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Utilizing microalgae as a local resource for fuels production in Papua province. A review: Strategies plans of biodiesel

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Abstract. Papua province has abundant of natural resources that can be utilized as sources of bio-renewable energy fuels. Specifically highly demand from industrial sector in this particular case electricity consumption has led to the production of biodiesel from plant as a replacement of diesel fuel. From many biodiesel sources that are exist, microalgae has been selected as the main source of biodiesel production due to the highly oil content of this plant. In addition, alternative fuel such as bioethanol is also considered to be produced from the solid waste of microalgae biomass because of its carbohydrate level. Therefore, through this study, it is expected in the future Papua Province will be able to support its industrial and transportation sectors by utilizing local sources as fuels.
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JEL. D91, J24, J28, O14, Z22.

1. Introduction

Energy demand has steadily increased over years widely all over the world. Although it is a fact that consumption of energy is increasing gradually, however, due to the limited amount of fossil fuels, therefore it is crucial to look for other alternatives energy sources. In Indonesia, many natural resources such as wind power, solar, hydro, geo-thermal and biomass can be converted into renewable energies. From all of these alternative energies, Biomass is one promising source due to many benefits offers for instance, it is easier to access this source everywhere on earth, relatively cheap, able to produce oxygen and it can help to reduce carbon dioxide level (Mandik *et al.*, 2015). Specifically, in 2012 Indonesia has produced 2.2 billion liters of biodiesel as a replacement of diesel fuel in large scalethat is coming from biomass plant called palm in which rich in oil or lipid content (Mandik *et al.*, 2015; Slade, & Bauen, 2013; Susilowati, 2010). From total production of 2.2 billion liters, only 669 million liters used for biodiesel consumption while the rest was exported (Climate, Energy, and Tenure Division, 2014).

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Data gathered from Ministry of Agriculture has reported total area used for palm oil plantation was 9.5 million hectare back in 2012, however, the area is expected to expand to reach 13 million hectares in 2020 (Climate, Energy, and Tenure Division, 2014). Although it is predicted that palm plantation is increasing gradually every year, however, as palm oil itself is one of the primary logistic needs for human being as cooking oil, therefore making the availability trend of this supply can become competition for food sector. As a consequence, biodiesel production will always depend on the consumption rate of palm oil. Therefore, other alternative plant must be considered for the sustainability of biodiesel production in Indonesia.

Microalgae is one promising source for the production of biodiesel. Three main components from this plant are carbohydrate, protein and triglycerides as the primary source for biodiesel production (Mandik *et al.*, 2015; Slade, & Bauen, 2013; Susilowati, 2010). From many different kinds of microalgae that are exist, oil content can be varied between 20 – 75 % from total plant mass (Mandik *et al.*, 2015; Slade, & Bauen, 2013; Susilowati, 2010). Other than rich in oil content, microalgae is also very suitable for biodiesel production due to the easiness for oil extraction, therefore additional step such as milling can be skipped. In addition, plantation area needed for growing microalgae is low compared to other biodiesel typical plants, because microalgae can grow well in wastewater, saline or brackish condition.

In Papua, twomajor sectors that require biodiesel are coming from electricity and transportation. However, this study is focusing on producing biodiesel to potentially meet partial electricity need of the province. Electricity Department of Government (Perusahaan Listrik Negara) is working on to expandelectricity development project to achieve the target to supply electricity reaching all rural areas in Papua by 2018. In order to reach this goal, Papua Research and Technology Institution is considering to take a role to supply partial diesel fuel for the electricity need inside Papua Province by producing biodiesel from microalgae.

2. Strategy plans

In this study, five main goals that are going to be achieved are collecting many different types of microalgae that are exist from few different location in Papua Province (1), conducting screening tests to observe the initial composition of each variety (2), Growing and harvesting selected microalgae variety (3), Oil extraction (4) and Biodiesel production (5).

Strategy plans developed to asses all these goals have to consider each of these goals. First objective targets are choosing selected representative areas in Papua, where microalgae can be found easily and transportations are relatively accessible to reach that particular place. Once, samples are being collected, initial composition analysis tests are going to be conducted to observe chemical compositions of microalgae plant. Furthermore, in order to meet the next three goals, there must be a proper cooperation between researchers, local government, and society. Growing and

harvesting microalgae will require space and sufficient technology. While Oil extraction, other than space and technology, right chemical analysis is also play a role in order to achieve maximum amount of oil will be extracted from microalgae. Finally, pilot plant of biodiesel production is developed.

In order to achieve these goals, it is very important to have an initial timeline, therefore, it can direct researchers, government officials, and all other components to have a proper expectation related to this biodiesel production project. Overall summary timeline of biodiesel production is presented at the table below.

Table 1. *Timeline Biodiesel Production Using Microalgae*

	June – Aug 2016	Sept – Nov 2016	Dec – Feb 2017	Mar – May 2017	Jun – Aug 2017
Biodiesel Pilot Plant					
Collecting Microalgae Samples					
Screening Tests					
Growing and Harvesting					
Oil Extraction					
Biodiesel Production					

Meanwhile, general biodiesel production is divided into two big phases as presented at the Figure 1.

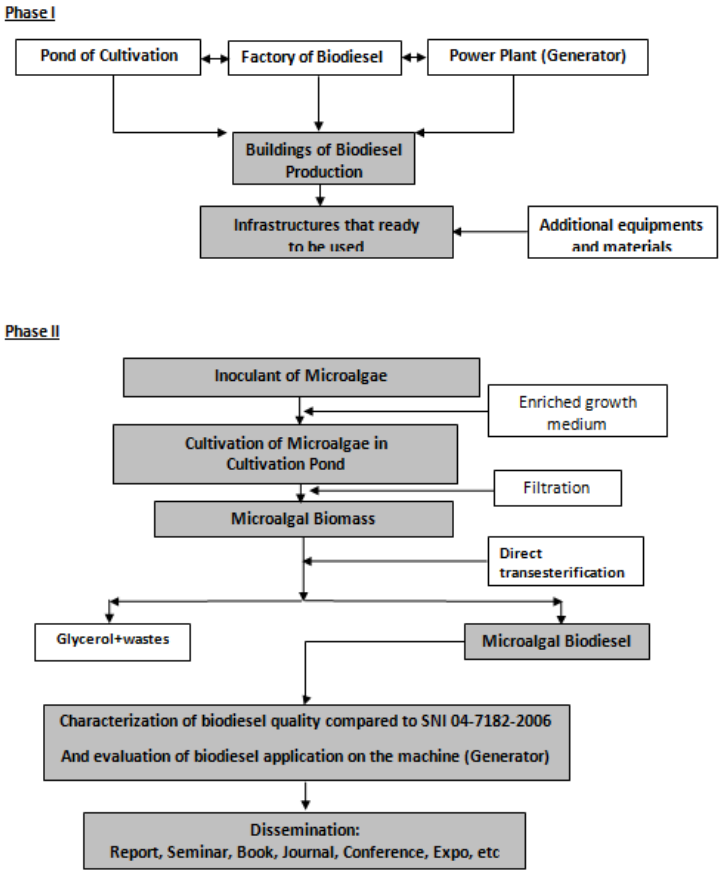

Figure 1. *Design of Microalgal Biodiesel Development*

These two phases have proposed targets to be achieved along with indicators of development as presented at table 2.

Table 2. *Target of Development*

Phase	Targets	Indicator of Development
I	1. Local microalgae which has potentials for biodiesel production.	Pure culture of local microalgae that can be utilized for biodiesel production.
	2. Microalgal cultivation ponds.	Constructed Microalgal cultivation ponds.
	3. Biodiesel Factory.	Constructed Biodiesel Factory
	4. Biodiesel Power plant.	Constructed Biodiesel Power plant.
II	1.Microalgal biomass	Produced microalgal biomass.
	2. Microalgal biodiesel	Produced microalgal biodiesel.
	3. Electricity from Biodiesel.	Produced electricity from biodiesel power plant.
	4.Information of microalgal Biodiesel application on generator machine.	Produced information microalgal biodiesel application on generator machine.
	5. Pilot Project of Microalgae cultivation-Biodiesel production-Biodiesel power plant.	Constructed Pilot Project of Microalgae cultivation- Biodiesel production-Biodiesel power plant.

3. Cost analysis

In order to produce biodiesel using microalgae as feedstock, it needs to take into account, the most appropriate way to cultivate microalgae. From literature study, two most models use are raceway pond and photo-bioreactor with the corresponding needs annually as presented at the table 3.

Table 3. *Comparison of two microalgal cultivation models*

Scenario	Active operation day (d)	Biomass productivity (g m^{-2} d^{-1})	Electricity (W m^{-2})	Land (ha)	Water evaporation (L m^{-2} h^{-1})
Raceway Pond	360	20	1	10	10
Photobioreactor	360	40	50	0.2	0.5

Meanwhile to produce each kg of microalgae, the averageproduction cost from raceway pond model is around Rp.2,000 while average of microalgal biomass production cost from photo bioreactor is Rp.13,000 with the approximate details presented at the Fig. 2.

In addition to that, with the approximation that 1 kg of microalgae consist up to 0.5 L of oil, therefore, it will require 2 kg of microalgae to produce 1 L of oil. Another assumption made was, from 1 L of oil, only around 70% will convert into biodiesel which is around 0.7 L.

Furthermore, in order to produce 1 L of biodiesel, our rough approximation will divide into. Microalgal oil is Rp5,714 and Chemicals is Rp 8,574. Therefore, total production cost per liter of biodiesel is Rp 14,289.

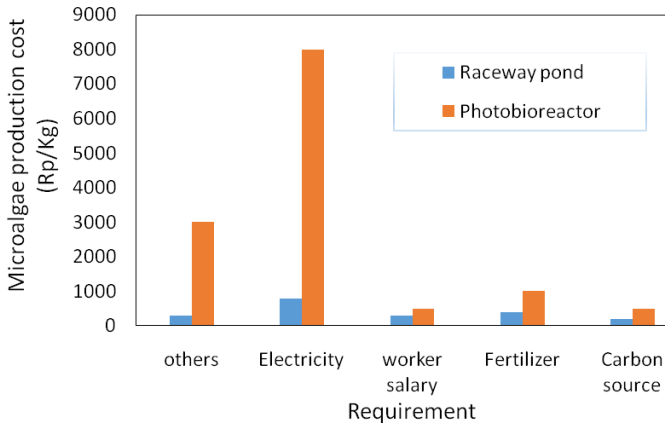

Figure 2. *Overall Microalgae Production Cost*

4. Conclusion

From two different ways of cultivating microalgae called raceway pond and photo bioreactor, our literature review and preliminary studies indicated that raceway pond will produce more economically microalgae. Therefore, we propose to use this method to cultivate microalgae and further produce biodiesel in Papua Province to support its industrial and transportation sectors by utilizing local sources as fuels.

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