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The Feasibility Analysis of Bioethanol Production From Potential Raw Materials in Indonesia

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ABSTRACT

The development of bioethanol agroindustry is important for supporting the availability of renewable energy. The objective of the research was to analyze the feasibility of bioethanol production from potential raw materials in Indonesia. The methodology used in this research was descriptive analysis, which is carried out by exploring secondary data and experts survey. The result showed that molasses is the best raw material for bioethanol production in Indonesia. It also indicated that significant factors to be considered in choosing raw material for bioethanol production are quantity, continuity, and the price of the raw material. In bioethanol processing, the first priority was fermentation (0.30%), followed by distillation and pre-process handling (0.25%). Furthermore, when cassava is used to substitute molasses as raw material of bioethanol, then it is important to focus on pre-process activities such as initial fermentation (0.35%) and liquification (0.33%). The result also showed that bioethanol has a promising marketing opportunity to substitute fossil fuel since the government has determined to increase the percentage of the use of renewable energy, from about 5 % in 2005-2010 to 10 % in 2011-2015, and 15 % in 2016-2025. Finally, the financial analysis showed that the establishment of a small scale bioethanol industry with production capacity of about 4000 litres a day was feasible with the investment cost of IDR 2.713.500.000,-. The investment will generate profit on the rate of IDR 340.000.000, and will be recovered in 7.9 months.

Keywords: feasibility analysis, bioethanol, raw material.

INTRODUCTION

The Development of bioethanol industry, as one of agricultural-based industry, is quite complex and involve interdependence among related elements [1][2]. However, its development is significant to maintain environment quality. It also plays an important role as the agent for improving farmer's economic competitive. It is beneficial to increase bussiness activities and rural community development as well [3].

Major problems identified in bioethanol development including raw materiasl [4][5][6], technical and technological aspects [7][8]; as well as marketing [9]. Complexity of bioethanol agroindustry development is showed by close correlation among some factors that often show *trade off* and need to be managed comprehensively [10].

Indonesia has many potential resources to support bioethanol production. There are three types of potential raw materials of bioethanol. The first one is starchy material such us cassava, sweet potato, corn starch, corn, grain sorghum, wheat, potatoes and others. The next type of materials are those with high-yield sugar such us molasses, palm sap, sweet sorghum and others. The last one is material with high-yield cellulose, such us logging waste, agricultural waste as rice straw, corn cobs, tapioca waste, banana trunks, sawdust and others.

Molasses is one of the potential raw materials for bioethanol production. In 1999, the availability of molasses in Java, an island in Indonesia which has the greatest amount of sugar plant, is about 451.373 tons and in increase to 804.300 tons in 2007 (Indonesia Statistic, 2009). This potential will continue to increase from year to year because Indonesian government policy to support the improvement of sugar industry. Beside molasses, Indonesia has cassava and palm sap which are potential to support development of bioethanol agroindustry.

The objective of the research was to analyze the feasibility of bioethanol production from potential raw materials in Indonesia with regards to some influential aspects such us raw material, processing, marketing and financial.

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MATERIALS AND METHOD

This research is carried out in four stages, they are (i) priority determination of raw material for bioethanol production, (ii) analysis of key stages in the processing of bioethanol, (iii) analysis of future demand of bioethanol by considering government strategy on the fulfillment of national energy need and (iv) feasibility analysis of the establishment of bioethanol industry.

The data used in this research consist of primary and secondary data. Primary data was collected by conducting expert survey involving academician and practitioners in production of bioethanol, while secondary data was obtained from the government and by exploring information from previous research.

In the stage of determination of raw materials priority, the considered variables included the adequacy of the amount of raw material, the continuity of its availability, prices of raw materials and the ease of pre-process handling. Furthermore, several tools such as pair wise comparisons [11], trend analysis and feasibility analysis are deployed in the later stages.

RESULTS AND DISCUSSIONS

Priority Determination of Bioethanol Raw Material

The selection of raw material for bioethanol production is carried out by considering four aspects namely quantity, continuity, price and the ease of pre-process handling. Those afore-mentioned aspects were used to determine the priority among investigated potential raw materials which are molasses, cassava, palm sap and other starch sources. In this stage, importance analysis with Analytical Hierarchical Process (AHP) was utilized to achieve the targeted objective. The hierarchical structure of raw material selection for bioethanol production is depicted on Figure 1.

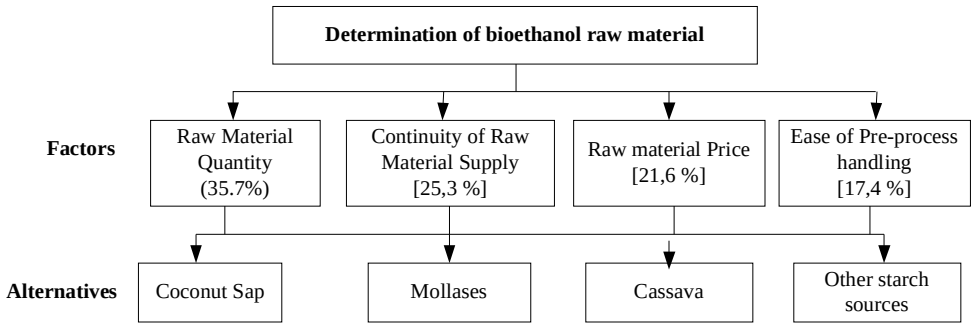

Figure 1. Hierarchical Structure of Raw Material Selection

The Figure 1 shows that the degree of importance of factors considered in raw material selection for bioethanol production are quantity of raw material (35.7%), ccontinuity of availablility of raw material supply (25.3%), raw material prices (21.6), and ease of pre-process handling of (17.4%).

Quantity, continuity and price were inter-related and inter-dependent among each other, so that they give equal contribution to the success of the establishment of bioethanol industry. Moreover, the ease of pre-handling process is contribute non only for quality of the product, but also for the presence of additional equipments, investment cost and operational cost. The result of this stage was presented in Table 1.

Table 1. Results of determination of raw material of bioethanol production

Raw materials	Factors considered in raw material selection			
	Quantity	Continuity	Price	Ease of pre-process
Palm Sap	0.12	0.25	0.27	0.31
Mollases	0.42	0.30	0.35	0.46
Cassava	0.28	0.25	0.22	0.12
Other Sources	0.18	0.20	0.16	0.11

Table 1 shows that the quantity of mollases as bioethanol raw material was the highest (0. 42) compared to other materials. One reason is the high amount of mollases in Indonesia which is continuously increasing due to the decrease of its use as the raw material of MSG production. The second is cassava (0.28), then other starchy substances (0.18) and palm sap (0.12).

Continuity of supply is one of the important factors in agro-industry. Based on this aspect, molasses has the highest priority at about 30%, followed by sap, cassava and other starchy substance at level of 25%, 25% and 21% respectively. The continual supply of molasses in Indonesia is supported by 1.4 million hectares cassava plantation in 10 provinces. For example, Lampung produces 15 tones per hectare while East Java can produce up

to 17-18 tones per hectare. While it is believed that 20% of petroleum demand can be substituted to gasohol BE-10, then 2 million tons of cassava should be produced from about 100.000 hectares farm area in Indonesia.

In the next factor, the result showed that molasses has highest score (0.35), followed by palm sap (0.27), cassava (0.22), and others starchy substance (0.16). Even though molasses price is more expensive than other sources but it is still considered as one of the prospective raw materials because it contains sugar relatively higher than other sources.

In the other hand, Palm sap has low yield-sugar, so that even though the price of palm sap is cheapest among all sources (about IDR 300 - 500 a liter), but it is less preferred as it requires more materials than molasses to produce the same amount of bioethanol. To produce a liter of bioethanol, it needs 13 liters palm sap. In addition, the price of cassava and other starch sources are cheaper than mollases, however the use of molasses is considered to be cheaper than those two materials because molasses-based bioethanol industry needs less invesment cost and operational cost than its mentioned counterparts.

The last factor to consider is the ease of pre-process handling. The result showed that molasses is the first priority (46 %) to be the raw material of ethanol production, followed by palm sap (31%), cassava (12%) and other starchy sources (11%). Molasses and palm sap were glucose substances that were easier, in term of pre-process handling, to be processed as the material of bioethanol compared to other sources. High-yield starch materials were also potential as the raw material of bioethanol; however it needs further pre-process handling as mentioned in later discussion.

Four important stages of pre-process handling of bioethanol production, namely (i) pilling and grinding, (ii) liquification, (iii) saccarification and initial fermentation. Each stage has different level of contribution and omportance in bioethanol production which depend on its difficulties and the targeted final result. Table 2 shows the importance level of bioethanol production process stages.

Table 2. Importance level of pre-process handling of bioethanol production from starchy raw materials

Pre-process on bioethanol production from starchy raw material	Importance level
Peeling and grinding	0.10
Liquification	0.33
Saccarification	0.22
Initial fermentation	0.35

Table 2 shows that the main stages of bioethanol production are initial fermentation, liquification, saccarification, and pilling and grinding. According to the importance level, initial fermentation is the most important stage to guarantee the readiness of raw material. In this stage, starch will be processed to become glucose. This is the most crucial stage that determines the success of bioethanol production.

After prepared in the pre-process handling, materials are then further processed through four stages of bioethanol production, namely pre-processing, fermentation, distillation, and dehydration or purification. The importance level of each mentioned stage is shown in Table 3.

Table 3 Importance level of bioethanol processing

Stages of Bioethanol processing	Importance Level
Pre-processing	0.25
Fermentation	0.3
Distillation	0.25
Dehydration/purification	0.21

Table 3 shows that fermentation is the most prioritized stage (0.3) in bioethanol production. The reason is that this stage involves utilization of microbial activities which need significant attention and supervision in order to gain the best result. The next prioritized stage is pre-processing which focuses on how to retrieve as much glucose as possible from available starch substances. Other stages are distillation and dehidration with the priority values of 95% and 99.5% respectively.

Before reaching the fermentation stage, materials are going through crushing and hydrolysis. The process of crushing is intended to ease the hidrolysis of starch. Materials should be cleaned and peeled by using washer and peeler machines before being crushed, however the crushing itself can be done either manually or using crusher machine.

The materials are then go through the hydrolisis process. This is a process to prepare cassava puree to be ready for the next process called saccharrification. Cassava puree is transported from receiver to the Cooking Tank. About 0.1% (of the amount of starch) of Enzyme α-Amilase is then added to the tank and is cooked together with the puree by using steam at the temperature of 80ºC for about 30 minutes. The temperature is then increased to 100ºC for 30 minutes, and after that the cooked puree is poured in to the Saccharifator. In the Saccharifator, the temperature is decreased to the level of 55ºC by using a Heat Exchanger. Gluco-Amylase 0.06 is then added for 60 Minutes, and is cooled at the temperature of 34ºC. The puree is now ready to be flowed to the Fermentor.

Fermentation is a process to convert glucose to be the bio-ethanol by using yeast. Like the pre-process handling, the Fermentation also plays an important role for the success of bioethanol production. Alcohol yielded from this yeast fermentation is about 8-10% of the material volume. The quality of yielded bioethanol can be increased by performing cleaning process to separate it from other substances.

Technically, the purity of the yielded bioethanol was about 30-40% which makes it cannot be classified as an ethanol-based fuel yet. Therefore, it should be further purified by using distillation to achieve the purity level of more than 95%.

Distillation is one of the methods to purify bioethanol so that it can be used as a fuel. In the distillation, yielded alcohol (purity level of 40%) was treated to separate alcohol from water by implementing the principle of different boiling points between those elements.

In this stage, the yielded alcohol is boiled at the boiling point temperature of ethanol (about 78^{o}C). At this temperature, ethanol evaporates and is separated from the water. The evaporated ethanol is then flowed in to a surrounded-water pipe so that it can be condensed to be the ethanol liquid. The result of this process is 95% ethanol, however it still can be soluted in petroleum, therefore, it should be further purified to achieve the purity level of 99% which is called as dry ethanol.

Marketing of Bioethanol

As the substitute of petroleum, bioethanol demand is high is keep increasing significantly from year to year. The national need of petroleum is about 17.5 billion per year, and this time Indonesia still imports about 30% of its petroleum need. Therefore, Indonesian Government has a target to substitute 1,48 billion litres petroleum by ethanol in 2007-2010 and is expected to increase 10% in 2011-2015, and 15% in 2016-2025.

In 2007-2010, the average demand of bioethanol is about 30,833,000 litres per month. From this amount, Indonesian government can provide only 137,000 litres bioethanol per month or about 0.4%. This condition shows that every month, the government needs 30,696,000 litres bioethanol to fulfill national need. This is a potential market which gives opportunity for the development of bioethanol industry.

Financial Analysis

In this research, a profile of small scale bioethanol plant is proposed. This profile use molasses as the raw materials of bioethanol. It showed that to achieve the production capacity of about 4,000 litres per day, 16 ton of mollases should be supplied every day. The initial investment is about IDR 2,713,500,000 and the operational cost is IDR14,498,000 per day. With the selling price of IDR 7.000/liter, it can be drawn that the generated profit will be IDR 3,400/litres and this investment will be recovered in 7.9 months. The detail calculation of the investment on the establishment of small scale bioethanol industry was shown on Table 4 and Table 5.

Table 4. The profile of small scale bioethanol plant with molasses as the raw material

Description	
Plant Capacity	4.000 litres/day
Sugar content	50%
Molasses (kg) : ethanol (litre) Ratio	4 : 1
Need of mollases per day	16 ton/day
Need of mollases per year (300 days/year)	4,800 ton/year
Plant field	3,000 m^2
Workers	18 persons
Investment	IDR 2,713,500,000

Table 5 Cost analysis of bioethanol production from molasses

Description	Total Needs	Unit Price (IDR)	Total Price (IDR)
INVESTMENT		2,713,500,000	2,713,500,000
Operational costs/day			
1. Mollases	16,000 kg	700 / kg	11,200,000
2. Yeast	18.4 kg	50,000 / kg	920,000
3. Fertilizer Urea	40 kg	2,500/kg	100,000
4. Fertilizer NPK	4.8 kg	10,000 /kg	48,000
5. Fuels	80 liters	4,500/litre	360,000
6. Electricity	800 kwh	650/kWh	520,000
7. Water	120 liters	1,000 / m3	120,000
8. Maintenance	4,000	150 / litres	600,000
9. Workers	18 persons	35,000/person	630,000
Operational Cost (IDR)			14,498,000
Production Cost (IDR/litre bioethanol)			3,630
Selling Price (IDR/litre)			7,000
Profit (IDR)			3,400
Profit (IDR/month)	25 x 4,000 x 3,400		340,000,000
Pay back period (months)			7,9

The use of cassava as raw material of bioethanol production is considered as prospective alternative to support the development of bioethanol industry. One reason is that the cassava can be a substitute for molasses which is limited and not always available in the required amount. At the capacity of 4,000 litres per day, a cassava-based bioethanol industry need 26 tons cassava per day. The initial investment cost is about IDR 3,095,500,000 and the total operational cost is about IDR 19,282,500 per day. If the product is sold at IDR 7,000.-/litre, It profit will be IDR 2,180.-/litre and the payback period is 14.2 months.

CONCLUSION

1. Important factors in the development model of bioethanol agroindustry are quantity, continuity and price. Based on its quantity, continuity and ease of pre-process handling, molasses was considered as the first priority to be the raw material for bioethanol agroindustry. In contrast, palm sap was more prioritized in term of price.
2. Fermentation was the most important stage in the bioethanol production (30%), followed by distilation and pre-handling at the level of 25% each. In the pre-process handling, initial fermentation was the most important factor (35%) followed by liquification (33%).
3. Based on Indonesian government regulation, 30,833,000 litres of bioethanol are required per month in 2007-2100. While the government can provide only 0,4% of the national need of bioethanol, then it is believed that there is opportunity to market 30,696,000 litre bioethanol for fuel.
4. The establishment of bioethanol industry from molasses requires the supply of molasses at about 16 ton per day to achieve the production capacity of 4,000 litres per day. The initial investment was about IDR 2,713,500,000 and the operational cost is about IDR14, 498,000/day. With the selling price at Rp.7,000,-/litre, it is concluded that the profit of this industry is IDR 3,400,-/ litre and the payback period is 7.9 months.

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