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# Resources, policy, and research activities of biofuel in Indonesia: A review

Yanuandri Putrasari [a,b], Achmad Praptijanto [b], Widodo Budi Santoso [b], Ocktaeck Lim [c,*]

[a] Graduate School of Mechanical Engineering, University of Ulsan, San 29, Mugeo2-dong, Nam-gu, Ulsan 44610, Republic of Korea

[b] Research Centre for Electrical Power and Mechatronics-Indonesian Institute of Sciences, Jl. Cisitu 154D/21, Bandung 40135, Indonesia

[c] School of Mechanical Engineering, University of Ulsan, San 29, Mugeo2-dong, Nam-gu, Ulsan 44610, Republic of Korea

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ABSTRACT

Fossil fuels as the main energy source of every country now predicted will be ended no more than 40 years. Therefore, alternative fuel such as biofuel has been developed by many countries including Indonesia. Indonesia as one of the highest populated country and has wide areas of agriculture, forest and crop field is potential to be the highest biofuel production in the world. However, after one decade since the Government of Indonesia launched the energy Policy in 2006, appears to be interesting that the biofuels progress in Indonesia seen not well developed. One of the basic weaknesses is the program only applied to the specific area with a high biofuel resource by central government without support by local government. Furthermore, the target of biofuel programs seems to be very high or too ambitious, while the condition of the people still very traditional which can be seen from the lifestyle and their energy consumption. This paper provides in detail a review of several topics related to resource, energy consumption, policy and the research and development activities of biofuel in Indonesia. As a discussion, some recommendation provided to encourage the biofuel development in the near future.



## 1. Introduction

The dependence situation of many countries in the world on fossil fuel delivers at least three serious conditions specifically (1) depleting fossil fuel stock, (Salvi and Panwar, 2012; Jayed et al., 2011; Kumar et al., 2012; Tariq et al., 2012) (2) increasing of fossil fuel price due to the high demand rate averaged 1.8% from 2005 to 2035, Atabani et al. (2012) and (3) greenhouse gas pollution especially CO2 due to the burning process of fossil fuel. Based on these matters, several ideas occurred to develop and utilize the renewable energy resources. Nowadays there are many energy resources to replace fossil fuel, namely fuel cells, geo-thermal, ocean power, solar power, wind power, coal, nuclear, gas fusions and biofuel (Abbaszaadeh et al., 2012; Shahid and Jamal, 2011; Vibhanshu et al., 2014). Among these alternative energy resources, biofuel is high potentially appropriate to solve the energy problems due to it has many advantages (Kumar et al., 2012; Abbaszaadeh et al., 2012; Demirbas, 2009; Kelkar et al., 2013; Jain et al., 2015).

The advantages of biofuel besides it can be renewed, it also environmentally friendly, (Ong et al., 2011; Atadashi et al., 2010, 2012) very degradable, has high potential to eliminate greenhouse effect, Arbab et al. (2013) and the raw material stock is abundant. The biofuel can be obtained simply such as crop plant cultivation and raising animal livestock (Atadashi et al., 2010; Nasir et al., 2013; Zarling et al., 2004; Hoekman et al., 2012; A et al., 2013; Tyagi et al., 2010; Mythili et al., 2014). Biofuel is different from the other type of alternative energy such as battery energy that complicated and expensive, coal that has billion ton dangerous carbon and non-renewable resource, natural gas that need a high capital, geothermal that not so simple and very expensive, and solar energy even though it is free but need expensive cost. Biomass (biofuel resource) is the only one renewable energy source that have a big potential to replace fossil fuels in many types (Harsono and Subronto, 2013). Meanwhile, the other energy sources such as solar, wind, water, geothermal, and nuclear energy will be easy only if converted to electric energy types.

As an agricultural country, Indonesia has a very big opportunity to utilize the new and renewable energy source from biomass. Agriculture product such as corn, bean, cassava, sugar cane, coconut, and oil palms (Costa et al., 2013) that have been known and used in order to fulfill the food supply of humans began to

* Corresponding author.
*E-mail address:* otlim@ulsan.ac.kr (O. Lim).

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be considered as an alternative fuel. In developed countries such as the United States, the utilize of corn for biofuels growing very fast, Zarling et al. (2004) even in Brazil, the Brazilian Government decided to introduce a National Biodiesel Program, initially by replacing 2% of current diesel oil consumption, implemented to reach 5% in 2013 (Costa et al., 2013). The vegetable oils from castor and palm are as the main inputs of the biodiesel. These opportunities are opening when the international market demand for biofuels over the past few years has also increased sharply.

Indonesia, since 2005, started with huge plantations of Jatropha curcas as biodiesel source since this particular oil is non-edible and potential to be converted to biodiesel (Jayed et al., 2011). Furthermore, since 2006 the Indonesian government has released an energy mix policy which is the implementation of a mixture of energy sources utilizing local resources (renewable energy) besides fossil fuel energy (Jupesta, 2010) and in the same year the biodiesel 5% began to be marketed in Indonesia. During one decade of 2005–2015, the research and development of biodiesel in Indonesia have ups and downs. However, after one decade since the Government of Indonesia launched the energy Policy on 2006, the biofuel development in Indonesia appears to be not well developed. One of the basic weaknesses is perhaps the program only applied to the specific area with high biofuel resource managed by central government without support by the local government. Furthermore, the target of biofuel programs is too high or too ambitious, while the condition of the people still very traditional which can be seen from the lifestyle and energy consumption. Then, the comprehensive information related to biofuel research and development in Indonesia cannot be found easily. Therefore, this paper presents a review of resources, policy, and research activities of biofuel in Indonesia. The information about biofuel, energy resource, energy consumption policy and research activities in Indonesia will be covered in this paper based on good quality literature source and trusted references.

## 2. Biofuel as alternative of petroleum fuel

Biofuel can be determined as a fuel from organic resources including plants and animals. Biofuel has a specific characteristic that is renewable, whereas it can be produced by using raw material which can be grown or developed. There are a variety of biofuels potentially available, but the main biofuels being considered globally are biodiesel and bioethanol.

Bioethanol is a fuel produced from crops which have properties almost the same with gasoline. Bioethanol is a kind of alcohol produced from fermentation of glucose then continued with the distillation process. The distillation process can produce ethanol with 95% of purity, to be used as fuel (biofuel) the ethanol necessary to be purified until 99% or so called fuel grade ethanol. Bioethanol can be produced from a number of crops, including sugarcane, corn (maze), wheat and sugar beet. The raw material of bioethanol usually can be divided into 3 groups, i.e.

a. Glucose material, the glucose materials, including sugar cane, palm, sweet sorghum, grapes, coconut etc. (Dyartanti et al., 2015)
b. Starchy material, the starchy material, including corn, banana, cassava, sweet potato, etc. (Widodo et al., 2015a,b)
c. Lignocellulose material, the lignocellulose material, including woods, rice straw, seaweed, banana stem, tapioca solid waste etc. (Wahyuono et al., 2015; Puspawati et al., 2015).

There are many techniques and methods to produce bioethanol based on the raw materials that used, conventionally and also advanced method, while, the standard process always consists of fermentation, distillation, and dehydration (Jeon et al., 2014; Meinita et al., 2015; Triwahyuni et al., 2015b; Muryanto et al., 2015; Wahono et al., 2014)

Biodiesel is a fuel that appropriate for compression ignition (diesel) engine which is produced from biological resources such as fatty oils of vegetable or animal fat. The main component of biodiesel is an ester. Biodiesel is the fuel that can be produced from straight vegetable oils, edible and non-edible, recycled waste vegetable oils, and animal fat. The raw materials of biodiesel, which is developed, depend on the country resources. Indonesia has many resources for biodiesel such as coconut, palm, *Jatropha Curcas* etc. Biodiesel should have the same properties with diesel fuel for its chemical and physical properties. The detail of properties, production process, and the advantages or disadvantages of biodiesel compared to diesel fuel will not be explained here, it can be obtained from the reference (Hassan and Kalam, 2013)

## 3. Energy resource in Indonesia

The statistical data from ministry of Energy and Mineral Resources 2013 (Dewan Energi Nasional Republik Indonesia, 2014) shows that for unrenewable resources beside fossil fuel with potential stock, 3.85 billion barrels, the other huge energy resources in Indonesia are natural gas 150.7 TSCF and coal 28.97 billion Ton, then, followed by some renewable energy such as geothermal 28,910 MW and hydro resource 75,000 MW. Meanwhile, in the biomass sector for about 32,654 MW there are many potential energy from bio resources such as palm oil, crops, non-food crops, and livestock manure. For the other renewable energy resources such as solar 4.80 RWh/M2/day, wind 3–6 m/s, sea wave 49 GW and uranium 3000 MW. Fig. 1. Shows the detail of energy resource for oil and gas in Indonesia (Dewan Energi Nasional Republik Indonesia, 2014).

The energy resource from biomass in Indonesia can be discussed through several categories specifically forestry residue, agriculture residue, waste and crops.

### 3.1. Forestry residue

In 2014 the potential Bioenergy from forestry residue in Indonesia is approximately 271 MW. It was resulted from the annual wood production of seven big islands namely Sumatra, Kalimantan, Jawa–Madura–Bali, Nusa Tenggara, Sulawesi, Maluku, and Papua. The wood production activities are included replanting rubber wood, logging, sawn timber, plywood, and veneer.

### 3.2. Agriculture reserves

The total potential supply from agriculture residues in Indonesia is almost from rice, sugar and corn production annually approximately 123.4 million tonnes. The detail productions are rice 67.8 million tonnes, sugar cane 20.1 million tonnes, corn 3.8 million tonnes, palm oil 8.5 million tonnes, and coconut 3.1 million tonnes.

### 3.3. Wastes resource

Waste generation is defined as the waste produced by humans or livestock in everyday activities such as solid waste and manure (cattle dung). Source of biomass energy from waste generation is estimated approximately 94.84 million tons per year (except the recycle material). The specific data of municipal solid waste from 400 regencies and 98 cities are around 18 million tonnes and animal manure around 82.61 million tonnes.

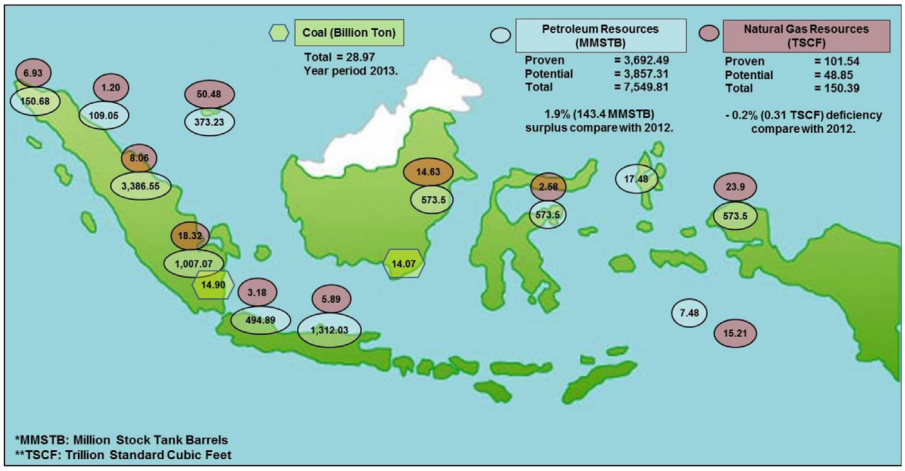



**Fig. 1.** Oil and gas supply in Indonesia (Dewan Energi Nasional Republik Indonesia, 2014).

### 3.4. Fuel crops resource

Indonesia has huge crops plantation for raw material of biofuel. The crops plantation can be categorized as bioethanol resource and biodiesel resource.

#### 3.4.1. Potential crops for bioethanol

Bioethanol fuel is an ethanol (ethyl alcohol) that derived from the biomass resource. The ethanol is the same type of alcohol found in alcoholic beverages. It can be used as an engine fuel, mainly as a biofuel additive for gasoline. It can be made from biomass of agriculture feedstock such as corn, sugar cane and cassava. These agriculture crops are abundant in Indonesia. According to the data from the Ministry of Agriculture for 2013 the production of corn in Indonesia is about 18,511,853 Ton, sugar cane 2,551,024 Ton and cassava 23,936,921 Ton.

#### 3.4.2. Potential crops for biodiesel

Biodiesel is a chemically modified alternative fuel for use in diesel engines, derived from vegetable oils and animal fats. The definition of biodiesel, according to ASTM biodiesel standard D6751, is defined as a "fuel comprised of mono-alkyl esters of long-chain fatty acids derived from vegetable oils or animal fats, designated B100". There are many types of crop plant that potentially can be produced to be biodiesel such as castor, grape seed, maize, camelina, pumpkinseed, beechnut, rapeseed, lupin, pea, poppy seed, peanut, hemp, linseed, chestnut, sunflower seed, palm, olive, soybean, cottonseed, and Shea butter (Salvi and Panwar, 2012). In Indonesia, there are special crops plantation that very easy to cultivate and a huge amount in a separate area and islands specifically palm oil and coconut oil. The palm oil is very reasonable to be the main raw material for biodiesel production. Indonesia is the largest producer of palm oil in the world with total production in 2012 reaching 27 billion tons produced from its roughly 6 million hectares of plantations (Mukherjee and Sovacool, 2014) The data from Ministry of Agriculture shows that the potential of palm oil in Indonesia for 2013 is 10,465,020 Ha with total production is about 5,556,401 Ton.

## 4. Energy consumption in Indonesia

Based on the type of energy resource the fossil fuel still become the important energy source, for about 48% has consumed during 2013 followed by coal, 19%, natural gas, 19%, and others 14%. During 2013, industrial sector consumed the highest final energy for about 33%, and then followed by housing sector 27% and transportation sector 27%. Meanwhile, the commercial sector and the others used energy for about 10% (Dewan Energi Nasional Republik Indonesia, 2014). The Indonesia's final energy consumption based on sector summarized in Fig. 2. While the detail energy consumption based on sectors and an energy source for 2013 presented in Fig. 3.

In this paper, the recorded data for biofuel that can be obtained is only biodiesel. Biodiesel was introduced first time to the market in Indonesia in 2006 with 5% mixed into the neat diesel fuel. Fig. 4 shows the biodiesel consumption in the transportation sector from 2006 to 2013 in Indonesia (Wright and Wiyono, 2014) From the figure, it can be seen that the biodiesel (B100) consumption increased sharply from about 0.06% in 2006 to 5.57% in 2013. Meanwhile, the complete biodiesel production information in Indonesia is presented in Table 1 (Wright and Wiyono, 2014).

## 5. Biofuel policy in Indonesia

One of the key policies for the development of biofuels in Indonesia is Presidential Regulation No. 5/2006 concerning the National Energy Policy. The policy provides a biofuel incorporation target of 2% of national energy consumption by 2010, increasing to 5% by 2025. It tasked the Ministry of Energy and Mineral Resources with developing a national energy management blueprint, covering various energy sources, including biofuels. The blueprint outlines the government strategies for the management and use of energy resources. Based on this blueprint, the Ministry of Energy and Mineral Resources estimates that the annual production capacity for biodiesel should increase from 2010 to 2025 (Jupesta, 2010; President of Indonesia, 2006).

Fig. 5 shows the Energy mix policy based on the national energy policy (Jupesta, 2010) From the figure it can be seen that renewable energy source such as hydro energy and geothermal supposedly increase in 2025. It also can be seen that biofuel was started to introduce on 2006 with objectives to reduce 5% of the total energy consumption in 2025.

The other regulations and policies related to biofuel development in Indonesia are mentioned as follows:

1. Presidential Instruction Number 1 Year 2006 concerning on the provision and utilization of biofuel as alternative fuel. This instruction is related or addressed to Minister, Governor and Mayor to take action in order to accelerate the provision and utilization of biofuels.
2. Law Number 30 Year 2007 concerning on energy consist of regulation about priority supply and use of renewable energy, one of them is biofuel.

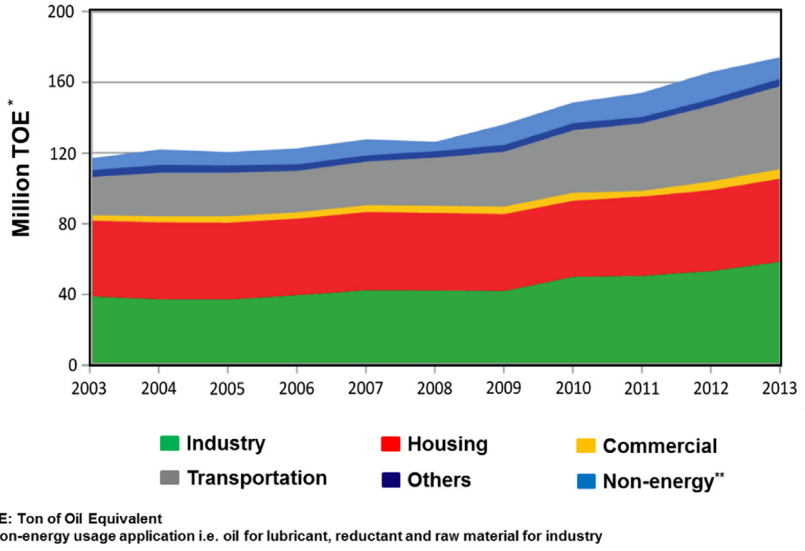
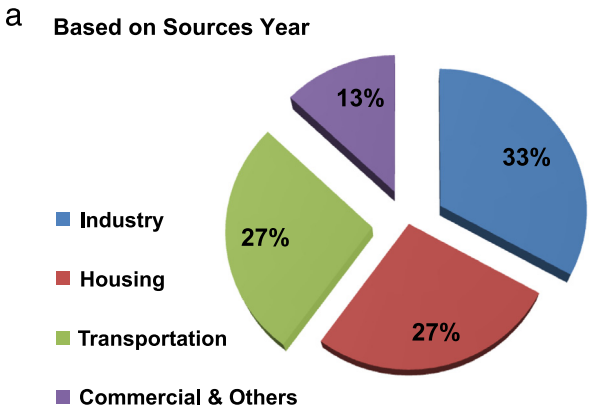



**Fig. 2.** Indonesia's final energy consumption based on sector (Dewan Energi Nasional Republik Indonesia, 2014).



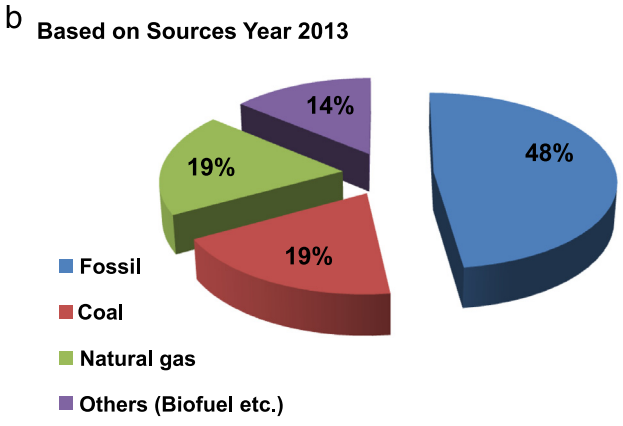




**Fig. 3.** Indonesia's energy consumption based on (a) source and (b) sector for 2013 (Dewan Energi Nasional Republik Indonesia, 2014).

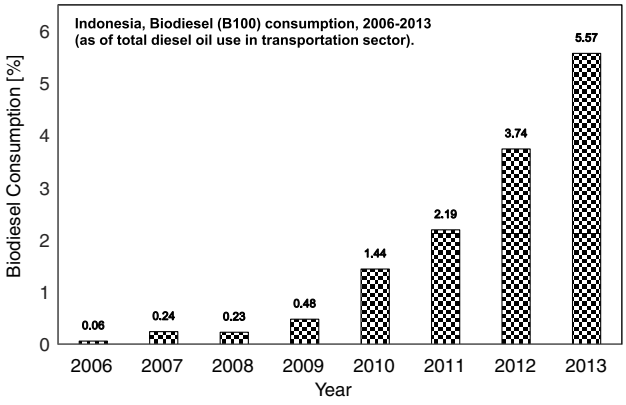



**Fig. 4.** Biodiesel consumption trend in Indonesia (Wright and Wiyono, 2014).

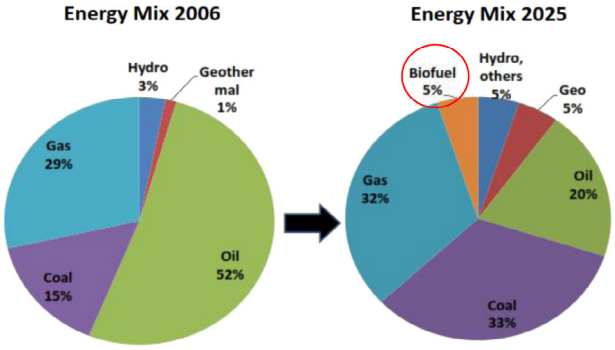



**Fig. 5.** Indonesia's energy mix policy (Jupesta, 2010).

3. Ministry of Energy and Mineral Resource Regulation Number 32 Year 2008 the concerning on provision, utilization and procedures of commerce of biofuel as an alternative fuel. This regulation consists of rules of such areas: (a) priority of biofuel utilization, (b) mandatory of biofuel utilization (biodiesel, bioethanol and bio oil) in transportation, industry, commercial, and electricity generation sector, (c) standard and quality of biofuels, (d) pricing policy, and (e) commercial activities of biofuel.
4. Indonesian Ministry of Energy and Mineral Resources (MEMR) Regulation No. 25/2013 amends Number 32 Year 2008, aims to diversify domestic biodiesel consumption beyond the transportation sector. According to this regulation the biofuel mandatory usage roadmap for each sector can be seen in Tables 2 and 3.
5. Vehicle emission regulation Decree of Ministry of Life Environment No. 04/2009 minimum limit of vehicle emission in Indonesia based on Euro 2.

Related to biofuel, as like Indonesia, the regional area of the ASEAN countries and some other countries around the world have

**Table 1**
Biodiesel production, consumption and trade (Million liter)
*Source:* * Indonesia Biofuel Annual 2014. ++ Estimation.

| Calender year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013* | 2014* | 2015* ++ |
|---|---|---|---|---|---|---|---|---|---|---|
| Production, Total | 24 | 35 | 110 | 350 | 455 | 650 | 700 | 2450 | 3650 | 4150 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Exports | 42 | 0 | 0 | 200 | 235 | 250 | 300 | 1356 | 1000 | 1000 |
| Consumption | 11 | 44 | 46 | 120 | 223 | 355 | 425 | 1048 | 2625 | 3130 |
| Ending stocks | 15 | 6 | 70 | 100 | 97 | 142 | 117 | 101 | 126 | 146 |
| Production capacity | | | | | | | | | | |
| Capacity (Mil. Liters) | 215 | 1709 | 3138 | 3528 | 3936 | 3936 | 3936 | 5670 | 5670 | 5670 |
| Capacity use (%) | 11 | 2 | 4 | 10 | 12 | 17 | 18 | 43.2 | 64.4 | 73.2 |
| Feedstock use—conventional (1000 MT) | | | | | | | | | | |
| Feedstock (CPO) | 26 | 39 | 121 | 385 | 501 | 715 | 770 | 2408 | 3588 | 4079 |

**Table 2**
Biodiesel (Minimum biodiesel contain in the marketed fuel).

| Biodiesel (B100) | Old biofuel mandatory program (MEMR Regulation 32/2008) | | | New biofuel mandatory (MEMR Regulation 25/2013) | | |
|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Transportation (PSO). | 5 | 10 | 20 | 10 | 20 | 25 |
| Transportation (Non-PSO) | 7 | 10 | 20 | 10 | 20 | 25 |
| Industry | 10 | 15 | 20 | 10 | 20 | 25 |
| Electricity | 10 | 15 | 20 | 25 | 30 | 30 |

Note: the percentage refers to total diesel oil use in the sector.
PSO: Public sector obligatory.

**Table 3**
Bioethanol (Minimum bioethanol contain in the marketed fuel).

| Biodiesel (E100) | Old biofuel mandatory program (MEMR Regulation 32/2008) | | | New biofuel mandatory (MEMR Regulation 25/2013) | | |
|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Transportation (PSO) | 3 | 10 | 15 | 1 | 5 | 20 |
| Transportation (Non-PSO) | 7 | 12 | 15 | 2 | 10 | 20 |
| Industry | 7 | 12 | 15 | 2 | 10 | 20 |
| Electricity | 7 | 12 | 15 | 2 | 10 | 20 |

Note: Total gasoline use (%) per sector
PSO: Public sector obligatory.

their own policy and target scenario for long and near future in term of development and commercialization. The comparison of policy and target of the ASEAN countries can be seen in Table 4, while the target to promote biofuel in some other countries in the world presented in Table 5 (Mofijur et al., 2015).

## 6. Research and development of biofuel in Indonesia

Since ten years ago several Indonesian research institutions have been working on biodiesel research and development, including LEMIGAS (Oil and Gas Technology), PPKS Medan (Indonesian Oil Palm Research Institute, Department of Agriculture), ITB (Bandung Institute of Technology), BPPT (Agency for the Assessment and Application of Technology) and LIPI (Indonesian Institute of Sciences) (Yamaguchi, 2012; Widodo and Rahmarestia, 2008) The recorded activity on 2014 conducted by LIPI in collaboration with UTHM Malaysia is the study of biodiesel using sonochemistry approach with a clamp on tubular reactor (Praptijanto et al., 2015a) The results showed that in the esterification process, higher free fatty acid (FFA) concentration was removed lower 1% by tube of diameter 60 mm at 5 min time of reaction, then the optimum condition of the transesterification process was achieved at molar ratios of methanol to oil of 7:1, catalyst concentration of 1%, time of reaction of 5 min. The other recorded activity for biodiesel and bioethanol research is conducted by Indonesian Institute of Sciences since 2005 until now, which is the research and development on biodiesel from crude palm oil (CPO), *Jatropha Curcas* and bioethanol from palm empty fruit bunch for the 2nd generation of bioethanol (Abimanyu, 2013; Dahnum et al., 2015; Jeon et al., 2014; Muryanto et al., 2015; Styarini et al., 2013; Sudiyani et al., 2013; Triwahyuni et al., 2015a,b; Wahono et al., 2014). The development of the 2nd generation of bioethanol was also collaborating with KOICA-KIST Korea. The successful collaboration can be seen by the development of a pilot plant for bioethanol and analytical instrument laboratory at the Indonesian Institute of Sciences (Abimanyu, 2013; Jeon et al., 2014) The recent research activity data that conducted by LIPI related to the application of bioethanol into the engine for its performance and emission can be obtained not only for gasoline (SI) engine, but also for diesel (CI) engine (Nur et al., 2015; Praptijanto et al., 2015b; Putrasari et al., 2013, 2014) The result showed that bioethanol does not give negative effect on the engine performance. However, it has very high potential to reduce the emission of HC, CO and smoke of the engine.

## 7. Discussion

Based on the obtained data and information presented previously, it can be discussed that the program for the development and utilization of biofuel to reduce petroleum fuel usage in Indonesia seem to be very far from the target. Even though there are many series of policy and efforts in the research and development of biofuel. During 2008–2013 the higher energy consumptions are housing, transportation, and industry, then, based on the data from reference (Dewan Energi Nasional Republik Indonesia, 2014) the highest energy resource consumption is still a fossil fuel. This condition is thought to be caused by several factors that can be discussed as follows:

1. There is an overlapping of policy between central government and local government, and also one ministry with other

**Table 4**
Policy and target to increase biofuel production of some ASEAN countries (Mofijur et al., 2015).

| Country | Policy and target |
|---|---|
| Indonesia | • Biofuel share to reach target 5% of total energy share.<br>• 15% bioethanol and 20% biodiesel to replace gasoline and diesel within 2025. |
| Thailand | • Implementing E20 and E85.<br>• Promote flex fuel vehicle (FFV) and reach 2070,000 FFVs within 2017–2022.<br>• B10 mandate and currently requires 8.5 million liters/day of biodiesel. |
| Malaysia | • To implement B5 nationwide.<br>• The introduce B7 in November, 2014. |
| Vietnam | • To reach 5% of primary commercial energy in 2020, and 11% by 2050.<br>• Annual output of 50,000 T of B5 and 100,000 T of E5. |
| Laos | • Established an Ad hoc committee for formulation of national strategy on biofuel energy. |

ministries which is out of tune, or sometimes opposites of each target. For example, the policy from the Ministry of Energy and Mineral Resource is to drive the utilization of biofuel, however, in 2013 the policy of the Ministry of Trade is about the marketed low cost vehicle to grow the domestic automotive industry by ignoring the use of biofuels. This can lead the growth of vehicles on the road and the higher of fossil fuel consumption in the transportation sector.

2. Related to the biofuel's price, in the earlier, the utilization of biofuel is subsidized by government due to the price is higher than fossil fuel. But, recently the Government of Indonesia has not allocated the budget for biofuel subsidy. Then, it is difficult for the local biofuel producer to sell their product to the state-owned national oil company of Indonesia (Pertamina, Tbk.) due to the higher price and there is no incentive from the government. They always lose and gradually collapse.
3. The lack of creativity from the Government of Indonesia to make a policy for the utilization of biofuel. For example, the government should make a policy of requiring the auto industry to develop technology FFV (Flexi Fuel Vehicle). This technology allows the use of two types of fuel as well, namely biofuel and non-biofuel.
4. Infrastructure problems, the fuel stations that provide biofuel (up to 10% for biodiesel and 5% for bioethanol) only can be found in several places. Therefore the utilization of biofuel cannot be implemented in the entire territory of Indonesia continuously. Starting from 2011 until now the numbers of fueling-stations that provides biofuel is 3213 from total 4800 fueling-stations in Indonesia. The 3213 fueling-stations spread in almost a half of Indonesia's area which is Sumatra, Java, and Bali. In this area beside the fueling stations, there are 118 non-fueling-stations (retailer) that also provide biofuel. In these areas since the only one Indonesia's oil company (Pertamina, Tbk.) distributes the fuel, as automatically publics will use 5%–10% biofuel for their vehicle especially for biodiesel. The distribution map of market coverage biofuel in Indonesia can be seen in Fig. 6 (Pertamina, 2011).

Based on the problem discussed previously to optimize the huge potential resource of Indonesia for biofuel development, it is necessary for the Government of Indonesia to deal with several suggestion aspects as follows:

1. *Advanced biotechnology as the basic science for biofuel development*.

   By using advanced biotechnology it can be found the best quality of raw materials from local resource and the best technique to produce biofuel. Then the advanced biotechnology is also necessary to protect the environmental damage due to bad agricultural activities. Currently, there are many raw materials which are potential for biofuel through advanced biotechnology research, such as sea algae for biodiesel and several raw materials for the second generation of bioethanol specifically palm empty fruit bunches, rice straw, waste paper and sugar cane waste.
2. *Infrastructure support*.

   The infrastructure support is very important for biodiesel production, which is can reduce the market price. The infrastructure supports, including the access for the local raw material producer to the biofuel manufacturer, distributor, and biofuel market. The good synchronization between farmer as the raw material producer and biofuel manufacturer which is can access each other through the good infrastructure support will stimulate the increasing of biofuel production.
3. *Economics system which is caring for energy security and environment friendly*.

**Table 5**
Target to promote biofuel in some countries in the world (Mofijur et al., 2015).

| Countries | Years | Target | Feedstock |
|---|---|---|---|
| USA | 2012 | 8 Billion ethanol | Corn, soybean oil, sorghum, cellulosic sources in the future |
| | 2013 | 1 Billion liters of cellulosic ethanol | |
| | 2020 | 25% Ethanol | |
| | 2005 | 2% Biodiesel | |
| Brazil | 2012 | 25% Ethanol and B2 | Soybean, sugarcane, palm oil |
| | 2013 | B5 (2.4 billion biodiesel) | |
| | 2020 | B20 | |
| EU | 2005 | 2% | Rapeseed, sun flower, wheat sugar beet, barley |
| | 2010 | 5.75% | |
| | 2020 | 10% | |
| China | 2010 | 1.5–2 Million biodiesel | Corn, cassava, sweet potato, rice, Jatropha |
| | 2020 | 10% Ethanol ( = 8.5 million tonnes) 10.6–12 million biodiesel | |
| Canada | 2010 | 5% Ethanol | Corn, wheat |
| | 2012 | 2% Biodiesel | |
| India | 2012 | % Biofuel | Molasses, sugarcane in the future, Jatropha |
| | 2017 | 10% Biofuel | |
| Australia | 2010 | 350 Million liters of biofuel | Wheat, sugarcane, molasses, palm oil, cotton oil |
| | 2012 | 0% Ethanol and 10% biodiesel | |
| | 2017 | 20% Ethanol and 20% biodiesel | |
| Japan | 2010 | 360 Million liters biofuel | Imported ethanol and rice bran |
| | 2020 | 6 Billion liters biofuel | |
| | 2030 | 10% Biofuel | |

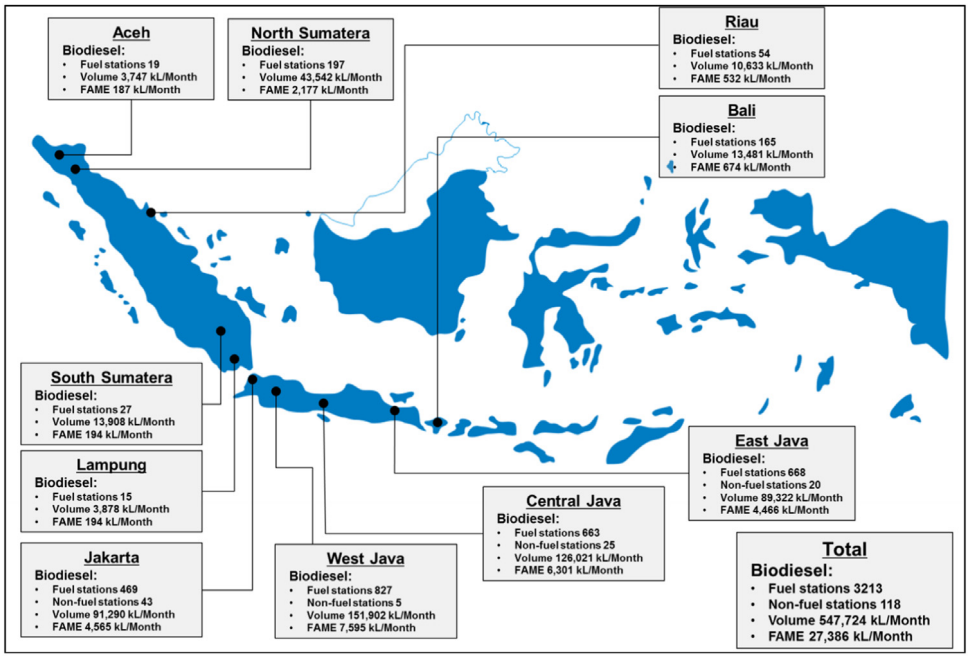



**Fig. 6.** Market coverage of biofuel (Pertamina, 2011).

Indonesia, it is also possible followed by other countries, should apply the economics program which is not only based on the supply and demand of the main commodity but also consider about energy security and environmental friendly commodity such as raw material for biofuel. This strategy also will drive the formation of domestic market for biofuel and its resources. In the next future when the market for biofuel already created, it will be easy to the stakeholder (government, producer and farmer) to optimize their strategy related to the supply and demand of biofuel and its resources. Therefore the ambition to be the highest biofuel producer in the world will be realized.

4. *Law*

   In order to make sure the legal certainty, therefore, the consistency and sustainability of law enforcement are definitely needed, especially in some sectors which are supporting the development of biofuel. The new policy about an incentive award to the fuel distributor or producer, free tax for the vehicle owner and infrastructure developer who consumed and dedicated their activity to the biofuel will increase the biofuel development system. However, the strict policy to manage the preservation of forest and environment is also very important to avoid the deforestation and environmental damage as a result of uncontrolled resource exploration.

5. *Social education*

   The education and socialization of society are also a very important factor not only in urban society, but also especially in rural or remote area society in order to change their mind, habits, and attitude by using biofuel and thinking about environmental friendly activities. The changing paradigm of biofuel development not only for alternative energy but also as the solution for sustainable energy security is very important to announce and socialized. This strategy can be supported by the private sector, education institution, research institution or university, and also non-government organization.

## 8. Conclusion

From the comprehensive discussion in this paper, it can be drawn a conclusion that Indonesia has a huge raw material for Bioenergy or biofuel production, especially biodiesel due to the greater availability of land and many types of agricultural plantation can be cultivated easily. During about eight years from 2005 to 2013 the unrenewable energy resource stock in Indonesia shows the stable condition, however, the renewable energy resource stock and production show increasing condition year by year. Along with the sharp increasing in biofuel production from 2006 to 2013 the consumption of biodiesel was also increased dramatically and demonstrated the value of 5.57% in 2013. The research and development of biofuel in Indonesia beside influenced by stock and price of fossil fuel situation are also very dependent on the government policy. The government policy is the key factor in the successes of the research and development of biofuel in Indonesia. The greatest achievement in the research and development of biodiesel currently can be observed from many institutions and collaborating in this field as a reflection that the government of Indonesia fully supports for biofuel development. To support the increasing demand for biofuel in Indonesia, it is necessary to build a synergy of cooperation in term of research and development of biofuel between the government and the private sector both nationally, regionally and internationally. Then, they should deal with several suggestion aspects in term of advanced basic sciences, infrastructure, economic system, law and social educations which should be synchronized with biofuel program.

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**Yanuandri Putrasari** was born in Indonesia, in 1982. He received his B.Eng.Ed in Mechanical Engineering from Yogyakarta State University in 2005 and B.Eng. in Mechanical Engineering from Mandala College of Technology in 2007, and the M.Eng. degree in Mechanical Engineering from University Tun Hussein Onn Malaysia, in 2011. He works at the Indonesian Institute of Sciences, and currently, he takes study leave, to pursue his Ph.D. in Mechanical and Automotive Engineering under the supervision of Professor Ock Taeck Lim at the School of Mechanical Engineering at University of Ulsan Rep. of Korea.

**Achmad Praptijanto** graduated from Mechanical Engineering Brawijaya University Indonesia in 1995. He continued to study master in the same area and passed in 2012 from University Tun Hussein Onn Malaysia. From 1996 until now, he works as a reseacher in the area of Internal combustion Engine and Renewable Energy in the Reserach Center for Electrical Power and Mechatronics (RCEM)–Indonesian Institute of Sciences (LIPI).

**Widodo Budi Santoso** was born in Sidoarjo, Indonesia in 1969. He recieved his B.Eng in Mechanical Engineering from Institut Teknologi Sepuluh Nopember (ITS) in 1993, M.Eng in Mechanical Engineering in Mechanical Engineering from Institut Teknologi Bandung (ITB) in 2000, and Ph.D. in Automotive Engineering from Universiti Malaysia Pahang, Malaysia in 2016. He is currently a researcher at Indonesian Institute of Sciences in the field of internal combustion engine.

**Ocktaeck Lim** received his B.S. and M.S. degrees in Mechanical Engineering from Chonnam National University, Korea, in 1998 and 2002, respectively. He received his Ph.D. degree from Keio University in 2006. Dr. Lim is currently a Professor at the School of Automotive and Mechanical Engineering at Ulsan University in Ulsan, Korea. Dr. Lim's research interests include Internal Combustion Engines, Alternative Fuels and Thermodynamics.