year. The technology adopted is molecular sieve (Prihandana *et al*, 2007). Besides big manufacturer, small scale distillers are also expected to grow, especially for the development of DME. Several pilot plants have been built and are in operation for commercial purposes. The investment cost is varying from Rp 2 millions to Rp 100 millions (Prihandana *et al*, 2007). For feasibility reason, it is recommended that small scale plant produces ethanol 90-96%, while dehydration to 99.5% is done by medium and big scale of distillery. It is also for maintaining the quality of fuel grade ethanol as required by the national standard for fuel grade, SNI Bioetanol No. DT-27-0001-2006.

3.3. Agricultural Waste

Estate Crops Waste

Estate crops that generate biomass waste in this regard are those of rubber, oil palm, coconut and sugarcane plantations (estates) where the areas and their main crop production tend to significantly increase year by year. Further, such estate crops wastes (Table 4) selected are only the ones potential with the woody biomass matter such as woody trunks, shell, bunch, and also organic rich liquid waste.

Food Crops Waste

Waste of food crops which have a large area thereby becoming the potential for energy source are paddy (rice straw and hull). Potential sources of waste from other food crops are: maize (stem, leaves, hairs, and fruit core), cassava (stem, leaves), peanut (stem, leaves, and fruit shell), soybean (stem, leaves, fruit shell). Table 5 shows estimation in the potency of food crops waste.

Direct burning of biomass either for daily cooking or production heat/ steam in industries is a part of combustion technique. This classic technology is still be used in Indonesia and many other countries, particularly third world countries, because of its ease and low cost technology. In Indonesia, firewood consumption for cooking and small scale or home industries still high i.e. about 50% of national energy consumption. Direct burning inside furnace and the heat passes into heat exchanger for generating heat in drying process of agricultural products. Gasification of rice husk already developed for electrical generation up to 0.5 MW. Several sugarcane factories utilized bagasse for heating boiler of electrical generator.

Integrated charcoal processing means processing of biomass into charcoal and activated charcoal with maximum waste utilization i.e. char powder for briquette charcoal and smoke is condensed into wood vinegar or smoke liquid. This technology adapts clean technology process because of zero waste achievement, where solid waste is converted to char-briquette and polluted gas exhaust is condensed and converted into wood vinegar. So, this technology offers high effectiveness and efficiency in processing that could decrease the production cost. Moreover, selling value of activated charcoal about 10 times higher than charcoal, while wood vinegar about 5 times (crude) to 50 times higher (refined).

Table 4. Estimation of estates crops waste potency (Sudradjad, 2004; MOA, 2005)

No	Kind of waste	Area (ha)	Conversion factor (%)	Potency (m^3/ha)	Total Potency (ton/yr)
1	Rubber trunk	3,279,391	3.33*	35	3,279,391
2	Oil palm	6,370,217			11,861,615
	Trunk		5.46*	78	16,277,688
	Shell		5**		593,080
	EFB		20**		2,372,323
	Ditch CPO		15**		1,779,242
3	Coconut	3,803,614			3,096,845
	Trunk		2.0*	80	3,651,469
	Shell		12****		371,621
4	Sugarcane	381,786			2,241,806
	Bagasse		4****		76,357.2
	Molasses		3****		57,267.9
Total					45,658,705

Remarks: * Rate of tree replantation per year, ** percentage from FFB
**** Percentage from the whole fruit, ***** percentage from sugarcane

Table 5. Harvesting areas, productions and waste potency of some food crop products

No	Kind of Agricultural Products	Harvesting area (10^3 ha)	Production (10^3 ton)	Yield Rate (quintal/ha)	Conversion Factor (ton/ha)	Potency (10^6 ton)
1	Paddy**	11,786.430	54,454.937	46.20	5.1	60.110
2	Maize	3,345.805	11,609.463	34.70	5.2	17.398
3	Cassava	1,227.459	19,986.640	163.00	6.1	7.487
4	Peanuts	706.753	838.096	11.86	2.0	1.413
5	Soybeans	580.534	747.611	12.88	1.8	1.045
	Total					87.453

Source: (Sudradjad, 2004; MOA, 2006)

Agricultural Industry Waste

Waste management is an important factor on agricultural industry. Wastes of the farm or agricultural industry enable environmental pollution into soil, water and air. They have been implicated as a cause of decrease quality of life for neighboring communities, with additional possible negative consequences on human health and welfare. Outputs of wastes should be managed to minimize adverse effect and maximize beneficial effects in the production system and environment. Pilot project for waste management is needed to initiate and persist in environmentally friendly practices. One of many methods of waste handling is delivery liquid waste into central water treatment and/ or biogas digester systems by anaerobic fermentation process. Several benefits of biogas digester system are eliminating greenhouse gas, reduction of nuisance odors, betterment of fertilizer, production of heat and power (electrical and mechanical power). These utilizations would be economically viable because of rising price of fossil fuel and inorganic fertilizer. Moreover, by manage the waste wisely, it could also give multiple effects and generate new business opportunity by empowering community in rural area.

In palm oil factory, production of 1 ton Crude Palm Oil (CPO) will results in 2.5 ton waste. Cassava, sugar mill factory also has large amount of waste water. Animal husbandry farming, such as cattle, dairy and buffalo with amount of 13.7 million heads, if in average produces 12 kg waste/head/day, totally will be 164.2 ton waste per day. This feedstock could be utilized for biogas production by anaerobic fermentation inside biogas reactor.

ICAERD in 2005 developed a digester for small farming. Digester designed at 18 m^3 holding capacity for cattle dung of 10-20 heads. The digester enables to produce 6 m^3/ day of biogas. Biogas was utilized to generate stove, mantle lamp, and engine for mechanical power / electrical generator. Effluent from digester could be used for fertilizer and fish pond. Based on feasibility study, the biogas installation was feasible technically and economically for development. Excellences of the biogas installation are (1) the digester are made of locally available materials, easy to operate and low maintenance cost, (2) dual-fuel engine for electric generator (mixture of 90% biogas with 10% diesel oil), simple biogas filter, long duration of operation time and low gas emission of exhaust gas engine. (3) By integrated model development of biogas installation, the process is more effective, efficient and optimal profit achievement.

Digester produces biogas continuously, therefore storage and biogas bottling are considered to be an important research for development.

Figure 4. Biogas reactor, dual-fuel engine for electric generator and biogas bottling

IV. Challenge and Opportunity of Bioenergy Development in Indonesia

4.1. Biodiesel

Global biodiesel production capacity in 2001 was 900,000 tones (approximately 1,000 million liters). Of this amount, Europe supplied 850,000 tons and the United States 50,000 tones. In Europe, Germany, France, and Italy are major producers with Germany contributing about 400,000 tones of biodiesel whilst France and Italy produced 330,000 and, 75,000 tones of biodiesel respectively during that year. Within the last few years, biodiesel production capacity is expanding worldwide due to the soaring oil price and greater concern on environment protection which turns the enthusiasm of the individuals and nations to find the alternative and more environment-friendly fuel; that makes biodiesel attractive. Year 2005 shows global biodiesel production capacity has been quadrupled from the year of 2001 capacity. The world biodiesel production by country for 2005 with Germany keeps the leading role as a major producer. It is interesting to observe that a number of countries – other than the big four in 2001 – are start playing a significant role. Currently, many Asian countries such as Malaysia, India and Indonesia have taken the initiative and start contributing to the world total biodiesel production.

To assess the potential of worldwide biodiesel market, one can consider 2001 world fossil diesel consumption that reached 637,405.8 million liters for transportation only. Based on the increase of world middle-distillate oil consumption, the aforementioned number is estimated to have grown up to at least 700,000 million liters at the beginning of 2006. Considering of only 5% biodiesel substitution into fossil diesel (B5), the required biodiesel capacity would be 35,000 million liters and that is for transportation only. Hence, there is still more than 30,000 million liters of worldwide biodiesel potential market open to grab, again it is only for transportation. Moreover, a huge more of biodiesel productions are envisaged since B20 is foreseen by many countries as their future target.

Considering the abundance of raw material, the increasing domestic consumption of diesel oil and to satisfy the target as projected on the National Energy Policy, developing biodiesel in Indonesia has a good prospect. As stated on the National Energy Policy that biofuels as a part of renewable energy sources targeted to contribute at least 5% of the total national energy consumption in 2025. According to the biodiesel roadmap, the total biodiesel should be produced for such a program could reach around 1.5 million kL per year by 2010, 3 million kL per year by 2015 and at least 6.4 million kL per year by 2025.

Transportation Sector

The renewable energy policy, especially biofuels, it is stated that the target of biodiesel use in 2010 is 10% of the total diesel oil for transportation consumption. Table 6 shows the potential biodiesel for the substitution of transportation sector. The figure of 10% equals to an amount of 1.337.000 million tones biodiesel per year. To meet this target, Indonesia should develop 15 to 40 units' biodiesel plant at commercial scales with the plant size of 30,000 to 100,000 tones per year.

Industrial Sector

To fulfill the industrial demand of biodiesel, the regulation is not restricted to the blending regulation of 10% biodiesel. As a result, industries are different types of market which has the magnitude of almost unlimited number. Thus, pure biodiesel can be marketed without any trade limit (Table 7). The price of biodiesel will compete with the market price of any types of industrial fuels. Department of Energy and Mineral Resources (July 2006) released that the price of industrial diesel fuel is in the range of IDR 6,014.91 per liter to IDR 6,227.27 (DESDM 2006). Meanwhile, the price of crude palm oil (CPO) per kg is about IDR 3,628 per January 2006, and the real potential price can reach IDR 4,000 per kg. The price of CPO processing to produce biodiesel is approximately at IDR 1,500.00 per liter for any plant with production capacity of 500 tones per year, and at IDR 550.00 per liter for a plant with production capacity of 120,000 tones per year. Assuming that oil density is 0.8, therefore the price of CPO is around CPO IDR 3,800 per liter and price of biodiesel for industrial sectors is between IDR 4,300 and IDR 5,300 per liter. Biodiesel demand as industrial raw material or additives has not been calculated. The reason is that biodiesel is not yet so popular in domestic demand as raw material for other chemical production.

Table 6. Potential biodiesel substitution in the transportation sector

Year	Automotive Diesel Oil (Thousand kL)	Biodiesel (Thousand kL)	Total (Thousand kL)
2005	11,791	0	11,791
2006	14,411	87	14,498
2007	12,669	167	12,836
2008	13,101	377	13,478
2009	12,949	1,203	14,152
2010	13,522	1,337	14,859

Source: DESDM, 2006

Table7. Projected Biodiesel Consumption for Industrial Sector up to 2010 with various Blending percentage (Thousand kL)

Year	Diesel oil for Industry	10% Biodiesel-Fossil	20% Biodiesel-Fossil	30% Biodiesel-Fossil	40% Biodiesel-Fossil
2005	8320	8327.488	16 646.656	24 965.824	33 284,992
2006	8570	8577.713	17 146.856	25 715.999	34 285.142
2007	8827	8837.944	17 657.062	26 486.179	35 315.296
2008	9091	9098.182	18 187.273	27 276.364	36 365.455
2009	9364	9368.428	18 737.491	28 096.555	37 465.618
2010	9645	9658.681	19 297.716	28 946.752	38 585.787

Source: DESDM, 2006.

As a state-owned company which carries out business in oil gas, LNG, energy and petrochemical industries, PERTAMINA has announced its intentions to produce and sell biodiesel in Indonesia. The target of PERTAMINA is to gradually substitute diesel oil especially used as transportation fuel. Since 20 May 2006, PERTAMINA has been selling a blend of 95% diesel fuel (ADO) and 5% SNI standard biodiesel which the trade name of BIOSOLAR Currently, PERTAMINA has been selling BIOSOLAR with the price of IDR 4.300, same with the subsidized automotive diesel oil at around 170 diesel fuel public filling station (SPBU) in Jakarta and more than 5 SPBU in Surabaya (East Java) with a total volume around 1.400 kL per day (Pertamina, 2006) By the continuously growing of domestic biodiesel producer, PERTAMINA will open the BIOSOLAR's SPBU in all big cities in Indonesia and increase the biodiesel blending content (B10, B15, etc). Table 7 shows the Projected BIOSOLAR and FAME Estimation.

4.2. Bioethanol

Besides diesel fuel, gasoline is also consumed widely in Indonesia. To decrease consumption of gasoline by can be done by bioethanol mixing with gasoline. In this case government has also released regulation of gasohol mixture 10 % of gasoline fuel (E-10). Bioethanol could be produced easily from sugar contain crops, such as sugar cane, sago, corn and cassava. Molasses as by product of sugar mill factory has opportunity for mass production of ethanol.

The current total consumption of gasoline in Indonesia is about 15 million KL per year. If 2% of the gasoline consumption in 2010 is substituted by ethanol, the requirement of gasohol at 10 per cent blend ratio works out to 4.2 billion liters. The requirement of fuel grade ethanol on the national basis is estimated at 420 million liters per year. It implies a total of cassava feedstock about 2.73 million tons that requires cultivated area of 100,000 ha. Cassava is believed as a potential resource of bioethanol. It is very easy to be planted and farmer familiar to this plant. Based on the research result, 1 ton cassava can produce 167 liters ethanol. Development of new variety of cassava can improve this yield up to 250 liters. Comparing to corn as ethanol source material, cassava has several merit, it can be planted on marginal soil and does not require special treatment.

In addition, every year, in Indonesia, there is 365 thousand tons ethanol produces from sugar mill factory. By this fact, it is easy to fulfill the government target of 2% bioethanol substitution in the year 2010. This target is possible to increase more than 2% in order to eliminate gasoline consumption and national budget for subsidy.

4.3. Agricultural Waste

The utilization of renewable energy in Indonesia is still very low compare to its huge potential. Biomass is around 50 GW but utilization is less than 1%. The barriers in developing renewable energy technology and clean energy technology is related to its high investment cost due to the most of the technologies are still imported, therefore it is important to conduct research and development activities to produce locally proven technology that are able to reduce its cost.

Kerosene consumption is dominated by household need. In 2005, household consumption of kerosene is 11,233 millions liter or 99.2% of total national consumption. It is very hard, because the Government of Indonesia (GOI) subsidy around 67% from market price. Therefore, GOI conducted program to convert kerosene to LPG. This program will profitable to all party because utilization of 1 liter of kerosene is equal to 0.4 kg of LPG.

By this fact, there is an opportunity to develop conversion energy technology of biomass such as furnace, gasification, charcoal and briquette. In addition, methane gas enrichment technology for biogas bottling has potency to support and succeed of the government program.

IV. Conclusions

1. Indonesia has a comparative advantage for bioenergy production because of greater availability of land, favorable climatic conditions for agriculture and lower labor costs. However, Indonesia faces socio-economic and environmental implications affecting the potential to benefit from the increased local and global demand of bioenergy.

2. The interrelationship between land uses and the competing needs of energy and food security is a key issue in the bioenergy that should be considered. In addition, the effects of large-scale bioenergy production on global commodity prices are a significant trade concern. Bioenergy production may also entail harmful environmental effects such as deforestation and loss of biodiversity. Regulation is required to reduce the negative impacts of large-scale production, as well as to ensure that the most cost-effective and highest-energy conversion technologies are used.

3. The stages of bioenergy development from research to be ready commercialized have been done. These include how to accelerate the construction of new bioenergy plants, plantation as a key driver in the continuity of raw material which is supported by the government policy and regulation commitments.

4. Opportunity to market biodiesel and gasohol has been widely opened as the current government fully supports biofuel development. This support is manifested into several government regulations regarding fuel blending regulation and conversion of kerosene to LPG.

5. Village self-sufficiency energy program (Desa Mandiri Energi or DME) is a program of special region for biofuel development to open job opportunity and eliminate poverty at isolated or remote villages by empowering the society to fulfill their energy need.

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