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"The Project for Producing Biomass Energy and Material through Revegetation of Alang-alang (*Imperata cylindrica*) Fields"

Potency and challenges in the commercialization of bioethanol first and second generation in Indonesia

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Abstract

This article introduces the current status of bioethanol commercialization in Indonesia. The review includes government policy and technical approach of bioethanol production regarding its efficient production methods. Molasses is the only first generation's bioethanol raw material that is used for commercialization so far. Its potency is about 1.3 to 1.6 million tons a year and only 30 to 40 percent is used for bioethanol production. Meanwhile, a second-generation bioethanol pilot plant has been established and is still being optimized to improve its effectiveness. Currently, there is no report for the consumption of bioethanol for fuel even though there is a regulation from the Ministry of Energy and Mineral Resources No. 12/2015 for using 5 percent ethanol (E5) as a gasoline blending in the year 2020. Recently, Pertamina, a national energy company, has taken the initiative to launch the A20 (alcohol 20 percent that consists of 15 percent methanol and 5 percent ethanol) to overcome the still-high price of ethanol. Besides fuel grade ethanol (FGE), industrial grade ethanol (IGE) consumption was about 100 million liters in 2019. Second generation bioethanol potency is about five million liters only from 44 million tons of oil palm empty fruit bunch yearly. The production of bioethanol, both first and second generations, is still promising in the future.

Keywords: *bioethanol, commercialization, molasses, oil palm empty fruit bunch*

1. Introduction

In the year 2018, in Indonesia, energy consumption was about 875 million barrels of oil equivalent (BOE) or 127.9 million ton oil equivalent (MTOE) [1]. Meanwhile, National Energy Council reported that total energy consumption was about 114 MTOE without biomass sources [2]. The type of energy was dominated by fuel such as gasoline, avtur, avgas, diesel oil that mostly uses for transportation sector 40%. Furthermore, the rest is for industrial sector 36%, household 16%, commercial sector 6% and other sectors 2%.

Based on Figure 1, the import dependency ratio was 35% in 2018. Pertamina, the national energy company, reported that in 2020 fuel consumption is about 1,4 million barrels a day and the national production is only about 850,000 barrels. Therefore, about 550,000 barrels of fuel or 40% of total consumption is imported [3]. Figure 1 clearly shows that we have to import crude oil to fulfill national energy demand.

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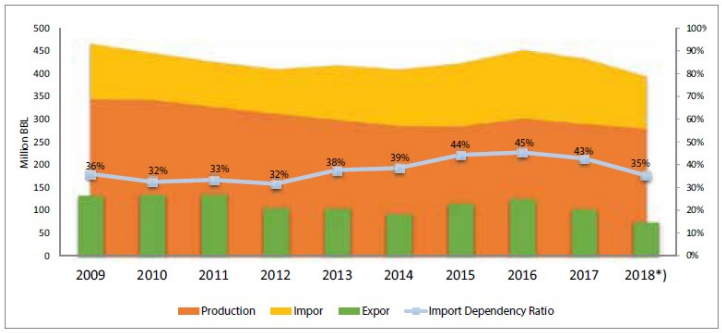

Figure 1. Condition of crude oil production, import and export [4]
(source: DEN 2019 from MEMR, processed by Secretariat General of NEC, 2019)

Because of the concern of national energy security, greenhouse gas emission issues and the decline of crude oil production in Indonesia, the government has launched a commitment to use new and renewable energy. Government Regulation No. 79 of 2014 on National Energy Policy state that the new and renewable energy mix target is at least 23% by 2025 and 31% by 2050. Indonesia started to adopt biofuels policy by issuing Regulation 1 governing the procurement and usage of biofuels in 2006. Subsequently, Presidential decree 20/2006 established a National Biofuels Development Team.

Several other factors for energy transformation are climate change, especially the Paris agreement that targeted increasing temperature below 2°C in this century; air quality index; and job opportunities in the field of new and renewable energies. By 2017, renewable energy only accounted for about 8% of the primary energy mix in Indonesia [5] and slightly increasing to 9% in 2019. The renewable energy portion is presented in Figure 2.

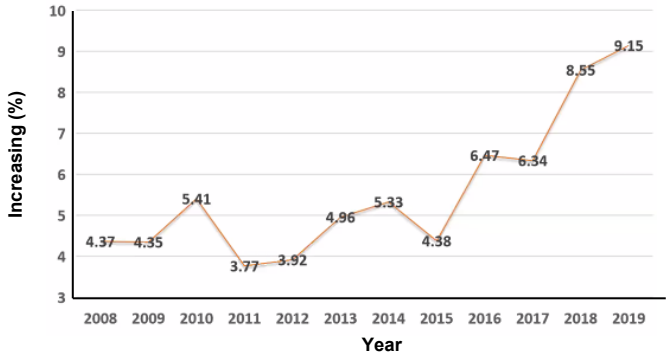

Figure 2. Renewable energy percentage of total energy in Indonesia

Based on Figure 2, it is shown that 23% of energy from new and renewable energy (NRE) as targeted by the government will hardly be achieved without serious effort. Currently, increasing for NRE in Indonesia is about 0.5 GW a year.

Renewable energy sources in Indonesia can be listed come from solar, water, wind, bioenergy, geothermal and ocean wave as presented in Table 1. All of these sources were utilized. However, the utilization of these NRE sources is still under its potency. Directorate General of New, Renewable and Energy Conservation of Ministry of Energy and Mineral Resources (MEMR) reported that total bioenergy potency was 30.05 GW in 2016 in 33 provinces. The highest potency was in Riau, East Java and North Sumatera with 4.2, 2.85 and 2.79 GW respectively [2].

Based on the regulation of the Ministry of Energy and Mineral Resource, liquid biofuels were becoming part of the renewable energy source for electricity generation. In Table 1,

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bioenergy potency is about 32 GW and it has been utilized about 1.89 GW, the third most widely used after water and geothermal energies. Bioenergy comes mostly from biodiesel dan bioethanol.

This article will discuss the potency of bioenergy by focusing on bioethanol for both first and second generations in Indonesia. Moreover, bioethanol potency as chemicals in industrial sectors and bottleneck factors to bring bioethanol commercially will also be discussed.

Table 1. Renewable energy sources and its utilization

Energy source	Total potency (GW)	Utilized (GW)	Ratio of utilized/potency (%)
Solar	207.8	0.15	0.07
Water	75.0	6.08	8.10
Wind	60.6	0.15	0.30
Bioenergy	32.6	1.89	5.80
Geothermal	23.9	2.13	8.90
Ocean wave	17.9	0.00	0.00

2. Discussion

Bioenergy potency is very promising, regarding its abundant raw material in Indonesia. Biodiesel and bioethanol are two potential bioenergies that currently were produced from crude palm oil and molasses, respectively. Regarding bioethanol, raw material for second-generation is abundantly available. Oil palm empty fruit bunch alone is produced about 40 to 50 million tons yearly from oil palm companies as presented in Table 2.

Table 2. Bioethanol potency from Oil Palm EFB

	Potency
OPEFB (ton)	44.623.920
Cellulose (%)	40-44
Cellulose conversion	x 0.76 (efficiency conversion to sugars)
Ethanol	x 0.51 (1 mol of sugar to ethanol)
Fermentation efficiency	x 0.75 (efficiency conversion to ethanol)
Ethanol (million litter)	5.19

Source: [6] the data was updated

B30 program has a significant impact on the increase of biodiesel production, especially for the non-public (non-PSO) transport sector. Moreover, a sharp demand from the domestic and international market for biodiesel makes this type of bioenergy is promising in the near future. Therefore, this study will focus on bioethanol production.

There were 29,030 million gallons or 109,890 million liters of fuel ethanol produced in 2019 worldwide. The top two highest producers were the United State of America (USA) and Brazil, 15,776 and 8,570 million gallons respectively [7]. In the case of Indonesia, in the year 2018, there was no blending of bioethanol and gasoline for fuel reported so far [8].

The current status of bioethanol production is closely related to sugar mills. Indonesia currently has 63 sugar mills owned by 18 companies [9]. With the plantation area 430-470 thousand ha, the sugar production was about 2.1-2.8 million tonnes. The molasses and bagasse production were about 1.6 and 11 million tonnes, respectively. Molasses is the main raw material for first-generation bioethanol (G1), meanwhile, second-generation bioethanol (G2) could be produced from sugarcane bagasse.

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The first recalcitrant of bioethanol G1 is limited raw material. The utilization of molasses for ethanol industries is about 30-40%. Meanwhile, the rest of 60 % is used for MSG/amino acid industries 30% and exported 25-30%. We can assume that the raw material for bioethanol G1 from molasses is competing with other sectors. Secondly, the cost of molasses is increasing every year. Based on the Joint Marketing Office (Kantor Pemasaran Bersama), the average price of molasses from 15 November 2019 to 14 March 2020 was about IDR 1,863 per kg [10]. One liter of bioethanol can be produced from 4 kilograms of molasses. Therefore, the raw material cost for 1 liter bioethanol will be IDR 7,452 (4 x molasses cost/kg).

Bioethanol price was determined from the HIP (Harga Index Pasar). The HIP is based on the Minister of Energy and Mineral Resources Decree No. 6034 K/12/MEM/2016 concerning HIP BBN mixed into types of Oil Fuel. This decree was then be amended by the Decree of the MEMR No. 350 K/12/DJE/2018. The calculation of HIP has been determined based on the formula: Average price of Kantor Pemasaran Bersama of sugarcane for 3 months period x 4.125 kg / L) + 0.25 USD / liter. The factor of 4.125 is defined as the ratio of molasses to bioethanol, where 1 liter of bioethanol is produced from 4.125 kg of molasses, while 0.25 refers to the production cost and profit margin. Based on the formula, the bioethanol price is about IDR 11,400-11,500 per liter. The higher price compares to gasoline is the factor that bioethanol for fuel is still not available commercially as targeted in Table 3.

Table 3. Target biofuel blending in Indonesia

Sector	Biodiesel (% blending)			Bioethanol (% blending)		
	2016	2020	2025	2016	2020	2025
Transportation, Public Service Obligation (PSO)	20	30	30	2	5	20
Transportation, Non-PSO	20	30	30	5	10	20
Industry	20	30	30	5	10	20
Electricity	30	30	30	-	-	-

Source: MEMR Regulation 12/2015

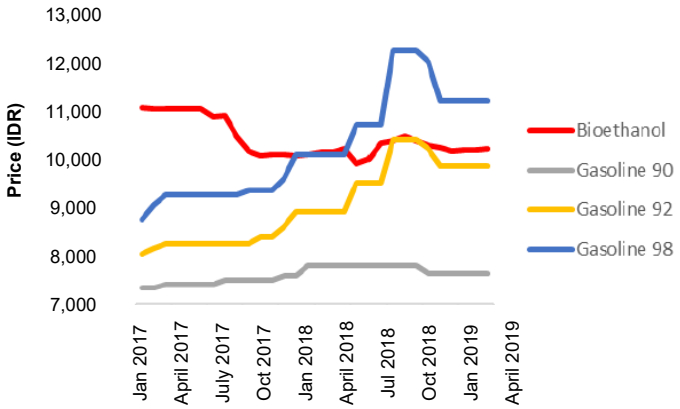

Figure 3. Comparison of bioethanol price to gasoline [2; 8]

Concerning bioethanol G1 from sugarcane, there is a real example of a success story in this area. Brazil has known to reduce its dependency on fossil fuel by utilizing bioethanol G1. The plantation area of sugarcane in Brazil in 2020 is about 8.5 million hectares [11]. This area is much larger than the plantation area in Indonesia that only accounted for 0.5 million hectares. If the government of Indonesia seriously follows what Brazil did, E5 and E10 in 2020 will easily

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be achieved, because the technology is well proven and is widely applied in existing sugar mills in Indonesia. Nowadays, gasoline contains a blending of 27% of anhydrous ethanol in Brazil [12]. Moreover, it was reported that bioethanol blending in Brazil is 18 up to 27.5% [13]. Brazil is successful to reduce fossil fuel consumption, ethanol represented 4.8% of the energy consumption in 2013 and continuously increasing every year [13].

In addition to bioethanol G1, Indonesia has a very promising raw material for bioethanol G2. The technology is still developing, especially to reduce the cost of production. Research Center for Chemistry, Indonesian Institute of Sciences has developed a pilot plant scale for second-generation bioethanol with cooperation with KOICA, Korea since 2011.

Figure 4. Pilot plant bioethanol G2 at RC Chemistry LIPI

The pilot plant area is 70 m^2 and consists of three sections: pretreatment; saccharification and fermentation; distillation and dehydration. Currently, cost production is about 2 to 3 times higher than bioethanol G1. The higher cost comes from pretreatment and enzyme cost for saccharification. Therefore, to reduce the cost, several experiments have been being carried out such as pretreatment modification. Currently, the pretreatment reactor is a batch system that using sodium hydroxide at higher temperatures and pressure. Another approach to achieve cost-effectiveness is to produce the co-products such as lignin from black liquor and glutathione from fermentation waste. Black liquor that contains lignin is produced abundantly during the pretreatment process. The lignin can be utilized as materials; blending agent to plastic; adhesive; and depolymerize to produce fine chemicals such as vanillin, etc. Furthermore, glutathione, a substance for cosmetics, can be produced after fermentation.

The government of Indonesia (GoI) tried to overcome the high price of bioethanol and other technical problems by decreasing the blending ratio to E2, 2 % ethanol and 98% gasoline [14]. However, this scenario has not succeeded yet. Recently, PT Pertamina (Persero) launched an initiative program to utilize A20, a fuel with a mixture of 15% methanol, 5% ethanol and 80% gasoline. With this mixture, the price of gasoline can be cheaper than E5 with a higher combustion system. Currently, the methanol price is USD 310/MT or about IDR 5,000.-/liter [15], two times lower than bioethanol.

Different from fuel grade ethanol (FGE), industrial grade ethanol (IGE) consumptions were about 100 million liters in 2019 [7]. Industrial grade ethanol price has a wide range of prices. Analytical grade ethanol for application in analytical instrumentation has a very high price, it is about several hundred thousand to millions in IDR per liter. This market open opportunity for bioethanol G2 production and development. Moreover, very wide derivatives products from ethanol such as hand sanitizer etc. can be produced.

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3. Conclusion

The production of bioethanol, both first and second generations, is still promising in the near future. The limiting factors of bioethanol G1 could be solved if GoI expands the plantation area for sugarcane as Brazil did. Not only molasses supply can be exceeded but also bioethanol can be directly produced from sugarcane juice. Meanwhile, the cost of production of bioethanol G2 can be reduced by implementing effective pretreatment and by using local enzymes for the saccharification process. In addition, the development of high value co-products should be considered. The market for fuel-grade ethanol (FGE) will open in line with the implementation of A20. Moreover, industrial grade ethanol (IGE) demand will continuously increase.

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