Design of Hydrogen Fuel Supply Chain Distribution Network from the Potency of Palm Oil Empty Bunches

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Abstract: In Indonesia, the production of biomass is wasted because it is considered as "waste" that has no use anymore such as bagasse, rice grain skin, corn cob, and oil palm waste. Oil palm empty bunches have C and H chemical bonds, where most of the materials with chains C and H store heat energy so that hydrogen can be obtained as fuel. Process to convert a biomass into hydrogen is by gasification and pyrolysis. The purpose in this research is to design the distribution network from the potential oil palm empty bunches. The hydrogen produced is only 0.469% of the available potential and is similar to the existing of the used empty bunches potential. Selection of factory location is based on 4 criteria. From the criteria, obtained LabuhanBatu District as the best regencies in North Sumatra. Potential plantations can supply as much as 6,390,423,000 kg with the ability of oil palm factory distribution of 1,469,797,290 kg.

1 INTRODUCTION

As the depletion of fossil fuel and natural gas reserves make the world look for replacement energy. Biomass is an alternative fuel source that is still abundant and has not been fully utilized(Mirela, 2018)

Exploration for renewable alternative energy sources for the long term will takes an environmentally friendly source of energy, one of which is hydrogen. In the long term, especially in Indonesia, the production of hydrogen through coal gasification and through biomass gasification will provide economic benefits. Consider the potential of biomass in Indonesia today and in the future, hydrogen production will have a positive effect on the national economy.

Globally the need for hydrogen as an alternative energy has been increasing in recent years hydrogen as one of the hydrocarbon fuels that has the advantage of being eco-friendly and having great energy efficiency especially if used on vehicle fuel (Michael, 2018)

Biomass that has the potential to be processed is empty bunch palm oil. Oil palm empty bunches have considerable potential to be utilized. However, empty bunch utilized as organic fertilizer presently. The remaining empty bunches will make problem for the place and its disposal transport resulting in additional production costs for the processor (Chen, *etc*, 2018)(Yanan, *etc*, 2018)

Hydrogen in the industry is generally produced using the Steam Methane Reforming (SMR) method from natural gas resulting from pyrolysis and gasification methods(Josua, etc, 2018)(Melaina and Penev, 2013). Steam Methane Reforming is more efficient with low cost through pyrolysis and gasification process (Delgado, *etc*, 2018)

Supply chain management is now important for oil palm companies and other companies as the competition grows and the position of palm oil and mill suppliers and millers as partners. The process of fulfilling the customer needs in the supply chain is a value-adding chain that not only stops at one company but includes all the companies that are members of the supply chain (Muhammad, 2012).

Pyrolysis is decomposed with the aid of heat in the absence of oxygen or with a limited amount of oxygen. Usually there are three products in the process of pyrolysis such as charcoal, gas, and liquid. Pyrolysis process is influenced by several factors such as time, temperature, particle number, particle size, particle weight (Ramadhan, *etc*, 2018)(Ali, 2018).

Strategic business location can maximize the business profit. Location is where to serve consumers, defined as a place to introduce goods. Thus the

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definition of a location is a place to run an activity that serves consumers, production activities, storage activities, or to control the activities of the company as a whole part of the company. The main factors in choosing the location are (1) Availability of Raw Materials, (2) The location of the intended market, (3) Availability of energy source, water, and communication facilities, (4) Availability of manpower and (5) Availability of transportation (Sunil, *etc*, 2013).

Supply chain is a network of companies that work together to produce and deliver a product into the end users. These companies usually include suppliers, producers, distributors, stores or retailers, as well as support agencies such as logistics services agencies. (Dawei, 2011). According to the definition, several number of key characteristics that used to portrait a supply chain. First, supply chain needs participation of more than one company. Second, the participating companies within a supply chain should be in difference business ownership, therefore there is a legal independence in between. Third, those companies are inter-related on the common commitment to add value of material flow that run through the supply chain. The material flow, to every company, transformed inputs and goes out as outputs with value added. (Directorate general of the farm, 2017)

2 METHODOLOGY

Research object is hydrogen fuel that produced from palm oil empty bunch with pyrolysis method. The data gathered from the result of empty bunch, plantation location and factory locations in Sumatera Utara. This data then processed to gain the information of distribution network palm oil empty bunch.

First step is to figure out the needs of raw material by define the capacity per day based on the steam methane reformer machine. Second step is to define the needs of raw material needed based on the percentage of hydrogen by gas and the percentage of gas from empty bunch from the result of pyrolysis process and also percentage data from empty bunch and fresh fruit bunch. In this step, also resulting the hydrogen potential that can be get from empty bunch in Sumatera Utara.

Next, designing the distribution network is done by defining the location of hydrogen plant in Sumatera

2. Needs of Empty Bunch per hour CalculationThe hourly empty bunch requirement is calculated

Utara with qualitative method. The assessment based on raw material supply and added material, utility, transportation and surroundings. The result is the best location to build the hydrogen plant.

The last step is figuring the distribution network after resulting the ideal plat location and factory data in Sumatera Utara. The result is shown by the distribution figure from farm to hydrogen plant.

3 RESULT AND DISCUSSION

3.1 Production Capacity

The determination of production capacity is based on rated power capacity (MW) using Steam Methane Reformer. The results of a study by the National Renewable Energy Laboratory for the production of hydrogen using pyrolysis and Steam Methane Reformer methods obtained a production capacity of 1,000 kg / day (Joshua Eichman, etc.2016).

3.2 Raw Materials Needs

The needs of raw material calculated by the following steps :

1. Hydrogen Calculation Result
   Based on the calculation, Percentage of empty bunch turns in to gas is 52.02%. Then the percentage of hydrogen in gas is 8.69%.
2. Potential of Hydrogen Produced in North Sumatera
   The processing of fresh fruit bunches (FFB) will produce 23% palm empty fruit bunches, 6.5% shell waste, 4% wet decanter, 13% fiber and liquid waste as much as 50%.
   The following is the calculation of the amount of hydrogen produced in North Sumatra.[14]
   a. The number of FFB produced in 2015 is 6,390,423,000 kg.
   b. The percentage of oil palm empty fruit bunches from fresh fruit bunches is 23% so that there are empty bunch of 1,469,797,290 kg.
   c. The percentage of oil palm empty bunches into gas as much as 52.02% to obtain gas of 764,588,550 kg by pyrolysis method.
   d. The percentage of hydrogen in the gas as much as 4.52% to obtain hydrogen of 690.265.368 kg per year.

   using the hydrogen percentage in empty bunch The results can be seen in Table 1.

Table 1: The Needs of Palm Oil Empty Bunch

	Percentage (%)	Weight (Kg)	Type	Weight (Kg)	Type
Percentage Hydrogen in Gas	4,52	22,123.89	Gas	1,000	Hydrogen
Percentage Gas in Empty Bunch	52,02	42,529.58	Empty Bunch	22,123.89	Gas
PercentageEmpty Bunch from Fresh Fruit Bunch	23	184,911.24	Fresh Fruit Bunch	42,529.58	Empty Bunch

Table 1. shows that the need of empty bunch fruit to gain 1000 kg hydrogen per day is 42,529.58 kg.

3.3 Plant Site Selection

The ideal plant site selection is the location that will provide the minimum total cost of production and transportation and maximum profit for the company. The selected regions are districts located in the province of North Sumatra. In the selection process of several alternative locations will be used qualitative methods to determine the alternative locations should be selected.

Then the determination of the weight of the criteria that affect the selection of factory location. Giving weight of each factor or criteria identified based on degree of importance. The highest market share is Labuhan Regency with 37.09% market share followed by Asahan District with 13.13% market share and Langkat Regency with market share of 12.05% as location 1, location 2 and location 3 (Data center and farmig information system, 2016).

Table 2: Weight and Value Matrices from Each Location Factor and Alternative

Criteria	Weight	Alternatives		
		Alternative 1	Alternative 2	Alternative 3
Easy supply of raw materials and auxiliary materials	35%	9	7	7
Utility	30%	8	9	7
Easy Transportation	20%	8	8	8
Environmental and social circumstances	15%	8	8	8

The value get from research considerations based on the actual conditions in which location. Then get the values of each alternative location that can be seen in Table 3.

Table 3: Assessment of Location Alternatives

Criteria	Alternative		
	Alternative 1	Alternative 2	Alternative 3
Easy supply of raw materials and auxiliary materials	3.15	2.45	2.45
Utility	2.8	3.15	2.45
Easy Transportation	2.8	2.8	2.8
Environmental and social circumstances	2.8	2.8	2.8
Total	11.55	11.2	10.5

From the results of the calculation above, then the selection of alternative locations that are considered good alternative location that has the greatest value of z / total. Thus location 1 has the largest total value of 11.55, so the best location according to this analysis is alternative 1.

3.4 Distribution Network

Supply chain problem can be done by using a facility location capacity approach. The development of supply chain networks is carried out at three levels of supply chain distribution (suppliers, distribution centers, and consumers) in consider of multi-period, multi-product issues, and adding inventory issues to anticipate uncertainty in supply. Hydrogen fuel supply chain distribution network can be seen in figure 1.

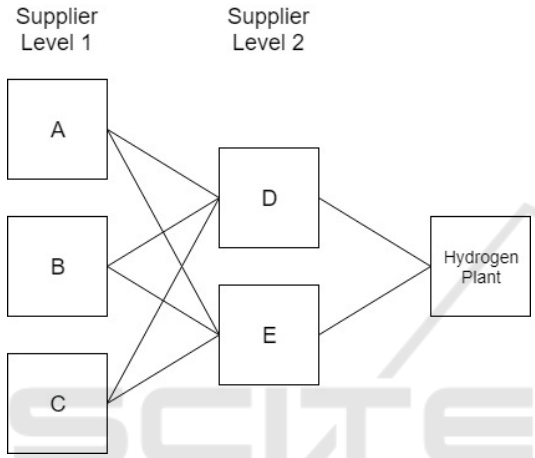

Figure 1. Hydrogen Fuel Supply Chain Distribution Network

The supply chain is divided into three groups: (1) Suppliers level 1, that is oil palm plantations that produce FFB for processing in Palm Oil Mill, (2) Suppliers level 2, which is leaving empty bunch to become the raw material for the process of making hydrogen fuel, and the last destinationwhich is Hydrogen Plant that produces hydrogen fuel.

4 CONCLUSION

Sumatera Utara has a great potential of empty bunch for making a hydrogen fuel. To make it come true, it needed a distribution network start from fresh fruit bunch from farm until hydrogen fuel from factory. Supply chain consist of three part such as supplier level 1, supplier level 2, and hydrogen plant as consumer. Supplier level 1 is farm that send a fresh fruit bunch to supplier level 2. Supplier level 2 is a palm oil factory that sent palm oil empty bunch to hydrogen plant. The calculation shows that the palm oil farm in Sumatera Utara can supply empty bunch as the production capacity that makes this supply chain can be applied.

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