# Cost-benefit analysis of biodiesel related policies: the assessment of applicability

A case study in new biodiesel policies in Indonesia

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## MASTER THESIS

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# Cost-benefit analysis of biodiesel related policies: The assessment of applicability

A case study in new biodiesel mandatory in Indonesia

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# Abstract

Until recently, biodiesel development in Indonesia is far from the target. The previous government policy cannot substantially increase its domestic consumption. Moreover, as the crude price oil decrease, the viability of biodiesel development is still questionable. This is due to the fact that biodiesel still remains uncompetitive since the production cost of biodiesel is higher than fossil diesel. A cost benefit analysis (CBA), as an important and systematic approach in estimating the best possible policy options has already been conducted in biodiesel sectors. It was applied specifically to analyze the financial feasibility of the industries in different countries. Despite its remarkable use, the applicability assessment of CBA in investigating the impact of different policies has been hardly examined. Thus, this research aims to investigate the applicability of CBA within biodiesel related policy changes in Indonesia. It should be noted that the Indonesian government has particularly implemented the new biodiesel related policy. The applicability of CBA to analyze the impact of any biodiesel current and future policy has given some new insights. Beside several effects that cannot be monetized, a stakeholder's analysis plays an important role in analyzing the added value of CBA in this particular case study. The application of CBA can be used to briefly determine what the main purpose of each policy will be.

# Executive Summary

Energy plays a fundamental role in the global economy. Changes in the energy cost have significantly affected the economic growth of the country. Increasing oil prices, rising energy demands and any concerns over global warming have eventually encouraged many countries to gradually promulgate the development of both biofuel domestic and international market by introducing different type of incentives, such as consumption targets/mandates, tax breaks, production subsidies, and reduce border tariffs.

Since 2005, biofuels have increasingly attracted Indonesian government's attention due to their potential to reduce the country's reliance on fossil fuels. After became a net importer of oil in 2004, Indonesian's economy is greatly affected by fluctuation in global fossil fuel prices. However, without having a long history of encouraging the use of alternative and renewable fuels, Indonesia has difficulties in promoting biofuels e.g. biodiesel and bioethanol for domestic consumption. As the institution that can legally regulate the market, the Indonesian government is thus seeking to promulgate biodiesel domestic consumption due to other reasons such as: increasing the country's energy supply, reducing palm oil excess supply and increase palm oil world market price. Numbers of new policy was regulated at the end of 2014 by the government to increase the consumption of biodiesel. With regards to the reliable policy implementation, a basic theory needs to be applied i.e. cost-benefit analysis (CBA). Its main purpose is to determine whether the investments or policies are feasible and provide a thorough comparison among projects / policies by calculating the total expected cost against the total expected benefits.

The motivation of this case study analysis is based on the fact that several research have been conducted to examine the financial feasibility of biodiesel in several countries by applying a cost-benefit analysis. However, none has been done to analyze the applicability of cost-benefit analysis within biodiesel related policy. Besides, the case study shows that the interdependence among the stakeholders involved in biodiesel system (i.e. Indonesian government, palm oil producers, biodiesel industries and oil distribution company) have eventually limited the domestic growth of biodiesel.

This study aims to assess the applicability of cost-benefit analysis in analyzing the impact of biodiesel policy changes in Indonesia. It proposes to look into the suitability of the theoretical framework in assessing cost-benefit analysis and the case study. First, the case study shows that a fundamental issue has been addressed and determined. Despite its contradictive nature, it is

clear that there is no issue concerning the existence of universal human right. Moreover, evaluating the suitability of policy objectives is also crucial. That the policy objective must be clearly stated and confirm its value of achievement. Third, an investigation of policy programs that have been developed is also the main requirement in assessing the applicability of cost-benefit analysis for this case study. Lastly, examining the monetary valuation of each effect of policy program will ultimately clarify the applicability of cost-benefit analysis regarding this issue. Therefore, it can be argued that cost-benefit analysis is suitable in examining the case study.

In addition, based on the assessment criteria used in this study in evaluating the applicability of CBA, there are some critical arguments that should be addressed. First, it can be argued that future policies that will be implemented within biodiesel will reduce the net welfare of society and the Indonesian government, yet it will increase the net benefit of palm oil producers and biodiesel industries. Second, CBA can be used to examining the effect of future uncertainty. Changes in palm oil prices and pricing formula will not affect the net social benefit. The main objectives of Indonesian government to eventually increase palm oil price might be controversial since CPO has been also widely used in food industries. Third, cost-benefit analysis can clarify the influencing factors for future development of biodiesel. It can be argued that future policies focusing on cost reduction would eventually increase the net social benefit, while at the same time taking the crude oil price into account.

Despite its limitation, a cost-benefit analysis can, to some extent, contribute to guide the policy maker not only in making a rational decision based on the highest net benefit attained, but also to sustain the implementation of certain policy. Such an analysis may not address all the questions of a political–economy nature in determining which policies should be selected and implemented but at least it is a quantitative basis for making judgment as to the attractiveness of the policies and provide the basis for assessing the roots of support and opposition that the project is likely to face.

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This master thesis is part of my deep contemplation that in order to increase the economic growth, the government should actively participate in regulating the market. Otherwise, a free market will increase the inequality among people and will unequally distribute the income among society. Cost benefit analysis, as a well-known systematic tool in analyzing the wealth distribution in society, is the most common approach for firms and government to examine several fundamental analysis prior their decision. However, CBA has also its own limitation. Yet, based on the advantages and disadvantages, it is important for businessman, entrepreneur, and the government to carefully analyze the applicability of CBA in examining the current and future policy impact within renewable energy sectors.

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Ignasius Ferry Halim

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# Chapter 1 – Introduction

## 1.1 Research background

Energy plays a fundamental role in the global economy. Changes in the energy cost have significant effects on the economic growth. Increasing oil prices, rising energy demands and any concerns over global warming have eventually encouraged many countries to developed biofuels (FAO 2008, Verchot *et al.* 2010). Moreover, in the context of the emergence of renewable energy, particularly biofuels, many countries have substantially put efforts in promulgating the adoption rate of both domestic and international market. Specifically, in order to stimulate the development of biofuels, many countries have introduced different type of incentives, such as consumption targets/mandates, tax breaks, production subsidies, and reduce border tariffs. As a result, those incentives have stimulated the growth of biofuel production and trade globally during 2000 – 2011 (Caroko *et al.,* 2011).

Indonesia, as are many developing countries, has been currently seeking to take the advantage of this emerging global market for biofuels. Since 2005, biofuels have increasingly attracted Indonesian government's attention due to their potential to reduce the country's reliance on fossil fuels, while providing an additional domestic market outlet for palm oil products. Additionally, in 2007, the Ministry of Energy and Mineral Resources claimed that the existing oil reserves would last only 25 years based on the current rate of extraction and use. Despite the fact that the oil production level of Indonesia has declined during 2000 – 2010, the consumption levels have increased (Caroko *et al.,* 2011). Consequently, after became a net importer of oil in 2004 (ADB, 2009a), Indonesian's economy is greatly affected by fluctuation in global fossil fuel prices. The spike in the global oil price in 2008 had important implication for the Indonesian economy since the fuel subsidy costs have almost doubled from US$ 4.4 billion in 2005 to US$ 7.4 billion in 2006, which is almost 10 percent of the total state budget (Dillon *et al.,* 2008). Thus, it is expected that biofuel development will reduce expenditures in the fossil fuel subsidies.

Without having a long history of encouraging the use of alternative and renewable fuels, the Indonesian government (GOI) established its first national policy on biofuels as part of the National Security Act in 2006, which mainly aims to increase biofuels use to 5 percent of national energy consumption by 2025. The Indonesian government instructed the national oil

company, Pertamina, to start selling mixed fuels (primarily biodiesel produced from palm oil)[1]. In 2010, in contrast with the stagnant condition of Indonesia's bioethanol, Indonesia's biodiesel sector maintained healthy growth. The bioethanol distribution was ironically ended due to inconsistent supply and price volatility (Wright and Wiyono, 2014), yet palm oil biodiesel has been commercialized (Panjaitan, 2013). The taskforce, namely the National Team for Biofuel Development [2], has certainly claimed that the use of biodiesel is expected to account for 10 percent (2.4 billion liters) of the total diesel fuel by 2010 and 20% (or 10.22 billion liters) by 2025. (Caroko *et al.,* 2011). Based on the target, the taskforce aimed to develop 5.25 million hectares of new biofuel feedstock plantation by 2010, 1.5 million hectares of which was to be palm oil plantation.

As the biggest producers of *crude palm oil* (CPO), it was seen that Indonesia has the opportunity to also become the largest biodiesel producer (Zhou and Thomson, 2009). Indonesia together with Malaysia supplied 85 percent of the global demand for palm oil (Teoh, 2010) in 2009 and produced about 30 million tons of CPO in 2014[3]. However, the country failed to achieve the 2010 target. The production in 2010 was only 21 percent of the target. A subsidized fossil fuels and the increasing price of CPO was claimed to be the main aspect that have made biodiesel uncompetitive, as stated in Notonegoro, 2012. In 2011, the amount of CPO used for biodiesel was 715,000 tons (just 2.8% of Indonesia's total CPO production). Besides, the number of mills increased from two in 2006 to 22 in 2011. These figures do not imply that biodiesel production was booming, since the use of bio-refineries capacity remains low. In 2011, it was estimated that the capacity use was about only 17%, leaving most of biodiesel refineries idle (Slette and Wiyono, 2011). Eventually, low domestic consumption of biodiesel has led the Indonesia government to allow biodiesel producers to export (Slette and Wiyono, 2011).

Accordingly, as the institution that can legally regulate the market, the Indonesian government is thus seeking to promulgate biodiesel domestic consumption due to the urgency in increasing the country's energy supply. Numbers of new policy was regulated and changed until the end of 2014 by the Indonesian government to increase the consumption of biodiesel. With regards to

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[1] Pertamina sells biodiesel blended with fossil diesel under the brand name "Bio Solar" at service stations throughout Indonesia; a blend of ethanol with gasoline "Bio Premium" is being trialed at several service stations, as is "Bio Pertamax", an unsubsidized high performance gasoline-ethanol blend.

[2] The National Team for Biofuel Development, which is known as Timnas BBN in Bahasa Indonesia, was established by the Presidential Decree No. 10/2006 in June 2006 to develop a roadmap for the biofuels industry as means to reduce the poverty and unemployment. This taskforce reports directly to the President through the Coordinating Minister for Economic Affairs (CMoE)

[3] Palm Oil. (2014). In Tree Crop Estate Statistic of Indonesia. Jakarta: Directorate General of Estate Crop.

the reliable policy implementation, a basic theory needs to be applied. A cost-benefit analysis (CBA) is a systematic process that is mainly aims to calculate and compare the benefits and costs and often used by governments and other organizations, such as private sector businesses, to appraise the desirability of given policies. The purpose of CBA is to determine whether the investment or decision is sound and to provide a thorough comparison among projects / policies by calculating the total expected cost against the total expected benefits. Several research have been conducted to emphasize the feasibility of biodiesel within several countries (Lee and Han, 2008; Gokianluy et al.,2014; Santamaria and Azqueta, 2015). However, none has been done to analyze the applicability of cost-benefit analysis within biodiesel system.

Therefore, this study attempts to clarify the implication for the applicability of CBA of this particular case. By doing so, this paper also tries to clarify the criteria that must be defined for the use of cost-benefit analysis and whether the government of Indonesia can implement future policy with respect of the outcome of CBA. This research will be conducted using a case study of biodiesel development in Indonesia focusing on current implemented policies and other future policies, which was executed during this study. Using a cost benefit analysis attempts to extend the theory of macroeconomics, that the government intervention i.e. regulating the market was based on income distribution orientation. The purpose is, in order that in the future, the politicians as well as the scientist may further examine the applicability of cost benefit analysis in examining the macro economic of certain country.

## 1.2 Research problem

### 1.2.1 Limited application of CBA in biofuel energy

The application of CBA within biofuel sectors in general and biodiesel in particular, had been conducted in different countries. In Korea, Lee and Han (2008) accessed the economic feasibility of biodiesel based on cost benefit analysis. The study presented future directions that must be significantly emphasized in promoting biodiesel as the role of bio-energy, due to the continuous rise in crude oil price and environmental problems. Moreover, a study conducted by Gokianluy *et al.* (2014) established the present viability of a certain type of biofuel i.e. first or second generation in order to predict the future viability of the industry in different types of countries. Based on the findings, the empirical evidence and quantitative analysis broadly agreed that biofuels were, and would remain, a viable fuel source over the next several decades with specific circumstances. Santamaria and Azqueta (2015), on contrary, argued that biofuels, despite its positive impact on environment quality, would displace the income from other economic sectors resulting in a net negative impact.

### 1.2.2 Main issues of biodiesel development in Indonesia

Biodiesel have the potential to form a small but important elements of Indonesia's energy mix in the near future. According to Dermawan *et al.* (2012), there were several indicators need to be thoroughly considered by Indonesia, as part of the South-East Asia countries, in developing biofuels. There are clear economic benefits to be gained, employment opportunities to be developed, national energy security strengthened, and greater economic efficiencies to be realized. Those aspects are mentioned in the following paragraph.

First, national government needs to find ways to reduce fossil fuel subsidies and to align policies. Despite the unpopular political decision, this particular policy is necessary if biodiesel for once can compete comparatively with the fossil fuel. The government needs also to implement temporary subsidies for biodiesel on a consistent basis to ensure wider acceptance. Second, the policy makers need to ensure that the current and future expansion plantation of palm oil is on barren land. This will help alleviate environmental concerns in key buyer market and will reduce the restriction, which are increasingly being imposed in the form of environmental safeguards. Last but not least, while the threat from palm oil based biodiesel to food security has so far not materialized; the Indonesian governments need to ensure that an increase in fossil fuel prices does not trigger a rush to develop biofuel plantations, which could compromise land allocated for the production of food.

### 1.2.3 Policy making process

Despite the advantages and disadvantages of biodiesel, the development of biodiesel in Indonesia was mainly constrained by, more or less, some political issues. A reluctant behavior of biodiesel producers was due to the fact that exporting biodiesel is more profitable than fulfilling the government's mandates for domestic consumption. Moreover, the underutilized refineries in Indonesia were also partly caused by a tendency of palm oil producers to produce CPO for food rather than for fuel. For instance, Sinar Mas, the company that has the largest oil palm land bank, has prioritized CPO production for food (Habib, 2011). The tender executed by Pertamina, in addition, was mainly based on an effort to reduce the loss occurred in blending biodiesel with fossil diesel.

As mentioned above, it can be seen that there are interrelationships between stakeholders involved within biodiesel system such as: the Indonesian government, palm oil producers and biodiesel industries that need to be taken into account to ultimately increase the consumption

of biodiesel. The sustainability of any certain policies will thus not only depend on the net difference between the aggregate costs and benefits, but also on how they are distributed between stakeholders. This is why a focus on stakeholders can deepen and enrich the traditional economic approaches such as cost-benefit analysis.

In addition to the economical perspective, the Indonesian government's effort to gradually increase the consumption of biodiesel has also raised many critics among other stakeholder for instance the economists and environmentalists. One may say that the current policy had been regulated without substantial analysis due to the unfeasible pricing formula of biodiesel since it was based on the crude oil prices. Others may also say that biodiesel development can ultimately worsen the deforestation rate in Indonesia. Elvik (2001) has particularly claimed that a cost-benefit analysis is neutral with respect to distributive outcomes. It means that what counts is the aggregate size of benefits and costs, not how these impacts are distributed among the stakeholders. By relying the decision based on the aggregate outcome, will CBA tools can still be used to make a rational decision and to sustain the biodiesel development in Indonesia?

Furthermore, in the context of policy-making process, this study will focus on the following theory: First, "An effective executives do not make a great many decisions. They concentrate on what is important. They try to make the few important decisions on the highest level of conceptual understanding. They know when a decision has to be based on principle and when it should be made pragmatically, on the merits of the case" (Drucker, 1967). Second, due to their interdependencies, actors in the network tend to behave strategically. It means that actor's behavior is not determined by his opinion, but is aimed at consolidating his power position in the network (Bruijn and Heuvelhof, 2008). Also, they will rarely be explicit about their interest in the network.

### 1.2.4 Framework for assessing the applicability of cost-benefit analysis

While previous studies had explicitly addressed certain policy recommendation based on the outcome of cost-benefit analysis (Lee and Han, 2008; Gokianluy et al.,2014; Santamaria and Azqueta, 2015), the application of cost-benefit analysis has partly remained controversial (Hauer, 1994). The author rejected the basic principles of cost-benefit analysis as put forward in the field of welfare economics to be applicable in the field of road safety. Putting a monetary value on human life does not make sense and is ethically unacceptable. Elvik (2001) has therefore built a framework for assessing the applicability of cost-benefit analysis to assess road safety measures, which identified five stages to that certain problem. Those stages are:

a. Assess the basic principle of cost-benefit analysis.
b. Determined the type of issue to be decided.
c. Evaluate the suitability of policy objectives for cost-benefit analysis.
d. Determine if suitable policy programs can be developed.
e. Evaluate the consequences of policy programs, especially with respect to the possibility of monetary valuation.

## 1.3 Research gap, objectives and questions

The previous description gives brief information that there are constraints concerning biodiesel development in Indonesia and the urgencies to increase domestic. Thus, as mentioned above, the Indonesian government has been successively changing its biodiesel related policy.

Regarding the application of cost and benefit analysis, the research will extend the implementation of CBA concerning the changes in biodiesel related policy. There are several studies, which were conducted to analyze costs and benefits of biodiesel industries and eventually address specific requirement for enterprises in making beneficial economic decisions (Lee and Han, 2008; Gokianluy et al.,2014; Santamaria and Azqueta, 2015). The other published studies, which has thoroughly analyzed all costs and benefits of biofuels policies, did not thoroughly emphasize how different government's policy can influence the total effect for each stakeholders involved within the system (Charles *et al.*, 2013). Furthermore, other impacts for instance employment rate, subsidy level, fossil fuel import etc., which have been studied in some countries e.g. European Union, are not available for Indonesia case. It can be seen that cost benefit analysis has been hardly applied in investigating the impact of policy changes due to the interrelated as well as the interdependence among actors within the system. Therefore, this research proposes to look into the applicability of cost-benefit analysis in analyzing the impact of policy changing in Indonesia and investigating the main interest of Indonesian government by analyzing the distribution of costs and benefits of each alternatives policies.

Based on the research gap mentioned above, it can be concluded that a complexity in biodiesel development system and few studies available regarding the applicability of cost-benefit analysis are eventually confirming the main logical reasoning for further research. This research will also focus on dealing with the cost to the environment. The other objectives of this research are providing insights in:

1. Any current and future biodiesel policies.
2. Technical and actor analysis related to biodiesel and agricultural integration.

3. The effects of the current biodiesel production on the deforestation.
4. The costs and benefits of biodiesel.
5. The distribution of costs and benefits among stakeholders in biodiesel system.

The objectives can thus be obtained by addressing the following research question:

***How the cost benefit analysis can contribute in analyzing the biodiesel related policy in Indonesia?***

In order to answer the main research questions, this study will address several related sub-questions, which will be divided into three phases. The first two sub-questions deal with the current situation of biodiesel in Indonesia, as well as the current biodiesel related policy. Sub-questions three will mainly examine the result of a simple CBA and based on that, this study will eventually answer the last two sub-questions in investigating the added value of CBA concerning biodiesel policy analysis. The following are the sub-questions that will be addressed in this research:

1. *What are the current biodiesel policies and what results do they deliver to the biodiesel adoption rate?*
2. *What are the main issues arise and need to be overcome by the Indonesian government?*
3. *What will future policies be and what impacts will it contribute to the biodiesel adoption rate?*
4. *How can the costs and benefits of current and future policies be allocated to each stakeholders involved within the system?*
5. *To what extent the input variables and other uncertainties will influence the cost and benefit analysis?*
6. *To what extent a cost benefit analysis is applicable to analyze biodiesel related policy in Indonesia?*

## 1.4 Research scope and relevance

### 1.4.1 Research Scope

This research will discuss the current and future biodiesel related policy. It will also include stakeholder analysis, market situation and environmental issues related to each alternative policy made by the Indonesian government. The unit of analysis in this research is Indonesia, who takes the lead not only in palm oil production, but also deforestation rate. The new policy made by the new President, which aims to increase the domestic consumption and allocate the scrapped fossil fuel subsidies for biodiesel industries, is however leading to a problematic issue

and can therefore influence the adoption rate of biodiesel. Thus, it is necessary to further analyze which policy is more beneficial for the welfare of Indonesian society by using cost and benefit analysis. In particular, this research will be restricted to use a case study in Indonesia. The biodiesel development analysis in other country will indeed not be included in this research due to the time constraints.

### 1.4.2 Social and Scientific Relevance

The social relevance of this research is aimed to describe the interdependencies among actors within biodiesel system. This has to do with the fact that first, biodiesel domestic consumption needs to be increased to reduce the dependency to a non-renewable source of energy i.e. fossil fuel. Second, there are many studies being conducted to show the difficulties in expanding the domestic market. The Indonesian government thus urges the implementation program by regulating the minimum percentage of biodiesel to be blended and imposing the financial penalties for non-compliance with its mandate. Third, since government play an important role in regulating the fuel market, thus they can indirectly influence the adoption rate of biodiesel as an alternative fuel. This will directly influence the decision since it probably results both gains and looses for investors in investing their financial resources. Fourth, each of the policies outcomes, the main interest of this research, will deliver different effects on actors within biodiesel network and therefore need to be carefully analyzed. Last but not least, future generations have to deal with the policies made today.

The scientific relevance of this study is twofold. First, the study lies in the need of quantifying the information gathered in the current situation of biodiesel development in Indonesia to rationally conduct the decision and policy-making processes. Second, it is based on the comparative analysis of several biodiesel related policies with regards to the Indonesian government's commitment in dealing with the climate change in general and reducing the green-house-gas emission in particular. Narrowing down the task, the research will contain the description of the differences in each biodiesel related policies direction as well as the policy outcomes of each alternative. Furthermore, the master thesis will scrutinize the factors that will influence the net social benefit for Indonesian society. In accordance with the written above, the scientific relevance of the master thesis is objected on the observation and investigation of the uncertainty by applying the sensitivity analysis. All of which will be used as the main principle in applying the biodiesel related policy specifically the allocation of government incentives for the renewable energy development in Indonesia. The result of this research will be reference, not only for the Indonesian government, but also for the researchers who will use different approaches and criticize the findings.

## 1.5 Research Approaches and methodology

### 1.5.1 Research approaches

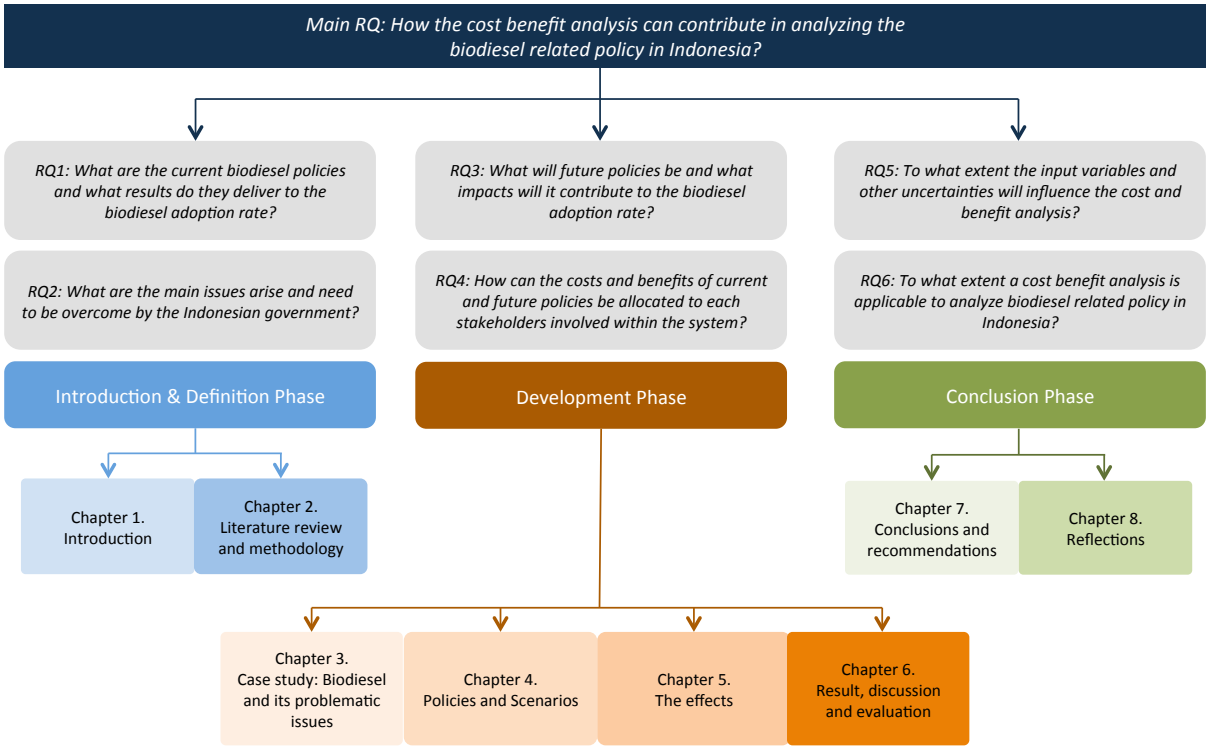
This research will mainly use the methodology based on the step-by-step plans, which is explained by Boardman et al. (2011). The following is a list of steps that comprise a generic cost and benefit analysis:

1. Problem analysis;
2. List of alternative projects / programs;
3. List of stakeholders;
4. Select measurements and measure all cost and/or benefit elements;
5. Predict the outcome of costs and benefits over relevant time period;
6. Convert all costs and benefits into a common currency;
7. Apply discount rate;
8. Calculate the net present value of each projects;
9. Perform sensitivity analysis;
10. Adopt policy recommendation choices

### 1.5.2 Research design

During this study, the application of cost and cost benefit analysis will present the result of the evaluation of all relevant socio-economic costs and benefits caused by the implementation of Indonesian government's current and future policies. The objective of this particular approach will not only answer to the question of whether the implementation of the new policies will result in sufficient return within biodiesel industries but also to determine the degree to which extent the socio-economic welfare will increase/decrease as a result of the realization of chosen policy. Based on the results of the evaluation, the study ultimately aims to answer the main research question: How the cost benefit analysis can contribute in analyzing the biodiesel related policy in Indonesia?

Figure 1. Research structure




In the beginning, several relevant issues within biodiesel development in Indonesia will be discussed. Based on that, several policies made by the Indonesian government are further defined and investigated. Those policies will be further examined to determine the effects by using technical (infrastructure, production), environmental and agricultural parameters. Furthermore, the impact of each policy to the financial and environmental aspect will be quantified. Finally, after all of the cost and benefit parameters are well measured, the net present value of each policy and the allocation of the CBA among stakeholders will be determined. All findings in this study will therefore used to answer the main question.

## 1.6 Thesis Outline

To facilitate the line of the inquiry of the project, this master thesis is outlined as follows (see figure 1). Chapter two of this thesis comprises theoretical framework and literature analysis. In that chapter, the study highlights the importance of using cost benefit analysis (CBA) and steps that need to be taken. Moreover, this paper will emphasize the limitation in using this particular analysis. Chapter three explores the case description further by describing what was happened in biodiesel trajectory in Indonesia, what are efforts conducted by the government to promote biodiesel consumption domestically since 2006. At the end, it will briefly emphasize the policy that has been regulated and planned in order to stimulate biodiesel adoption rate in Indonesia. Chapter four will mainly address further description concerning any current and future policy

of the government. Moreover, the most likely effects based on the aforesaid policies will then be analyzed in this chapter by using a reliable source of assumption. Chapter five consists of the effects analysis based on the policy built in the previous chapter. Chapter six summarizes this study by addressing the result of cost-benefit analysis and indicating the added value by applying a cost-benefit analysis in the research. With regards to the uncertainty, this study will perform a sensitivity analysis in this chapter. The concluding remarks, research limitation and recommendation for future research are defined in this chapter seven. General reflection concerning the process and final outcome will be described in the last chapter.

# 2. Cost-benefit analysis and the methodology

## 2.1 Introduction

Theoretical framework plays an important role in providing a frame of reference and describing the methodology used to examine and evaluate the impact of certain policy. In this study, cost-benefit analysis will be used particularly to analyze the impact of certain biodiesel related policies implemented in Indonesia. As the methodological approach, the definition of CBA will be described in section 2.1. Furthermore, this writing will also emphasize the difference between financial cost-benefit analysis and social cost-benefit analysis, which will be used as a theoretical basis in this study. Afterwards, a theoretical framework used to analyze the applicability of cost-benefit analysis in other studies will be described and the proposed framework for analyzing the applicability of cost-benefit analysis for this particular case study will then be suggested. This particular section will define the advantages and limitations in using the aforesaid approaches. Finally, a step-by-step plan used to perform cost-benefit analysis will be described in the last part of this chapter. In essence, this chapter serves as a primary tool used to convey a relevant answer of the research questions.

## 2.2 What is cost-benefit analysis?

Cost-benefit analysis (CBA) is an economical method that is commonly used in evaluating the impact of a given intervention e.g. project, program, policy, etc. It is also widely used in the appraisal of the energy sector for instance biodiesel. The theoretical framework of CBA is mainly based on microeconomics point of view and it deals with the welfare theory. Essentially, cost-benefit analysis will evaluate the extent to which the benefits generated by a specific intervention will exceed the costs of its realization.

The main purpose in using CBA is to support the decision-making processes from a rational perspective. It mainly aims to find the most efficient allocation of society's resources (Hansjürgens, 2004). As stated before that the main principle of cost and benefit analysis is microeconomics and welfare economics. The individual interest in a perfect market will result the most efficient allocation of resources. However, in the real world, market is unlikely working perfectly. This is also applied within the fuel market in which the externalities are generally took place and they generate the market failure, one of the reasons for government intervention.

Furthermore, cost and benefit analysis is a tool for comparing the status quo (do nothing) and several policies (Boardman et al. 2011). Three forms of CBA are commonly used in practice, namely ex ante CBA, in medias CBA, and ex post CBA. The difference among those methods is the period of execution. While the first is executed before making the decision or implementing the policy, the second and the latter were carried out during and after projects' implementation respectively.

This study is therefore using the ex ante CBA as an appropriate methodology with several reasons. First, while the biodiesel has been already implemented for several periods of time, the new policy in scrapping the subsidies for fossil fuel and allocating the budget for biodiesel industries is the most update policy in Indonesia. Second, the essence of ex ante CBA is its decision oriented approaches so that it is expected that this methodology will correspond to the Indonesian government's plan to ceaselessly looking for the most feasible and beneficial renewable energy for Indonesian society.

## 2.3 Theoretical foundation of cost-benefit analysis

CBA that can be distinguished into two types: *financial cost-benefit analysis* (FCBA) and s*ocial cost-benefit analysis* (SCBA). There are several substantial elucidations concerning these two types of CBA. First, a *financial cost-benefit analysis* (FCBA), according to Eijgenraam *et al.* (2000), is used to address the issue in which the financial returns of a project, taking its entire life span into account, can justify the costs invested by the investor/operator adequately, On the other hand, *social cost-benefit analysis* (SCBA) answers the question of whether an intervention to the specific investment will contribute to social welfare. It has also become a major tool for policy analysis in many countries. The main criterion used in CBA to determine the most desirable intervention is the Hicks-Kaldor criterion, a measure of economic efficiency that captures some of the intuitive appeal of Pareto efficiency. Under Pareto efficiency, an outcome is more efficient if at least one person is made better off and nobody is made worse off. Thus, the criterion assumes that certain intervention will result in Pareto improvement if those who are better off after the intervention can potentially compensate those who are worse off and still benefit from the project implementation (Eijgenraam *et al*., 2000).

Second, SCBA is used to identify all relevant positive and negative effects of a given intervention to the society. Financial aspects such as the investment cost, operational cost as well as the revenue generated from the intervention is included not only in FCBA but also used in SCBA. Nevertheless, the SCBA includes some additional items, which have a socio-economic effect,

such as environment, mobility and safety. Thus, while SCBA will take both the utility maximization for producers and consumers into account, FCBA views only the interests of producers (Pearce and Nash, 1981).

Third, in CBA, the intervention's i.e. the policy's effect will be valuated in monetary terms, preferably using market prices (Beuthe, 2002). The valuations of effects are generally based on the willingness-to-pay of the potential winners for the benefits they will receive as a result of the intervention and the willingness-to-be-paid of potential losers to accept the compensation for the losses (DCLG, 2009). Moreover, to valuate the non-financial aspects included in SCBA, other relevant or surrogated markets are can then be used (Saitua, 2007).

Lastly, both in FCBA and SCBA, the cost and benefit streams expressed in monetary terms will be discounted and aggregated over the whole appraisal period. Next, the results of the analysis are presented using one or more financial/social value measurement, such as Net Present Value (NPV), Benefit/Cost ratio (BCR) and/or Internal Rate of Return (IRR) (Eijgenraam et al, 2000). In general, by doing CBA, many practitioners will conduct the intervention that yields a positive net present value. On one hand, in FCBA, this means that a particular project will be financially profitable and on the other hand, in SCBA, that means that the project will contribute to social welfare (Beuthe, 2002). Furthermore, after several beneficial interventions have been identified, a comparison between them in terms of net benefit needs to be conducted. It mainly aims for project prioritization and selection.

Based on the NPV criteria mentioned in the previous paragraph, it should be noted that the NPV of public investment projects given by SCBA has important differences compared with the NPV of private investment projects given by FCBA because in CBA: a. The additional wealth created by the project does not entirely take the form of monetary transfers accruing to specific stakeholders; b. The dividends are not evenly distributed amongst multiple stakeholders; c. Interpersonal utility comparisons are made, according to the principle that winners should win more than the losers lose, although effective compensation of the losers does usually not take place (at least fully) (De Brucker and Verbeke, 2007).

### 2.4 Similar projects' characteristic shared in cost benefit analysis

According to Elvik (2001), most textbooks in cost-benefit analysis and applied economic welfare theory (Dasgupta and Pearce, 1972; Sassone and Schaffer, 1978; Sugden and Williams, 1978; Boadway and Bruce, 1984; Mishan, 1988; Gramlich, 1990; Johansson, 1991; Hanley and Spash,

1993; Williams and Giardina, 1993; Layard and Glaister, 1994) contain examples of such analyses, intended to show their basic logic. In general, the problems used to illustrate cost-benefit analysis share the following characteristics:

a. They involve public expenditure, often investment. Projects are sometimes financed by direct user payment, but more often by general taxation.
b. There are multiple policy objectives, often partly conflicting and requiring tradeoffs to be made. It is assumed that policy makers want solutions that realize all policy objectives to the maximum extent possible
c. One or several policy objectives concern the provision of the non-marketed public good e.g. cleaner environment.
d. It is assumed that an effective use of public funds is desirable, since these funds are scarce and alternative uses of them numerous.

The aforesaid characteristics of problems have become what the economist regard that is suitable for cost-benefit analysis. Applied welfare economic has also supplied the basic principle of cost-benefit analysis: consumer sovereignty, welfare maximization, valuation of goods according to willingness-to-pay and neutrality with regards to the distributive outcomes.

The principle of consumer sovereignty as briefly mentioned means that the welfare is defined in terms of how consumers choose to spend their income between commodity options. The right of consumers to choose how to spend their income is respected. As a result, the strength of consumer preferences for the provision of public goods is measured by the amount of money that consumers are willing to pay for these goods.

Furthermore, the other objective of cost-benefit analysis is welfare maximization. To determined whether the specific projects/policies increase the welfare, cost-benefit analysis is then relied on Pareto-criterion, which states that the net welfare of society increase when a policy change makes at least one person better off and nobody worse off. However, in practice, many public projects will make some one stakeholder better off and others worse off. Thus, the Pareto criterion is not very practical and many economists define a less demanding criterion of welfare maximization, stating that welfare is enhanced when a potential Pareto improvement occurs. This means that the projects or policies will satisfy this criterion when those who benefit will compensate those who lose in utility terms and still retain a net benefit.

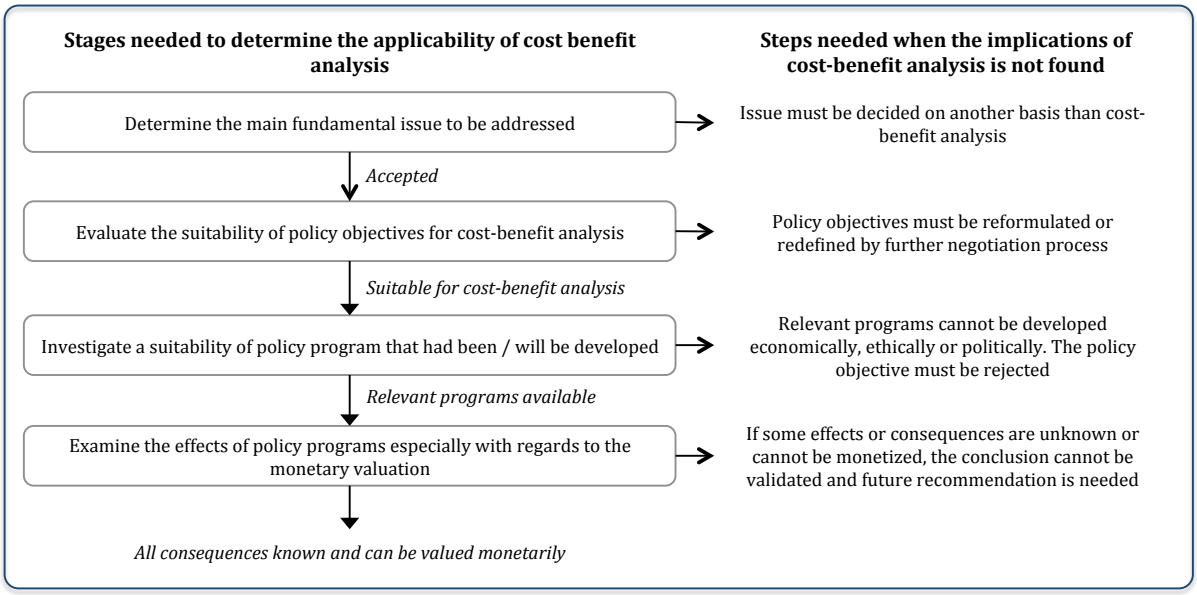
Cost-benefit analysis is neutral with respect to the outcome distribution. What fundamentally counts is the aggregate size of benefit and cost, not how the effects are distributed between various groups of the population.

## 2.5 Approach used for assessing the suitability of CBA

Based on the characteristics as well as problems mentioned above, this study will be continued by developing a framework in order to assess the applicability of cost-benefit analysis. The framework will be developed based on the preceding study, which conduct cost-benefit analysis of biodiesel development. It will be displayed graphically on figure 1. Based on the studies, the framework identifies other characteristics and stages that need to be taken into account. Those are:

a. Determine the main fundamental issue to be addressed.
b. Evaluate the suitability of policy objectives for cost-benefit analysis.
c. Investigate a suitable policy program that can be / has been developed.
d. Examine the effects of policy programs especially with regards to the monetary valuation

Figure 2: A multi stage model to determine the applicability of cost-benefit analysis




Source: adapted from Elvik, 2001

### 2.5.1 Assess the basic principle of cost-benefit analysis from the preliminary study

According to the framework illustrated on figure 1, assessing the applicability of cost-benefit analysis proceeds through five stages. The first stage is to assess the basic principle of cost-benefit analysis. Those who reject these principles, rule out using cost-benefit analysis at all. In

this stage, there are number of basic tenets of cost-benefit analysis such as: consumer sovereignty, willingness-to-pay as measure of value, welfare maximization and the irrelevance of distributive outcomes. As far as biodiesel development is concerned, there is no commonly made argument for rejecting the principle of consumer sovereignty as well as welfare maximization.

### 2.5.2 Determine the main fundamental issue to be addressed

The first stage in an assessment of the applicability of cost-benefit analysis is to determine the nature of policy issue that need to be decided. According to Elvik (2001), there is a typology of four main types of policy issues that has been developed. According to Max Webber (1971), the typology will be based on the ideal types, which in practical way of thinking; it may be the case that there are mixtures of those types of issue. Table 2.1 also gives some examples of issues belonging to each category.

Proponents of cost-benefit analysis have already recognized that the application of cost benefit analysis will indeed not suitable to analyze every type of issue. Issue concerning the existence of universal human rights is not a subject to a calculation of cost and benefits. Arrow (1997) refers the goods as invaluable goods.

Moreover, issues that mainly concern justice and fairness are also widely agreed lie outside the scope of cost-benefit analysis (Elvik, 2001). In the case study, it can be noted that the perception of a public policy issue is, in some context, subjective and varies between people. Whereas some people regards biodiesel related policy mainly based on the technical and economical perspective, other maybe, in some extent, regard it as a problematical policies due to its environmental issue that may arise. In this case, the former group may accept the implementation of cost benefit analysis regarding biodiesel development whereas the latter group is likely to reject it.

The third category is macro-economic issues. It should be noted that the most common formal analysis with regards to this issue will likely to be some form of general equilibrium model for the whole economy as a whole. Other macro economic perspective i.e. unemployment are widely agreed not to be particularly suitable to cost-benefit analysis.

The last type of issue concerns with specific social problems and it may be the most suitable cases for cost-benefit analysis. Cost-benefit analysis is typically applied to the problems that are not sufficiently solved by marked mechanism. The fact that the Indonesian government regulate

the mandate of biodiesel consumption is a relevant example on the strategies to reduce the environmental problems.

### 2.5.3 Evaluate the suitability of policy objectives for cost-benefit analysis

Elvik (2001) argues that in order to sufficiently implement cost-benefit analysis, it is important that the policy objectives have to satisfy certain formal requirements. The first requirement is that the policy objectives must be clearly stated to confirms its value of achievement in monetary terms. This does not mean that the policy objective needs to be quantified since it may be inconsistent with the principle of cost-benefit analysis i.e. welfare maximization, consumer sovereignty, etc. Yet, a policy objective must be clearly stated that the economist can design a study intended to assign monetary value to various level of goal achievement (Elvik, 2001). Second requirement has to do with fact that multiple policy objectives are, in certain case, stated sufficiently and the tradeoffs between them need also to be defined. The last requirement, which is recognized in practiced, is argued by Eriksen *et al.* (1994). It states that policy objectives should not be highly controversial since the political controversies cannot be resolved by delivering a calculations concerning the worthiness of certain policy in monetary terms.

### 2.5.4 Investigate a suitability of policy programs that had been/will be developed

The theory of cost benefit analysis suggests the policy makers to choose those policy programs that result the greatest benefits in relation to the costs. However, the analysis does not tell the decision makers how to obtain the results. The criteria needed to determine the suitability of policy programs are proposed in the following:

a. A suitable policy program should be effective, which means that it ought to help in solving the problem it designed to solve. Purely symbolic programs, which are designed only to give an impression that something is being done to solve the problem, are not suitable.
b. A suitable program should be cost-effective meaning that the benefits should be grater than costs. Consequently, if the benefits are smaller than costs, the programs cannot be justified within the framework of cost-benefit analysis.
c. A suitable program should be ethically acceptable that means it should not employ policy instruments that violate widely supported ethical principles.

Importantly, cost-benefit analysis rests on the assumption that it is possible to separate means from ends, at least due to the fact that a recursive (unidirectional) relationship will prevail between ends and means. An example will be suitable in illustrating the applicability of cost-

benefit analysis for the particular programs. Suppose that a quantified target has been set of reducing the import level of fossil diesel by 30% and it turn out that the outcome of cost-benefit analysis depict that increasing biodiesel consumption will only reduce the amount of import by 20%. It is then against the rules of cost-benefit analysis to tamper with the willingness to pay estimate in order to make a program to reduce the number of fossil diesel import by 30% cost effective. By this, a more appropriate conclusion would be to give up the target of a 30% reduction of fossil diesel imports because the population is not willing to pay what it cost to reduce the imported fossil diesel. However, this example illustrates both the principle of consumer sovereignty implies and how the policy target can be inconsistent with the application of cost-benefit analysis.

#### 2.5.5 Examined the effect of policy programs

According to Hanley and Spash (1993), cost–benefit analysis also relies on the assumption that all economically relevant impacts of policies are valued in monetary terms according to the principles of welfare economics. An economically relevant impact is the one that affects the welfare of an individual. It is indeed difficult to quantify all relevant impacts and include them in a cost-benefit analysis. However, this study will try to value more items that had not been included in a cost-benefit analysis.

## 2.6 Assessment criteria for assessing the applicability of CBA

Besides the general framework used to investigate the suitability of CBA in analyzing biodiesel related policy changes in Indonesia, this study will also develop the assessment criteria with regards to the applicability of cost-benefit analysis in examining the impact of policy changes in biodiesel development system in Indonesia. The following are criteria used in this study to determine the added value of cost-benefit analysis for the case study.

- Will cost-benefit analysis confirm that the policy changes can increase the net social benefit?
- Will the effect of future uncertainty be well addressed and analyzed by using CBA?
- Can CBA clarify the influencing factors for future development of biodiesel in Indonesia?
- Can CBA give new insights concerning policy alternatives that might be more favorable for biodiesel industries?
- Finally, can CBA structure the problem regarding the development of biodiesel in Indonesia?

## 2.7 Conclusions

This chapter has defined literature backgrounds and the theoretical framework that will be used to appropriately assess the applicability of cost-benefit analysis. This chapter is begun with

the explanation about the cost-benefit analysis, and why it is important to use that method. The rationale of using the cost-benefit analysis is explored and the paper has also defined the methodological step used to acquire research objectives.

In the next chapter, this paper will describe the relevant information concerning the development of biodiesel in Indonesia. The outcome of that chapter can be used to evaluate future policies based on any related policy objectives and examine each of them by using the methodological approaches, which is mentioned in this chapter.

# 3. A case study: Biodiesel and its problematic issues

This chapter will thoroughly describe the case study concerning biodiesel development in Indonesia. First, any fundamental issues arisen and need to be taken into account will be discussed in order to define what are the problems of Indonesian biodiesel. Afterwards, this chapter of the study will also emphasize the value chain of biodiesel including the discussion of biodiesel's added value, palm oil development in Indonesia, stakeholders involved within the system, and current production of biodiesel. The uncertainty of biodiesel will also be discussed as basic understandings why biodiesel cannot substantially developed and what will the future market of biodiesel look like.

## 3.1 Introduction: Fundamental issue of fuel sector in Indonesia

Most countries in Southeast Asia are facing challenges in securing energy resources. There are two main aspects: population growth and economic expansion, both of which lead to a need for more energy. In the mid of 2000s, biofuels emerged as the most important way to address the demand of energy. The countries within the region, such as Indonesia began to plan strategies to develop the bioenergy sector in order to become energy-secure and less dependent on imports of fossil fuel (Dermawan *et al.*, 2012).

In Indonesia, the need to ensure the security of domestic energy supply and to support a sustainable development led to the drafting in 2006, which was formed in the national energy policy. Since 2004, Indonesia has been a net oil importer (ADB 2009a). Indonesia's imports of oil increased from 296,000 barrels per day in 2009 to 450,000 barrels per day in 2011 (Dermawan *et al.*, 2012). Besides, the feasibility of biodiesel production was highly depending on the relative price of CPO and crude oil, the product that was substituted by biodiesel. Most of the initiatives in the Southeast Asia region were based on the increasing crude oil prices and the escalating of state's subsidies. In 2008, when the oil price exceeded US$ 130 per barrel, the Indonesian government allocated IDR 223 trillion (nearly US$ 25 billion) for fuel subsidies. In 2012, the subsidy for fossil fuel reached nearly US$ 14 billion, about 1.5% of Indonesia's GDP. [1] Table 3.1 elaborates fuel subsidies description in Indonesia during 2005 – 2012:

[1] The 2012Indonesian government 123.6planned to reduce fuel s13.7ubsidies and increase1.5 the prices of petrol by April 1, 2012. However, this plan was not approved by the parliament and was put on hold. With the allocation for subsidized fuel almost exhausted, the pressure on the government to fund fuel subsidies is getting stronger. It is possible that removal the subsidy will be enacted in late of 2012.

Although the subsidy for fossil fuel since 2006 cannot be seen directly as the failure of the Indonesian government in promoting biodiesel for domestic consumption, Caroko *et al.* (2011), METI (2011) and Soerawidjaja (2011) claimed that the failure to achieve the target caused by a relatively high and fluctuating prices for the raw material i.e. CPO (see figure 2) and the inability of biodiesel to compete with a subsidized fossil fuels. Policies to promote the development of biodiesels are in place and initiated by an enthusiasm from the private sectors. However, the lack of progress has mostly to do with how effectively the Presidential instructions have been implemented by relevant ministries. Some ministries, such as mining, agriculture and forestry, have structured their master plans to develop biofuels in their respective sectors, although there has been concern about the lack of coherence among the plans [2]. Concerning the achievement of blending mandates, it is also difficult to be verified. This has to do with the fact that palm oil was grown for various purposes. Thus, while plantations for palm oil have expanded in most provinces, little information is available about the commitment of specific area to biodiesel production.

Table 3.1: Fuel subsidies in Indonesia during 2005 – 2012

| Year | Amount (IDR trillion) | Amount (US$ billion) | Proportion of GDP (%) |
|---|---|---|---|
| 2005 | 104.0 | 11.6 | 3.4 |
| 2006 | 94.6 | 10.5 | 1.9 |
| 2007 | 116.9 | 13.0 | 2.1 |
| 2008 | 223.0 | 24.8 | 2.8 |
| 2009 | 45.0 | 5.0 | 0.8 |
| 2010 | 82.4 | 9.2 | 1.3 |
| 2011 | 129.7 | 14.4 | 1.8 |
| 2012 | 123.6 | 13.7 | 1.5 |

Source: Dermawan *et al.*, 2012

Based on the aforesaid aspect in biodiesel development, it should be highlighted that the constraints in promoting biodiesel in Indonesia were fuel subsidies made by the Indonesian government until late of 2014 and prices volatility of CPO that makes biodiesel production cost is higher than petroleum and eventually make biodiesel less competitive than petrol diesel. Moreover, lack of coordination among the ministries in implementing the Presidential instructions was also believed can influence the adoption rate of biodiesel in Indonesia. In

[2] According to Dermawan (2012) based on an interview with Director of Bioenergy, the Ministry of Energy and Mineral Resources, April 2012.

general, significant barriers to the widespread implementation of biodiesel as well as other renewable energies and low carbon energy strategies are primarily political and not technological. Wiseman *et al*. (2013) have argued that the key roadblocks of biodiesel are: climate change denial, the fossil fuels lobby, political inaction, unsustainable energy consumption, outdated energy infrastructure, and financial constraints.

In the following section, thorough analysis concerning the advantages of biodiesel, palm oil development in Indonesia, biodiesel production and standardization, its future potential market, the technical specification and the uncertainty of biodiesel will be discussed. It mainly aims to illustrate the trajectory of biodiesel in Indonesia and the main constraint in developing biodiesel as well. By the case study, it is expected that this study can coherently address what was occurred, what has been done and what need to be executed in boosting biodiesel domestic consumption in Indonesia. This chapter also aims to give the fundamental issues with regards to the development of biodiesel in Indonesia.

## 3.2 General overview of biodiesel and its value chain

### 3.2.1 The advantages and disadvantages of biodiesel

There are several researches examining the advantages of biodiesel. At the beginning, biodiesel was seen as a prominent alternative fuel due to its promising characteristics. Demirbas (2007) clarifies several important reasons in using biodiesel. Biodiesel, according to the author, can be defined as the monoalkyl esters of fatty acids derived from animal fat or vegetable oil. It can be used as an extender of combustion in *Compression Ignition Engines* (CIEs). The benefits of using biodiesel as an alternative fuel are related to its availability and renewability, higher combustion efficiency, lower sulfur and aromatic content (Ma and Hanna, 1999; Knothe *et al.*, 2006), higher cetane number and higher biodegradability (Mudge and Pereira, 1999; Speidel *et al*., 2000; Zhang et al., 2003).

Based upon research, the notion of availability and renewability of biodiesel has to do with the fact that biodiesel is one of the compatible alternative fuels that can be applied on a conventional unmodified diesel engine with maximum 20% blended in petrol diesel. This also means that biodiesel is possible to be stored together with petrol diesel. The most common blend consists of 20% biodiesel with 80% petroleum diesel, i.e. B20. In European countries, the current regulation foresees a maximum 5.75% biodiesel in 2010 whereas in Indonesia, the mandatory content in biodiesel is raised to 15% (B15) in February 2015. Moreover, biodiesel can be made from domestically produced, renewable oilseed crops such as soybean, rapeseed

and sunflower. Again, low blends of biodiesel can be used in any normal internal combustion diesel engine with no modifications. Higher blends of biodiesel (over 20%) may require minor modifications.

Based on the study, biodiesel can also improve combustion efficiency due to the increase of homogeneity between the oxygen and the fuel during combustion. In fact, biodiesel contains 11% oxygen by weight and contains no sulfur. The use of biodiesel can also extend the life of diesel engines because it is more lubricating than petroleum diesel fuel. Moreover, the Higher Heating Values (HHVs) of biodiesel are relatively high (40 MJ/kg), but it is still lower than petroleum diesel (43 MJ/kg). This is compensated with 90% reduction in total unburned hydrocarbons (HC) and 75-90% reduction in polycyclic aromatic hydrocarbons (PAHs) when using biodiesel alone. Moreover, Biodiesel further provides significant reduction in particulates and carbon monoxide than petroleum diesel. However, biodiesel produce a slightly increase or decrease in nitrogen oxides depending on engine group and testing procedures. According to Demirbas (2007), biodiesel can also degrade four times faster than the petroleum diesel due to the oxygen content it has. Thus, biodiesel was initially regarded as one of the most applicable and feasible alternative fuel regarding the emissions reduction issue in transportation sector.

Despite the advantages, there are also some constraints faced by biodiesel application. Demirbas (2007) at the end of his paper also claims several disadvantages that will be experienced by the customer when using this renewable fuel. Due to its lower HHV, it is obviously clear that biodiesel will ultimately produce lower energy content, lower energy speed and power. Moreover, the result of that study also emphasizes that biodiesel has a higher viscosity, higher cloud point and pour point, and higher nitrogen oxides ($NO_2$) emissions. The fact that higher composition of biodiesel – petrol diesel than 20% will require minor modification of diesel engines, shows that biodiesel has lower compatibility with the incumbent technology.

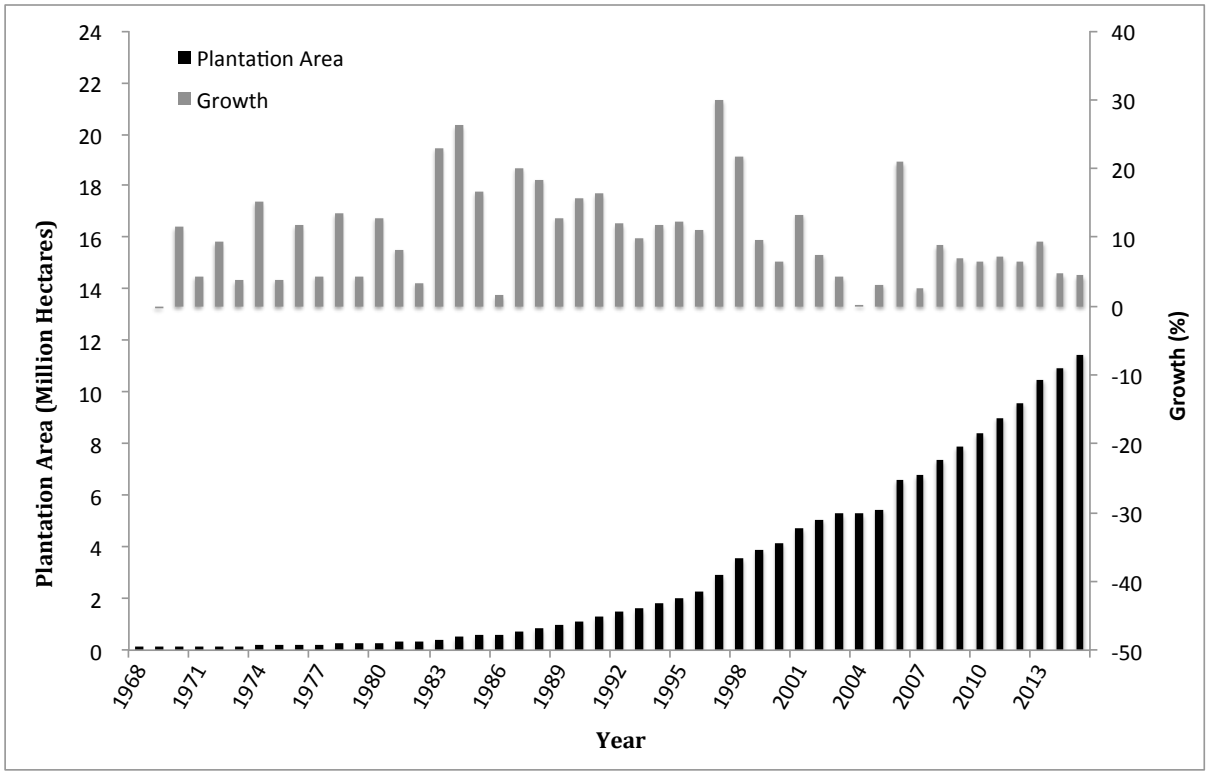
### 3.2.2 Palm oil development in Indonesia

The fact that the domestic and world demand for vegetable oil including palm oil grew rapidly, coupled with the need for biodiesel as a substitute for fossil fuels with their decreasing reserves and production, has accelerated the expansion of oil palm plantations in Indonesia. From 630,000 ha in 1985, the plantation area had increased to 1,117,000 ha in 1990, doubled again in 1991, and became three, four, five, six, seven and nine times larger in 1994, 1997, 2000, 2002,

2004, and 2006, respectively, which can be seen in figure 2. In 2007, the plantation area reached 6.65 million ha or more than ten times greater than that in 1985. (Sentosa, 2008)

The annual growth of oil palm plantation area from 1986 to 1997 tended to increase from 12 to 14%, see figure 2. The growth then fell to 5% just after the Asian financial crisis in 1997 to 1998 and gradually increased again during the Reformation Era, which replaced the Orde Baru in 1998. In the last two years, the growth has sharply increased to 15 and 19% in 2006 and 2007, respectively. These sharp expansions in 2006 and 2007 were driven by the efforts of government to accelerate the development of biodiesel from palm oil after Indonesia became a net oil importer in July 2004 (Jakarta, 2006).

Figure 3: Expansion and annual growth of Palm Oil Plantation in Indonesia since 1968




Source: adapted from Palm Oil, 2015

As illustrated in figure 3.1 that the palm oil plantation in Indonesia tends to develop from time to time. It can be seen from the average of plantation area from 2004 to 2014, which is 7.67% per year and the growth of palm oil production is 11.09% per year. This has to do with the fact that the price of crude palm oil is relatively stable in the international market, which is beneficial for the farmers. According to the statistical data of plantation directorate general, the total area of palm plantation area in 2014 is 10.9 million hectares with total production is 29.3 million tons of CPO. About 41.55% of the total area (4.55 million hectares) owned by the

smallholder farmers, 6.83% (0.75 million hectares) is owned by the government, and 51.62% (5.66 million hectares) are owned by private sectors (both local and foreign) (Administrator, 2014). Table 3.1 illustrates the development of palm plantation area in Indonesia.

Table 3.2: Palm Plantation Area in Indonesia during 2004 - 2014

| Year | Smallholders (Ha) | Government (Ha) | Private (Ha) | Total (Ha) | Growth (%) |
|---|---|---|---|---|---|
| 2004 | 2,220,338 | 605,865 | 2,458,520 | 5,284,723 | |
| 2005 | 2,356,895 | 529,854 | 2,567,068 | 5,453,817 | 3.2 |
| 2006 | 2,549,572 | 687,428 | 3,357,914 | 6,594,914 | 20.92 |
| 2007 | 2,752,172 | 606,248 | 3,408,416 | 6,766,836 | 2.61 |
| 2008 | 2,881,898 | 602,963 | 3,878,986 | 7,363,847 | 8.82 |
| 2009 | 3,061,413 | 630,512 | 4,181,369 | 7,873,294 | 6.92 |
| 2010 | 3,387,257 | 631,520 | 4,366,617 | 8,385,394 | 6.50 |
| 2011 | 3,752,480 | 678,378 | 4,561,966 | 8,992,824 | 7.24 |
| 2012 | 4,137,620 | 683,227 | 4,751,868 | 9,572,715 | 6.45 |
| 2013 | 4,356,087 | 727,767 | 5,381,166 | 10,465,020 | 9.32 |
| 2014 | 4,551,854 | 748,272 | 5,656,105 | 10,956,231 | 4.69 |
| | | Average | | | 7.67 |

Source: adapted from Palm oil, 2014

On the other hand, the growth of export of CPO has also grown for the average of 25.76% per year. In 2013, it can be seen that the total of CPO export reached 20.58 million tons and its value is US$ 15.84 millions. In September 2014, the total export has reached 15.96 millions ton and its value is US$ 12.75 millions. It shows the increasing compared to September 2013 with the total export had only reached 14.831 millions ton (Administrator, 2014). In detail, total exports of palm oil from Indonesia can be seen in table 3.2.

Table 3.3: The Crude Palm Oil total export volume and its value during 2004 - 2014

| Year | Volume (Ton) | Volume Growth (%) | Value (000 US$) | Value Growth (%) |
|---|---|---|---|---|
| 2003 | 6,386,409 | | 2,454,626 | |
| 2004 | 8,661,647 | 35.63 | 3,441,776 | 40.22 |
| 2005 | 10,375,792 | 19.79 | 3,756,557 | 9.15 |
| 2006 | 10,471,915 | 0.93 | 3,552,810 | (6.22) |
| 2007 | 11,875,418 | 13.40 | 7,868,640 | 123.36 |
| 2008 | 14,290,687 | 20.34 | 12,375,571 | 57.28 |
| 2009 | 16,829,205 | 17.76 | 10,367,621 | (16.23) |
| 2010 | 16,291,856 | (3.19) | 13,468,966 | 29.91 |

| | | | | |
|---|---|---|---|---|
| 2011 | 16,436,202 | 0.89 | 17,261,247 | 28.16 |
| 2012 | 18,850,836 | 14.69 | 17,602,180 | 1.98 |
| 2013 | 20,577,976 | 9.16 | 15,838,850 | (10.02) |
| | Average | 12.94 | Average | 25.76 |

Source: adapted from Palm oil, 2014

In addition to palm oil, there are other natural resources that can be used as a feedstock of biodiesel. They are Jatropha Curcas and Coconut oil (Novianto, 2008). These two sources that are attractive but there are critical aspects that make those sources cannot be used as a reliable feedstock. First, both Jatropha Curcas and Coconut oil are currently available only in a limited number of plantation and second the Jatropha Curcas has particularly low extraction oil, compared to palm oil. Concerning this issue, many researches have been conducted to seek other options for biodiesel feedstock development, which is high yield varieties (Novianto 2008; Wibowo and Manurung, 2013). In sum, there are currently three main potential feedstock of biodiesel that have been developed in Indonesia, each of those feedstock differ in the development stage as well as the critical aspect needs to be addressed with regards to their development. Table 3.3 depicts detail of each source.

Table 3.4: Biodiesel feedstock potential in Indonesia

| Raw materials | Conditions | Remarks |
|---|---|---|
| Crude Palm Oil | • Plantation area: > 10,000,000 Ha<br>• Current CPO yield: 29,000,000 tons<br>• Domestic CPO consumptions: almost 10,000,000 tons<br>• Export: higher than 20,000,000 tons | • Palm oil has the highest energy ratio, the measure to determine the effectiveness of biodiesel in replacing the fossil-based fuel, when compared to other sources |
| Jatropha Curcas | • 14.2 million Ha very suitable<br>• 5.5 million Ha are suitable<br>• 29.7 million Ha marginally suitable | • Plantations are still in the developing stage<br>• Jatropha is non-edible |
| Coconut Oil | • Plantations area: 3,800,000 Ha<br>• Ownership: small holders scattered throughout the country 97% | • Potential for small islands and remote area |

Source: adapted from Novianto, 2008 (Jathropa Curcas and Coconut Oil)

### 3.2.3 Biodiesel production and standardization in Indonesia

Having known what are the advantages and disadvantages of biodiesel and the supply of palm oil and other possible feedstock of biodiesel in Indonesia, this paper will continue to investigate

current production output as well as the standardization process of biodiesel in Indonesia. This will be a relevant issue to mainly investigate the growth of biodiesel in Indonesia as a comparison to the gradual growth of palm oil.

According to Panjaitan, 2013, there are currently first and second generations of biodiesel, which have been commercialized and studied in Indonesia respectively. The first generation that is mainly made from pure plant oil was introduce in 1900 when Rudolf Diesel introduced an engine that can operates by using peanut oil. The second generation in contrast was made from the lignocellulose that is treated with a simultaneous process of gasification and Fischer-Tropsch synthesis method (Panjaitan, 2013). In Indonesia, both generations of biodiesel are differing in their implementation stage. While the first generations made from palm oil and other non-edible oil are in the commercialization stages, the second generations are still in the research and development stages (Panjaitan, 2013). Table 3.4 will briefly depict the existence of biodiesel technologies in Indonesia.

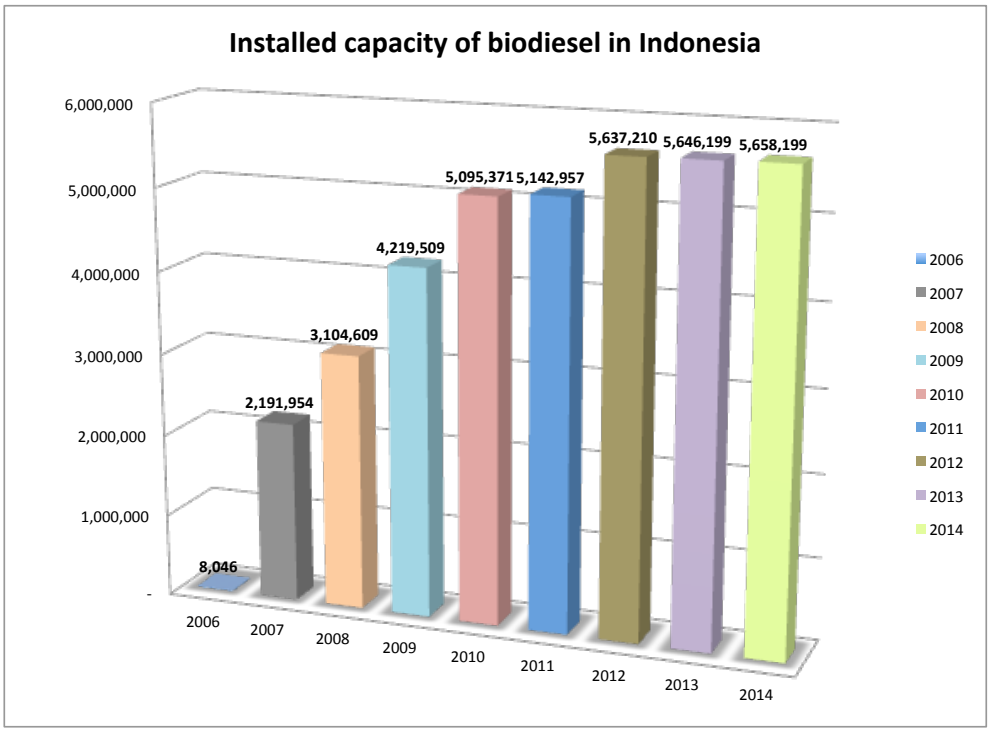
Table 3.5: The existence of biodiesel technologies in Indonesia

| | | | |
|---|---|---|---|
| **Biodiesel** | **First generation: Vegetable oil** | **Vegetable oil Pal Oil** | **Commercially available** |
| | | Coconut oil | Research and development stages |
| | | Non-edible vegetable oil: Jatropha curcas | Plantation are being developed |
| | **Second generation: Lignocellulose-based** | Oil palm empty fruit bunches, Bagasse, Rice straw, Corn stover, wood | Research and development stages |

Source: adapted from Panjaitan, 2013

As the biggest palm oil producer, Indonesia has an opportunity to become the leader in biodiesel production. Regarding the production, the installed capacity of biodiesel in Indonesia is illustrated in the following figure.

Figure 4: Installed capacity of biodiesel in Indonesia (KL)




Source: adapted from EBTKE, 2015

It can be seen that the total installed capacity of biodiesel in Indonesia is more than five million KL. In details the installed capacity of biodiesel industries in Indonesia can be seen in the following table.

Table 3.6: Installed capacity of each biodiesel producers in 2014

| No. | Producers | 2014 | | |
|---|---|---|---|---|
| | | MT / year | KL / year | Location |
| 1 | PT. Eternal Buana Chemical Industries | 40,000 | 45,977 | Tangerang, Banten |
| 2 | PT. Indo Biofuels Energy | 60,000 | 68,966 | Cilegon, Banten |
| 3 | PT. Anugrah Inti Gemanusa | 40,000 | 45,977 | Gresik, East Java |
| 4 | PT. Eterindo Nusa Graha | 40,000 | 45,977 | Gresik, East Java |
| 5 | PT. Wilmar Bio Energi Indonesia | 1,050,000 | 1,206,897 | Medang Kampai, Dumai |
| 6 | PT. Sumi Asih Oleo Chemical | 100,000 | 114,943 | Tambun, West Java |
| 7 | PT. Darmex Biofuels | 150,000 | 172,414 | Bekasi, West Java |
| 8 | PT. Pelita Agnug Agrindustri | 200,000 | 229,885 | Bengkalis, Riau |
| 9 | PT. Musim Mas | 850,000 | 977,011 | Batam, Riau |
| 10 | PT. Sintong Abadi | 30,450 | 35,000 | Asahan, North Sumatra |
| 11 | PT. Primanusa Palma Energi | 20,880 | 24,000 | Pluit, North Jakarta |
| 12 | PT. Multi Energi Nabati | 20,000 | 22,989 | Cikarang, Bekasi |
| 13 | PT. Cemerlang Energi Perkasa | 400,000 | 459,770 | Dumai, Riau |
| 14 | PT. Petro Andalan Nusantara | 130,500 | 150,000 | Dumai, Pelintung |

| | | | | |
|---|---|---|---|---|
| 15 | PT. Bioenergi Pratama Jaya | 66,000 | 75,862 | East Kutai |
| 16 | PT. Pasadena Biofuels Mandiri | 8,909 | 10,240 | South Cikarang, Bekasi |
| 17 | PT. Wahana Abdi Tritaenika Sejati | 11,484 | 13,200 | Tubagus Angke, Jakarta |
| 18 | PT. Alia Mada Perkasa | 9,570 | 11,000 | Kosambi Tangerang |
| 19 | PT. Damai Sentosa Cooking | 120,000 | 137,931 | Kawasan Sier, Surabaya |
| 20 | PT. Oil Tanking Merak | 504,000 | 579,310 | Pulo Merak, Cilegon Banten |
| 21 | PT. Ciliandra Perkasa | 250,000 | 287,356 | Pekanbaru |
| 22 | PT. Tjengkareng Djaya | 72,000 | 82,759 | DaanMogot, Jakarta |
| 23 | PT. Energi Alternatif | 7,000 | 8,046 | Tanjung Priok, Jakarta |
| 24 | PT. Wilmar Nabati Indonesia | 690,000 | 793,103 | Kebomas, Gresik |
| 25 | PT. Sinar Alam Permai | 41,400 | 47,586 | Central Kalimantan |
| 26 | PT. Alpha Global Cynergy | 10,440 | 12,000 | Merak, Banten |
| | **Total** | **4,922,633** | **5,658,199** | |

Source: adapted from EBTKE, 2015

Furthermore, the other fundamental aspects need to be addressed by countries within fuel market is the standardization. The definition of standardization is a framework of agreements to which all relevant parties in an industry or organization must adhere to ensure that all processes associated with the creation of a good or performance of a service are performed within set guidelines. This is done to ensure the end product has consistent quality, and that any conclusions made are comparable with all other equivalent items in the same class (INVESTOPEDIA). Within biodiesel industries, it is important for biodiesel producers to produce a standardized biodiesel since it can help to maximize compatibility, safety and quality. The detailed comparison between biodiesel standardization in Indonesia, European countries and USA can be seen in the following table.

In February 2006, the National Standardization Agency approved biodiesel and bioethanol standards, which were based on similar standards in the United States and European Union.[3] The Ministry of Energy and Mineral Resources issued new fuel specifications, which permit diesel and gasoline fuels to contain up to 10% fatty acid methyl ester (biodiesel) and 10% bioethanol. This decree allowed Pertamina to start selling B51 and E52 fuel in mid-2006.[4] Details of the specification can be seen on the appendixes table 3.1

[3] Biodiesel (SNI 04-7182-2006) and bioethanol (SNI DT27–0001–2006) standards were approved. These standards were based on the United States' standard (ASTM D6751) and the European Union's standard (EN14214:2002).

[4] The Director General of Oil and Gas Decree No. 3674 and Decree No. 3675 issued on 17 March 2006.

### 3.2.4 Stakeholder involved in biodiesel industries in Indonesia

This part of the thesis will mainly analyze the stakeholders involved within biodiesel system in Indonesia, which is represented in each step of the value chain. In general, biodiesel production is started from the upstream level e.g. agricultural activity to the downstream level e.g. selling and distribution process to the end consumers. However, this research will mainly focus on the upstream level taking into account the level in which the plantation, harvesting and palm oil distribution to biodiesel producers who produce biodiesel will take place. Thus, the downstream level (blending, selling and distributing) biodiesel is out of scope in this research. The key stakeholders in biodiesel and oil palm development in Indonesia are described in Table 3.7

Table 3.7: Key stakeholders in the biodiesel and palm oil sectors in Indonesia

| **Stakeholders**[5] | **Description, interests and motivation** |
|---|---|
| Affected communities | Some communities feel that palm oil has positively affected their livelihood, providing a steady income, access to health facilities and basic education. Other communities consider oil palm as having negative impacts on their livelihoods and capital. |
| Indonesian Association of Biodiesel Producers (APROBI) | APROBI is an association of private business entities, some of which have established biofuel plants and links to oil palm growers. In 2007, 5 of the 22 APROBI members had biofuel processing facilities, with a total installed capacity of 1.1 million tons per year. Unfortunately, only 15% of the capacity was being used due to limited domestic demand and supplies. |
| Indonesian Palm Oil Association (GAPKI) | This association of oil palm companies was established to develop oil palm plantations and join companies to function as an economic entity that would help improve prosperity and government revenues, and would increase the bargaining position of oil palm companies in the international market. In 2011, the association has 382 members and has been active in providing inputs to the development of policies (e.g. market prices) [6] |

[5] The above stakeholders are in addition to national government institutions and the biofuel taskforce

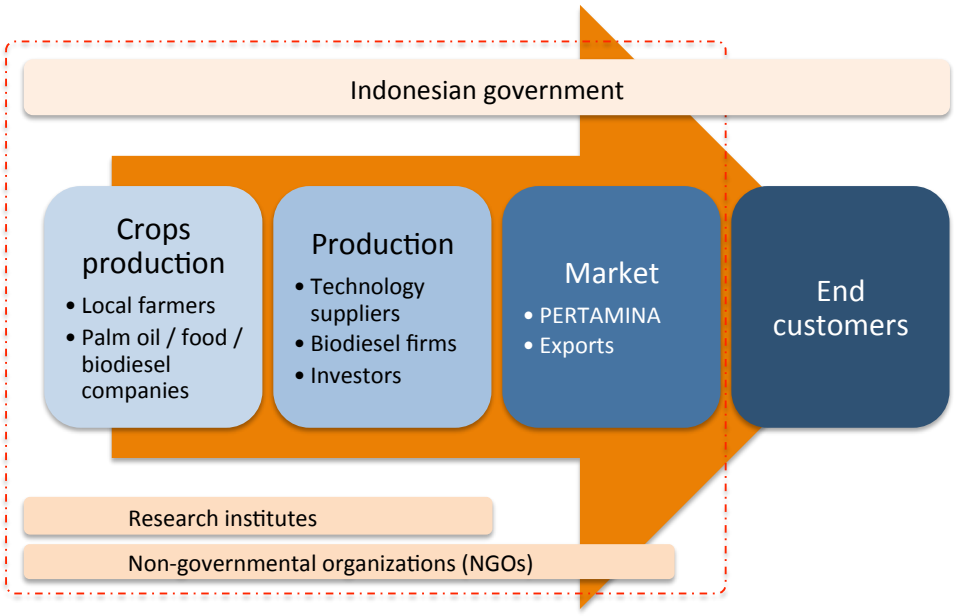
[6] It is the association's role to express its members' interests and concern about specific policies affecting business performance. However, the association and its members disagree, as indicated in their response to the recently issued Presidential Instruction No. 10/2011 on the postponement of the issuance of new licenses for business on primary forests and peat lands. While the executive director of the association protested that the instruction will adversely affect oil palm industries, one of its member and a leading oil palm company, PT Smart, considered the instruction a positive step and in line with the company's policy to conserve forests (Kontan 2011).

| | |
|---|---|
| Provincial and district government | Most provincial and district governments consider oil palm plantations and palm oil–based biodiesel development critical for the development of their regions. These industries are regarded as important for the generation of revenues, employment and welfare. This view is particularly obvious in regions, which are dependent on agriculture and those newly created (as a result of regional division). Provincial and district governments have the authority to issue location permits and conduct environmental impact assessments. Depending on the scale and geographical location of the proposed concessions, provincial and district governments also have the authority to issue plantation permits that enable investors to start operations. |
| Scientific community | This group includes academics and research institutes. While their views are rarely heard in oil palm and biofuel debates, they play a major role in providing scientific evidence and informing decision-making processes. Despite their neutrality, the institutional missions influence their views on the sustainability of biofuels. Some support and others oppose the expansion of oil palm. |
| Small-scale palm oil growers | This includes family-based enterprises producing oil palm on less than 50 ha. In 2010, 42% of the country's oil palm plantations (7.8 million ha) were managed by communities. Through various schemes, smallholders play a significant role in the development of the oil palm industry. |

Source: Caroko *et al.* (2011).

Concerning the upstream level of biodiesel industries, the main stakeholders involved in the systems are local farmers, palm oil industries, biodiesel producers and PERTAMINA as the main buyer of biodiesel. Having discussed the scope and the stakeholders involved within the upstream level of biodiesel, the following part of this chapter will further examine types of uncertainty based on biodiesel current progress in Indonesia, and it is thus used to clarify the implication of relevant factors that will influence the biodiesel related policy making process. The following figure demonstrates the business process occurred in biodiesel development in Indonesia.

Figure 5: Stakeholders in biodiesel industry




Noted: adapted from Panjaitan, 2013

## 3.3 The uncertainty of biodiesel development

### 3.3.1 Technical overview of biodiesel in Indonesia

As one of the alternative renewable energy, biodiesel can be used to substitute the petroleum diesel to be used in a constant-pressure engine. In principle, biodiesel is fatty acid ethyl or methyl ester. Biodiesel has similar properties when compare with petroleum diesel. The properties of biodiesel when compared with petroleum diesel can be seen in table 3.5

Table 3.8: Property of biodiesel

| Property | Rapeseed methyl ester | Soybean methyl ester | Diesel fuel |
|---|---|---|---|
| **Formula** | C18 – C19 | C18 – C19 | C8 – C25 |
| **Specific gravity** | 0.88 | 0.87 | 0.81 |
| **Pour point ($^0$C)** | -15 | -3 | -23 |
| **Viscosity mPa at (20$^0$C)** | 3.6 | 3.6 | 2.6 – 4.1 |
| **Lower Heating Value (kJ/L)** | 37 | 32 | 35 - 37 |
| **Flash point ($^0$C)** | 179 | - | 74 |
| **Cetane number** | 62 | 52 | 40 - 55 |

Note: adapted from Panjaitan, 2013

Biodiesel is expected to have significantly less emission compared to fossil diesel. Fossil diesel is one of the fuel types that can emit an additional carbon level to the atmosphere and therefore is considered to influence greatly on the climate change. Diesel exhaust contains toxic air contaminants and is listed as carcinogen for humans. Diesel exhaust contains fine particles that are harmful. Diesel exhaust pollution was thought to account for around one quarter of the pollution in the air in previous decades, and a high share of sickness caused by automotive pollution. Mixing biodiesel with fossil diesel is one of the alternatives to overcome the dangerous effect concerning the air pollution. However, without any modification, the existing diesel engine can only use the mixture of petroleum diesel and up to 20% biodiesel (B20), and result in the reduction in torque output. In fact, the mixtures of biodiesel in the petroleum diesel have been commercialized in Indonesia, according to the Ministry of Energy and Mineral Resources (EBTKE, 2015).

However, the mixtures of biodiesel and petroleum diesel are seen to emit less (25 – 50%) particulate matter but small increase in $NO_2$ emission, when compared to pure petroleum diesel as the Base Line. The result on the biodiesel emission test on IDI diesel engine can be seen in table 3.6.

Table 3.9: Biodiesel emission test result

| Specification | PM (g / km) | CO (g / km) | HC (g / km) | $NO_2$ (g / km) | HC + $NO_2$ (g / km) |
|---|---|---|---|---|---|
| **BS-II limit** | 0.17 | 1.5 | | | 1.2 |
| **Base Line** | 0.129 | 0.77 | 0.37 | 0.79 | 1.16 |
| **B10 (10% blended)** | 0.093 | 0.65 | 0.22 | 0.83 | 1.04 |
| **B15 (15% blended)** | 0.080 | 0.62 | 0.16 | 0.89 | 1.05 |
| **% Improvement (to the base line)** | | | | | |
| **B10 (10% blended)** | 28 | 15 | 41 | -4 | 10 |
| **B15 (15% blended)** | 38 | 20 | 50 | -12 | 10 |

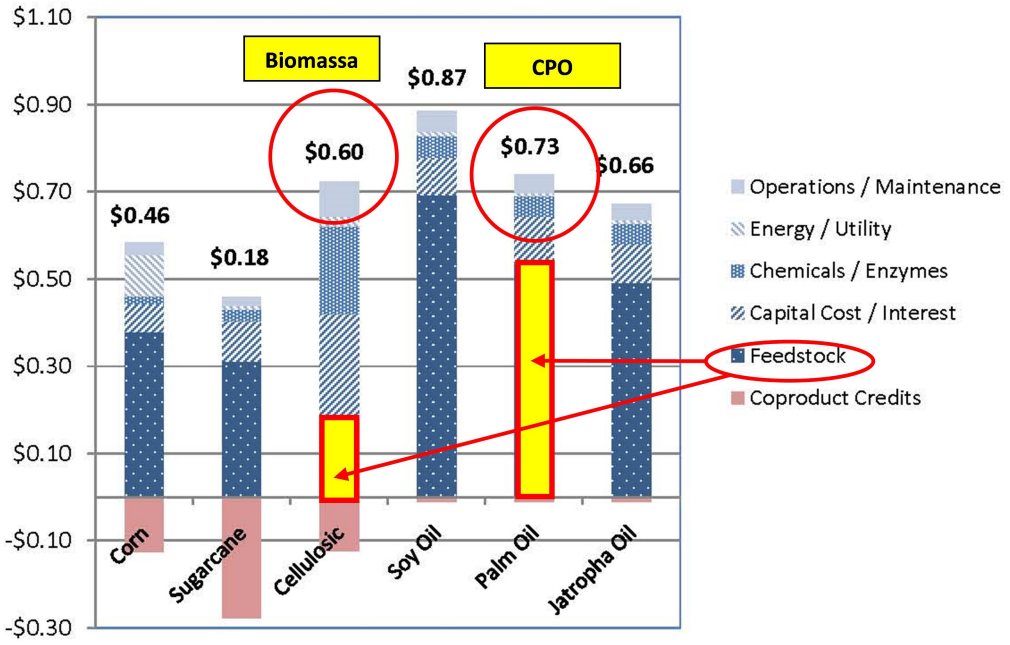
Note: adapted from Panjaitan, 2013

### 3.3.2 Technological uncertainty of biodiesel in Indonesia

With respect to biodiesel development, there are several critical issues that will be faced by palm oil biodiesel industries in the future. Bozbas (2005) claims that the highest percentage of production costs is feedstock costs, the value of raw materials required for an industrial process. Krawczyk (1996) claims that the cost of raw materials accounts for 60% to 75% of the

total biodiesel production cost. On the other hand, Haas (2005) argues that the cost of raw materials constitutes for 88% of the overall production cost. These results are consistent with the result of other analyses from refined soy oil (American Biofuels Association & Information Resources Inc., 1994; Bender, 1999; Graboski and McCormick, 1998). It should be note that many bioenergy institutions such as the APEC Energy Working Group (EWG) have addressed a similar argument. EWG (2010) claims that the biodiesel made from crude palm oil in Malaysia generally appear to have production cost historically above those of their corresponding petroleum product. It results that palm oil biodiesel has difficulty to compete without ongoing subsidies or government schemes that act to mandate volumetric biodiesel consumption in transport fuels. The report also claims that reducing the feedstock cost by utilizing crude Jatropha oil feedstock will increase its competitiveness with petroleum products. This paper is now going to more elaborate in detailed on the case study in Indonesia. Previously, the comparison of biofuel production cost summary can be seen in the following figure.

Figure 6: Biofuels production cost comparison summary




Source: EWG, 2010

Furthermore, other studies have also been conducted to prove that feedstock prices influence the final assessment of biodiesel uncertainty. Tang *et al.* (2015) argued that there are various uncertain parameters in the techno-economic assessments (TEAs) of biodiesel production, including capital cost, interest rate, feedstock price, maintenance rate, biodiesel conversion efficiency, glycerol price and operating cost. The paper analyzed the effect of those parameters

on the life cycle cost and the unit cost in the TEAs of biodiesel production. As the conclusion, the authors claim that both feedstock price and the interest rate produce considerable effect on the TEAs, and they can be used as guidance for entrepreneurs. Furthermore, Gulsen *et al.* (2014) also argued that there is a real impact of feedstock diversification on the cost-effectiveness of biodiesel. In their paper, the writers argued that there is a potential to diversify the feedstock to reduce the operational cost. Moreover, Brownbridge *et al.* (2014) claim that the oil content from algae is the main effect that can influence the feasibility of biodiesel production. They also mention that there are other aspects that need to be taken into account such as the annual productivity as a significant effect for the technical biodiesel uncertainty. That argument has already been validated by other research conducted in 2013, by Luna and Martinez. In this particular research, the authors used the Baynesian optimal design to prove that the variability of feed composition affect the uncertainty level of biodiesel. Those aforementioned studies show how the feedstock's prices and technical feedstock specification will determine the feasibility of biodiesel production system. The similar conditions also occur in Indonesia when the biodiesel producers have to absorb losses when the price of CPO (product of palm oil) are currently near US$ 650, and as a result, some of them have lowered or even stopped altogether their biodiesel supplies to the stated-owned oil company, PERTAMINA

In addition, MalÇa and Freire (2011) do a comprehensive review concerning the life-cycle studies of biodiesel made from rapeseed in Europe. The study negates the conclusion that biodiesel has a clear advantage over fossil diesel in terms of life cycle GHG intensity, which was supported by other studies. In that study, they argue that there is an uncertainty influencing the level of reliability of the research, such as the level of $N_2O$ and carbon emissions from cultivated soil. Based on the surveyed studies, there is a correlation between soil cultivated and an increasing value of the aggregate Green House Gas (GHG) if the soil emissions are taken into account. They show that soil emissions take the lead over energy used in terms of the critical factor for the overall GHG intensity of biodiesel. In particular, considering the parameter of uncertainty for soil emissions will strongly affects the GHG emission, resulted from biodiesel manufacturing process. At the end of the paper, they conclude that their life-cycle modeling has addressed the uncertainty since several sources of uncertainty have been investigated. In Indonesia, a similar research has also been conducted. Harsono *et al.* (2012) claims that the output to input ratios are positive in the biodiesel production from palm oil, which requires the largest energy input during the industrial phase. The Green House Gases emissions, on the other hand, are largely produced in *Land-use change (LUC)* phases and followed by the industrial phases. Those studies illustrate that one possible issues may arise by utilizing the land for

biodiesel purposes i.e. Green House Gas. Thus, it will create lot of debates among actors within biodiesel system and it will directly influence the future biodiesel worthiness.

Furthermore, Le *et al.* (2012) found and explained the terms of feedback loop within the environmental modeling study. The author explain that the concept of feedback loop means that there are at least two unidirectional cause and effect relationship between two or more system components and thus representing circular causalities. They also emphasizes that understanding the feedback loops in a system is a basis for understanding the regulation, adaptation and resilience, as well as system vulnerability and collapsing. Ng *et al.* (2010) in their research has particularly emphasized the importance of matching the increase in production capacity of biodiesel with its rising demand. It means that the increase in the demand of biodiesel need to be aligned by it production capacity, and this should be considered beyond the environmental and energy securities aspects, including rural agricultural development, the creation of jobs and wealth. Thus, by conducting this particular research, Ng and Gan have already argued that there is a feedback loop occurred within the system, as a feedback loop represents a causal path between variables, in which each variable is affected by the previous one. Another example for feedback loop could be the deforestation level in Indonesia. If there is an excess supply in the palm oil due to deforestation, the palm oil price will decrease. It will reduce the feedstock price of biodiesel and make the biodiesel producers increase their production. This will increase the demand and it will eventually increase the level of deforestation.

### 3.3.3 Competitive volatility of biodiesel

Competitive volatility refers to both intensity in degree of change and the uncertainty about competitors and their strategies. (Mohr *et al*, 2010). Biodiesel, as one of the alternative fuel, can also be seen as a competitor for fossil fuel and thus they have interdependency one to another. For example, the current index of biodiesel prices, which set by Indonesian government, uses the MOPS (Means of Platts Singapore). By using this reference, biodiesel producer has no other choice but to accept that the selling price of their product will be referred to the average of a set of Singapore-based oil price assessments published by Platts.

Despite the fact that Indonesia is the biggest palm oil producer, palm oil based biodiesel development in this country has been constrained by the tendency for most CPO production to be channeled towards the domestic food markets and exports. In 2013, about 74% of CPO produced in Indonesia was exported (Palm Oil, 2015). Furthermore, Caroko *et al.* (2011)

claimed that about 25.7% of CPO is consumed as cooking oil and other edible fats. In contrast, in the same year, only 2,408,000 ton of CPO (less than 10% of CPO produced) was used as biodiesel feedstock. As a result, the development of biodiesel has fallen far short of expectations in terms of the rate of production growth and contribution to the national economy.

As stated before that the result was the infeasible business activity since the production cost was higher than the selling price. The current short-term solution was the additional subsidy from central government in order to keep running this environment oriented energy policy. It is indeed problematic due to the fact that Indonesia government has already scrapped the subsidy for fossil fuel to reduce the financial deficit in one hand, but on the other hand, the government must increase the subsidy for biodiesel to deal with their main policy target i.e. the domestic consumption of biodiesel. This will therefore bequeath another future policy issues that can eventually influence the competitive advantages of biodiesel implementation program since this requested new policy will leave debates among the involved actors within the system. On one hand, many actors suggest that it is important for Indonesian government to increase the subsidy for biodiesel. The chairman of Indonesian Biodiesel Producers Association (APROBI), Paulus Tjakrawan and the Director of Bioenergy in the Ministry of Energy and Mineral Resources, Dadan KUS$iana, both agree that the subsidy is needed in order to realize this strategic program (Farida, 2015). On the other hand, the executive director of the Institute for Development of Economics and Finance (INDEF), Enny Sri Hartati, argues that the subsidy for the output is not an effective policy because it will burden the financial budget (Suryowati, 2015). E.S. Hartati suggests that the government needs to look for the other aspects that can be subsidized such as the productive infrastructure that can reduce the operational cost of biodiesel producers.

### 3.3.4 Social and political uncertainty of biodiesel

One of the requirements for the innovation to be successful is the interaction with different stakeholders (Rogers, 2003; Hurst, 1982). It may be uncertain whether the innovation has potentially harmful or disruptive side effects for the stakeholders (Hall & Martin 2005). In that sense, the interaction is also a significant source of uncertainty. Interaction can be defined as a process whereby the diversity of interests amongst members of an organization is revealed. Sartorius (2006) and Ortt & Smits (2006) found that the result of the interaction is a fundamental uncertainty caused by the wide variety and high complexity of interaction between actors. Koch (2004) and Gales & Mansour-Cole (1995) describe the situation as a paradox: in seeking to reduce the uncertainty, the actors engage in relationships with others, which lead to social and political uncertainties. Based on the argument, innovation is potentially disrupt

power structures and work routines within an organization (e.g. Jun & Weare 2010; Chen 2005; Gibbons & Littler 1979). Most decisions relating to the development of innovation take place under high levels of uncertainty (van Riel *et al.* 2004). Although decisions can be improved with better information, they are always influenced by political and value judgments (Hanft & Korper 1981). Therefore, adaptation of an innovation may be difficult to achieve, and will be beholden to internal politics (Hannan & Freeman, 1984). In addition, while political and social uncertainty may cause conflict in the short term (Hurst, 1982), uncertainty may produce over-conservatism in the longer term

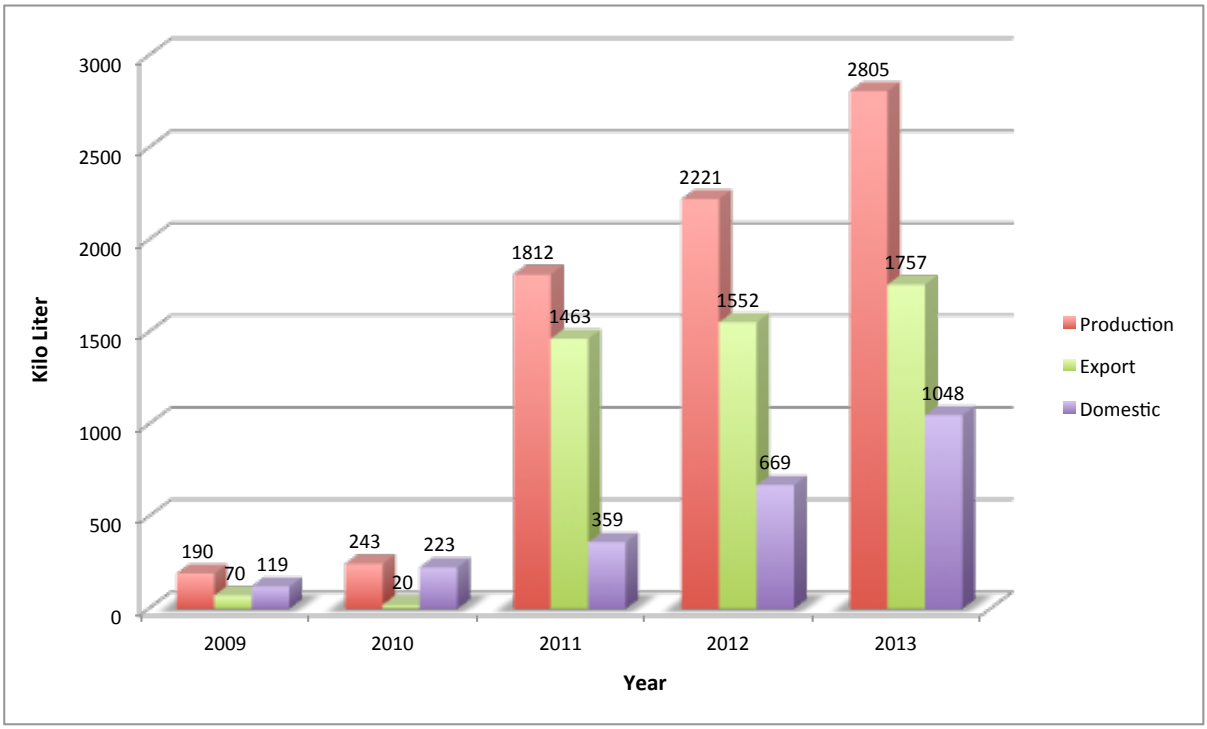
The real case for the social and political uncertainty explained above would be a future debate concerning other critical impacts of biodiesel application around the world. A study has been conducted to emphasize the policy making on biodiesel future trends in European countries by considering the aggregate impact on the environment protection through Green House Gas (GHG) savings, energy security through import substitution and rural development particularly in the south (Franco *et al*., 2010). The study points the interactions and interdependencies illustrated among Germany, Brazil and Mozambique. It is obvious that the development of biodiesel will encounter various frictions, which is an intentional resistance needs to be overcome. The authors mention three aspects leading to critical debate among important actors. First, treating the land as a marginal on one side may justify its appropriate utility for agro-industrial biodiesel, but on the other hand can also provoke protest from local poor people who were being dispossessed. Second, while the agro-industrial plantation can create employment, but on the other hand, it may also degrade the readily undermine other livelihood in informal economy. Lastly, promoting such an agro-industrial development creates conflicts with environmental protection law, which arise mainly from a specific normative account of rural development and sustainability. These current contradictions are likely to be intensified by any future rise of biodiesel and will continue to warrant systematic attention through critical research. By comparing those points of view against practices, critical research can highlight harmful effects, their causes and deceptive language that may conceal or sanities those effects. Some further questions regarding fundamental development models served by corporate-led biodiesel and how those models are implemented need to be addressed. The authors finally claims that such research can thereby contribute to build and advocate in strengthening advocacy efforts that mainly aims for addressing alternative development pathways. Thus, debates concerning future development of biodiesel are getting more intensive, and this will directly increase the level of uncertainty confronted by the biodiesel manufacturing industries.

## 3.4 Indonesian biodiesel potential market

Nowadays the global biodiesel market has shown an exponential growth both in production and trade span the globe. More biodiesel than ever before is sourced from abroad and procurement areas, especially of large-scale producers and traders. While this trend of market development is strongly increase, the market and trade themselves are strongly linked to support as well as trade policies. Explicitly, the biodiesel industry is indeed strongly linked to other sectors e.g. agriculture and mineral oil industries and thus faces significant disturbances some of which have led to various inefficiencies.

The increasing production and trade of biodiesel among countries also influence the biodiesel development path in Indonesia. Both domestic and foreign demand for Indonesian biodiesel are promising and continuing to rise. Those two markets are crucial for Indonesian future financial growth. The following figure, which is adapted from EBTKE, 2015 will illustrate the market volume from 2009 to 2013.

Figure 7: Production, export and domestic consumption of Indonesian biodiesel




Source: adapted from EBTKE, 2015

Based on the figure, it can be seen that the export level of biodiesel are higher than the level of domestic consumption. In 2013, as shown in the figure, the realization of domestic consumption of biodiesel only reached 1,048 KL while the level of export was almost twice. Regarding this

issue, the Indonesian government needs to balance the level of those two markets by introducing a mandates to obliged the oil companies in Indonesia to sell the produced biodiesel to the domestic market in a certain percentage prior the company export their biodiesel (Jupesta *et al.*, 2011). The mandates are executed by the Ministry of Energy and Mineral Resources, under the supervision of the Directorate General of New and Renewable Energy and Energy Conservation, in Indonesia: Direktorat Jendral Energi Baru Terbarukan dan Konservasi Energi (EBTKE) and was administered in the minister regulation number 32 in 2008. The details of the policy can be seen in table 3.9.

Table 3.10: Mandatory of biodiesel utilization in Indonesia regulated in 2008

| Sector | 2008 | 2009 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|
| **Transportation, Public Service Obligation (PSO)** | 1% | 1% | 2.5% | 5% | 10% | 20% |
| **Transportation, Non PSO** | | 1% | 3% | 7% | 10% | 20% |
| **Industries** | 2.5% | 2.5% | 5% | 10% | 15% | 20% |
| **Electricity** | 0.1% | 0.25% | 1% | 10% | 15% | 20% |

Source: EBTKE, 2013

Furthermore, as the reserves of fossil fuel have significantly reduced, the Indonesian government has already set up a strategic issues, for instance, by increasing the target of biodiesel domestic consumption to almost four millions kilo liter in 2014. Concerning the domestic market, the policy implementation until recently is however facing several obstacles that may ultimately reduce the adoption rate of biodiesel in Indonesia. Those factors are the index prices regulated by the government as the buying price of oil company, a high composition of feedstock cost in biodiesel operational cost, high price of crude palm oil (CPO), low incentive or subsidies from the government and the deterioration of world fossil fuel price. All of which are directly hampers the development of biodiesel in Indonesia. As a result, in 2014, over the total installed capacity of 5.6 million KL/year (Rofiq, 2014), Indonesia's biodiesel consumption is only 1.7 million tons, even far from the government's target of 3.5 million tons (Indonesia investments, 2015). Table 3.11 indicates how the domestic consumption of biodiesel is relatively low and how the mandatory policy, which has been regulated in 2008, is seem like a "toothless" mandate.

Table 3.11: Realization and the mandatory regulation for biodiesel in Indonesia (in KL)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014[7] |
|---|---|---|---|---|---|---|
| **Mandatory** | 775,941 | 1,076,051 | 1,297,000 | 1,641,000 | 2,017,000 | 2,956,688 |
| **Realization** | 119,348 | 223,041 | 358,812 | 669,398 | 1,070,000 | 1,241,818 |
| **Percentage** | 15.38% | 20.73% | 27.66% | 40.79% | 53.05% | 42% |

Source : adapted from EBTKE, 2015

In addition to emergence of several issues within domestic market, Indonesia must also confront the proposition within exports market. Wright and Wiyono, 2014 claim that Europe had become a growing export market for Indonesian biodiesel exports during 2008 – 2012. Indonesian biodiesel exports to Europe, however, dropped 60 percent from 1,29 billion liters in 2012 to 0,521 billion liters in 2013 due to non-tariff trade barriers imposed by the European Commission (EC). The impeachment of EC was mainly concern the dumping strategy conducted by biodiesel producers in Indonesia as well as the subsidies they receive from the government, which result the Indonesian biodiesel producers can export the biodiesel with a very competitive price. The investigation concerning the dumping and subsidies duties started in November 10, 2012 yet on November 26, 2013 the EU had officially stopped the anti-subsidy investigation. On the same day, the EU had also announced the Council Implementing Regulation number 1194, 2013 with regards to the Anti Dumping Import Duty.

Indonesia will also face several challenges to expand its biodiesel export outside of Europe due to the following reasons:

- Europe is the world's largest biodiesel producer followed by the United States and Canada. European countries, however, have limited feedstock supplies compared to North America. As a result, Europe is Indonesia's most important biodiesel export market.
- Environmental issues, combined with ample supplies in North America discourage Indonesian biodiesel exports to the United States.
- Indonesia exports some biodiesel to India, China, The Philippines, Thailand, and Japan. These markets remain small and highly variable.

Based upon the study, it can be concluded that the current market of biodiesel can be seen as a market failure since the potential customers of biodiesel may not demand the output of biodiesel producers. Market failure, which is very much a neoclassical and Keynesian concept, is said to occur when the market does not achieve an efficient allocation of resources with respect

[7] Target and realization in the third quarter of 2014

to different types of goods and services. Three major sources of market failure are distinguished, which are externalities, imperfect competition and inadequate information. According to Kalirajan (2006) by far the most important is the market imperfection, judged by the attention given to it by economists, is the problem of market power existence.

## 3.5 Relevant policies of biodiesel

The previous section of this chapter illustrates the problems concerning the imbalances between the development of palm oil in Indonesia and a modest growth of biodiesel. Moreover, it also describes several problems occurred in promoting biodiesel domestic consumption within the country. With regards to the problems mentioned previously, this section describes general policies, which was regulated by the Indonesian government on biodiesel and the specific regulations on production, processing and investment. It also explores the government's role in supporting farmers and small- and medium-size enterprises in biodiesel industry through various incentives such as taxes, pricing, subsidies, production targets and other fiscal and non-fiscal instrument.

### 3.5.1 General policies

One of the key policies for the development of biodiesel in Indonesia is Presidential Regulation No. 5/2006 concerning the National Energy policy. The policy provides a biofuel incorporation target of 2 per cent of national energy consumption by 2010 (Caroko *et al.*, 2011). This particular regulation tasks the Ministry of Energy and Mineral Resources with developing a national energy management blueprint, covering various energy sources, including biofuels. According to the blueprint, it is expected that the annual production capacity for biodiesel should increase from 1.16 million kiloliters in 2010 to 4.16 million kiloliters in 2025 (DESDM, 2006).

As stated in the previous chapter of this paper, a national biofuels taskforce for biofuel development was established comprising representatives from government institutions and corporations, and individuals with an interest in biofuels. While the taskforce had eventually issued the blueprint for biofuel development, the blueprint is however frequently criticized for the manner in which it was produced. Despite the need for public participation and consultation, the blueprint was developed with limited involvement from stakeholders such as

the business sector, nongovernmental organizations and the scientific community. Stakeholder input was sought only when the final draft was released [8]

The biodiesel industry is one of the sectors eligible for incentives detailed in the Government Regulation No. 1/2007. These incentives take the form of income tax reduction, accelerated depreciation and amortization, and a government guarantee against operational losses. In 2009, the Presidential Regulation No. 45/2009 was issued concerning the procurement and distribution of biofuels. This regulation mandates the Ministry of Energy and Mineral Resources to determine the market price of petroleum and biofuels. In the same year, the government decided that the House of Representatives would consider a subsidy of IDR 1,000 (US$ 0.1) per liter for biofuels if the cost of production were higher than that of petroleum. The subsidy allocated was increased to IDR 2,000 per liter and the government has currently increased the subsidy to IDR 4,000 per liter (Indonesia investment, 2015)

### 3.5.2 Regulations to support small- and medium-size biofuel enterprises

In late 2006, the Ministry of Finance issued Decree No. 117/PMK.06/2006 to provide subsidized loans for farmers to help them develop biofuel plantations. The decree provides credit to farmers at an interest rate lower than that offered by commercial banks, particularly for planting palm oil. It is interesting to note that Jatropha is not targeted by this decree (Caroko *et al.*, 2011).

In 2007, the Minister of Finance issued other decree (No. 79/PMK.05/2007) that enables small- and medium-size firms to obtain subsidized financing for food and energy crops. The decree was issued to support the government projects for food security and biofuel feedstock, as the banks do not charge a credit commission or administrative fees; however, they do impose commercial interest rate. For its part, the government provides an interest subsidy to farmers or cooperatives for a period of 5 years.

The biodiesel industry and biodiesel feedstock growers in particular benefit from another regulation issued in 2007, Government Regulation No. 8/2007, which focuses government financing on long-term investment projects deemed important for economic development of the country. In collaboration with the private sector or state-owned companies, the government can provide investment funds to help develop production facilities and supporting infrastructure.

[8] In an interview with one of the directors of the Agency for the Assessment and Application of Technology (BPPT), Jakarta, 28 April 2010, it was revealed that the document was formulated by just three scientists from this institution who served as members of the national team for biofuel development.

## 3.6 Conclusions

Throughout this chapter, this study has already developed a fundamental issue regarding the development of biodiesel as one of the renewable energy. This chapter has also discussed what have been occurred within the Indonesian biodiesel as well as the obstacles and uncertainties faced by the industries. In the following chapter, this study will further discuss any current and future policies implemented by the Indonesian government, which respect to the global biodiesel related policies.

# 4. Policies and relevant programs

After evaluating the issues that need to be evaluated in biodiesel development context, this chapter will describe some current and future relevant policies. First, this chapter will further describe the current renewable energy policy around the world specifically for biodiesel. This will be used as a background and comparison with the current policies regulated by Indonesian government, which can be used in evaluating the policy objectives. Afterwards, this chapter will develop future possible policy directions and based on the policy programs, the impacts can be determined. The effect of each policy on both the adoption rate and the net benefit for the society will be examined in the next chapter. The analysis will be based on the assumption that the policy will be made for the next 10 years, assuming that the current President will be elected again for 2019 – 2024 period.

## 4.1 Introduction: Mandatory of biodiesel in several countries

Nowadays, the biodiesel sector has a major distinction from other agricultural commodities consuming sectors regarding the sustainability of its supply chains. In Indonesia as well as other developed or developing countries, the government has passed substantial efforts, which results the additional and fast growing demand for the feedstock. The case study exhibit a more substantial discussion regarding the obviousness that producing biodiesel is not about how to create a "greener" demand and supply chain but in how to create a new adequate supply of feedstock, which will not undermine, environmentally or socially, the production and utilization of agricultural commodities in other sectors. Several biodiesel policies, which have been implemented in many countries, have to deal with other consequences related to energy, agriculture, and regional development and environment protection. Thus, the content of this chapter mainly describes biodiesel policies that have been implemented by developed and developing countries and compare those with what has been implemented in Indonesia. Afterwards, this chapter will continue analyzing some possible policy programs and investigating the Indonesian government's future plan concerning several policy programs made to encounter the issues, which was described in the previous chapter. Those policies, addressed with different possible programs, will then be defined and used as the main scope of analysis. The following will first define the current implemented policies within several countries that have a strong business relation with Indonesia within biodiesel market.

### 4.1.1 **Mandates in the Argentina**

As another country whose biodiesel was imposed by anti-dumping duties by European Union, the government has boosted a mandatory biodiesel blend from currently 8% to 10% in order to help offsetting the slump in its exports in November 2013. Additionally, in transportation utilization, the government has also required a thermal electric plants running on diesel to comply with the B10 mandate. This particular policy was expected to save the country US$ 50 million in foreign exchange annually (Lane, 2014).

Moreover, in March 2014, the government has set the biodiesel price at US$ 576.5 per metric ton; a price which producers say is too high for blenders to buy. As such, less than 5% of biodiesel was consumed from the total diesel consumption, which was less than half of the blending mandate. Moreover, the tariffs on exports to the European Union were expected to drop volumes to just 750,000 tons this year, down from more than 1.15 million tones in 2013.

### 4.1.2 **Mandates in the EU**

Biodiesel is one of the types of biofuel that serves as a renewable alternative to fossil fuels in the European Union's transport sector, helping to reduce greenhouse gas emissions and improve the EU's security of supply. The European Union (EU) has currently a 5.75 percent mandate directive in place, and was scheduled to move to 10 percent by 2020 (European Commission, 2015). However, in September 2013, the European Parliament voted to cap the first generation biodiesel consumption at 6% of fuel demand by 2020 rather than the original 10%, which was mandated by the Renewable Energy Directive.

While biofuels are important in helping the EU meet its greenhouse gas reductions targets, biofuel production typically takes place on cropland, which was previously used for other agriculture sectors such as growing food or feed. Since this agricultural production is still necessary, it may be partly displaced to previously non-cropland such as grasslands and forests. This process is known as indirect land use change (ILUC). Indirect land use change risks negating the greenhouse gas savings that result from increased biofuels because grasslands and forests typically absorb high levels of CO2. By converting these land types to cropland, atmospheric CO2 levels may increase.

To reduce the risk of indirect land use change, the European Commission has proposed amending the current legislation on biofuels, specifically the Renewable Energy Directive and the Fuel Quality Directive. The proposed new rules seek to ensure that:

a. Biofuels from new installations emit at least 60% less greenhouse gases than fossil fuels (the current requirement is 35%)
b. Emissions that might be caused by indirect land use change must be included in the reporting of fuel providers and EU countries. This will be done by estimating emissions that would take place globally when land is used for growing crops for biofuels to be used in the EU instead of growing food and feed crops (estimated ILUC emission values)
c. Only half of every EU country's 10% renewable energy target in the transport sector can be met by first generation biofuels (produced from palm oil, rapeseed, corn etc.) At the same time, 2nd and 3rd generation biofuels will count more. This biofuels are typically produced from materials (municipal waste, algae, etc.) that do not compete with food and feed crops. After 2020, governments would financially support only 2nd and 3rd generation biofuels.

### 4.1.3 **Mandates in Malaysia**

As the world's second largest palm oil producer, Malaysia looks to lower the stocks and prop up the oil prices that have lost more than 20% in 2014. The country will lift its mandate for biodiesel to use 7% palm oil in stages from November onwards, up from 5% now ("Malaysia raising", 2014). The higher mandate for the biodiesel domestic consumption will also at the same time help cut back on reliance on petroleum diesel. Datuk Amar Douglas Uggah Embas, in The Rakyat Post, 2014, said that the implementation of B7 program would consume 575,000 tones of biodiesel. This will contribute towards a savings of 667.6 million liters of petroleum diesel per year. He also said that the move to implement the B7 program would position Malaysia to be on par with other developed nations in the use of renewable energy sources. The implementation of the B7 program demonstrates the government's efforts toward the diversified use of crude palm oil, thus reducing dependence on petroleum diesel, as well as greenhouse gas emissions via environmentally friendly energy sources.

In addition, Lane, 2014 mentions that the country is also exploring boosting the blend to 10% but a timeline for such a move has not yet been set. The Malaysian Palm Oil Board (MPOB) has been studying B10 biodiesel compatibility through the implementation of the palm oil biodiesel incentive scheme (IBS) on a voluntary basis with the industrial sectors. Datuk Amar Douglas Uggah Embas said that to encourage the use of palm oil biodiesel in industrial sectors, MPOB has allocated RM3 million under IBS by offering the fuel for sale or usage at RM300 per ton (Tan, 2015). By adding the allocation to the program, which had been implemented since March 2013, could increase palm oil biodiesel consumption by as much as 10,000 tones per year.

### 4.1.4 **Mandates in South Korea**

In South Korea, the government has decided to boost the biodiesel blend to 2.5% in August from 2% currently. Plans are for the mandate to rise to 3% by 2018. The Korea Petroleum Association is complaining that complying with the mandate has cost US$ 77.5 million in 2014, will cost US$ 91.2 million in 2015 and US$ 118.7 million in 2018. Most of the biodiesel produced in the country comes from imported palm oil. Production reached 420,000 metric tons last year, just shy of a third of total demand.

### 4.1.5 **Mandates in Thailand**

Thailand is the world's third-largest producer of palm oil, but it is well behind top producers Indonesia and Malaysia. Thai industry sources estimate the country produced 2 million metric tones (MT) of palm oil in 2013, up from 1.8 million MT in 2012, with about half of the 2013 output going into cooking oil, 30% to biodiesel and 20% exported as crude palm oil. Moreover, Thailand's diesel consumption rose 2% per year to 57.1 million liters/day in the first 11 months of 2013, from 55.9 million liters/day, according to the Department of Energy Business.

Currently, the government is slashing the B7 mandate to just 3.5% in order to reserve palm oil supplies. This is due to the lower stocks to just 100,000 metric tones, which the 50,000 tons has been approved to ensure enough supplies for cooking oil. The smaller stock is a result of the annual dry season period when production slips (Sapp, 2015). A recent seasonal weather patterns caused palm oil production to drop sharply and pushed prices higher, Thailand's commerce ministry asked the energy ministry to delay implementing its B7 mandate that was set to take effect January 1, 2014, up from the B5 blend mandated in mid-2011. The action was designed to protect a three-year-old Baht 42 (US$ 1.32) / liter cap on retail prices of palm cooking oil.

Successive governments have supported the cap on palm cooking oil prices while at the same time enacting increasingly higher biodiesel blending mandates. However, the blending rates have shifted inconsistently and often-on short notice. In McGraw Hill Financial 2014, Van Zuylen reported that the palm oil producers association wants the government to make the biodiesel blending policy more flexible, allowing prices to rise when supplies fall rather than capping cooking oil prices as is currently being done. The group said that capping cooking oil prices distorts the market, as does exports. Exports rose 39% year-on-year as of November 2013 to Baht 12.4 billion (US$ 390 million) and there is not enough biodiesel domestically to supply the

B7 mandate that was scheduled to come into effect on January 1, 2014. Those plans are currently on hold until supplies improve.

### 4.1.6 **Mandates in Indonesia**

The first decree, known officially as Regulation No. 32/2008, was signed on 13 October 2008 and effective in January 2009, mandates a minimum of 1 percent biodiesel mixture in fuel sold in petrol stations in two major cities in Indonesia – Jakarta and Surabaya. It was made due to the fact that since its initial launch in 2006, Pertamina had already decreased the amount of biodiesel used in 2007 from 5 percent mixture to only 1 percent mixture caused by the increasing of CPO price. This mandates was endorsed in conjunction the Presidential Regulation No. 5/ 2006 to help diversify and secure the energy supplies and support a more sustainable economics development.

In 2013, The Indonesian Ministry of Energy and Mineral Resources (MEMR) had endorsed the new regulation No. 25/2013. It is an ambitious biodiesel program that aims to diversify domestic biodiesel consumption beyond the transportation sector i.e. Indonesia's main biodiesel consumer. Challenges to expand biodiesel expansion include inadequate infrastructure, producer and blender disagreement on biofuel price index formulation, and the absence of strong political will to remove or cut fuel subsidies. Furthermore, this ambitious mandate was followed by the second revision, which was known as the Ministry of Energy and Mineral Resources Regulation No. 20/2014. It mainly aims to increase the mixture of biodiesel (B100) from 20 percent mixture to 25 percent mixture in 2020, and from 25 percent mixture to 30 percent mixture in 2025.

However, in early March 2015, the government issued six policy packages to respond the weakening of the rupiah against the US dollar. One of which was raising the biodiesel blending in diesel fuel to 15 percent. It was endorsed in the Ministry of Energy and Mineral Resources No. 12/2015. It is also expected that this particular policy can increase the palm oil market price as it deteriorated due to its excess supply. Furthermore, it was expected that the Indonesian government could save up to US$ 2,54 billion. It was also expected that there are 5,3 million of biodiesel will be absorbed or equivalent to 4,8 million tons of crude palm oil (CPO).

### 4.1.7 **Key findings of the implementation of biodiesel policies**

All in all, the implementation of biodiesel related policy within the aforesaid countries are vary depend on the fundamental issue that arises within the state. While Argentina, Malaysia and

Indonesia plan to increase the mandates of biodiesel due to the need to reduce the import of fossil diesel, offset the slump of the exports and increase palm oil price, the European Union, South Korea and Thailand urge to reduce the consumption of biofuels due to other reasons. Environmental and economical impact in importing the feedstock of biodiesel and maintaining the safety stock of the crude palm oil are the reasons of not promoting biodiesel consumption into a higher level. The following deals with analyzing the policy objectives as the next step in determining the applicability of cost-benefit analysis.

## 4.2 Policy direction for biodiesel in Indonesia

### 4.2.1 Introduction

Having identified the mandates that was implemented in several countries with various purposes, this section of the thesis will further discuss the tendencies of Indonesian government in implementing biodiesel related policies. Getting an appropriate and reliable policy implementation is critically important. A failure in policy implementation can cause financial waste, political frustration, and disruption for ordinary citizens, as demonstrated in biodiesel development in Indonesia. While the empirical data concerning the policy implementation failure is considerable, there is a gap around the application of cost benefit analysis in the practical and implementation context.

Furthermore, in order to determine the monetary value of the policies' effect, any current and future possible policies based on an empirical study concerning biodiesel development in Indonesia is developed. The current policies, which will be used as the main principle to develop a zero alternatives or case references (baseline) will be based on the government regulation until late of 2014. To be more precise, the case reference is based on the Ministry of Energy and Mineral Resource no. 20/2014. Afterwards, some future policies that was currently regulated by the Indonesian government are further dicussed. At the end, by investigating the policy alternatives, several effects that may occur will be evaluated in monetary terms.

### 4.2.2 Policy alternatives background

Climate Change management is a top priority for the Government of Indonesia. The National Medium-Term Development Plan (RPJMN 2010-2014) highlights the importance of conservation, and utilization of the natural environment to support sustainable economic growth and increased welfare of the people. To anticipate the impact of climate change the Government is working on pollution and emission controls, reducing deforestation, peat lands management improvements and environmental rehabilitation (Moediarta and Stalker, 2007). In

support of these efforts, the Government seeks to increase climate change funding sources and to improve the coordination among related ministries.

As the implementation of the National Medium-Term Development Plan, the Indonesian government, has given until recently a subtantial support to ethanol and biodiesel, the two most widely used biofuels, in the form of mandated fuel use, tax incentives, loan and grant programs, and certain regulatory requirements. It is clear according to the case description mentioned previously that the first type of support is still remains. As a lower middle economy, Indonesia has demonstrated its commitment to address climate change by making the largest absolute emission reduction commitment made by any developing country. At the G20 Summit in 2009, the country committed to reduce CO2 emissions by 26% against a business-as-usual trajectory using domestic resources, and by 41% if receiving financial support by developed nations, by 2020.

However, in addition concerning both logistical and infrastructure hurdles that can plague the ambitious mandatory program i.e. during 2013 - 2015 as well as a recent sharply falling crude oil prices, there are constraints that need to be carefully analyzed by the government: unfeasible selling price and high feedstock price. Each of these problematical issues will be further discussed.

#### 4.2.2.1 Unfeasible selling price

Despite the biodiesel mandatory policy that have been implemented by GOI since 2006, the biodiesel consumption target for domestic market was however not achieved, as mentioned in the research background, caused by a reluctant behavior by biodiesel producers. Moreover, even though there is a real action from Pertamina in biodiesel tender procurement, many biodiesel producers are still not interested to market their product domestically due to one reason. The Pertamina has already set the buying price of biodiesel by using the Mean of Platts Singapore (MOPS) price index. In October 2014, it was reported that the index prices has been below than US$ 450 per ton, implying that Indonesian biodiesel producers have to absorb losses as CPO prices are currently near US$ 650 per ton. Based on the case, it has been estimated that the losses incurred by Indonesian biodiesel producers is about US$ 900,000 per day (Indonesia investments, 2015). This is one of the aspects that can illustrate how the selling price was not feasible and has become a problematic issue among biodiesel producers. Indonesian biodiesel producers are still eager to see the country's biodiesel price is set based on a different benchmark than the MoPS.

In addition, Indonesian Biofuel Producers Association (Aprobi) expected that the government can implements the new benchmark biodiesel formula, the association also hopes that Pertamina will also follow the new benchmark as well not only for new tenders but also for contracts that were signed during the first two years of the program (2013-2014) (Indonesia investments, 2015). By applying this policy, the Aprobi predicts that in 2014, the regional biodiesel consumption will reach 9.29 millions kiloliter (kl) in 2020 or equal to 20% of solar total consumption (46.43 millions kiloliter) (Rofiq, 2014).

#### 4.2.2.2 High feedstock cost and distorted energy market

A high international price of CPO, which on one hand has encouraged many palm oil producers to export the CPO, has also on the other hand discouraged biodiesel producers to construct a fundamental corporation with Pertamina in achieving the targeted biodiesel consumption. A global spike in CPO prices in 2007 – 2008 caused many biofuel processing facilities to operate irregularly and below their installed capacities and often temporarily suspending operations when facing unfavorable market conditions. Several plants ceased operations all together. This means that a high volatility of feedstock price will substantially influence the feasibility of biodiesel industries.

Furthermore, the previous failure of Indonesian government to significantly reduce the subsidies for fossil fuel has also distorted the energy market and cause biodiesel to be less competitive. However, at the end of 2014, the newly elected president Joko Widodo took the advantage of plunging oil prices to eliminate petrol subsidies and allow the fossil fuel price to be sold with a global market basis. It was expected that the subsidies cost the state US$ 22 billion or more than 13 percent of the federal budget. In conjunction with the that policy, on February 2015, the officials signaled they intend to apply some of the savings to prop up Indonesia's biofuel industries, which turns palm oil and sugar cane into biodiesel and ethanol respectively. The minister of Energy and Mineral Resources, Sudirman Said, said that the target subsidy for the current year will by IDR 19.4 trillion (US$ 1.53 billion), or more than six times last year's figure (Butler, 2015). Yet, the environmentalist hoped that some of the savings could be reallocated for more productive purposes, like boosting education, healthcare, and programs for poor Indonesians. The fuel subsidy had been widely viewed as a handout to middle and upper class Indonesians who owned vehicles.

### 4.2.3 The rationale of policy alternatives

Based on the aforesaid problems, this study has identified several future policy alternatives announced by the government. First, increase the subsidy for biodiesel industries and change the market price for biodiesel; second, introduce the CPO Supporting Fund (CSF) used for subsidizing biodiesel and funding a research and development (R&D) program to increase the productivity of palm oil in Indonesia. Third, apply other fiscal incentive to reduce the feedstock price (CPO) domestically. The following will describe policy alternatives that may occur based on the policy alternatives that have been announced by the government. The effects of each policies will be categorized and evaluated in the next chapter by analyzing several concerns that may occur in promoting biodiesel in Indonesia.

#### 4.2.3.1 Subsidy palm oil based biodiesel

The intervention from the government is needed to subsidies this particular industry. The Indonesian government has already announced that biodiesel subsidies have been raised to IDR 4,000 per liter (from IDR 1,500 per liter in 2014) in a move to protect the domestic biofuel industry as production costs exceed market prices amid the low global palm oil prices. This policy regulated by the ministry and endorsed by the parliament is one of the overlapped legislations with the government plan to increase the mandatory of biodiesel due to a funding gap needed to achieve the mandatory target. Moreover, another constraint is that biodiesel will be blended mostly with subsidized diesel fuel, the largest demand in transportation sector.

In addition to the previous policy, on February 2015, a new formula to set the biodiesel price in Indonesia was legalized and it is hoped can strengthen biofuel industry. The formula is: (***CPO + US$ 188/ton) x 870 kg/m3*** (Indonesia investments, 2015). However, one month afterwards, the Ministry of Energy and Mineral Resources planned to revise the formula aiming to lower the price of the mixed substance that will be purchased by oil distributors. Under the new formula, the biodiesel index price will be calculated based on the crude palm oil (CPO) base price plus US$ 125 per tons. The conversion cost is lower than the previous formula that put it at US$ 188 per ton. Rida Mulyana, the Ministry's director general said that the producers have agreed to lower the conversion cost since it will help the users, such as Pertamina, as they will buy at a lower price, resulting lower biodiesel prices. This can be achieved through a fully supervised policy implementation regarding the biodiesel mandatory consumption as stated in the new regulation of the Ministry of Energy and Mineral Resources no. 12/2015.

#### 4.2.3.2 Impose the CPO supporting fund (CSF)

Another policy options that was planned by the Indonesian government is to impose a levy, namely CPO Supporting Fund (CSF) from CPO producer in selling their product overseas. The implementation of this alternative policy will be mainly based on exports of crude palm oil. One of the main purposes of this policy is for replanting the unproductive smallholders' palm oil plantation area to boost their productivity. Besides, this fund will also be used to subsidize its downstream industries i.e. biodiesel industries.

The Ministry of Energy and Mineral Resources states that this policy has been legalized on May 5, 2015 by the President. The GOI will also involve the Development Finance Controller and other competent agencies to monitor the implementation of the policy. Palm oil exporters would be levied US$ 50 per metric ton for crude palm oil (CPO) shipments and US$ 30 for the derivatives of CPO products, when CPO prices stand at below US$ 750 a ton. Yet, when the CPO international prices are above US$ 750 a ton, the CSF as well as the export duty will be applied.

Furthermore, the executive director of the Indonesian palm Oil Producers Association (GAPKI), Fadhil Hasan, claims that the export volume of palm oil from Indonesia in 2014 was 21 million tons per year or equal to 1.8 million tons per month, and it is expected the same volume in this year. Since the CPO supporting fund will be implemented from April, this means that this fund will be imposed for the 16.2 million tons i.e. the exports from April to December 2015. In addition, Fadhil Hasan said that the palm oil exports contains of 60 percent of CPO and 40 percent of its derived products. By that, it can be calculated that it is expected a US$ 680 million will be collected from this fund.

Regarding the monitoring process, the government will form a public service agencies to record and regulate the fund allocation. By implemeting this policy, the head of public Communications of the Ministry of Energy and Mineral Resources, Dadan Kusdiana said that besides the fact that this levy will substantially reduce the pressure of state budget, this particular policy will also lead the palm oil producers to favorably sold their product to biodiesel producers instead of export it. It is expected that by applying the CSF, the uptake of biodiesel for domestic consumption will reach 1.7 million kiloliters for Public Service Obligation fuel (PSO). However, based on the case study, we have not found any further direction that the government may use this fund to stimulate the development of second generation of biodiesel.

#### 4.2.3.3 Introduce the new fiscal incentive for feedstock price

As part of the investment incentives, fiscal incentives are provided through tax provisions. They are typically intended to reduce the cost that is related to the investment and plant operation. Some of these have been introduced for renewable energy in Indonesia but only to a limited extent. Fiscal incentives related to renewable energy sectors include both income tax facilities and import duty and VAT facilities. The application of income tax facilities include: income tax reduction, accelerated depreciation and amortization and compensation for losses for foreign investors. Furthermore, the import duty and VAT facilities include the exemptions from import duty for capital goods and machinery.

As the price of biodiesel was considerably higher than the petroleum price, in 2015 the Energy and Mineral Resources Ministry has accessed several policy options to help biodiesel producers to fulfil the demand, which continues to rise following the implementation of mandatory biodiesel blending. One of the options in increasing the consumption of biodiesel is by regulating the crude palm oil (CPO) price for domestic market, which mainly aims to lower FAME producers' production cost (Cahyafitri, 2015). It was considered important by taking the previous experience, in which the price of subsidized fossil fuel make more difficult for biodiesel to compete on a price basis, into account. In fact, it has been partially solved as the government has currently scrapped the fuel subsidy. Also, until recently the Indonesian government has only regulated the export index, namely Harga Patokan Ekspor (HPE). However, this particular alternative policy will not be used since there was no clear and further discussion within the policy maker concerning the implementation of this policy.

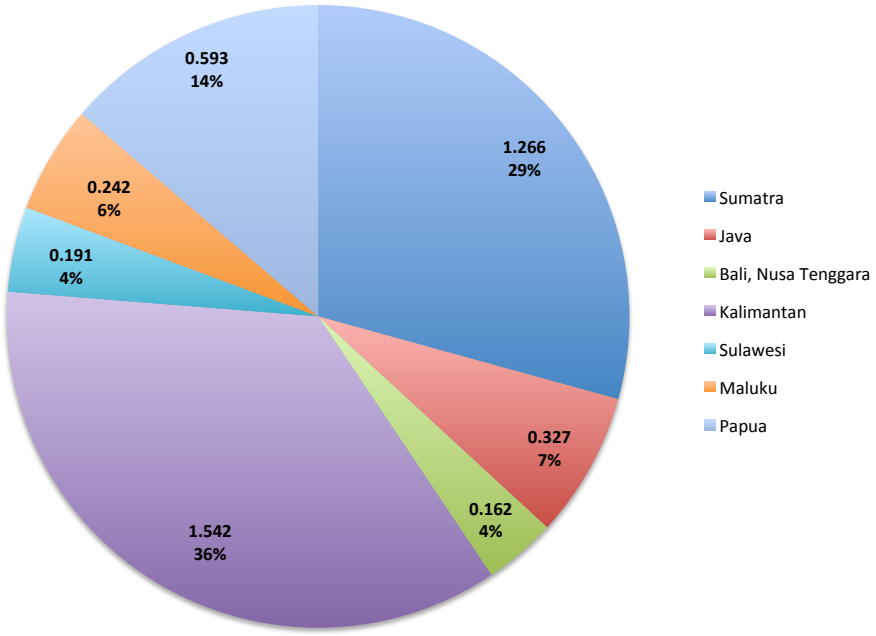
### 4.2.4 Issues may arise

#### 4.2.4.1 Deforestation

As the world's top palm oil producer, it is important for Indonesia to remain competitive by being the largest producer of palm oil, one of the main feedstock of biodiesel. As stated in the previous part, the new mandatory regulation to increase biodiesel domestic consumption will directly demand a higher supply of palm oil given an unchanged rate of export and other palm oil market. The subsidy for biodiesel would increase the proportion of biodiesel used in Indonesia's conventional fuel blend, which will worsen deforestation that has occurred at an alarming rate as it would increase the expansion of oil palm plantation in Indonesian forest. Currently, roughly half of Indonesia's natural forest loss occurs outside from officially designated concession areas as reported by Forest Watch Indonesia, 2014. It concludes a new assessment that illustrates a higher deforestation rates in places with worse forest governance

scores. At the beginning of 2015, the Indonesia's forest cover is down to 46 percent of its landmass, a drop of 2.5 percentage points since 2009 (Butler, 2015). The report also concludes that Indonesia averaged deforestation was 917,000 ha per year between 2009 and 2013, which is above the figure cited by the Ministry of Forestry. Additionally, more than three-fifth of that loss occurred in Kalimantan and Sumatra, shown in Figure 7.

Figure 8: Share of deforestation in Indonesia from 2009 to 2013

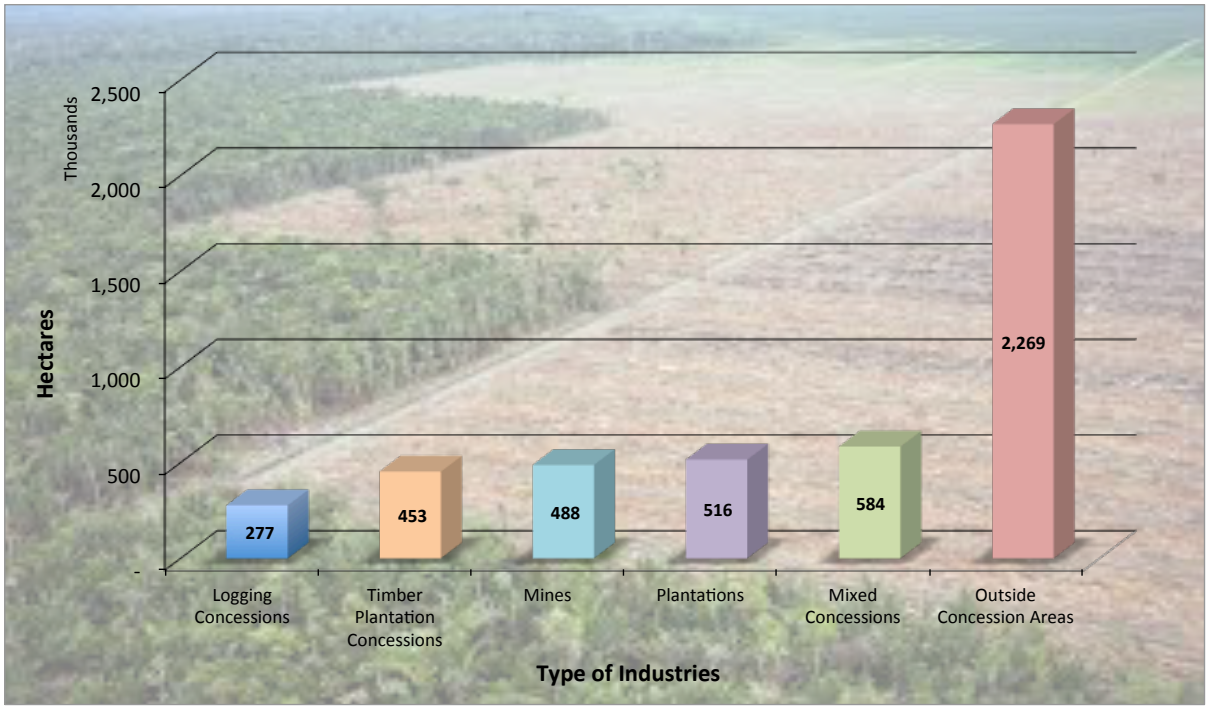



Source: Forest Watch Indonesia 2014 data

Furthermore, some fundamental issues arise following the implementation of MEMR Regulation No. 12/2015. While on one hand, this policy can directly increase the domestic consumption of biodiesel but on the other hand, it can also arise two main problematic issues. First, it is argued that this particular policy may increase the rate of deforestation. Zenzi Suhadi, a forest campaigner at the Indonesian Forum for the Environment (WALHI), said that the President's administration was making "a big blunder" with the plan and he was arguing that boosting biofuel production would require clearing more forested land for oil palm plantations to produce the palm oil needed in biofuel (Laia, 2015). He also said that with this land-based biofuel subsidy policy, the government is violating its commitment to saving our environment and supporting local people to independently cultivate their lands. Therefore, despite its advantages, this policy has some limitation in not accounting the effect of deforestation in fulfilling the increasing demand of palm oil as the main feedstock of the first generation of biodiesel. This paper will take this into account in cost benefit analysis.

The figure however does not break out the drivers of deforestation in non-concession areas, but agriculture, palm oil, rubber, and fire are typically the biggest contributors (Butler, 2015). Within the concessions area, deforestation is evenly distributed between permitted areas for palm oil and timber plantation, which lost the largest percentage of their forest cover. The natural forest loss within Indonesian concession area from 2009 to 2013 can be seen in figure 8.

Figure 9: Natural forest loss in Indonesia from 2009 to 2013




Sources: adapted from Forest Watch Indonesia 2014 data

Palm oil is one of the biggest drivers of land use change in Indonesia. Carbon-dense forests and peat lands have been particularly targeted for expansion, meaning that production of palm oil-based biodiesel is often associated with substantial greenhouse gas emissions. The palm oil sector has also contributed to conflicts between local people and corporations seeking to establish new plantations (Butler, 2015)

#### 4.2.4.2 Net Green-house-gas emission and food security

The first generation of biodiesel is typically produced using a trans esterification process and chemically known as Fatty Acid Methyl (FAME). The land-based or first generation of biodiesel have another associated problems. There is much debate over their actually benefit in reducing green house gas (GHG) and carbondioxide emissions due to the fact that some biofuels can produce negative net energy gains, releasing more carbon in their production than their feedstock's capture in their growth. Moreover, the most contentious issue with first generation

biofuels is 'fuel vs food'. As the majority of biofuels are produced directly from food crops the rise in demand for biofuels has lead to an increase in the volumes of crops being diverted away from the global food market. This has been blamed for the global increase in food prices over the last couple of years.

## 4.3 Policy alternatives development

### 4.3.1 Background

Getting an appropriate and reliable policy implementation is critically important. A failure in policy implementation can cause financial waste, political frustration, and disruption for ordinary citizens. As described previously, the Indonesian government has already implemented the mandates to boost the development of biodiesel in particular the domestic consumption rate. Table 4.1 compares the mandates during 2008 - 2015, which had been regulated by Indonesian government.

Table 4.1 Changes in biodiesel mandatory during 2008 - 2015

| **MEMR Regulation no. 32/2008 ; in October** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sector** | **2008** | **2009** | **2010** | **2013** | **2014** | **2015** | **2016** | **2020** | **2025** |
| Transportation Public Service Obligation (PSO) | 1% | 1% | 2,5% | | | 5% | | 10% | 20% |
| Transportation Non PSO | - | 1% | 3% | | | 7% | | 10% | 20% |
| Industry | 2,5% | 2,5% | 5% | | | 10% | | 15% | 20% |
| Electricity | 0,1% | 0,25% | 1% | | | 10% | | 15% | 20% |
| **MEMR Regulation no. 25/2013 ; in September** | | | | | | | | | |
| **Sector** | | | | **2013** | **2014** | **2015** | **2016** | **2020** | **2025** |
| Transportation Public Service Obligation (PSO) | | | | 10% | 10% | 10% | 20% | 20% | 25% |
| Transportation Non PSO | | | | 3% | 10% | 10% | 20% | 20% | 25% |
| Industry | | | | 5% | 10% | 10% | 20% | 20% | 25% |
| Electricity | | | | 7,5% | 20% | 25% | 30% | 30% | 30% |
| **MEMR Regulation no. 20/2014 ; in July** | | | | | | | | | |
| **Sector** | | | | **2013** | **2014** | **2015** | **2016** | **2020** | **2025** |
| Transportation Public Service Obligation (PSO) | | | | | 10% | 10% | 20% | 30% | 30% |
| Transportation Non PSO | | | | | 10% | 10% | 20% | 30% | 30% |
| Industry | | | | | 10% | 10% | 20% | 30% | 30% |
| Electricity | | | | | 20% | 25% | 30% | 30% | 30% |
| **MEMR Regulation no. 12/2015 ; in April** | | | | | | | | | |
| **Sector** | | | | **2013** | **2014** | **2015** | **2016** | **2020** | **2025** |
| Transportation Public Service Obligation (PSO) | | | | | | 15% | 20% | 30% | 30% |
| Transportation Non PSO | | | | | | 15% | 20% | 30% | 30% |
| Industry | | | | | | 15% | 20% | 30% | 30% |
| Electricity | | | | | | 25% | 30% | 30% | 30% |

Source: EBTKE (2015)

However, compared with other countries, biodiesel development in Indonesia remains sluggish. As describe in the case study, the Indonesian government's target to consume 4 million kilo liter of biodiesel is too ambitious and based on several information source, that target is unachieved. The too ambitious target are based on the assumption that:

- Pertamina is expected to blend 1,644 million kilo liters of biodiesel with the subsidized diesel oil in the transportation sector;
- The state-owned electricity company (PLN) is targeted to use 0,80 million kilo liters of biodiesel in its power plants;
- Pertamina and the other private oil and gas company e.g. SHELL and TOTAL are expected to mix 1,57 million kilo liters of biodiesel with non-subsidized diesel oil

While the mandatory was made to regulate domestic market and increase its consumption, there are also promising export markets e.g. Europe, which has became a growing market for Indonesia biodiesel during 2008 – 2012. However, Indonesia biodiesel export to Europe also dropped 60 percent from 1.29 million kiloliters in 2012 to 0.521 million kiloliters in 2013 due to non-tariff trade barriers imposed by the European Commission. This circumstance is exacerbated by the challenges to expand biodiesel export outside of European countries due to the following aspects. First, Europe has become the world's largest biodiesel producers followed by the United States and Canada. Second, the environmental issues as well as the ample supply eventually discourages Indonesian biodiesel exports to the United States. Third, the export to the current market such as India, China, The Philippines, Thailand and Japan are considerably small and volatile. Thus, it is expected that the Indonesia biodiesel export will stay constant at 1 million kiloliters in 2014 and 2015 (Wright and Wiyono, 2014). Table 4.2 describes the biodiesel balance sheet during 2006 – 2013 as well as the prediction of 2014 – 2015.

Table 4.2. Biodiesel balance sheet 2006 – 2015

| Aspect / Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Beginning stocks | - | 27 | 18 | 15 | 81 | 38 | 40 | 55 | 101 | 126 |
| Production | 65 | 270 | 630 | 330 | 740 | 1,800 | 2,200 | 2,450 | 3,650 | 4,150 |
| Imports | - | - | - | - | - | - | - | - | - | - |
| Exports | 33 | 257 | 610 | 204 | 563 | 1,440 | 1,515 | 1,356 | 1,000 | 1,000 |
| Consumption | 5 | 22 | 23 | 60 | 220 | 358 | 670 | 1,048 | 2,625 | 3,130 |
| Ending Stocks | 27 | 18 | 15 | 81 | 38 | 40 | 55 | 101 | 126 | 146 |
| **Production Capacity** | | | | | | | | | | |
| Number of Bio refineries | 2 | 7 | 14 | 20 | 22 | 22 | 26 | 26 | 26 | 26 |
| Nameplate capacity | 215 | 1,709 | 3,138 | 3,528 | 3,936 | 4,281 | 4,881 | 5,670 | 5,670 | 5,670 |
| **Capacity Use (%)** | **30.23%** | **15.80%** | **20.08%** | **9.35%** | **18.80%** | **42.05%** | **45.07%** | **43.21%** | **64.37%** | **73.19%** |
| **Feedstock Use (1,000 MT)** | | | | | | | | | | |
| Feedstock A (CPO) | 64 | 265 | 619 | 324 | 727 | 1,769 | 2,163 | 2,408 | 3,588 | 4,079 |
| Feedstock B | | | | | | | | | | |
| Feedstock C | | | | | | | | | | |
| Feedstock D | | | | | | | | | | |
| **Market Penetration (Liters – specify unit)** | | | | | | | | | | |
| Biodiesel, on-road use | 5 | 22 | 23 | 60 | 220 | 358 | 670 | 930 | 1,644 | 2,060 |
| Diesel, on-road use | 9,059 | 9,400 | 10,311 | 12,781 | 15,291 | 26,383 | 18,690 | 20,727 | 22,986 | 25,492 |
| **Blend rate average** | **0.06%** | **0.23%** | **0.22%** | **0.47%** | **1.44%** | **1.36%** | **3.58%** | **4.49%** | **7.15%** | **8.08%** |
| Diesel, total use | 15,636 | 15,575 | 17,001 | 20,158 | 23,049 | 22,921 | 24,611 | 26,257 | 28,014 | 29,888 |

Source: Wright, Wiyono (2014)

Next, based on the previous and future policy made by the government as the alternatives to promote biodiesel in Indonesia, the following policy alternatives can be defined.

### 4.3.1 Zero alternatives / case references / baseline

The case references are the programs when there is no change in government policy concerning the development of biodiesel. It will mainly based on the ministry of Energy and Mineral Resources regulation no. 25/2013 and no. 20/2014, which the target on 2020 afterwards was the difference. In case references, no new policy will be implemented.

In zero alternatives, the previous Indonesian biodiesel related policy is continued. It means that the market price of biodiesel will be based on the MoPS, which make biodiesel uncompetitive compared to fossil diesel. As a result, the development of biodiesel will be expected increase based on the historical growth on the previous period. Furthermore, it should be noted that there is no historical relevant data to determine the distribution of biodiesel domestic consumption in each sector (i.e. transportation, industrial and electricity), yet an official statement from the Ministry of Energy and Mineral Resources can be used to evaluate the issue. According to the Minister, total realization in 2014 until October was 1.44 million kiloliters, which the realization in October 2014 for the transportation, industrial and electricity were defined in the following table:

Table 4.3: The realization of biodiesel in October 2014

| | Transportation | Industrial | Electricity |
|---|---|---|---|
| **Realization** | 962,594 | 308,666 | 165,256 |
| **Percentage** | **67%** | **21.5%** | **11.5%** |

Source: Adapted from Ferial, 2014 and author's calculation

Based on the statement, it is expected that the biodiesel adoption rate for the following year will be distributed similar to it. The following table illustrates the growth of biodiesel domestic consumption in a case references.

Table 4.4: Biodiesel domestic consumption on zero alternatives

| Year | BIODIESEL consumption (Kilo liters) | | | |
|---|---|---|---|---|
| | Transportation | Industrial | Electricity | TOTAL |
| 2006 | - | - | - | 5,000 |
| 2007 | - | - | - | 22,000 |
| 2008 | - | - | - | 23,000 |
| 2009 | - | - | - | 119,348 |
| 2010 | - | - | - | 223,041 |
| 2011 | - | - | - | 358,812 |
| 2012 | - | - | - | 669,398 |
| 2013 | - | - | - | 1,048,000 |
| 2014 | 1,192,600 | 382,700 | 204,700 | 1,780,000 |
| 2015 | 1,311,044 | 420,708 | 225,030 | 1,956,782 |
| 2016 | 1,565,852 | 502,475 | 268,766 | 2,337,093 |
| 2017 | 1,820,660 | 584,242 | 312,501 | 2,717,403 |
| 2018 | 2,075,468 | 666,008 | 356,237 | 3,097,714 |
| 2019 | 2,330,276 | 747,775 | 399,973 | 3,478,024 |
| 2020 | 2,585,084 | 829,542 | 443,709 | 3,858,335 |
| 2021 | 2,839,893 | 911,309 | 487,444 | 4,238,646 |
| 2022 | 3,094,701 | 993,076 | 531,180 | 4,618,956 |
| 2023 | 3,349,509 | 1,074,842 | 574,916 | 4,999,267 |
| 2024 | 3,604,317 | 1,156,609 | 618,651 | 5,379,577 |

Source: The realization from 2006 to 2013 was adapted from Wright and Wiyono, 2014. The realization in 2014 was adapted from Ferial, 2014. The prediction of biodiesel consumption during 2015 – 2024 was based on author's calculation using the forecast formula.

### 4.3.2 Current policy's implementation

In the beginning of 2015, as stated in the previous chapter, the Indonesian government has already increased the subsidies for biodiesel to IDR 4,000 per liter from IDR 1,500 per liter in

order to boost domestic consumption, as it has been regulated by the new mandates to 15 percent from 10 percent. In addition, the implementation of this alternative policy will also be supported by another Indonesian government's policy in imposing a levy, namely CPO Supporting Fund (CSF), on crude palm oil exports. The fund will be used in subsidizing biodiesel, replanting, research and development of oil palm farmers in increasing their productivity. Palm oil exporters would be levied US$ 50 per metric ton for crude palm oil (CPO) shipments and US$ 30 for processed palm oil products, when CPO prices stand at below US$ 750 a ton. Yet, when the CPO international prices are above US$ 750 a ton, the CSF as well as the export duty will be applied.

By implementing this policy, sufficient provisions for the enforcement of the mandatory blending targets must be taken into account. Whether this new regulation provides enough handles for law enforcers to implement the mandatory blending targets remains to be seen. As a response to the new regulation, some state-owned enterprises and companies have taken serious steps towards compliance. However, in this particular policy, it is expected that the market regulation was not sufficiently monitored by the GOI. Thus, it is expected that the blending rate of biodiesel for domestic consumption will increase by 5% per year caused by a more favorable business condition for biodiesel industries. The following table contains a figure about the increase of biodiesel domestic consumption:

A slightly increase in biodiesel domestic consumption in 2015 due to the fact that the new mandates, which had been regulated by the GOI, will be effectively implemented after the GOI impose the CPO supporting fund to palm oil producers.

Table 4.5: Biodiesel domestic consumption on second policy

| Year | BIODIESEL consumption (Kilo liters) | | | |
|---|---|---|---|---|
| | Transportation | Industrial | Electricity | TOTAL |
| 2006 | - | - | - | 5,000 |
| 2007 | - | - | - | 22,000 |
| 2008 | - | - | - | 23,000 |
| 2009 | - | - | - | 119,348 |
| 2010 | - | - | - | 223,041 |
| 2011 | - | - | - | 358,812 |
| 2012 | - | - | - | 669,398 |
| 2013 | - | - | - | 1,048,000 |
| 2014 | 1,192,600 | 382,700 | 204,700 | 1,780,000 |
| 2015 | 1,424,713 | 438,339 | 232,674 | 2,095,726 |

| | | | | |
|---|---|---|---|---|
| 2016 | 1,677,056 | 502,059 | 264,197 | 2,443,311 |
| 2017 | 1,951,071 | 575,032 | 299,697 | 2,825,800 |
| 2018 | 2,248,295 | 658,600 | 339,655 | 3,246,551 |
| 2019 | 2,570,364 | 754,301 | 384,608 | 3,709,274 |
| 2020 | 2,919,019 | 863,894 | 435,155 | 4,218,068 |
| 2021 | 3,296,114 | 989,393 | 491,965 | 4,777,472 |
| 2022 | 3,703,620 | 1,133,104 | 555,786 | 5,392,510 |
| 2023 | 4,143,637 | 1,297,667 | 627,451 | 6,068,755 |
| 2024 | 4,618,397 | 1,486,104 | 707,891 | 6,812,392 |

Source: The realization from 2006 to 2013 was adapted from Wright and Wiyono, 2014. The realization in 2014 was adapted from Ferial, 2014. It is expected that blending percentage of biodiesel during 2015 – 2024 increase by 5 percent.

### 4.3.3 Regulate the market intensively

As stated previously that another aspect that make biodiesel producers to not sell the FAME for domestic market is the unregulated market mechanism. Even though the government has regulated the new pricing formula, it is also important for the government to regulate the market so that the market failure can be avoided. Furthermore, it is expected that the policy can be more efficiently implemented due to a sufficient supervision by the Indonesian government. Biodiesel industries can operate in their installed capacity since the buying price determined by Pertamina is based on the agreement and regulation. Pertamina as well as the other private oil company such as Petronas and Shell, can also strategically run the business in a perfect competition. The following table will summarize the biodiesel growth based on this particular policy tendency.

Table 4.6: Biodiesel domestic consumption on third policy

| Year | BIODIESEL consumption (Kilo liters) | | | |
|---|---|---|---|---|
| | **Transportation** | **Industrial** | **Electricity** | **TOTAL** |
| 2006 | - | - | - | 5,000 |
| 2007 | - | - | - | 22,000 |
| 2008 | - | - | - | 23,000 |
| 2009 | - | - | - | 119,348 |
| 2010 | - | - | - | 223,041 |
| 2011 | - | - | - | 358,812 |
| 2012 | - | - | - | 669,398 |
| 2013 | - | - | - | 1,048,000 |
| 2014 | 1,192,600 | 382,700 | 204,700 | 1,780,000 |
| 2015 | 2,031,454 | 852,302 | 2,189,441 | 5,073,197 |
| 2016 | 3,036,523 | 1,131,824 | 2,712,069 | 6,880,415 |

| | | | | |
|---|---|---|---|---|
| 2017 | 3,364,440 | 1,127,245 | 2,796,809 | 7,288,494 |
| 2018 | 3,692,358 | 1,122,666 | 2,881,548 | 7,696,572 |
| 2019 | 4,020,275 | 1,118,087 | 2,966,288 | 8,104,651 |
| 2020 | 6,522,289 | 1,670,263 | 3,051,028 | 11,243,580 |
| 2021 | 7,014,166 | 1,663,394 | 3,135,768 | 11,813,328 |
| 2022 | 7,506,042 | 1,656,526 | 3,220,507 | 12,383,076 |
| 2023 | 7,997,918 | 1,649,658 | 3,305,247 | 12,952,823 |
| 2024 | 8,489,794 | 1,642,790 | 3,389,987 | 13,522,571 |

Source: The realization from 2006 to 2013 was adapted from Wright and Wiyono, 2014. The realization in 2014 was adapted from Ferial, 2014. The prediction of biodiesel consumption during 2015 – 2024 was based on fulfillment of the mandates.

## 4.4 Conclusions

Three possible policy programs have been developed in this section with regards to the current and political circumstances occurred within biodiesel development system in Indonesia. Those three programs are varies from aggregate impact they will influence. The previous Indonesian government policy will be used as a zero alternative or case reference. In this particular policy, it is expected that the growth of biodiesel will increase in a common way. The prediction of future biodiesel production, consumption and the export will be based on an extrapolation or forecasting method. There will be no significant effect of this policy. In this particular program, the Indonesian government also did not have any strategic plan to boost biodiesel domestic demand.

In the second alternative policy, the Indonesian government implements the new policy by increasing a new mandate as well as the subsidies. Moreover, a new pricing formula has been legalized to increase the biodiesel consumption. By this, the government aims to increase the palm oil price in the world market by reducing its market supply. Moreover, by the new biodiesel buying price formula, it is expected that biodiesel industries are more benefited and the biodiesel blending percentage will increase by 5 percent. It should also be noted that the government would also impose a CPO supporting fund in this policy in order to compensate the subsidies for biodiesel industries.

Lastly, in the third policy, the government will enforce its biodiesel blending mandates by conducting a sufficient supervision and regulating the market with a substantial intervention. It is expected that the blending target percentage as defined by the ministry of Energy and Mineral Resources regulation will be attained.

# 5. Impact's valuation

The following chapter explores a range of economic and non-economics costs and benefits resulted by each policy programs mentioned in the previous chapter. Those effects, which can be explicitly defined, will be thoroughly analyzed with limitation of data.

## 5.1 Economic costs

### 5.1.1 Investment and operational cost

#### 5.1.1.1 Investment cost

There are numbers of literature that have already conducted to estimate both investment and engineering or operational cost of biodiesel production. The estimation illustrates significant variation of production cost, which reflects the uncertainty of modeling approaches and the wide range of production process and type of feedstock. The overall production costs of biodiesel include a number of main items. These can be mainly divided into the capital (investment) costs and the operational costs including raw materials, utilities, labor, supplies, and general works (Haas et al., 2005).

First, regarding the investment cost, the table below illustrates sources from researches that have been conducted to analyze the investment cost of palm oil based biodiesel.

Table 5.1: International estimates for capital expenditure cost for biodiesel refineries

| Biofuel type | Source | Capacity | Cost/ton CPO |
|---|---|---|---|
| **BIODIESEL** | Ong et al, 2012, Life cycle cost and sensitivity analysis of palm biodiesel production. | Annual biodiesel production capacity 50 kilo ton/year | IDR 2,825 |
| | Phitthayaphinant, and Nissapa, 2010, Financial Analysis of biodiesel production from palm Oil under stand alone risk in the South of Thailand | Annual biodiesel production capacity 96,000 liters/year | IDR 1,560 |
| | Sembiring, M.T. et al, 2015, Biodiesel production Cost Assessment from different Palm oil material as feedstock | Annual biodiesel production capacity 1000 kg of CPO/day | IDR 1,650 |

Note: based on author's calculation

As mentioned in the table, the range of investment cost calculation was based on the specific country and the capacity of the plant. Table 5.1 can be use in indicating the capital cost of

biodiesel refineries from different sources, which includes details on the size of the plant and the literature used.

This paper, which mainly aims to analyze cost benefit analysis in Indonesia palm oil biodiesel, will therefore use the result from Sembiring *et al.*, 2015 that specifically determine an IDR 1,650/liter as an investment cost for palm oil biodiesel development in Indonesia. In general, the capital costs for financing and building biodiesel refineries however accounts for a relatively small proportion of total biodiesel production cost.

5.1.1.2 Production cost of CPO and biodiesel

Second, regarding the engineering estimation of the operational cost, Sembiring, M.T. (2015) claims that the operational cost for producing biodiesel can be differentiated based on the type of feedstock being used by the producers. Based upon a study, the author concluded that the operational cost for producing biodiesel by using CPO was IDR 1,115 per kg of CPO. This cost consists of the outside battery limit (OSBL), inside battery limit (ISBL) and general cost. The following table indicates the cost and the assumption that will be used to determine the biodiesel production cost.

Table 5.2: Costs structure of biodiesel development

| Components | Type od costs | Calculation assumptions |
|---|---|---|
| **Inside battery limit (ISBL)** | Cost of raw materials | Based on the market price of palm oil |
| | Cost of utility | Based on the steam and electricity price |
| | Cost of auxiliary | Based on the market price of methanol, Paratoulene, Sulfonic Acid, Caustic Soda, Silica |
| **Maintenance** | Engine maintenance cost | 2-20% of machine investment cost |
| **Insurance** | Insurance cost | 1% of total investment cost |
| **Labor** | Labor cost | Regional minimum wages (UMR) |
| **Public administration** | | 20-30% of operation labor |
| **Depreciation** | | 10% of machine investment cost |
| **Marketing and Distribution** | | 2% of total production cost |
| **Tax** | | 2% of total investment cost |

Source: adapted from Sembiring (2015)

Moreover, according to Wijaya, 2012, the production cost of crude palm oil in Indonesia was IDR 1,501.39 per kg. The cost consists of the direct cost for labor and the overhead cost.

#### 5.1.1.3 Feedstock price

In Februari 2015, the price of fresh fruit brunches (FFB) as the feedstock of CPO was IDR 1,761.34. (Antara, 2015). This price will be used in cost-benefit analysis as the main feedstock cost for producing biodiesel.

Table 5.3: International palm oil price during 2005 – 2015

| Year | Price [a] (US$ / Metric Ton) |
|---|---|
| 2005 | 371.47 |
| 2006 | 416.81 |
| 2007 | 719.12 |
| 2008 | 862.92 |
| 2009 | 644.07 |
| 2010 | 859.94 |
| 2011 | 1,076.50 |
| 2012 | 939.83 |
| 2013 | 764.20 |
| 2014 | 739.41 |
| 2015 | 663.00 |
| 2016 | 659.00 |
| 2017 | 657.00 |
| 2018 | 655.00 |
| 2019 | 654.00 |
| 2020 | 652.00 |
| 2021 | 650.00 |
| 2022 | 649.00 |
| 2023 | 646.00 |
| 2024 | 644.00 |
| 2025 | 642.00 |

On contrary, other significant cost in biodiesel production in Indonesia is the palm oil price [a]. It accounts for more than 80 percent of the total production cost of biodiesel (Haas et al., 2005). Table 5.2 shows the fluctuation of palm oil price from 2006 to 2015. This leads to a volatile feedstock cost for biodiesel industries and based on the figure, it can also be seen that there is a vulnerability of producing biodiesel by using CPO since the feasibility of biodiesel industries depend hardly on the feedstock price.

Furthermore, there are two types of sources for estimating the total production cost for biodiesel. The former is derived from engineering estimates for theoretical plants, in which basic plant characteristic are defined and data are obtained from the suppliers and consultants to estimate the cost of the aforesaid plants. Second, an actual data such as reviews of the actual production cost from the real project, which was done by the Indonesian Biodiesel Producers Association (APROBI) will be reliable enough to estimate total FAME production cost.

Besides, another reliable sources that can be used to determine the operational cost of biodiesel

[a] Source: Palm oil prices from 2005 to 2014 are based on indexmundi.com. Palm oil prices from 2015 to 2025 are based on World Bank Commodities Price Forecast released on January 22, 2015; retrieved from http://www.worldbank.org/content/dam/Worldbank/GEP/GEP2015a/Price_Forecast.pdf

was based on the pricing formula set by the Indonesian government. However, this was not relevant since such issues were discussed with respect to the economical selling price of biodiesel. Therefore, the pricing formula regulated by the GOI will be used for analyzing the output subsidy as a support from the government and biodiesel revenue as well. As cited from the statement of the Ministry's director general for new and renewable energies and energy conservation that:

*"Price regulation is necessary to ensure that producers can continue supplying and distributors can continue purchasing FAME to be blended into diesel fuel to comply with the government's mandatory biodiesel blending policy amid ongoing decline in the price of crude oil, which makes the fossil fuel more attractive than non-fossil fuels."* (Cahyafitri, 2015)

The following table summarizes the production cost of biodiesel that will be used in cost benefit analysis, which are based on both the literature study and the regulated pricing formula.

Table 5.4: Production cost of biodiesel

| Components | Sources | (IDR / kg) | Remark |
|---|---|---|---|
| **Investment / capital cost** | Research study | 1,650 | |
| **Feedstock cost** | MEMR regulation | MoPS prices | Policy one |
| | MEMR regulation | CPO prices | Policy two and three |
| **Operational cost** | Sembiring *et al.,* 2015 | 1,115 * | |

### 5.1.2 Biodiesel and feedstock subsidies

It was claimed that biodiesel as one of the renewable energy industries benefits highly some financial support from the Indonesian government. As part of the stakeholders within the biodiesel system, like many industries, biodiesel producers are seek in gaining reliable profit. Due to a gap between high national oil prices and low CPO price, biodiesel industry was initially an attractive business sector in 2008. According to Hidayatno *et al.* (2011), it was estimated that in late of 2008, there were 11 biodiesel producers with total capacity of 1.6 million tones. Many of them are previously CPO producers who would like to capitalize the new market, diversifying their old market, especially with the fluctuation of world CPO prices in 2008. However, at the end of 2009, the US Department of Agriculture's Foreign Agriculture Service reported that only one producer left with producing only 50 percent of its installed capacity (Bromokusumo, 2009).

Despite the problematic issues that had been arising within biodiesel development, the Indonesian government had already allocated some fund to subsidize biodiesel programs. However, the degree of uncertainty exists when calculation the subsidies, given the limited information available on the implementation of government's plans since the announcement of Indonesia biofuel development program. This might be the case due to several delays and cancellation of the policies that occurred until recently. Furthermore, the low transparency of the government must also be taken into account. The 2006 Open Budget Index ranked Indonesia in its middle tier based on the information provided by the state concerning fiscal expenditure. Furthermore, the key budget document, which is known as APBN used as the executive budget statement, scored only 45 per cent (a 100 per cent ranking would provide the public with a comprehensive picture of government financial activity). Pre-budget statements and in-year reports remain unavailable to the public. Many federal budget documents are not available online (Dillon *et al.*, 2008). Thus, in some cases, it has been necessary to rely on media reports of government funding announcements, when official sources were not available.

According to Dillon *et al.*, (2008), there are several subsidies element such as intermediate input, output-linked, production, labor, land, research and development, support for consumption subsidies that need to be further considered.

#### 5.1.2.1 Biodiesel output subsidies

Output subsidies can take the form of direct support, such as per liter payments for biodiesel production, and indirect support through measures that artificially elevate the prices received by producers (market price support such as import tariffs, government procurement, or mandatory consumption policy).

Until recently, the primary source of output subsidy for biodiesel in Indonesia was the government's mandates to oil distributor companies to sell blended diesel fuel since 2006. This resulted in significant subsidies, as they were required to sell biodiesel at the same price as petroleum diesel. For most of the time, during 2006 – 2015, biodiesel was more expensive to be procured than fossil diesel. Due to data and information constraint, Dillon *et al.*, (2008) claimed that the output support provided by the government in 2006 and 2007 was IDR 1,032 and IDR 1,729 per liter respectively. Furthermore, as stated previously, the Indonesian government has allocated IDR 4,000 per liter as the subsidy budget in 2015 for encouraging domestic consumption.

Additionally, in order to encounter the funding gap, the Indonesian government has also regulated the CPO supporting fund (CSF) in April 2015. As the world's top palm oil producer, the government of Indonesia will impose a levy on exports of crude palm oil to subsidizing biodiesel, replanting, research and development of oil palm farmers to boost their production as well. When CPO prices stands at below US$ 750 per ton, palm oil exporters would be levied USD 50 per metric ton for CPO shipments and US$ 30 for processed palm oil products. Based on the historical data, the total exported CPO in 2013 was 20,577,976 tones and it can be calculated that the additional cost for palm oil producers will be US$ 1.029 million. Therefore, by increasing biodiesel domestic consumption, it is expected that there are losses caused by uncollected CSF as the palm producers would not export the CPO. The following table summarizes the output subsidies as well as the CSF loss per liter of biodiesel.

Table 5.5: Output subsidies of biodiesel

| Components | Type of Sources | (IDR / kg CPO) |
|---|---|---|
| **Biodiesel subsidy** | Government budget [a] | Limited to IDR 4,0000 |
| **CPO supporting fund** | Palm oil producers [b] | IDR 568.19 |

Note: [a] the subsidy will be used to fill the gap as the biodiesel price is higher than the fossil diesel price.
[b] USD 50 will be imposed for the exported CPO; USD 1 = IDR 12,500; The conversion rate suggests that one metric ton of CPO can produce 1,100 liters of FAME

Moreover, the Indonesian government's support for biodiesel industry was also indicated by the intervention in regulating the basis price index for biodiesel. As stated previously, another reliable secondary sources used to determine the production cost can be acquired from the pricing formula, which has been regulated by the ministry of Energy and Mineral Resources. This regulation, which was made to encourage biodiesel industries in raising the domestic consumption, had been however revised for three times during 2014 – 2015. In Policy 1, where the Indonesian government did not implement the new pricing formula, the production cost of biodiesel was 3.48 percent of the MoPS index prices. Moreover, in the second and third Policy, the pricing formula was based on the CPO prices. Table 5.4 summarizes the detail of Indonesian government policy during 2014 – 2015.

Table 5.6: Selling price formula of biodiesel

| | Sources | Production |
|---|---|---|
| **Policy 1** | The ministry of energy and mineral resource regulation no. 2185 K/12/MEM/2014 [b] | MoPS Gasoil + 3.48 percent |
| **Policy 2 and 3** | The ministry of energy and mineral resource regulation no. 0726 K/12/MEM/2015 [c] | (CPO + USD 188) * 870 kg/$m^3$ |

Note: * based on the Indonesian government pricing regulation that the operational cost of biodiesel is USD 188. With the assumption that 1 USD = IDR 12,500. This will only be applied to the second and third Policy

However, one month later, in a move to support a rise in the proportion of biofuel that must be added to diesel, the Energy and Mineral Resources Ministry plans to introduce a new formula aiming to lower the price of the mixed substance purchased by oil distributor. Based on the new formula, the biodiesel index price will be calculated based on CPO base price added with USD 125 per ton, which is the cost of converting CPO into fatty acid methyl ester (FAME) used to produce biodiesel. However, this was not the case since the new pricing formula was not regulated yet.

#### 5.1.2.2 Agricultural and biodiesel feedstock subsidies

There is a range of measures in place to encourage the development of biodiesel feedstock plantation, the renewal of existing plantation, and to improve seeding quality and increase value-added production.

Firstly, another direct support that has been commonly provided by the government was the fertilizer subsidy. This was the direct payment by central government to state-owned fertilizer manufacturers to compensate them for selling certain fertilizer products to farmers at government determined ceiling price, namely Harga Eceran tertinggi (HET), below the prevailing market prices. It is estimated that the subsidy was USD 1.8 billion per year (OECD, 2014; Dillon *et al.,* 2008)

Secondly, a subsidized credit scheme for farmers for biofuel plantation development and revitalization was created in 2006. An IDR 1 trillion was allocated for palm, rubber, cocoa, cassava, sugarcane, and possibly jatropha (Dillon *et al.*, 2008). Estate crop expansion,

[b] According to the Ministry of Energy and Mineral Resources Regulation; retrieved on June 12, 2015 from http://prokum.esdm.go.id/kepmen/2014/Kepmen%20ESDM%202185%202014.pdf

[c] According to the Ministry of Energy and Mineral Resources Regulation; Source: Ferial, 2015

regeneration, and rehabilitation were also promoted by offering small-scale farmers undertaking seed, fertilizer, and farmland maintenance improvements, preferential credit rates (Caroko, *et al.*, 2011; Boer, *et al.,* 2009). Food and biofuel crops were stimulated by subsidized financing for smallholders in 2007 (OECD, 2014). The subsidy is paid to ordinary commercial banks, via the Bank of Indonesia, to enable them to provide concessional loans and allow farmers to borrow from the banks at below market interest rates. There are currently three such credit subsidy programs, although the OECD has tracked provision of similar concessional loans back to 1990: Food Security and Energy Credit (Kredit Ketahanan Pangan dan Energi, KKP-E), Bio Energy Development and Plantation Revitalization Credit (Kredit Pengembangan Energi Nabati and Revitalisasi Perkebunan, KPEN-RP) and Cattle Breeding Credit (Kredit Usaha Pembibitan Sapi, KUPS)." It is expected that the support from the Indonesian government will cost USD 51 million per year.

Thirdly, the government's subsidy has been also paid to state-owned seed manufacturers' to enable them to distribute seeds to farmers at subsidized prices. IDR 22,466 million (US$ 2.36 million) (OECD, 2014) will be the average cost from 2009 – 2012. Moreover, to encourage R&D activities for developing palm oil seeds, it is estimated that IDR 30.7 billion (US$ 3.2 million) was allocated for the interest rate subsidies for developing palm oil seeds. 2006-2009. In addition, five Provinces in Java and Sulawesi have allocated IDR 249 million (US$ 27,000) to establish seed nurseries. Therefore, it is expected that the support of the government for this typical interest rate will be US$ 0.8 million per year.

Lastly, another indirect support from the government in promoting biodiesel was given to subsidize the transport fuel for agricultural sector. It is estimated that the cost was US$ 2.98 billion per year. Table 5.6 summarizes the feedstock subsidies that have been implemented by the government until recently. In sum, based on the fact that the subsidy is hardly determined whether it has been allocated sufficiently, this study will thus only apply the credit scheme subsidy and R&D subsidy in cost-benefit analysis, as highlighted in the following table.

Table 5.7: Output subsidies of biodiesel from 2006 to June 2008

| Components | Cost sources | (USD / year) | Sources |
|---|---|---|---|
| **Fertilizers subsidy** | Government | **1.8 billion** | OECD, 2014,<br>Analysis also in: Dillon *et al.*, 2008; Sheil, *et al.,* 2009" |

| | | | |
|---|---|---|---|
| **Farmers' credit scheme subsidy** | Government | **51 million** | OECD, 2014<br>Analysis also in: Dillon *et al.,* 2008; Caroko *et al.,* 2011; Boer *et al*., 2009 |
| **Subsidy to encourage R&D activities for developing palm oil seeds and distribute seeds to farmers** | Government | **3.16 million** | OECD, 2014<br>Analysis also in: Dillon *et al.,* 2008; Caroko *et al.,* 2011; Boer *et al*., 2009 |
| **Transport fuel for agricultural sector** | Government | **2.98 billion** | IISD, 2014<br>Caroko, *et al.*, 2011; Dillon *et al*., 2008 |

#### 5.1.3 Impact on palm oil export

The effort of Indonesian government to boost the consumption of palm oil for producing biodiesel will directly influence the amount of palm oil exported and thus will reduce the VAT. Moreover, a reduction of CPO supporting fund will also occur in accordance to the new government policy, as exporting the CPO will be less favorable, it will eventually deteriorate the CPO supporting fund. Thus, this will be counted as a cost in CBA.

### 5.2 Non-Economic cost

#### 5.2.1 Social and environmental impact

##### 5.2.1.1 Escalating food prices

In 2008, biodiesel production in Indonesia had diverted a minimum amount of food commodities i.e. palm oil to fuel domestically, due to low production levels. However, the government's biodiesel mandates will result in escalating amounts of palm oil being diverted to biodiesel production. Palm oil is one of the important staple foods in Indonesia and used for cooking and in food processing. For poor people, palm oil is an important source of calories and the average per-person domestic consumption of palm oil for food is approximately 16 kg per person per year. [d]

Despite being a net exporter of palm oil, Indonesia consumers are still vulnerable to price rises and shortages, as evidenced by riots over rising vegetable oil prices in January 2008. The poor suffer food shortages, not because there is no food, but because they cannot afford it. Furthermore, expanding global biofuels production has also demonstrated can give a

[d] Estimated domestic food consumption in 2008 = 3,700,000 tones (U.S. Department of Agriculture, 2008d). The population of Indonesia is 235 million (CIA World Factbook)

substantial influence to food prices and scarcity. In 2007, the world produced approximately 70 million liters of biofuels, converting million tons of sugarcane, corn, wheat, sugar beet, rapeseed, soy and tallow into fuel (Kutas *et al.*, 2007).

However, estimates were varies regarding the relative role of biofuel in the rising price of food commodity. The IMF estimated that biofuels accounted for almost half of the increase demand in major food crops in 2007 (IMF, 2008), while the OECD estimated that around 60 percent of the increase in consumption of cereals and vegetable oils was due to biofuels (OECD, 2008). Mitchell (2008) estimated that biofuels contributed to 75 percent of the recent food price rises. According to Oil World, a forecasting service in Germany, biofuels accounted for almost half the increase in worldwide demand for demand vegetable oils in 2007, and represented seven percent of total consumption of the oils (Bradsher, 2008).

According to cost benefit analysis theory, a higher food commodity prices will be translated into a higher income for plantation owners and some farmers, processors and exporters, and the government (due to higher taxation income) and thus the effect of this cost will be equally distributed. Therefore, this indirect effect, on which the food prices will be escalated, is neglected in the CBA. However, higher food prices can undermine the purchasing power of the poor, including in Indonesia (World Bank, 2008). This issue needs to be taken into account since poor households may spend around 75 per cent of their income on food, with many sacrificing education or medical care in order to afford basic foods, and the worst occurred when others unable to afford even a sufficient food (Ivanic and Martin, 2008). Higher food prices affect urban and rural poor alike, as most rural households are net consumers rather than producers of food. Ivanic and Martin (2008) estimated that 100 million people fell into poverty because of the escalating food price.

#### 5.2.1.2 The potential of land grabs

The continued expansion of plantations as a result of biofuel production could have negative impacts on some local communities at the site of new developments. Social impacts associated with the development of plantations (especially by logging companies and operators of palm-oil plantations) have attracted considerable attention in recent years as they negatively and disproportionately impact indigenous peoples, often depriving them of their land and their means for subsistence (e.g., Wakker, 2005).

The Indonesian Constitution bestows on the State the power to control and (re) allocate natural resources for public purposes. The ambiguity contained in this power provides the government

with broad discretion over policies concerning land and forest conversion. Decisions on the maximum and minimum area to be used for palm oil and other commercial crop plantations are in the hands of the Minister of Agriculture (Guerin, 2007). It is the local administrations in the respective provinces, however, that officially dispense concessions to the plantation companies—usually for 35 years on a renewable basis—based on the availability of land, population density and other factors.

Unjust land-acquisition, due to corrupt community leaders or local governmental officials, has created friction between local leaders and their own communities, sometimes erupting into violence (Wakker, 2005). According to a study conducted by Sawit Watch and its partner organizations in 2006 (cited in Wakker, 2005), four main factors have typically created the conditions for such conflicts:

- Contradictory laws which fail to secure indigenous rights while encouraging land expropriation for commercial projects under the pretext of "national interests";
- An absence of regulations obscuring procedures for the recognition of collective land rights enforced by customary-law communities;
- Weak institutional capacity both in the national land agencies and district bureaucracies which makes recognition of customary rights even more difficult; and
- National and regional policies as well as spatial planning processes, which favor the conversion of traditional lands and forests into oil-palm plantations in order to increase national and regional revenues.

Other sources of friction include information asymmetry, the use of force and human- rights abuses, unpaid compensation and benefits, and breach of contract timetables. However, it is difficult to monetize the impact of this effect in this CBA and this aspect will be neglected in CBA.

### 5.2.2 Green house gas emission from the feedstock production

Greater production and utilization of biodiesel are being promoted to support, amongst other goal, mitigation of climate change. Government in both developed and developing countries, as mentioned before, are adopting mandates and incentives to drive greater use of biodiesel for transportation. Furthermore, biodiesel pathways tend to be evaluated against a number of criteria, including greenhouse gas (GHG) emissions and efficiency of land use. GHG profiles are important because the reduction of GHG is a major reason behind the effort of developed countries, the key potential importers of biodiesel and financers of the projects, for promoting this particular type of energy.

Frieden et al. (2011) has already conducted a research that particularly calculated the GHG emissions due to biodiesel production from the cultivation through the first point of distribution in the country of production. The report used the GHG calculation tool of the EU-funded project 'Harmonized calculation of biofuel greenhouse gas emissions in Europe (BioGrace)'. It was mainly used to facilitate the calculations for the case studies of biofuel. Based upon the research, there are three GHGs that were considered: Carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$).

According to Frieden et al. (2011), Global warming potentials (GWPs) are used to express the contribution of each gas to global warming using a common unit. $CO_2$ is used as the standard, and the warming impact of a kilogram of other GHGs is expressed in relation to the warming impact of a kilogram of $CO_2$. Consequently, the impact of 1 kg of gases other than $CO_2$ is indicated as a multiple of the impact of 1 kg of $CO_2$. By using these multipliers, referred to as 'equivalent factors', emissions of $CH_4$ and $N_2O$ are converted into equivalent amounts of $CO_2$ emissions ($CO_2$-eq). Equivalent factors for these 3 gases are:

- 1 kg $CO_2$ = 1 kg $CO_2$-eq
- 1 kg $CH_4$ = 25 kg $CO_2$-eq
- 1 kg $N_2O$ = 298 kg $CO_2$-eq

Regarding the biodiesel development by using palm oil, the author considered the pathways into two alternatives: with and without capture of $CH_4$, the emissions from palm oil mill effluent (POME) from the extraction process. Where $CH_4$ is captured, it is assumed that it is used for generation of electricity occurring outside the analyzed system. Table 6.1 – 6.8 in the appendix provide an overview of the generic data used in that particular research and table 6.9 – 6.12 in the appendix provide country-independent data for processing palm oil into biodiesel as well as palm oil cultivation and transport in Indonesia.

The following table provides an overview of the results calculated by using the BioGrace tool. Figures afterwards illustrate these values to give a better impression of the relative importance of the different sources of emissions.

Table 5.8: Overview of emissions due to biodiesel production from palm oil without $CH_4$ capture, Indonesia (in-country consumption)

| All results in g $CO_2$-eq / $MJ_{FAME}$ | Non-allocated results | Allocation Factor (%) | Allocated results | Total | Default values RED Annex V.D |
|---|---|---|---|---|---|
| **Cultivation** | | | | **20.9** | **14.00** |
| Cultivation of FFB | 23.00 | 91.0 | 20.94 | | 14.26 |
| Storage of FFB | 0.00 | 91.0 | 0.00 | | 0.00 |
| **Processing** | | | | **49.9** | **49.00** |
| Extraction of oil | 34.64 | 91.0 | 31.54 | | 31.53 |
| Refining of vegetable oil | 1.14 | 95.7 | 1.09 | | 17.88 |
| Esterification | 18.05 | 95.7 | 17.27 | | |
| **Transport** | | | | **0.8** | **5.00** |
| Transport of FFB | 0.31 | 91.0 | 0.28 | | 0.19 |
| Transport of oil | 0.00 | 95.7 | 0.00 | | 3.55 |
| Transport of FAME | 0.48 | 100.0 | 0.48 | | 0.83 |
| Filling station | 0.00 | 100.0 | 0.00 | | 0.44 |
| **Land use change** | **118.00** | **100.0** | **118.00** | **118.0** | **0.00** |
| **$E_{sca} + e_{ccr} + e_{ccs}$** | **0.00** | **100.0** | **0.00** | **0.0** | **0.00** |
| **Total** | **195.60** | | | **189.6** | **68.00** |

FFB: fresh fruit bunches; FAME: fatty acid methyl ester

$e_{sca}$ : emission savings from soil carbon accumulation via improved agricultural management

$e_{ccr}$ : emission savings from carbon capture and replacement

$e_{ccs}$ : emission savings from carbon capture and sequestration

Table 5.9: Overview of emissions due to biodiesel production from palm oil with $CH_4$ capture, Indonesia (in-country consumption)

| All results in g $CO_2$-eq / $MJ_{FAME}$ | Non-allocated results | Allocation Factor (%) | Allocated results | Total | Default values RED Annex V.D |
|---|---|---|---|---|---|
| **Cultivation** | | | | **20.9** | **14.00** |
| Cultivation of FFB | 23.00 | 91.0 | 20.94 | | 14.26 |
| Storage of FFB | 0.00 | 91.0 | 0.00 | | 0.00 |
| **Processing** | | | | **18.4** | **49.00** |
| Extraction of oil | -0.01 | 91.0 | -0.01 | | 31.53 |
| Refining of vegetable oil | 1.14 | 95.7 | 1.09 | | 17.88 |
| Esterification | 18.05 | 95.7 | 17.27 | | |
| **Transport** | | | | **0.8** | **5.00** |
| Transport of FFB | 0.31 | 91.0 | 0.28 | | 0.19 |
| Transport of oil | 0.00 | 95.7 | 0.00 | | 3.55 |
| Transport of FAME | 0.48 | 100.0 | 0.48 | | 0.83 |
| Filling station | 0.00 | 100.0 | 0.00 | | 0.44 |
| **Land use change** | **118.00** | **100.0** | **118.00** | **118.0** | **0.00** |
| **$E_{sca} + e_{ccr} + e_{ccs}$** | **0.00** | **100.0** | **0.00** | **0.0** | **0.00** |

| | | | |
|---|---|---|---|
| **Total** | **161.00** | **158.1** | **68.00** |

FFB: fresh fruit bunches; FAME: fatty acid methyl ester
$e_{sca}$ : emission savings from soil carbon accumulation via improved agricultural management
$e_{ccr}$ : emission savings from carbon capture and replacement
$e_{ccs}$ : emission savings from carbon capture and sequestration

In order to convert the above result to calculate the total amount of carbon dioxide ($CO_2$) resulted in producing a kilogram of biodiesel, a research by Demirbas in 2007 can then be used. According to the author, the high (gross) heating value (HHV) of biodiesel in between 39 – 41 MJ/kg. Other source also define that the HHV of biodiesel is 40.168 MJ/kg. This paper will thus assume that the HHV of biodiesel is roughly at 40 MJ/kg. Based on that, it can be calculated that the GHG emissions is **3.95 kg$CO_2$-eq/kg FAME** or equal to **3.476 kg$CO_2$-eq/liter.**

Furthermore, another study conducted by Harsono *et al.* (2011) had determines the GHG emissions from CPO-based biodiesel production, based on a life-cycle inventory and accounts for all GHG emissions that arise between initial land conversions and final use of the palm-oil-based energy. Similar GHG gases were analyzed in this particular study:

- 1 kg $CO_2$ = 1 kg $CO_2$-eq
- 1 kg $CH_4$ = 21 kg $CO_2$-eq
- 1 kg $N_2O$ = 310 kg $CO_2$-eq

As a result, the following table concludes the GHG emissions by using the global warming potential emission result (GWP-100)

Table 5.10: GWP-100 emission results

| **Aspects** | **Area** | **Type of Plantation** | **Value** | |
|---|---|---|---|---|
| | | | **(g $CO_2$-eq / MJ / year)** | **(kg $CO_2$-eq / liter)** |
| **Emissions incl. LUC** | Kalimantan | **Company plantation** | 150 | 4.95 |
| | | **Smallholder dependent** | 81 | 2.66 |
| | | **Smallholder independent** | 121 | 3.98 |
| **Emissions incl. LUC** | Sumatera | **Company plantation** | 126 | 4.16 |
| | | **Smallholder dependent** | 53 | 1.73 |
| | | **Smallholder independent** | 93 | 3.07 |
| **Average** | | | | **3.425** |

Source: adapted from Harsono *et al.,* 2011

A study conducted by Harsono *et al.*, 2011 also indicates the total emission by using biodiesel,

which is **2.77 $kgCO_2$-eq/liter**. It means that by considering the land used change (LUC), the consumption of biodiesel will likely increase the net emissions, as the other study conducted by the International Institute for Sustainable Development also suggest that the use of biodiesel will cause net cost on top of the subsidies to society as a result of ILUC (indirect land use changed). (Charles *et al.*, 2013). Therefore, in the cost benefit analysis, the resulting negative environmental effects are monetized as cost per liter biodiesel consumed.

## 5.3 Economic benefits

### 5.3.1 Tax payments generated by biodiesel industries

Tax payments, which are generated by the domestic biodiesel industries, will represent a benefit to the government. The ministry of Energy and Mineral Resources claims that by increasing the biodiesel mandatory to 15 percent will contribute in escalating the tax revenue for the Indonesian government up to IDR 30 trillion (Jati, 2015). However, depending on the growth of the industry and taxes paid, such an amount as mentioned in the newspaper could be changed. It should be noted that little information has been published regarding the taxes paid by biodiesel industries. The biodiesel industries, however, has also used the tax concern as an argument to get a special attention from the government for its expansion.

One method to verify the taxes paid by biodiesel industries is by investigating firm's data and its annual report. The particular type of source often includes profit before and after tax statements. Based on its plant capacity, it can then be calculated the tax paid per biodiesel produced by the company. By repeating the typical method to other biodiesel industries, total taxes paid can then be calculated by multiplying the average tax rate per unit of biodiesel with total annual production. Several hurdles in applying that method was the report of the firms themselves. Not all of them appropriately make the annual report and it was a very confidential data since it will give insights of company's performance. Moreover, certain biodiesel industries in Indonesia had not only biodiesel production but also other core businesses e.g. palm oil production. Thus, their profits before and after tax often apply to the entire company's business scope.

Therefore, based on the aforementioned aspects, the company-level estimates of taxes paid by biodiesel industries cannot be generated. The annual statement and financial reports published by the company are generally not differentiated between taxes paid relating to biodiesel business and other segment of the company. It should be also emphasized that the Indonesian government plan to impose a CPO supporting fund (CSF) that has been legalized in May 2015. It

will mainly used to replanting activity and to subsidize the loss occurred for buying biodiesel. Thus, instead of investigating the tax paid by biodiesel industries, the CBA will use this CSF as the government benefit for developing biodiesel (see section 6.1.2.1)

### 5.3.2 Benefits to palm oil producers

Farmers' income is another important consideration for Indonesian policy makers and thus it is important to understand the aggregate impact of biodiesel development for total feedstock sales from farmers for biodiesel market. Sudirman Said, the Minister of Energy and Mineral Resources also claims that the mandatory biodiesel will also increase the income of palm oil farmers in 32.2 percent. (Jati, 2015).

While not limited to biodiesel development, the director General of Estate Crops claimed that farmers' income have increase from USD 920 per household, per 2 hectares, per year in 2005 to USD 1,607 in 2010. It means that it increased 12.24 percent annually. In terms of plantation area targets, the achievements are difficult to be verified. This has to do with the fact that the main feedstock of biodiesel, the palm oil, is intended for various purposes. While plantations of palm oil have expanded, little information is available about the commitment of specific areas for biodiesel production, or the proportion of the existing feedstock plantation that is devoted for supplying biodiesel industries. Since the demands for expanding palm oil plantation have also been in competition with demands for other purposes, it can be argued that not all palm oil plantations are associated with biodiesel.

In 2006, when various initial policies concerning biofuels were issued, the total are planted with palm oil in Indonesia was about 3.59 million hectares. By 2009, this had increased to 4.5 million hectares (BPS, 2010), an increase of 920,000 hectares in three years. This is similar to the estimated 300,000 hectares annual growth in palm oil plantation claimed by EIA, 2009. The following table indicates the crude palm oil required to meet biodiesel target in Indonesia.

Table 5.11: Crude palm oil required for biodiesel targets in Indonesia

| Year | Production (KL) | CPO used (MT) | Conversion Rate |
|---|---|---|---|
| **2006** | 65,000 | 64,000 | 0.985 |
| **2007** | 270,000 | 265,000 | 0.981 |
| **2008** | 630,000 | 619,000 | 0.982 |
| **2009** | 330,000 | 324,000 | 0.981 |
| **2010** | 740,000 | 727,000 | 0.982 |
| **2011** | 1,800,000 | 1,769,000 | 0.983 |

| | | | |
|---|---|---|---|
| **2012** | 2,200,000 | 2,163,000 | 0.983 |
| **2013** | 2,450,000 | 2,048,000 | 0.983 |
| **Average** | | | 0.9825 |

Source: adapted from Wright and Wiyono (2014). The average of conversion rate shown above assumed that it is required 0.9825 MT to produce 1 kiloliters of biodiesel.

It can be seen from the table above that the physical volume of feedstock used for biodiesel production in Indonesia based on Wright and Wiyono (2014) is 2,048,000 metric tons. However, there is no data available that indicate the distribution of feedstock used for supply biodiesel industries, which make it difficult to determine the net benefit received by palm oil farmers. Thus, the aggregate benefit analysis within the agricultural sector will only be made in biodiesel producers level and by using the yearly average price of CPO during 2006 – 2013 table 6.6 indicates the sales revenue that had been booked by CPO producers during that period.

Table 5.12: Sales revenue booked by CPO producers

| Year | CPO used (MT) | CPO yearly price (USD) | TOTAL |
|---|---|---|---|
| **2006** | 64,000 | 416.81 | 26,675,840 |
| **2007** | 265,000 | 719.12 | 190,566,800 |
| **2008** | 619,000 | 862.92 | 534,147,480 |
| **2009** | 324,000 | 644.07 | 208,678,680 |
| **2010** | 727,000 | 859.94 | 625,176,380 |
| **2011** | 1,769,000 | 1076.5 | 1,904,328,500 |
| **2012** | 2,163,000 | 939.83 | 2,032,852,290 |
| **2013** | 2,048,000 | 764.2 | 1,565,081,600 |

Source: author's calculation based on Wright and Wiyono (2014). The CPO yearly price is based on indexmundi.com.

To summarize, the benefit received by the CPO producers will be different in each policy. In the first Policy, while the Indonesian government does not change their current policy, the selling price of CPO was based on the export price (Harga Patokan Ekspor/HPE). However, on the second and third policies, the CPO supporting fund imposed by the government will eventually increase the benefit of palm oil producers, as they will be more beneficial to sell the CPO for biodiesel domestic consumption. Moreover, as the CPO supporting funds will lead the CPO producers to unfavorably exporting the CPO, there will be an additional benefit for palm oil producers when the price of CPO exceeds US$ 750 due to the loss of VAT they have to pay. The benefit as mentioned above will however be counted as an additional cost for the society since it will reduce the benefit of the government.

### 5.3.3 Employment provided by biodiesel industries

This sections reviews the key issues that are associated with defining and measuring jobs generated by future development of current biodiesel policy as well as the Indonesian government's plan to implement the ne policy to boost biodiesel domestic consumption. The Indonesian government gives the particular attention for potential impacts on employment in developing biodiesel related policy. This has to do with the fact that biodiesel differs from wind and solar renewable energy as they involved energy inputs that are not freely available (in contrast with the wind and solar radiation. Biodiesel representatives claim that an expansion of biodiesel consumption, as what the Ministry of Energy and Mineral Resources have also emphasized, would create direct jobs within the industries and additional jobs in other sectors, such as agriculture. However, despite a job creation concern in Indonesia, which is considerably important objective for supporting the biodiesel mandates, the level of detailed information available on employment effects is currently insufficient.

According to the Minister of Energy and Mineral Resources, Sudirman Said, the additional employment of around 300,000 people was one of the positive consequences resulted by the new biodiesel mandatory. Furthermore, with the changes in biodiesel mandatory, it is expected that the consumption of biodiesel will reach 5.3 million kiloliters (Cahyafitri, 2015). Based on the figure, it can be calculated that the additional consumption of 3.5 million kiloliters will result the multiplier of 0.000057. However, other research conducted to analyze the biofuel policy in several countries in Europe mentioned different multiplier. The following table shows the sample of EU biodiesel facilities, the production capacity and onsite jobs created.

Table 5.13: Sample of biodiesel facilities in European countries, production capacity and onsite jobs.

| Company | Country | Jobs created | Annual production capacity (liters) | Multiplier |
|---|---|---|---|---|
| Futurol (in Pomacle)[1] | France | 12 | 180,000,000 | 0.00000007 |
| Nestle Oil (Rotterdam)[2] | Netherlands | 150 | 907,000,000 | 0.00000017 |
| Argent Energy[3] | UK | 39 | 51,000,000 | 0.00000076 |
| Infinita Renovables (Castellon)[4] | Spain | 75 | 679,000,000 | 0.00000011 |
| Infinita Renovables (Ferrol)[5] | Spain | 60 | 339,000,000 | 0.00000018 |
| Average biodiesel multiplier | | | | 0.00000026 |

Source: adapted from Charles et al. (2013). [1]Futurol, 2011; [2]Nestle Oil, 2011; [3]Argent Energy, 2011; [4]Infinita Renovables, 2011; [5]Infinita Renovables, 2011

To confront with the above result, a study that has been done by Center for International Forestry Research (CIFOR) based on the data from the National team for Biofuel Development

proved other substantial differences regarding direct and indirect employment within biodiesel industries. Based upon a study, the paper points that in 2010, the production of biodiesel reached about 6,000,000 tones (equal to 7,400,000 KL) of biodiesel and it will employ 750,000 direct labors and 1,167 indirect labors. With this figure, it can be then concluded that the multiplier is 0.00010. This substantial difference may be occurred due to a labor intensive in Indonesian industry compared to European.

Thus, by using the multiplier 0.00010 (see above), an estimate for the number of jobs at biodiesel plants as well as the other indirect labors for other supporting sectors was generated. The number of onsite jobs is estimated at 537,998 for 5.3 million kiloliters installed capacity of biodiesel industries as targeted by the government. Using this figure for on-site jobs created by biodiesel refineries facilities multiplied by a gross salary between IDR 1,060,005 and IDR 1,762,073 (see table 6.8) equates to the sector spending between IDR 570 billion and IDR 948 billion. This value is equal to USD 43.85 million and USD 73 million respectively and will be counted as an additional benefit for Indonesian society.

Table 5.14: Minimum regional salary range in Sumatra and Kalimantan in 2013

| Province | Minimum reginal salary |
|---|---|
| West Kalimantan | 1,060,000 |
| South Kalimantan | 1,337,500 |
| Middle Kalimantan | 1,553,127 |
| East Kalimantan | 1,762,073 |
| Nangroe Aceh Darussalam | 1,550,000 |
| North Sumatra | 1,305,000 |
| West Sumatra | 1,350,000 |
| Kepulauan Riau | 1,365,087 |
| Jambi | 1,300,000 |
| Bangka Belitung | 1,265,000 |
| Bengkulu | 1,200,000 |
| **Average minimum regional salary** | **1,398,779** |

### 5.3.4 Reduced consumption on fossil fuel

One of the main purposes in developing biodiesel for domestic consumption is to reduce dependency of fossil fuels. In the "Indonesia Energy Outlook 2014" paper, which prepared by the Center for Energy Resources Development Technology of *Agency for the Assessment and Application of Technology* (Badan Pengkajian dan Penerapan Teknologi / BPPT), there are

various projections concerning the demand and supply of biodiesel as well as other energy sources available to illustrate the uncertainty that exists around the industry size, level of production and exports. Moreover, the quantity of fossil diesel consumption that will be offset by the consumption of biodiesel is examined by analyzing the Handbook of energy and Economic statistic of Indonesia, which was prepared by the Ministry of Energy and Mineral Resources. Table 6.8 shows the consumption of biodiesel in different sectors during 2000 – 2013.

Table 5.15: Energy consumption in different sector in Indonesia (kiloliters)

| Year | Industrial sector | Commercial Sector | Transportation sector | | | Others |
|---|---|---|---|---|---|---|
| | ADO | ADO | Solar 51 | ADO | Bio-Solar | ADO |
| 2000 | 5,729,941 | 825,064 | | 9,365,288 | | 2,906,942 |
| 2001 | 6,082,584 | 875,842 | | 9,941,771 | | 3,085,847 |
| 2002 | 5,985,416 | 861,851 | | 9,782,952 | | 3,036,551 |
| 2003 | 5,764,971 | 830,108 | | 9,422,642 | | 2,924,714 |
| 2004 | 6,626,385 | 954,145 | | 10,830,594 | | 3,361,731 |
| 2005 | 6,155,112 | 886,286 | | 10,060,316 | | 3,122,642 |
| 2006 | 5,399,470 | 777,479 | 1,344 | 8,826,588 | 217,048 | 2,739,286 |
| 2007 | 5,208,388 | 749,965 | 1,288 | 8,514,215 | 877,457 | 2,642,345 |
| 2008 | 5,735,356 | 825,844 | 1,289 | 9,374,239 | 931,179 | 2,909,690 |
| 2009 | 6,349,977 | 914,345 | 1,955 | 10,378,815 | 2,398,234 | 3,221,502 |
| 2010 | 6,663,702 | 959,518 | 4,434 | 10,891,587 | 4,393,861 | 3,380,662 |
| 2011 | 5,627,864 | 810,366 | 6,392 | 9,198,546 | 7,180,806 | 2,885,156 |
| 2012 | 5,761,786 | 829,650 | 12,297 | 9,417,437 | 9,269,482 | 2,923,098 |
| 2013 | 5,181,580 | 796,105 | 23,053 | 8,469,110 | 10,934,294 | 2,628,745 |

Source: Handbook ESDM, 2014. ADO stands for the Automotive Diesel Oil; Bio-Solar is the brand product of PT. Pertamina, the State-Oil company, which contains the blended fossil fuel and biodiesel

The table above illustrates that the development of biodiesel shown by a higher consumption of bio-solar will directly reduce the consumption of ADO in the transportation sector. In order to estimate the level of fossil fuel import that can be reduced, the following table compiles the consumption of fossil fuel diesel and biodiesel during 2006 – 2013. Based on the historical consumption, the extrapolation formula can then be applied for each possible Policy based on the future policy alternatives. It is expected that biodiesel domestic consumption will increased to 5.3 million kiloliters in 2024 for the first Policy, and 6.8million kiloliters and 13.5 million kiloliters for second and third policies respectively. In the CBA, it is assumed that one liter of fossil-diesel (ADO) would cost US$ 0.8.

In Indonesia, the indigenously produced biodiesel displacing the imported petroleum products could provide the opportunity for improving the country's level of energy self-sufficiency. This would be the case since the raw materials were mostly produced in Indonesia. However, other concern in promoting biodiesel development in Indonesia will be the social and environmental effect, which has been thoroughly discussed in the previous section.

# 6. Result, discussion and evaluation

## 6.1 Introduction

This chapter aims to discuss the result of CBA based on the effects of each scenario discussed in the previous paragraph with regards to cost and benefit. It should be noted that there are assumptions as well as projections needed in CBA, which is further discussed in the first section of the chapter. Afterwards, the result of CBA by using the macro assumptions and various forecasting method are then presented. A sensitivity analysis will also be conducted to mainly analyze what impacts will occur in biodiesel development in Indonesia, given the changes of future uncertain variable changes. Lastly, this section will also present the distribution of cost and benefit among stakeholders within biodiesel system as well as the evaluation of the applicability of CBA, which is the keystone of this paper.

## 6.2 Assumptions and estimation used for CBA

### 6.2.1 Future energy demand

Table 6.1: Production of Biodiesel

| Year | Production (Kilo liters) | | |
|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 3 |
| 2006 | 65,000 | 65,000 | 65,000 |
| 2007 | 270,000 | 270,000 | 270,000 |
| 2008 | 630,000 | 630,000 | 630,000 |
| 2009 | 330,000 | 330,000 | 330,000 |
| 2010 | 740,000 | 740,000 | 740,000 |
| 2011 | 1,800,000 | 1,800,000 | 1,800,000 |
| 2012 | 2,200,000 | 2,200,000 | 2,200,000 |
| 2013 | 2,450,000 | 2,450,000 | 2,450,000 |
| 2014 | 3,650,000 | 3,650,000 | 3,650,000 |
| 2015 | 4,216,667 | 4,234,000 | 4,307,000 |
| 2016 | 4,941,667 | 4,911,440 | 5,082,260 |
| 2017 | 5,666,667 | 5,697,270 | 5,997,067 |
| 2018 | 6,391,667 | 6,608,834 | 7,076,539 |
| 2019 | 7,116,667 | 7,666,247 | 8,350,316 |
| 2020 | 7,841,667 | 8,892,847 | 9,853,373 |
| 2021 | 8,566,667 | 10,315,702 | 11,626,980 |
| 2022 | 9,291,667 | 11,966,214 | 13,719,836 |
| 2023 | 10,016,667 | 13,880,809 | 16,189,407 |
| 2024 | 10,741,667 | 16,101,738 | 19,103,500 |

Source: 2006 - 2013: Wright and Wiyono, 2014
2014 - 2024: Author's calculation

There are number of assumptions and forecasting methods used in calculating the growth of future energy demand. It will be distinguished based on the scenario since each policy alternative will give a particular impact on the energy being consumed in Indonesia. In zero alternatives, the growth of fossil fuel energy demand during 2000 – 2013 as written in the Handbook of energy and Economic Statistic of Indonesia (2014), will be used in forecasting its future demand. The projection method will also be used in second and third scenarios. In addition, the growth of biodiesel domestic consumption during 2006 – 2014 is thoroughly explained by Wright and Wiyono, 2014 in GAIN (Global Agricultural Information Network).

Furthermore, in the second scenario, the growth of biodiesel production and the export are expected to increase by 16% and 13% respectively, as forecasted by the Energy outlook of Indonesia, 2014. In the last scenario, where the Indonesian government regulates the market intensively, the growth of biodiesel industries will be more promising. It is therefore expected that the production of biodiesel and its exported level will increase by 18% and 15% respectively as also forecasted by the Energy outlook of Indonesia, 2014. Table 6.1 and 6.2 summarized production and export of biodiesel respectively. The forecast, which is based on the secondary data, is conducted to enhance the validity and reliability of the case study by means of multiple sources of evidence.

Table 6.2: Export of Biodiesel

| Year | Export (Kilo liters) | | |
|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 3 |
| 2006 | 33,000 | 33,000 | 33,000 |
| 2007 | 257,000 | 257,000 | 257,000 |
| 2008 | 610,000 | 610,000 | 610,000 |
| 2009 | 204,000 | 204,000 | 204,000 |
| 2010 | 563,000 | 563,000 | 563,000 |
| 2011 | 1,440,000 | 1,440,000 | 1,440,000 |
| 2012 | 1,515,000 | 1,515,000 | 1,515,000 |
| 2013 | 1,356,000 | 1,356,000 | 1,356,000 |
| 2014 | 1,560,000 | 1,560,000 | 1,560,000 |
| 2015 | 1,875,139 | 1,762,800 | 1,794,000 |
| 2016 | 2,082,656 | 1,991,964 | 2,063,100 |
| 2017 | 2,290,172 | 2,250,919 | 2,372,565 |
| 2018 | 2,497,689 | 2,543,539 | 2,728,450 |
| 2019 | 2,705,206 | 2,874,199 | 3,137,717 |
| 2020 | 2,912,722 | 3,247,845 | 3,608,375 |
| 2021 | 3,120,239 | 3,670,065 | 4,149,631 |
| 2022 | 3,327,756 | 4,147,173 | 4,772,076 |
| 2023 | 3,535,272 | 4,686,305 | 5,487,887 |
| 2024 | 3,742,789 | 5,295,525 | 6,311,070 |

Source: 2006 - 2013: Wright and Wiyono, 2014
2014 - 2024: Author's calculation

### 6.2.2 Future energy price

Energy prices are fluctuated during the previous decade. This is one of the aspects that Indonesian government concerns most besides the energy security. As the energy prices drop significantly in 2006 was the main reason for the Indonesian government to revise its energy policy direction. Additionally, high crude oil prices, which eventually increase the government subsidy, was also one of the cause of the state trade deficit and become the main driver for promoting a biodiesel development in Indonesia. A handbook of Energy, which is prepared by the Ministry of Energy and Mineral Resources, can be used as a reliable secondary data to illustrate the fluctuated prices. However, it is still difficult to predict future fuel oil prices due to a high level of uncertainty. In this study, a prediction made by the World Bank is therefore chosen in CBA. Moreover, regarding the fuel energy consumption, i.e. ADO, it is expected that in 2024, Indonesia will consume more than 47 million kiloliters of fossil diesel. Table 6.3 will briefly illustrate the forecasting fossil diesel consumption in Indonesia during 2014 – 2024.

Table 6.3: Fossil diesel demand during 2014 – 2024

| Year | DIESEL Consumption incl. FAME (Kilo liters) | | | |
|---|---|---|---|---|
| | Transportation | | Industrial | Electricity |
| | ADO | BioSolar | ADO | ADO |
| 2000 | 9,365,288 | - | 5,729,941 | 3,141,917 |
| 2001 | 9,941,771 | - | 6,082,584 | 3,575,348 |
| 2002 | 9,782,952 | - | 5,985,416 | 4,625,521 |
| 2003 | 9,422,642 | - | 5,764,971 | 5,024,362 |
| 2004 | 10,830,594 | - | 6,626,385 | 6,299,706 |
| 2005 | 10,060,316 | - | 6,155,112 | 7,626,201 |
| 2006 | 8,826,588 | 217,048 | 5,399,470 | 7,586,916 |
| 2007 | 8,514,215 | 877,457 | 5,208,388 | 7,874,290 |
| 2008 | 9,374,239 | 931,179 | 5,735,356 | 8,127,546 |
| 2009 | 10,378,815 | 2,398,234 | 6,349,977 | 6,365,116 |
| 2010 | 10,891,587 | 4,393,861 | 6,663,702 | 6,887,455 |
| 2011 | 9,198,546 | 7,180,806 | 5,627,864 | 8,943,880 |
| 2012 | 9,417,437 | 9,269,482 | 5,761,786 | 6,625,335 |
| 2013 | 8,469,110 | 10,934,294 | 5,181,580 | 6,291,667 |
| 2014 | 9,324,669 | 11,903,439 | 5,704,905 | 8,475,298 |
| 2015 | 9,287,252 | 13,543,027 | 5,682,012 | 8,757,764 |
| 2016 | 9,249,836 | 15,182,614 | 5,659,118 | 9,040,230 |
| 2017 | 9,212,419 | 16,822,202 | 5,636,224 | 9,322,695 |
| 2018 | 9,175,003 | 18,461,789 | 5,613,330 | 9,605,161 |
| 2019 | 9,137,586 | 20,101,377 | 5,590,436 | 9,887,627 |
| 2020 | 9,100,170 | 21,740,965 | 5,567,542 | 10,170,093 |
| 2021 | 9,062,753 | 23,380,552 | 5,544,648 | 10,452,559 |
| 2022 | 9,025,336 | 25,020,140 | 5,521,754 | 10,735,024 |
| 2023 | 8,987,920 | 26,659,727 | 5,498,861 | 11,017,490 |
| 2024 | 8,950,503 | 28,299,315 | 5,475,967 | 11,299,956 |

Source: Handbook energy of Indonesia (2014) and author's calculation

### 6.2.3 Discount rate and other conversion analysis

In 2015, the minster of Finance presented changes in macro assumptions in the draft of Revised State Budget (APBN-P) 2015. This draft has been agreed by the government and the working committee (Panitia Kerja / Panja) A of House of Representative (DPR). It was presented in a working meeting with the Budgetary Board of DPR to establish temporal posture in the APBN-P 2015. According to the macro assumption, it is expected that an economic growth will reduce to 5.7 percent. The government and DPR also agree to weaken the exchange rate of Rupiah at IDR 12,500 per US Dollar.

Moreover, as mentioned in the theoretical perspective, the outcome of CBA must be discounted over time. Bank of Indonesia will charge an interest rate to commercial banks and other depository institutions for loan received from BI discount window. Thus, a discount rate also refers to the interest rate used in discounted cash flow (DCF) analysis to determine the present value of future cash flows. Mostly, the discount rate takes into account not just the time value of money, but also the risk or uncertainty of future cash flows. According to Bank Indonesia (2015), the discount rate applied until recently was 7.50 percent.

In this paper, it will be assumed that one metric ton of crude palm oil (CPO) is equal to 1.085 liter of CPO. It is based on the density of crude palm oil, which is 0.9210 gram/ml at $15^0$C [1]. There are researches that have been conducted in order to analyze the yield of FAME in trans-esterification process. On one hand, Fei and Teong, 2008 claims that as optimum FAME yield of 83.3 percent can be obtained by using sulphated zirconia alumina as a potential heterogeneous catalyst for the production of FAME from palm oil. On the other hand, Alkabbashi *et al.,* 2009 in their optimization research, had already enhanced the biodiesel production and achieved the best possible yield, which was 93.6 percent of crude palm oil conversion. By having this range of yield, it can be concluded that the conversion rate suggests that one metric ton of CPO will yield from 904 to 1,014 liters of FAME, which the maximum yield will thus be used in CBA.

## 6.3 CBA result and discussion

In this section, the result of CBA is summarized. The impacts on each policy to net social benefit are presented in Table 6.4. Furthermore, further result of CBA in different scenarios will be thoroughly provided in the appendixes. Based on the price structure of biodiesel mentioned in Table 5.3 in chapter 5, one may say that the employment benefit should not be quantified since it has been included in the operational cost structure. However, concerning the policy making process and its impact analysis, that effect will indeed be relevant to be quantified. This will be valid also for monetizing deforestation as well.

[1] Ullmann's encyclopedia of industrial chemistry, Volume A 10, Fats and oils, VCH, Weinheim 1995

Table 6.4: The result of CBA (billion IDR)

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 26,478.08 | Total | 378,062.89 | 337,065.05 |
| **Net loss / benefit** | **- 5,301.19** | | **Net loss / benefit** | **- 40,997.84** | |

Source: Author's calculation

Based on the result of CBA, several analyses can be made to understand the impact of current and future policies within biodiesel system. According to the CBA aggregate summary, it can be seen that future policies in implementing the new mandates as well as regulating the pricing formula will result a higher net loss for the society. The benefit attained by the society in reducing the imported fossil diesel is not enough to compensate the cost occurred in policy implementation. Although the projected performance from all of the policies' effect is truly dismal, the Indonesian government has been instead implemented the policies. The questions why can be then asked. The reason for this is much clearer when the results of the distributive analysis are taken into account. While the projected net benefits for the society are negative, this study find that the stakeholders involved in this project are receiving substantial and positive net benefit, which is shows in table 6.7 – 6.8

Furthermore, the outcome of CBA can also illustrate that by imposing the CPO supporting fund (CSF), the government will get an additional cost due to its loss in both the levy and the VAT. The former cost has to do with the fact that increasing the consumption of CPO for biodiesel will result the opportunity cost of the government since a levy cannot be imposed for this particular outlet. Moreover, by imposing the levy, the CPO producers will prefer not to export their product and therefore the policy can hopefully escalate CPO price more than US$ 750 per metric ton as planned by the government due to the decrease in CPO supply in the market. In addition, imposing a levy, as described in the second and third policy alternatives will also increase the cost of the Indonesian government concerning the VAT received when the CPO prices exceed US$ 750. The government, however, has already made a rational decision since imposing a levy on CPO and its derivatives product, while on one hand will decrease its revenue within biodiesel market, but on the other hand, it will be beneficial for the state's account due to a higher

national income contributed by palm oil export.

## 6.4 Distribution of cost and benefit among stakeholders

As already emphasized earlier in the introduction that it is also important to take the distribution effects into account, which is also a key feature for political decision-making. This has to do with future possible resistance by the net losers for the upcoming policy when the aforesaid policy will be beneficial for the others. Thus, in this section, multiple stakeholders groups are distinguished and the analysis concerning the distribution of the welfare is conducted.

### 6.4.1 Government perspective

During this study, the Indonesian government is one of the important stakeholders since it regulates several aspects related to biodiesel. As the fuel market has been highly related to the tax, changes within the fuel market as well as biodiesel will influence the net benefit of the government. Based on the case study, it is expected that the Indonesian government can get an additional benefit by imposing a levy on the exported palm oil derivatives product. This will be allocated to support the biodiesel industries and compensate the government's expenditure.

Table 6.5: Welfare distribution in Government perspective (billion IDR)

| **NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT** | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

Source: author's calculation

Table 6.6 presents the effect of different adoption rate of biodiesel on the government's perspective. By imposing the levy and increasing the consumption of biodiesel, the Indonesian government will experience the opportunity cost by a loss of CSF and VAT loss on both the exported palm oil and imported crude oil. However, the government will gain its benefit from a decrease subsidy of fossil diesel and an addition levy for biodiesel exported. Furthermore, the

Indonesian government, as expected prior to this study, loses a considerable amount of tax income when the adoption rate of biodiesel is high. That can be considered as the cost to be paid by the government in order to increase the energy security within the nation and reduce the environmental effect. It should be noted that the Indonesian government, by this analysis, could impose other new tax sources, which is indeed not included in this study.

### 6.4.2 Biodiesel industries perspective

According to the case study, biodiesel producers are the actors who cannot fully influence the Indonesian government to change biodiesel related policy in Indonesia. This has to do with the fact that the new policy, which was regulated by the government in 2015, was initially driven by the weaken exchange rate of Rupiah and the decrease of palm oil price. However, as the mandates of the government was not achieved due to underutilized capacity of biodiesel refineries and the oversupply of palm oil in the market, the government has to eventually increase its support for this particular industries.

Table 6.6: Welfare distribution in biodiesel industries (billion IDR)

| **NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES** | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | - | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 505,279.46 |
| Total | 59,825.25 | 111,492.81 | Total | 469,564.84 | 540,824.48 |
| **Net loss / benefit** | **51,667.56** | | **Net loss / benefit** | **71,259.64** | |

Source: author's calculation

Table 6.7 illustrates how the additional subsidies as well as the new pricing formula and a new levy on exported palm oil can eventually increase the net benefit for biodiesel producers. The table describes that the revenue in selling FAME / biodiesel will be higher if the government adopt the second policy. The third policy will ultimately increase the net benefit by taking an economic scale into account, as the more biodiesel industries produce, the higher their profit will be.

### 6.4.3 Palm oil producers perspective

The palm oil producers will also gain some profit based on the implementation of second and

third policy alternatives. With current policy's implementation, palm oil producers will gain some loses due to a higher production cost compared to the CPO selling price. It is indeed the main reason of the Indonesian government in implementing the future policies in order to escalate the palm oil prices. The effect of future policy is that the palm oil producers get a substantial benefit due to the increasing price of palm oil. The loss of CPO supporting fund that was experienced by the government, is indeed transferred to the palm oil producers. However, this argument cannot be used to generalize final conclusion that palm oil producers are the net winners since they were imposed by a levy for the other exported CPOs.

Table 6.7: Welfare distribution in palm oil producers (billion IDR)

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | - | 16,161.81 | Loss on CPO supporting fund | - | 38,244.85 |
| VAT loss on exported palm oil | - | 2,295.67 | VAT loss on exported palm oil | - | 25,880.63 |
| Palm oil selling price | - | 42,627.53 | Palm oil selling price | - | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

Source: author's calculation

## 6.5 Sensitivity analysis

As stated previously, there are number of assumption used in CBA. In order to get deeper understanding concerning the main drivers of biodiesel development, a sensitivity analysis needs to be executed. Not only several critical aspects such as palm oil and crude oil prices as the uncertain value that beyond the Indonesian government's control, but also the pricing formula of biodiesel is one of the criteria in analyzing future uncertainty.

Table 6.8: Sensitivity analysis (billion IDR)

**Sensitivity analysis (IDR billion)**

| | Policy I impact | | | | Policy 2 impact | | | |
|---|---|---|---|---|---|---|---|---|
| | **Society** | **G.O.I** | **B.I** | **P.O.P** | **Society** | **G.O.I** | **B.I** | **P.O.P** |
| CBA result in business as usual (BAU) | - 5,301.19 | - 22,047.63 | 51,667.56 | 37,484.38 | - 40,997.84 | - 49,305.77 | 71,259.64 | 136,049.19 |
| Regulated pricing formula increase 25% | - 5,301.19 | - 22,047.63 | **66,206.41** | 37,484.38 | - 40,997.84 | - 49,305.77 | **105,663.94** | 136,049.19 |
| Regulated pricing formula decrease 25% | - 5,301.19 | - 22,047.63 | **37,128.72** | 37,484.38 | - 40,997.84 | - 49,305.77 | **36,855.34** | 136,049.19 |
| Palm oil prices growth increase 25% | - 5,301.19 | **- 23,278.22** | **48,434.12** | **41,948.41** | - 40,997.84 | **- 56,491.19** | **64,845.69** | **159,150.84** |
| Palm oil prices growth decrease 25% | - 5,301.19 | **- 20,844.24** | **54,835.40** | **33,113.15** | - 40,997.84 | **- 42,419.71** | **77,241.98** | **113,869.03** |
| Crude oil prices growth increase 25% | **- 2,721.92** | **- 22,533.43** | **35,628.08** | 37,484.38 | - 16,557.52 | **- 43,480.19** | **48,041.51** | 136,049.19 |
| Crude oil prices growth decrease 25% | **- 7,270.65** | **- 21,679.35** | **64,124.82** | 37,484.38 | - 60,008.32 | **- 53,852.79** | **89,296.09** | 136,049.19 |
| Investment cost increase 25% | **- 6,537.53** | - 22,047.63 | **50,431.22** | 37,484.38 | **- 42,966.97** | - 49,305.77 | **69,290.51** | 136,049.19 |
| Investment cost decrease 25% | **- 4,064.85** | - 22,047.63 | **52,903.90** | 37,484.38 | **- 39,028.71** | - 49,305.77 | **73,228.77** | 136,049.19 |
| Operational cost increase 25% | **- 7,107.39** | - 22,047.63 | **50,897.83** | **36,447.91** | **- 65,915.17** | - 49,305.77 | **60,640.88** | **121,750.62** |
| Operational cost decrease 25% | **- 3,495.00** | - 22,047.63 | **52,437.29** | **38,520.85** | **- 16,080.50** | - 49,305.77 | **81,878.40** | **150,347.76** |

Source: Author's calculation

Table 6.5 indicates the results of the sensitivity analysis in which changes in multiple variables and their effect on the outcome of CBA are examined. From the analysis, it can be argued that all effects have a predictable effect on the outcome to each stakeholder, yet the degree of effect varies.

As stated in the previous chapter of this study that the Indonesian government has just renewed the pricing formula for biodiesel, which directly affect the selling price of biodiesel producers. However, it can be seen that future policies of the Indonesian government in revising pricing formula in order to increase biodiesel domestic consumption and palm oil prices will not affect the net social benefit. This has to do with the fact that changes in pricing formula on one hand may be beneficial for biodiesel industries, but on the other hand will cost the other stakeholders e.g. oil distribution companies.

Furthermore, changes in crude oil prices based on the sensitivity analysis's outcome have an impact in the aggregate welfare of society. An increase of 25% of crude oil prices will substantially increase the welfare by more than 50%, and a decrease of 25% crude oil prices will reduce the net benefit by 47%. In addition, the result also indicates that a decrease of crude oil prices will make biodiesel development oriented policies are less beneficial since most of biodiesel will be used to mainly reduce a consumption of fossil diesel.

The worth of biodiesel policy will also be influenced by the changes in both investment and operational cost. While on one hand investment costs depend highly on how the Indonesian government regulates the investment policy to favor private enterprise in investing their financial resources, the operational costs on the other hand depend highly on how stakeholders involved within the system can simultaneously increase their productivity and at the same time align their perception on how biodiesel can reduce their country's reliance on fossil fuel. As shown in the table, an increase of the investment cost by 25% will affect the net benefit by at least 5%. It is relevant since the investment cost does not play a significant role in biodiesel total production cost. However, the net social benefit will be significantly affected by changes in the operational cost. An increase by 25% in the operational cost will affect more than 30% of net social benefit.

In sum, this sensitivity analysis has given what variable and to what extent it will affect the net aggregate benefit. Sensitivity analysis is also an appropriate approach when discussing the most preferable policy for each stakeholder within biodiesel system. Therefore, it is wise to use the sensitivity analysis to analyze what should be done for the policy maker within the system to

eventually address the most possible and applicable policy based on the impact it will contribute.

## 6.6 Evaluation

### 6.6.1 The result of cost-benefit analysis

The result of CBA shows that the government future policies may result a higher net benefit distributed among particular stakeholders within biodiesel system in Indonesia, i.e. palm oil producers and biodiesel industries. This is indeed still limited due to the fact that there are some effects that cannot be quantified or monetized such as deforestation rate. The author also identifies that the distribution of government's subsidy as another constraint in determining the net social benefit within the system. Furthermore, due to the scope limitation of this research, it can be argued that the result of CBA can only illustrate the upstream system of biodiesel implying that it cannot describes the net social benefit of other stakeholders such as the consumer of biodiesel.

Furthermore, the result of sensitivity analysis can be also used to determine the influencing factors of biodiesel development in Indonesia. For instance, the pricing formula, which has been currently criticized and changed by the Indonesian government, can directly increase the wealth of biodiesel producer who had been previously reluctant in producing biodiesel. However, changes the pricing formula will not influence the aggregate benefit in CBA. Increasing the palm oil prices, as previously illustrated in the case study, will also not influence the net social benefit in the CBA. Indeed, the result addresses several problematical concerns that need to be further analyzed by policy makers towards a more reliable and sustainable biodiesel related policies development. Another implication based on the result of CBA is that the government intervention within the fuel market in Indonesia can reduce income inequality within the system. However, further research is still needed to verify this argument since the application of CBA in the downstream market is not part of this research.

Therefore, by relying on the result of CBA, this study shows that there is mismatch between the main concerns of Indonesian government's future policy with the aggregate benefit it causes. Changing the pricing formula and paying considerably attention to the palm oil price will not give the effect on net social benefit. In addition, those aspects will only increase the welfare of biodiesel industries and palm oil producers, which were claimed by many environmentalists, can to some extent worsen the deforestation rate, which in an alarming rate.

### 6.6.2 The applicability assessment of cost-benefit analysis

This study will also clarify the applicability of using CBA in analyzing policy changes of biodiesel development in Indonesia. The theoretical framework proposed in this study has confirmed that cost-benefit analysis is suitable for this particular case study. First, the basic principle of cost-benefit analysis can be sufficiently applied in this case, since the consumer sovereignty is respected and willingness-to-pay is accepted as the basic criterion of value and welfare maximization is counted as the main objective of analysis.

Furthermore, the case study regarding biodiesel development and issue has been arising, which has been thoroughly described in chapter three, is also regarded as one that does not concern with the invaluable goods e.g. human rights etc. It can be also regarded, as it is not an issue to determine the justice of income distribution or any scarce goods since the supply of palm oil, as a major feedstock of biodiesel, has tremendously grown from year to year. The biodiesel development issue in Indonesia can be regarded since it focused on, to some extent, a general equilibrium analysis. This is particularly different with the policy fairness since the analysis will be based on how the policy can equally distribute the income and not how fair the income has been distributed.

With regards to the policy objective, a cost-benefit analysis is also suitable in the case study since the Indonesian government has already stated clearly what the policy objectives are. The proposed policies, as mentioned in chapter three, have sufficiently stated the objectives. While the main purpose of current policy is to promote biodiesel as the new renewable energy sources that play an important role in reducing fossil diesel import and increasing the energy security, the future policy is mainly regulated to increase the palm oil prices and increase the exchange rate of Rupiah. Despite the changes in the policies' objectives, a cost-benefit analysis was applicable to illustrate how changes in certain variables, which need to be specific, measurable and attainable, can eventually change the aggregate welfare for Indonesian society.

The programs that have been ruled by the government can also be developed, which is shown by several policy programs that have been regulated by the Indonesian government during 2015. Specifically, by implementing the policy to increase biodiesel mandatory to 15% from 10%, the Indonesian government needs to increase the subsidy and at the same time regulate the pricing formula and impose the new levy for palm oil producers. The outcome of this cost-benefit analysis can also be quantified, which is useful to determine the net welfare of certain policy. However, the outcome of CBA is not necessarily useful in analyzing which policies is more preferable but to sustain the implementation of future policies and provide a clear signal

of the groups which are likely to promote and those who will not favor a project.

Furthermore, based on the assessment criteria that have been developed in chapter two, this study can clarify the following applicability assessment. First, cost-benefit analysis has confirm that the policy changes, which had been implemented by the Indonesian government early in 2015, are expected may decrease the net social benefit as well as net benefit for the Indonesian government. However, cost-benefit analysis shows that the policy changes will eventually increase the net benefit for both palm oil producers and biodiesel industries. Thus, it is important for the Indonesian government to take this stakeholder's benefit distributive analysis into account for higher policy compliance. In addition, CBA application in the case study can give a misleading conclusion due to the fact that one of the stakeholders within the biodiesel system is also part of the other system. This is the case when examining the net welfare for palm oil producers. While they experience considerable loses in CPO export caused by the CPO supporting fund, they will be benefited within the biodiesel system.

Second, the application of cost-benefit analysis can to some extent be useful for examining the effect of future uncertainty. By the sensitivity analysis, it was clear that on one hand, the changes in palm oil prices would not impact the net social benefit. The current policy, increasing biodiesel mandates to reduce palm oil supply and eventually increase the price, will be a controversial policy since CPO has been widely used for food. On the other hand, the uncertainty of crude oil prices will influence the net social benefit.

Third, cost-benefit analysis can also be applied in clarifying the influencing factors for future development of biodiesel. Changes in the operational cost can significantly affect the net social benefit, which means that focusing on cost reduction policies will increase the net social benefit. This is similar to the statement of the Institute for Development of Economics and Finance's (INDEF) executive director, Enny Sri Hartati. She argued that output subsidy for biodiesel is not an effective policy. According to Hartati, subsidize the productive infrastructure can ultimately reduce the operational cost of biodiesel producers. This study also argues that it is important for the Indonesian government to take the production cost factors into considerations in developing biodiesel in Indonesia and aligning its future policy's concern.

Consequently, based on the application of cost-benefit analysis, this study can give new insights concerning other favorable and desirable policies for biodiesel industries. The highlighted area in the sensitivity analysis illustrates explicitly the impact on each policy to different stakeholders in biodiesel. For example, while focusing on pricing formula and increasing the

subsidy will be exclusively beneficial for biodiesel industries and increase the adoption rate of biodiesel, such policies will also problematical not only because of the negative impact it may cause e.g. deforestation but also no impact it will cause to the society. Based on that, the government planners need to ensure that any current or future expansion of plantations for biofuel feedstock is on barren land. This will help alleviate environmental concerns in key buyer markets and will loosen the restrictions, which are increasingly being imposed in the form of environmental safeguards. Scrapping the fix subsidy for fossil diesel will also be a desirable policy in increasing the competitiveness as well as the adoption rate of biodiesel. Yet, it needs to be carefully implemented due to the political and economical stability in Indonesia.

The application of cost-benefit analysis may also give other insights. Changes in crude oil prices, as pointed out previously, can be used to guide the Indonesian government in implementing a more desirable and appropriate policy. When the crude oil prices decrease, for instance, the more Indonesian government promotes biodiesel, the higher loss the society will experience. It can be simply seen that the benefit by reducing crude oil imports and subsidy will not sufficiently compensate the cost of biodiesel production. A higher crude oil price will indeed give a significant added value for the net social benefit. Another concern is that the crude oil price changes have been proportionally correlated with palm oil prices changes. Yet, it is not an issue since palm oil price changes, based on CBA, will not influence the net social benefit.

A cost-benefit analysis can be used to partially structure the problems occurred within biodiesel development in Indonesia. First, the previous biodiesel policy was indeed not favorable for biodiesel industries and future policies will increase the net benefit of biodiesel industries. Those are indeed crucial in promoting biodiesel domestically. However, that future policies are expected to decrease the net social benefit clarifies the stakeholder's orientation policies of the Indonesian government, rather than the society. Second, in addition to the aforesaid argument, the application of CBA in this case study also indicates that a reduction in the operational cost will be crucial in increasing the net welfare for the society. Third, the fact that the palm oil price changes will not only influence the net benefit of certain stakeholder's but also result a higher volatility of biodiesel operational cost, will sufficiently inform the Indonesian government to further develop other types of biodiesel instead of palm oil. Therefore, those insights can be used to give fundamental recommendation concerning future policy. With regards to welfare maximization and biodiesel sustainable development, it is important for the Indonesian government to focus on the crude oil price and at the same time implement biodiesel pricing formula based on CPO, cost reduction oriented policies, CPO pricing formula for domestic consumption (see chapter four) and develop the next generation of biodiesel to altogether

increase the adoption rate of biodiesel as well as the net welfare of society.

## 6.7 Conclusion

This chapter has been made to mainly deliver the result of CBA of biodiesel related policy changes in Indonesia. Several assumptions were made prior to the analysis in order to increase the accountability of the study. The assumption used in this study was based on the macro assumption used by the Indonesian government. Based on the outcome, it can be concluded that the policy made by the government was beneficial for both palm oil producers and biodiesel industries. However, the policy will cost substantially the Indonesian government as the need for the energy security supply.

Moreover, a sensitivity analysis made in this chapter can examine how changes in different variable will affect differently the net welfare of the society. It should be noted that the crude oil prices volatility demand higher attention of the government since it would impact the society significantly. A sensitivity analysis has also an added value, as it can address what policy is more preferable to each stakeholder within the system. CBA might also have some misleading conclusions due to the data limitation concerning government's subsidy allocation and distribution of biodiesel consumption. In addition, the fact that there is some stakeholders stand for more than one system will probably result a misleading conclusion. Palm oil producers will be a relevant case since they are substantially benefited within the biodiesel system but they were also suffered within the other system i.e. palm oil export.

A cost-benefit analysis can be used to determine several issues. First, future policies will result a higher net loss for the society but increase the welfare of certain stakeholders. Second, CBA can be used to determine the effect of future uncertainty and what are the influencing factors that need to be taken into consideration. Third, CBA is also applicable in determining future applicable and desirable policies for biodiesel industries. Lastly, CBA can give new insight in dealing with future uncertainty as the crude oil prices will influence the net social benefit, while palm oil price will not. That can also give several future policy recommendations.

# 7. Conclusion and recommendation

This part of the study will mainly sum up what has been done and what are key findings with regards to the applicability of cost-benefit analysis in biodiesel case study and policy changes in Indonesia. In chapter 2, this study has discussed the theoretical perspective to build the overall framework, which can be used to present basic steps of an approach that enriches traditional economic analysis by focusing on the stakeholders within biodiesel system. In chapter three and chapter four, this paper has already illustrated and examined the suitability of basic framework of traditional cost-benefit analysis to the case study. Moreover, the effects of the policy programs regulated by the Indonesian government have also mentioned in chapter five. On chapter six, this paper has also proved that cost-benefit analysis is also applicable to the case since the indicators for policy makers have also been investigated.

## 7.1 Answering research questions

Since 2004, Indonesia has become the net oil importer, which means that the country's economical performance is greatly influenced by the volatility of crude oil price. The country has already subsidized fossil fuel for more than a decade. This has been a crucial issue among the economists and other reformists due to the increasing of subsidies that have been allocated until recently. The economic growth as well as state's deficit has become a fundamental issue that needs to be solved. One of the chances to reduce the current deficit in country's budgetary account is to promote the utilization of biofuels i.e. biodiesel and bioethanol, the most common biofuel developed in Indonesia. Yet, the development of biofuel was considered far below the target.

The first conclusion made to answer the first sub-question. In 2006, the need to 'ensure the security of domestic energy supply and to support sustainable development led to the drafting of a national energy policy (Indonesia's Presidential Regulation no. 1/2006), which was significantly dedicated to the development of bioenergy. In general, the government set a target of 2% biofuel in national energy consumption by 2010 and 5% by 2025. Furthermore, the Ministry of Energy and Mineral Resources issued the regulations that stipulating a phased mandatory use of biofuels in various industrial sectors. (Indonesia's Ministry of Energy and Mineral Resources no. 32/2008). However, in 2010, the country failed to achieve the blending target, and until recently, the target was not obtained as well. Thanks to the tremendous growth of palm oil, biodiesel as one of its derivative product, were modestly grew more sustainable than bioethanol made from sugarcane. In 2010, the bioethanol project was ironically stopped due to the inconsistent supply of the feedstock.

Moreover, the following as the second conclusion was made to answer the second sub-question. Palm oil biodiesel, compared to bioethanol, has been proved had a more sustainable growth. The amount of biodiesel produced in Indonesia has increased from 24 million liters in 2006 to approximately 650 million liters in 2011. Due to low domestic consumption, Pertamina has allowed biofuel producers to export. Despite the increase in the number of refineries, the use of CPO was also relatively low. In 2011, the amount of CPO used for biodiesel was 715,000 ton. This means that only 2.8% of Indonesia's total CPO was absorbed to this market. Several aspects were considered to be main cause of this issue: First, until recently, the production cost of biodiesel is considerably higher than petrol diesel, which eventually makes biodiesel less competitive. Second, the pricing formula, which is regulated by the government, was not carefully monitored resulting the buying price of biodiesel was based on the traditional tender method. Lastly, a more promising market for CPO for cooking oil and exports will rationally led the palm oil producers not to sell the CPO for biodiesel.

Thus, in 2015, with concern to the problematical issues mentioned above, the Indonesian government has increased the new mandatory for biodiesel domestic consumption to 15% as mentioned in the Ministry of Energy and Mineral Resources regulation no. 12/2015. In accordance with the regulation, the government also increased the subsidies gap and formulated the new pricing formula of biodiesel, which was previously based on crude oil price, into the CPO price basis. Lastly, in order to support the funding gap resulted by the new mandates, the government has eventually impose the new levy to palm oil producers, US$ 50 for exported CPO and US$ 30 for exported derivatives product. The previous is to answering the third research question.

To answer the fourth sub-questions, a cost-benefit analysis and the sensitivity analysis has been conducted. Prior to this analysis, this paper has investigated current and future policy programs regulated by Indonesian government. It was found that the current policy, which based on the government regulation until late of 2014, delivered a net loss of Indonesian society. Ironically, a large adoption rate of biodiesel, with sufficient supervision by the government will lead also to a higher net loses to the society. However, a higher adoption rate, as a result of the new government policies, increases the net welfare of both palm oil producers and biodiesel industries. The net loses experienced by the government were seen as an effort to mitigate the climate change and increase the security of energy supply for the country.

To answer the fifth sub-questions, a sensitivity analysis has been conducted. According to the result, the basic argument of the Indonesian government in increasing the palm oil price by

reducing the supply can be argued not relevant in increasing the net welfare of society. It can be argued also that the outcome of cost-benefit analysis was mainly influenced by a production cost, which will be transferred to the other stakeholders outside the system. Moreover, the changes in selling price formula of biodiesel would not influence the net social benefit. Based upon the research, it can then be seen that the operational cost play significant roles in determining the welfare of society. In this study, higher operational cost with the same output means can be viewed as a lower productivity, which was theoretically related to a lower adoption rate of technology. In sum, lower technology adoption rate will significantly decrease the feasibility of biodiesel, even with a higher supervision by the government.

The applicability of CBA to analyze biodiesel related policy changes must also be assessed. The theoretical framework used to assess the applicability of CBA was based on previous study on road safety measures. In general, the framework can be used to clarify the suitability of CBA with this particular case study. Yet, a distributive analysis in analyzing the impact on each stakeholder within the system can generally be useful in investigating the complexity of policy making process. Moreover, based on the assessment criteria, cost-benefit analysis can be eventually used to give new insights and structure the problems, which were beneficial in determining future desirable policies.

Lastly, to answer the main research question, a cost-benefit analysis, despite its limitation, can contribute to guide the policy maker not only in making a rational decision based on the highest net benefit attained, which was not the case in policy changes in Indonesia, but also to sustain the implementation of certain policy. Such an analysis may not address all the questions of a political–economy nature in determining which policies should be selected and implemented but at least it is a quantitative basis for making judgment as to the attractiveness of the policies and provide the basis for assessing the roots of support and opposition that the project is likely to face.

## 7.2 Limitation, recommendation and further research

The main scientific contribution of this study is to demonstrate the practical applicability of cost benefit analysis in examining biodiesel policy changes in Indonesia. For the case study, this research gives thorough cost-benefit analysis, which has not been practically conducted in the case study. Moreover, the distributive analysis to the stakeholders involved within the system, which is also the keystone of this research, has also been conducted. Deeper analysis and thorough examination concerning the theoretical framework to assess applicability of cost-

benefit analysis have been done and based on that, the main question of this research can be answered.

There are concerns in determining the research problem. Applying cost-benefit analysis for different projects or policies is not unique, as it has been widely applied by the government, businesses and other communities along with other tools to support their decision-making. However, each case study must have differences as the biodiesel related policies development in Indonesia was the case. A modest growth of biodiesel was actually supported by a tremendous growth of the palm oil feedstock. Also, such issues concerning food security and importing feedstock have particularly differentiated with the other studies.

Another concern from this study is regarding the experimental study. Data limitation concerning the realization of government's subsidy was, in particular, considerably problematic. Likewise, the allocation of biodiesel consumption in Indonesia has been hardly defined. Without careful attention to those limitations, the outcome of cost-benefit analysis might be misleading. This study was not only focusing on further analysis concerning the outcome of CBA but also on income distribution and the applicability of cost-benefit analysis in analyzing policy changes of Indonesian biodiesel. That the operational cost can influence the net social benefit, as emphasized on the result of CBA and the assessment criteria, would be an interesting further research to mainly analyze the next second generation of biodiesel for example non-edible oil based biodiesel and used oil based biodiesel.

With regards to the main purpose of cost benefit analysis, further research focusing on ex-post CBA will give an added value in clarifying the applicability of the approaches for certain policy changes of Indonesian biodiesel. While the ex-ante CBA refers to the most common approaches in assisting the decision making process and appraising the cost and benefit of policy impact, ex-post CBA refers to the technique that will be carried out after the policy has been implemented. However, one important consideration is the cost of actually performing the CBA.

The case study has shown that there was sufficient feedstock supply for palm oil based biodiesel in Indonesia. While on one hand, this is indeed beneficial for the country; on the other hand, close approximation in determining biodiesel development dedicated area and production have to be also taken into account to ultimately increase the accountability of the outcome. This could be an opportunity for further research. Besides, as the cost-benefit analysis approach was basically made based on the real business model, it is also possible that the model was not built comprehensively. Further research focusing on survey research would be crucial in order to

thoroughly understand the model and address some possible policy recommendation for each stakeholder involved in biodiesel.

Furthermore, the policy alternatives built in this research were based on an explicit Indonesian government's future regulation. In order to give any possible and desirable policy recommendation, further research mainly emphasizing the scenarios development could also be conducted. Those might be based on some other main concerns of the Indonesian government regarding renewable energy development. Moreover, the sensitivity analysis in this study has reflected the most possible disturbances that might be occurred within the system. However, the range of uncertainties might be changed as the future can dramatically changes as well. Based on the aforesaid factors, further study might be needed to assess the extension of cost-benefit analysis application.

This paper provides a concise understanding of the cost and benefits for the Indonesian society. Cost-benefit analysis has been applied in an isolated biodiesel development system. However, biodiesel and palm oil, the main feedstock of biodiesel, have been operated also in the socio-technical system. This means that multiple actors and technological interaction occur within this system. Other emerging renewable energy sources e.g. electric, wind, and solar are to some extent complementary and can support mutual business cases. Further research might be interesting to investigate the socio-technical development among these stakeholders i.e. biodiesel industries, renewable energy enterprises and palm oil producers to eventually analyze the dynamics of the biodiesel system.

# 8. Reflections

## 8.1 Reflection on the research approach

This master thesis was made to mainly assess the applicability of cost-benefit analysis (CBA) for the biodiesel policy changes in Indonesia. By that, it is expected that this study can implicitly give new insights for the policy maker when better policy options are available. An extensive literature review regarding the case study has been presented in order to give thorough picture for the readers with regards to the current conditions and crucial issues that need to be well defined. This is indeed important due to the fact that until recently, the Indonesian government has not been successfully implemented its mandates.

This study used CBA as an approach to deal with future uncertainty e.g. palm oil and crude oil price. However, the author realizes that CBA needs to be comprehensively done to deliver a highly accountable report. Yet, it is still possible to argue that the result of this report can be relevant to structure the current problem of biodiesel development as well as determine what the main driver of a feasible and desirable future biodiesel policy will be.

In addition, the author also realizes that the business model built in this research is far from perfection. This has to do with the fact that for instance there are several integrated firms, which has been integrating the palm oil plantation, CPO producers and biodiesel industries, is not specifically investigated in this research. By a sensitivity analysis, it has been however clearly described the impact of future biodiesel related policy to every stakeholders so they can strategically align their future business plan with certain policies.

## 8.2 Reflection on the content of the outcome

Regarding to the application of CBA, there are some rough assumptions that were basically made to simplify the calculation. Despite all the assumptions were based on previous study, all calculation models can only represent the real and perfect business model and could not capture all components and the interaction within the system. Moreover, CBA could not also deal responsively with specific measurement changes for example to what extent biodiesel can be competitively feasible and desirable as well as how each variable is dependent to the others. The authors has eventually realized that CBA is only an applicable measurement for analyzing and investigating some specific and determined projects or policies, while other modeling tools are more useful in illustrating the dynamics within the system and determining the main drivers of biodiesel development.

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## Appendixes

Table 1: Standardization of biodiesel in Europe, USA and Indonesia

| Biodiesel Standards | | EUROPE | USA | INDONESIA |
|---|---|---|---|---|
| **Specification** | | EN 14214:2008 | ASTM D 6751-07b | SNI 04-7182-2006 |
| **Applies to** | | FAME | FAAE | FAME |
| **Density 15°C** | $g/cm^3$ | 0.86 - 0.90 | | 0.85 - 0.89 |
| **Viscosity 40°C** | $mm^2/s$ | 3.5 - 5.0 | 1.9 - 6.0 | 2.3 - 6.0 |
| **Distillation** | %, °C | | 90%, 360°C | 90%, 360°C |
| **Flashpoint (Fp)** | °C | 101 min | 93 min | 100 min |
| **CFPP** | °C | * country specific | | |
| **Cloud point** | °C | | * report | 18 max |
| **Sulphur** | mg/kg | 10 max | 15 max | 100 max |
| **CCR 100%** | %mass | | 0.05 max | 0.05 max |
| **Carbon residue (10%dist.residue)** | %mass | 0.3 max | | 0.3 max |
| **Sulphated ash** | %mass | 0.02 max | 0.02 max | 0.02 max |
| **Oxid ash** | %mass | | | |
| **Water** | mg/kg | 500 max | 500 max | |
| **Total contamination** | mg/kg | 24 max | | |
| **Cu corrosion max** | 3h/50°C | 1 | 3 | 3 |
| **Oxidation stability** | hrs;110°C | 6 hours min | 3 hours min | |
| **Cetane number** | | 51 min | 47 min | 51 min |
| **Acid value** | mgKOH /g | 0.5 max | 0.5 max | 0.8 max |
| **Methanol** | %mass | 0.20 max | 0.2 max or Fp <130°C | |
| **Ester content** | %mass | 96.5 min | | 96.5 min |
| **Monoglyceride** | %mass | 0.8 max | | |
| **Diglyceride** | %mass | 0.2 max | | |
| **Triglyceride** | %mass | 0.2 max | | |
| **Free glycerol** | %mass | 0.02 max | 0.02 max | 0.02 max |
| **Total glycerol** | %mass | 0.25 max | 0.24 max | 0.24 max |
| **Iodine value** | | 120 max | | 115 max |
| **Linolenic acid ME** | %mass | 12 max | | |
| **C(x:4) & greater unsaturated esters** | %mass | 1 max | | |
| **Phosphorus** | mg/kg | 4 max | 10 max | 10 max |
| **Alkalinity** | mg/kg | | | |
| **Gp I metals (Na,K)** | mg/kg | 5 max | 5 max | |
| **GpII metals (Ca,Mg)** | mg/kg | 5 max | 5 max | |
| **PAHs** | %mass | | | |
| **Lubricity / wear** | µm at 60°C | | | |

Source: Adapted from Biodiesel Standard and SNI 04-7182-2006

**Table 2: Emission factors for electricity**

| Electricity emissions | $CO_2$ per kWh (g) | Conversion to $CO_2$ per MJ (1 kWh = 3.6 MJ) |
|---|---|---|
| Indonesia | 726 | 202.00 |
| Mexico | 440 | 122.00 |
| South Africa | 835 | 232.00 |
| Europe | | 128.25 |

Source: IEA database (values from 2008). The value for Europe is derived from the BioGrace standard values, public version 3(http://www.BioGrace.net)
*Adapted from Frieden et al. (2011)*

**Table 3: Emission factors for liquid fuels for transport, all countries**

| Fuel emissions | g $CO_2$-eq/MJ |
|---|---|
| Diesel | 87.64 |
| Heavy fuel oil (HFO) for maritime transport | 87.20 |

Source: BioGrace standard values, public version 3(http://www.BioGrace.net)
*Adapted from Frieden et al. (2011)*

**Table 4: Transport efficiencies and exhaust gas emissions, all countries**

| Transport | Fuel efficiency | Transport exhaust Gas emissions | |
|---|---|---|---|
| | MJ/t.km | g $CH_4$/t.km | g $N_2O$/t.km |
| Truck for dry product (diesel) | 0.94 | 0.005 | 0.0000 |
| Truck for liquids (diesel) | 1.01 | 0.005 | 0.0000 |
| Truck for FFB transport (diesel) | 2.01 | 0.005 | 0.0000 |
| Tanker truck MB2318 for vinasse transport | 2.16 | 0.000 | 0.0000 |
| Tanker truck with water cannons for vinasse transport | 0.94 | 0.000 | 0.0000 |
| Dumpster truck MB2213 for filter mud transport | 3.60 | 0.000 | 0.0000 |
| Ocean bulk carrier (bulk oil) | 0.20 | 0.000 | 0.0007 |
| Ship/product tanker 50kt (fuel oil) | 0.12 | 0.000 | 0.0000 |

Source: BioGrace standard values, public version 3(http://www.BioGrace.net)

**Table 5: Emission factors for fertilizers and pesticides, all countries**

| Agro-inputs | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$-eq |
|---|---|---|---|---|
| | (g/kg) | | | |
| N fertilizer (N) | 2827.0 | 8.68 | 9.6418 | 5880.6 |
| Ca fertilizer (CaO) | 119.1 | 0.22 | 0.0183 | 129.5 |
| K fertilizer ($K_2O$) | 536.3 | 1.57 | 0.0123 | 576.1 |
| P fertilizer ($P_2O_5$) | 964.9 | 1.33 | 0.0515 | 1010.7 |
| Pesticides | 9886.5 | 25.53 | 1.6814 | 10,971.3 |

Source: BioGrace standard values, public version 3(http://www.BioGrace.net)

**Table 6: Emission factors for conversion inputs (input in kg), all countries**

| Conversion inputs | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$-eq |
|---|---|---|---|---|
| | (g/kg) | | | |
| Phosphoric acid ($H_3PO_4$) | 2776.0 | 8.93 | 0.1028 | 3011.7 |
| Fuller's earth | 197.0 | 0.04 | 0.0063 | 199.7 |
| Hydrochloric acid (HCl) | 717.4 | 1.13 | 0.0254 | 750.9 |
| Sodium carbonate ($Na_2CO_3$) | 1046.0 | 6.20 | 0.0055 | 1190.2 |
| Sodium hydroxide (NaOH) | 438.5 | 1.03 | 0.0240 | 469.3 |
| Potassium hydroxide (KOH) | 0.0 | 0.00 | 0.0000 | 0.0 |
| Pure CaO for processes | 1013.0 | 0.65 | 0.0076 | 1030.2 |
| Sulphuric acid ($H_2SO_4$) | 193.9 | 0.55 | 0.0045 | 207.7 |
| Ammonia | 2478.0 | 7.84 | 0.0087 | 2660.8 |
| Cycle-hexane | 723.0 | 0.00 | 0.0000 | 723.0 |
| Lubricants | 947.0 | 0.00 | 0.0000 | 947.0 |

Source: BioGrace standard values, public version 3(http://www.BioGrace.net)

**Table 7: Emission factors for conversion inputs (input in MJ)**

| Conversion inputs | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$-eq |
|---|---|---|---|---|
| | (g/kg) | | | |
| n-Hexane | 80.08 | 0.0146 | 0.0003 | 80.50 |
| Hydrogen (for HVO) | 80.87 | 0.2765 | 0.0003 | 87.32 |

HVO: hydrogenated vegetable oils

Source: BioGrace standard values, public version 3(http://www.BioGrace.net)

**Table 8: Emission factors for burning of straw and natural gas in CHP plants and for replaced electricity**

| CHP | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$-eq |
|---|---|---|---|---|
| | (g/kg) | | | |
| Burning of wheat straw | 1.75 | 0.0013 | 0.0001 | 1.80 |
| Electricity from straw (replaced by export from the system) | 5.56 | 0.0042 | 0.0002 | 5.72 |
| Burning of natural gas (NG) | 61.58 | 0.1981 | 0.0002 | 66.59 |
| $CH_4$ and $N_2O$ emissions from NG boiler (per MJ steam) | | 0.0028 | 0.0011 | 0.40 |

Source: BioGrace standard values, public version 3(http://www.BioGrace.net)

**Table 9: Emission factors for electricity**

| Electricity emissions | $CO_2$ per kWh (g) | Conversion to $CO_2$ per MJ (1 kWh = 3.6 MJ) |
|---|---|---|
| Indonesia | 726 | 202.00 |
| Mexico | 440 | 122.00 |
| South Africa | 835 | 232.00 |
| Europe | | 128.25 |

Source: IEA database (values from 2008). The value for Europe is derived from the BioGrace standard values, public version 3(http://www.BioGrace.net) adapted from Frieden et al. (2011)

**Table 10: Data for extraction and refining of palm oil**

| Extraction and refining of palm oil | Unit | Value |
|---|---|---|
| Energy content of FFB dry matter | MJ/kg | 24.0000 |
| Palm oil yield from extraction | $MJ_{oil}/MJ_{FFB}$ | 0.5300 |
| By-product kernel meal | $MJ_{meal}/MJ_{FFB}$ | 0.0268 |
| Electricity consumed for extraction | $MJ/MJ_{oil}$ | 0.0086 |
| Electricity surplus (export) | $MJ/MJ_{oil}$ | 0.0040 |
| $CH_4$ emissions from palm oil mill effluent (process without $CH_4$ capture) | $g/MJ_{oil}$ | 1.3218 |
| Yield from refining of oil | $MJ_{oil}/MJ_{oil}$ | 0.9600 |
| Natural gas input for refining (boiler) | $MJ/MJ_{oil}$ | 0.0130 |
| Grid electricity for refining | $MJ/MJ_{oil}$ | 0.0008 |
| Use of Fuller's earth for refinig | $Kg/MJ_{oil}$ | 0.0002 |

FFB: fresh fruit bunches

Source: BioGrace standard values, public version 3(http://www.BioGrace.net); electricity consumption and exports from Schmidt (2007)

**Table 11: Data for biodiesel production from palm oil (esterification)**

| Esterification of palm oil | Unit | Value |
|---|---|---|
| Biodiesel yield | $MJ_{FAME}/MJ_{oil}$ | 0.993600 |
| Co-product: refined glycerol | $Kg/ton_{FAME}$ | 105.600000 |
| Electricity consumed | $MJ/MJ_{FAME}$ | 0.006100 |
| Natural gas consumed | $MJ/MJ_{FAME}$ | 0.112000 |
| Phosphoric acid ($H_3PO_4$) | $kg/MJ_{FAME}$ | 0.000064 |
| Hydrochloric acid (HCl) | $kg/MJ_{FAME}$ | 0.000753 |
| Sodium carbonate ($Na_2CO_3$) | $kg/MJ_{FAME}$ | 0.000094 |
| Sodium hydroxide (NaOH) | $kg/MJ_{FAME}$ | 0.000253 |
| Methanol | $kg/MJ_{FAME}$ | 0.081800 |

FFB: fresh fruit bunches

Source: BioGrace standard values, public version 3(http://www.BioGrace.net); electricity consumption and exports from Schmidt (2007)

**Table 12: Data for palm oil cultivation, Indonesia**

| Palm cultivation | Unit | Value | Data source |
|---|---|---|---|
| Yield (FFB) | $kg_{WM}/(ha*a)$ | 17,950.00 | Schmidt (2007) |
| Water content | % | 34.00 | bioGrace |
| N fertilizer | kg N/(ha*a) | 228.00 | National expert |
| Ca fertilizer | kg CaO/(ha*a) | 0.00 | National expert |
| K fertilizer | kg $K_2O$/(ha*a) | 344.00 | National expert |
| P fertilizer | kg $P_2O_5$/(ha*a) | 123.00 | National expert |
| Pesticides | kg/(ha*a) | 3.42 | Nazir and Setyaningsih (2010) |
| Energy consumption | MJ/(ha*a) | 413.00 | Nazir and Setyaningsih (2010) |
| Field $N_2O$ emissions | Kg $N_2O$/(ha*a) | 0.081800 | Frieden et al. (2010) |

WM: wet matter; FFB: fresh fruit bunches

Source: BioGrace standard values, public version 3 (http://www.BioGrace.net)

**Table 13: In-country transport distances for biodiesel production from palm oil, Indonesia**

| Country transport distances | km | Data source |
|---|---|---|
| Feedstock transport to plant (diesel truck) | 30 | National expert |
| Biodiesel transport to point of distribution (in-country, diesel truck) | 200 | Schmidt (2007) |

**Table 14: Cost-benefit analysis - increase in pricing formula**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 26,478.08 | Total | 378,062.89 | 337,065.05 |
| **Net loss / benefit** | **- 5,301.19** | | **Net loss / benefit** | **- 40,997.84** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 120,581.18 | Selling price of FAME / biodiesel | | 539,683.76 |
| Total | 59,825.25 | 126,031.66 | Total | 469,564.84 | 575,228.78 |
| **Net loss / benefit** | **66,206.41** | | **Net loss / benefit** | **105,663.94** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

**Table 15: Cost-benefit analysis - decrease in pricing formula**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 26,478.08 | Total | 378,062.89 | 337,065.05 |
| **Net loss / benefit** | **- 5,301.19** | | **Net loss / benefit** | **- 40,997.84** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 91,503.49 | Selling price of FAME / biodiesel | | 470,875.15 |
| Total | 59,825.25 | 96,953.97 | Total | 469,564.84 | 506,420.17 |
| **Net loss / benefit** | **37,128.72** | | **Net loss / benefit** | **36,855.34** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

**Table 16: Cost-benefit analysis - increase in palm oil price growth by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 26,478.08 | Total | 378,062.89 | 337,065.05 |
| **Net loss / benefit** | **- 5,301.19** | | **Net loss / benefit** | **- 40,997.84** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 6,603.59 | | Government subsidies | 41,379.36 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,373.14 | | VAT loss on exported palm oil | 27,231.71 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 36,020.72 | 12,742.50 | Total | 127,435.75 | 70,944.56 |
| **Net loss / benefit** | **- 23,278.22** | | **Net loss / benefit** | **- 56,491.19** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 47,014.08 | | Feedstock cost (CPO) | 419,256.06 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 6,603.59 | Government subsidies | | 41,379.36 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 514,781.73 |
| Total | 64,211.81 | 112,645.93 | Total | 491,315.40 | 556,161.09 |
| **Net loss / benefit** | **48,434.12** | | **Net loss / benefit** | **64,845.69** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,373.14 | VAT loss on exported palm oil | | 27,231.71 |
| Palm oil selling price | | 47,014.08 | Palm oil selling price | | 419,256.06 |
| Total | 23,600.64 | 65,549.04 | Total | 325,581.78 | 484,732.62 |
| **Net loss / benefit** | **41,948.41** | | **Net loss / benefit** | **159,150.84** | |

**Table 17: Cost-benefit analysis - decrease in palm oil price growth by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 26,478.08 | Total | 378,062.89 | 337,065.05 |
| **Net loss / benefit** | **- 5,301.19** | | **Net loss / benefit** | **- 40,997.84** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 4,322.30 | | Government subsidies | 29,949.54 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,220.46 | | VAT loss on exported palm oil | 24,590.05 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 33,586.74 | 12,742.50 | Total | 113,364.26 | 70,944.56 |
| **Net loss / benefit** | **- 20,844.24** | | **Net loss / benefit** | **- 42,419.71** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 38,331.51 | | Feedstock cost (CPO) | 376,615.91 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 4,322.30 | Government subsidies | | 29,949.54 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 495,967.69 |
| Total | 55,529.24 | 110,364.64 | Total | 448,675.26 | 525,917.23 |
| **Net loss / benefit** | **54,835.40** | | **Net loss / benefit** | **77,241.98** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,220.46 | VAT loss on exported palm oil | | 24,590.05 |
| Palm oil selling price | | 38,331.51 | Palm oil selling price | | 376,615.91 |
| Total | 23,600.64 | 56,713.78 | Total | 325,581.78 | 439,450.81 |
| **Net loss / benefit** | **33,113.15** | | **Net loss / benefit** | **113,869.03** | |

**Table 18: Cost-benefit analysis - increase in crude oil price growth by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 25,488.30 | Reduce fossil fuel | | 312,268.59 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 29,057.35 | Total | 378,062.89 | 361,505.37 |
| **Net loss / benefit** | **- 2,721.92** | | **Net loss / benefit** | **- 16,557.52** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 4,593.03 | | Government subsidies | 27,508.92 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 12,071.04 | | VAT loss on imported crude oil | 20,660.81 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 35,275.92 | 12,742.50 | Total | 114,424.75 | 70,944.56 |
| **Net loss / benefit** | **- 22,533.43** | | **Net loss / benefit** | **- 43,480.19** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 4,593.03 | Government subsidies | | 27,508.92 |
| Selling price of FAME / biodiesel | | 90,860.30 | Selling price of FAME / biodiesel | | 490,097.43 |
| Total | 59,825.25 | 95,453.34 | Total | 469,564.84 | 517,606.34 |
| **Net loss / benefit** | **35,628.08** | | **Net loss / benefit** | **48,041.51** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

**Table 19: Cost-benefit analysis - decrease in crude oil price growth by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 20,939.57 | Reduce fossil fuel | | 268,817.79 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 31,779.28 | 24,508.63 | Total | 378,062.89 | 318,054.57 |
| **Net loss / benefit** | **- 7,270.65** | | **Net loss / benefit** | **- 60,008.32** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 6,103.33 | | Government subsidies | 41,777.07 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 9,706.66 | | VAT loss on imported crude oil | 16,765.26 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,421.85 | 12,742.50 | Total | 124,797.35 | 70,944.56 |
| **Net loss / benefit** | **- 21,679.35** | | **Net loss / benefit** | **- 53,852.79** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 6,103.33 | Government subsidies | | 41,777.07 |
| Selling price of FAME / biodiesel | | 117,846.74 | Selling price of FAME / biodiesel | | 517,083.86 |
| Total | 59,825.25 | 123,950.07 | Total | 469,564.84 | 558,860.93 |
| **Net loss / benefit** | **64,124.82** | | **Net loss / benefit** | **89,296.09** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

**Table 20: Cost-benefit analysis – increase in investment cost by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 6,060.50 | | Investment cost | 9,652.59 | |
| Maintenance cost | 121.21 | | Maintenance cost | 193.05 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 33,015.62 | 26,478.08 | Total | 380,032.02 | 337,065.05 |
| **Net loss / benefit** | **- 6,537.53** | | **Net loss / benefit** | **- 42,966.97** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 6,060.50 | | Investment cost | 9,652.59 | |
| Maintenance cost | 121.21 | | Maintenance cost | 193.05 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 505,279.46 |
| Total | 61,061.59 | 111,492.81 | Total | 471,533.96 | 540,824.48 |
| **Net loss / benefit** | **50,431.22** | | **Net loss / benefit** | **69,290.51** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

**Table 21: Cost-benefit analysis – decrease in investment cost by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 3,636.30 | | Investment cost | 5,791.55 | |
| Maintenance cost | 72.73 | | Maintenance cost | 115.83 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 30,542.94 | 26,478.08 | Total | 376,093.76 | 337,065.05 |
| **Net loss / benefit** | **- 4,064.85** | | **Net loss / benefit** | **- 39,028.71** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 3,636.30 | | Investment cost | 5,791.55 | |
| Maintenance cost | 72.73 | | Maintenance cost | 115.83 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,078.91 | | Biodiesel production cost | 42,475.06 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 505,279.46 |
| Total | 58,588.91 | 111,492.81 | Total | 467,595.71 | 540,824.48 |
| **Net loss / benefit** | **52,903.90** | | **Net loss / benefit** | **73,228.77** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 4,145.88 | | CPO production cost | 57,194.28 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 23,600.64 | 61,085.01 | Total | 325,581.78 | 461,630.97 |
| **Net loss / benefit** | **37,484.38** | | **Net loss / benefit** | **136,049.19** | |

**Table 22: Cost-benefit analysis - increase in operational cost by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 5,182.34 | | CPO production cost | 71,492.85 | |
| Biodiesel production cost | 3,848.64 | | Biodiesel production cost | 53,093.82 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 33,585.48 | 26,478.08 | Total | 402,980.22 | 337,065.05 |
| **Net loss / benefit** | **- 7,107.39** | | **Net loss / benefit** | **- 65,915.17** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 3,848.64 | | Biodiesel production cost | 53,093.82 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 505,279.46 |
| Total | 60,594.98 | 111,492.81 | Total | 480,183.60 | 540,824.48 |
| **Net loss / benefit** | **50,897.83** | | **Net loss / benefit** | **60,640.88** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 5,182.34 | | CPO production cost | 71,492.85 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 24,637.10 | 61,085.01 | Total | 339,880.35 | 461,630.97 |
| **Net loss / benefit** | **36,447.91** | | **Net loss / benefit** | **121,750.62** | |

**Table 23: Cost-benefit analysis - decrease in operational cost by 25%**

| NET SOCIAL BENEFIT FOR SOCIETY | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| FFB feedstock cost | 19,454.76 | | FFB feedstock cost | 268,387.50 | |
| CPO production cost | 3,109.41 | | CPO production cost | 42,895.71 | |
| Biodiesel production cost | 2,309.19 | | Biodiesel production cost | 31,856.29 | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| Reduce fossil fuel | | 22,909.03 | Reduce fossil fuel | | 287,828.27 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 29,973.08 | 26,478.08 | Total | 353,145.56 | 337,065.05 |
| **Net loss / benefit** | **- 3,495.00** | | **Net loss / benefit** | **- 16,080.50** | |

| NET SOCIAL BENEFIT FOR INDONESIAN GOVERNMENT | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Government subsidies | 5,450.48 | | Government subsidies | 35,545.02 | |
| Loss of CPO supporting fund | 16,161.81 | | Loss of CPO supporting fund | 38,244.85 | |
| Agriultural subsidies | - | | Agriultural subsidies | - | |
| GHG emissions | 154.37 | | GHG emissions | 2,129.54 | |
| VAT loss on exported palm oil | 2,295.67 | | VAT loss on exported palm oil | 25,880.63 | |
| VAT loss on imported crude oil | 10,727.80 | | VAT loss on imported crude oil | 18,450.28 | |
| Employment | | 531.56 | Employment | | 7,333.14 |
| CSF on biodiesel exported | | 9,173.44 | CSF on biodiesel exported | | 21,707.78 |
| Reduce fossil diesel subsidy | | 3,037.49 | Reduce fossil diesel subsidy | | 41,903.64 |
| Total | 34,790.13 | 12,742.50 | Total | 120,250.33 | 70,944.56 |
| **Net loss / benefit** | **- 22,047.63** | | **Net loss / benefit** | **- 49,305.77** | |

| NET SOCIAL BENEFIT FOR BIODIESEL INDUSTRIES | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Investment cost | 4,848.40 | | Investment cost | 7,722.07 | |
| Maintenance cost | 96.97 | | Maintenance cost | 154.44 | |
| Feedstock cost (CPO) | 42,627.53 | | Feedstock cost (CPO) | 397,505.49 | |
| Biodiesel production cost | 2,309.19 | | Biodiesel production cost | 31,856.29 | |
| CSF on biodiesel exported | 9,173.44 | | CSF on biodiesel exported | 21,707.78 | |
| Government subsidies | | 5,450.48 | Government subsidies | | 35,545.02 |
| Selling price of FAME / biodiesel | | 106,042.33 | Selling price of FAME / biodiesel | | 505,279.46 |
| Total | 59,055.52 | 111,492.81 | Total | 458,946.07 | 540,824.48 |
| **Net loss / benefit** | **52,437.29** | | **Net loss / benefit** | **81,878.40** | |

| NET SOCIAL BENEFIT FOR PALM OIL PRODUCERS | | | | | |
|---|---|---|---|---|---|
| **Policy Impact of Scenario 1** | | | **Policy Impact of Scenario 2** | | |
| Aspet | Cost | Benefit | Aspet | Cost | Benefit |
| Feedstock cost (FFB) | 19,454.76 | | Feedstock cost (FFB) | 268,387.50 | |
| CPO production cost | 3,109.41 | | CPO production cost | 42,895.71 | |
| Loss on CPO supporting fund | | 16,161.81 | Loss on CPO supporting fund | | 38,244.85 |
| VAT loss on exported palm oil | | 2,295.67 | VAT loss on exported palm oil | | 25,880.63 |
| Palm oil selling price | | 42,627.53 | Palm oil selling price | | 397,505.49 |
| Total | 22,564.17 | 61,085.01 | Total | 311,283.21 | 461,630.97 |
| **Net loss / benefit** | **38,520.85** | | **Net loss / benefit** | **150,347.76** | |