Low Carbon Support Programme

Rapid Assessment of Indonesian Biofuels Industry and Policies

Final Report

November, 2013

Low Carbon Support Programme to Ministry of Finance, Indonesia

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In Close Collaboration with:

The Center for Climate Change and Multilateral Financing Policy (PKPPIM), Fiscal Policy Agency (BKF), Ministry of Finance of the Republic of Indonesia

PREFACE FOR ENGLISH LANGUAGE VERSION

This report was initially prepared in the Indonesian language and copies are available from LCS and PKPPIM in the Indonesian language for interested readers. The English language version has been prepared through prepararation of a rapid and non certified translation from the Indonesian language. The non certified English language version is considered adequate to allow English language only readers to readily understand the contents. However it does not claim to be a fully certified or word perfect translation. Should differences be found between the English and Indonesian language versions then the Indonesian language version should be taken as the principal source of reference.

Disclaimers

This Discussion Paper has been prepared through the Low Carbon Support Programme to the Ministry of Finance Indonesia for purposes of policy development and discussion. The views expressed in the Discussion Paper are those of the sub-contracted authors alone and in no way should be construed as reflecting the views of the Ministry of Finance or the Government of Indonesia.

FOREWORD

This report was developed to fulfil a contract agreement between the writer (Tatang H. Soerawidjaja) and the Low Carbon Support Programme to the Ministry of Finance Indonesia (at the request of the Center for Climate Change and Multilateral Financing Policy (PKPPIM), Fiscal Policy Agency (BKF), Ministry of Finance of the Republic of Indonesia).

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ABBREVIATIONS

ABG	academics, business, government
APROBI	Indonesian Biofuels Producers Association
BHD	biohydrofixed diesel
BPSD	barrels per standard day
BTL	biomass to liquids
CPO	crude palm oil
DME	dimetil ester
EMAL	ester metil asam lemak
ESDM	Ministry of Energy and Mineral Resources
FAME	fatty acids methyl ester
FCC	fluid catalytic cracking
FT	Fischer Tropsch
FFV	flexible fuel vehicles
HPE	biodiesel export standard price (FAME) – Ministry of Trade
HPI	biodiesel market price index
LCA	life cycle assessment
MOPS	Mid-oil Platts Singapore (market price index)
PERMEN	Ministerial Regulation
PPO	pure plant oil
PSO	public service obligation
RBDP	refined bleached deodorised palm

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EXECUTIVE SUMMARY

As a response to the increasing price of fossil fuels as well as to the growing concentration and accumulation of greenhouse gases in the earth's atmosphere, societies and economies around the world are now making the transition from fossil-based economies to bio-based economies. The biofuels industry is one of the two main pillars of a bio-based economy; the other one being the food industry. In order to make a smooth transition into the era of the bio-based economy and to become a leading country in such an era, Indonesia must succeed in developing a strong and dynamic domestic biofuels industry. Indonesia's rich biodiversity and vast landscape are the two main factors that will support Indonesia in achieving this goal.

Various types of liquid biofuels are becoming increasingly in demand to substitute and replace fossil fuels, such as gasoline, diesel and jet fuel, that have so far dominated the transportation sector. These liquid biofuels can be categorised into two classes, namely:

- <u>Oxygenated biofuels</u> that can only be mixed at a limited percentage (10-20% of volume) with fossil fuel, because a higher percentage mix will require modification to the vehicle's engine, but the mix has lower emissions rate than pure hydrocarbon fuels; and

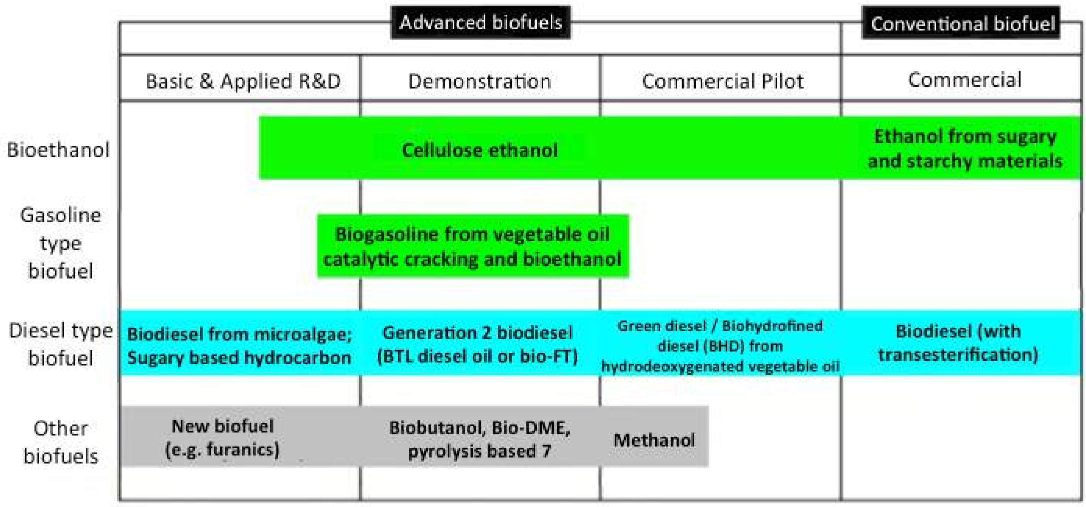
- <u>Drop-in biofuels</u> are a type of biofuels that have hydrocarbon chemical structures and therefore can be mixed with the corresponding fossil fuels in any percentage (up to 100%).

The following table summarises the types of existing biofuels in the two categories:

Corresponding fossil fuels	**Biofuels**	
	Oxygenated	**Drop-in**
Diesel	Generation 1 Biodiesel (EMAL/FAME* Biodiesel)	Bio-Hydrofined Diesel (BHD) or Green diesel and generation 2 Biodiesel (or BTL biodiesel or F-T biodiesel)
Gasoline	Generation 1 and 2 Bioethanol	Biogasoline or Green gasoline
Jet fuel	-	Bioavtur or Jet biofuel

* EMAl/FAME: *Ester Metil Asam-asam Lemak* / Fatty Acids Methyl Ester.

The diagram below summarises the status of commercialisation of various liquid biofuels, including those still under basic and applied research and development. The two types of biofuels that have been produced and utilised in Indonesia are EMAL/FAME biodiesel (developed with transesterification process) and generation 1 bioethanol (developed from sugary or starchy materials); both of them are oxygenated biofuels. The Energy and Mineral Resources Ministerial Decree (Permen ESDM) No. 32/2008 and its amendment (Permen ESDM No. 25/2013) stipulates the timeline and mandatory usage of both oxygenated fuels in Indonesia.



BTL = Biomass-To-Liquids; FT = Fischer-Tropsch; DME = DiMetilEter.

An evaluation of the domestic biodiesel and bioethanol industry towards the realisation of mandatory usage targets set in the Permen ESDM No. 25/2013 shows that:

A. From the aspect of the supply capacity:

- The biodiesel industry's installed as well as planned capacity will be able to fulfil the domestic demand (in line with Permen ESDM No. 25/2013) over the next few years; and

- The bioethanol industry's installed as well as planned capacity will not be able to fulfil the expected domestic demand for 2014, 2015 and 2016; and the government needs to provide adequate incentives if the domestic demand is to be fulfilled by 2017;

B. From the aspect of enthusiasm to supply:

- Industries believe the biodiesel purchase price set by the government prior to the publication of Permen ESDM No. 25/2013 failed to give an adequate margin of profit; and

- Industries believe the bioethanol purchase price set by the government prior to the publication of Permen ESDM No. 25/2013 is too low, causing the supply (and use) of bioethanol to fall to zero since 2009.

In addition to this, the recently enacted government policy on the purchase of biofuels through a bidding process with the requirement of a purchase price below MOPS (after the publication of Permen ESDM No. 25/2013) is not effective, as it will drive biofuels industries with relatively small capacity to bankruptcy whereas these industries could help the government in fostering more equal economic growth throughout Indonesia.

By taking into consideration that the biofuels industry is a strategic industry in the development of a bio-based economy, the Indonesian government needs to develop and nurture the domestic biofuels industry to become strong and dynamic. In order to achieve this goal, the government is recommended to take the following actions:

a. Provide various incentives (e.g. finance feasibility studies, tax holiday offer, etc.) that will boost the growth of the bioethanol fuels industry, particularly:

- Nipa palm agroforestry and sago trees and industrial forest plantations; and
- Sweet sorghum and sugar palm plantations.

Also to facilitate cooperation between industrial R&D and research institutions in developing and implementing the commercial use of generation 2 bioethanol technologies.

b. Set an attractive pricing policy at the beginning and gradually tighten it to boost the growth of a strongly competitive biofuels industry (including to support the growth of effective and efficient technologies); at the initial stage (for 2014), the price should be set according to the Market Price Index (HIP), as follows:

- Biodiesel Market Price Index (HIP) = Domestic olein price + USD120; and

- Bioethanol Market Price Index (HIP) = (Argus Price) x 788 kg/m^3 x (1 + 0.35).

Price adjustments in consequent years could be set following negotiations with biofuels producers and experts (synergy between Academic-Business-Government – ABG). Based on the information from several industrial players, the use of biodiesel and bioethanol using the above price formula will require an additional subsidy of not more than IDR 1,000 per litre, on top of the existing fuel subsidy. This additional subsidy can be fulfilled if the subsidised fuel price is increased by IDR 500/litre (in other words, diverting the subsidy from fossil fuels to biofuels). [The price of CPO (or CPO-based) derivative biofuels can be set below MOPS if the government can regulate their trade starting from feedstock up to the end product, considering the cost of goods manufactured for CPO is only around USD400/kg.]

c. Cancel the policy to purchase biofuels through a bidding process with the requirement of a purchase price below MOPS (after the publication of Permen ESDM No. 25/2013).

d. Continue to provide subsidy for biofuels on top of the fossil fuel MOPS price for the next few years, until biofuels prices falls below MOPS.

e. Do not impose a VAT (value added tax on sold products) on liquid biofuels producers.

f. Incorporate the growth and strengthening of the domestic bioenergy industry as one of the key performance indicators of the Ministry of Energy and Mineral Resources (downstream), the Ministries of Agriculture and Forestry (upstream), and the Ministry of Marine and Fisheries (in the years to come once research and development demonstrates the potential economic feasibility of macro- and microalgae-based biofuels).

The Indonesian government needs to take the following facts into consideration:

1. The demand for fossil fuels is rapidly increasing due to robust growth in the economy and the transportation sector;

2. The increase in demand must be fulfilled through imports, because domestic refineries production capacity has not increased; and

3. EMAL/FAME biodiesel and bioethanol can only reduce gasoline and diesel import up to 10-20%; the remaining demand (in much larger quantity) still needs to be fulfilled through imports.

In order to avoid pressure on the balance of payments and foreign exchange procurement by 2016, the Indonesian government can develop and build a biohydrofined diesel (BHD) industry and biogasoline as drop-in biofuels (as a substitute to imported gasoline and diesel), to complement the oxygenated EMAL/FAME biodiesel and generation 1 bioethanol that are currently already in the market. CPO, the majority of which remains exported (around 16 million tons in 2013 and 21 million tons projected by 2020) can be the initial mainstay of feedstock for the two drop-in biofuel industries.

Various scenarios elaborated and discussed in Chapter 4 of this report demonstrate that Indonesia will be able to maintain gasoline and diesel fuel imports at a constant level / value, if Indonesia manages to build and operate around six biogasoline plants/refineries via FCC (Fluid Catalytic Cracking) and 12 BHD plants/refineries via hydrodeoxygnenation by 2017, and increase them into around 26 biogasoline plants/refineries and 20 BHD plants/refineries by 2020. The total amount of investment needed until 2020 to actualise this scheme is around USD 13,800 million (or IDR 151.8 trillion). Although it seems like a very big amount of investment, it is actually smaller than the annual amount spent for petroleum fuel subsidies, which today amount to IDR 200 trillion. In addition, the investment will be spread over a period of time (2014-2020), and costs can also be partially diverted to the private sector. In order to implement this plan, the government is recommended to take the following steps:

A. Make an allocation in the state budget, or provide various incentives (i.e. finance feasibility studies, tax holiday, etc.) to support the development and operation of renewable hydrocarbon fuel production plants using hydrodeoxygenation or Fluid Catalytic Cracking (FCC) technologies.

B. Finance research and development in the plantation and agroforestry sector, particularly towards potential plants that produce inedible oils and fats, such as pongam oil tree, nyamplung oil tree, neem tree; and sunan candlenut.

C. Finance research and development of catalytic cracking technology for CPO and inedible oils and fats in pilot plants, with the aim of having commercial plants by 2017 or 2018.

1. Strategic Reasons for Developing and Nurturing the Biofuels Industry

1.1 Introduction

This chapter explains trends in world economy that will make the biofuels industry a strategic industry in the future, hence the need for the Indonesian government to develop and nurture the industry to become strong and dynamic.

1.2 Transition to a bio-based economy

Today the world economy and society are changing making the transition from:

- A fossil-based economy, namely an economy/society that is dependant entirely on fossil resources as fuel and feedstock for industries; into:

- A bio-based economy, namely an economy/society that is reliant on bio-resources, not only for food and animal feed, but also for energy and industrial products.

This transition is as a response towards:

- The increasing accumulation and concentration of greenhouse gases in the earth's atmosphere (with all its potential catastrophic impacts) due to overconsumption of fossil fuels, and

- The increasingly expensive cost of oil (detrimental to a country's energy resilience), due to depleting resources amidst increasing demands from around the world.

In more detail, the transition to a bio-based economy needs to be achieved so as to meet the following objectives:

- to strengthen energy security, while in parallel reducing and toning down the need for fossil fuels;

- to develop industry and strengthen the country's balance of payments;

- to reduce global warming (greenhouse gas emissions);

- to boost the creation of added value industrial products and to open new markets for the agriculture sector;

- to open new employment opportunities, especially in rural areas so as to develop these areas and eradicate poverty; and

- to reduce poisoning of products and processes so as to improve health.

Diagram 1.1: Various products and activities globally that demonstrate the global transition into a bio-based economy.

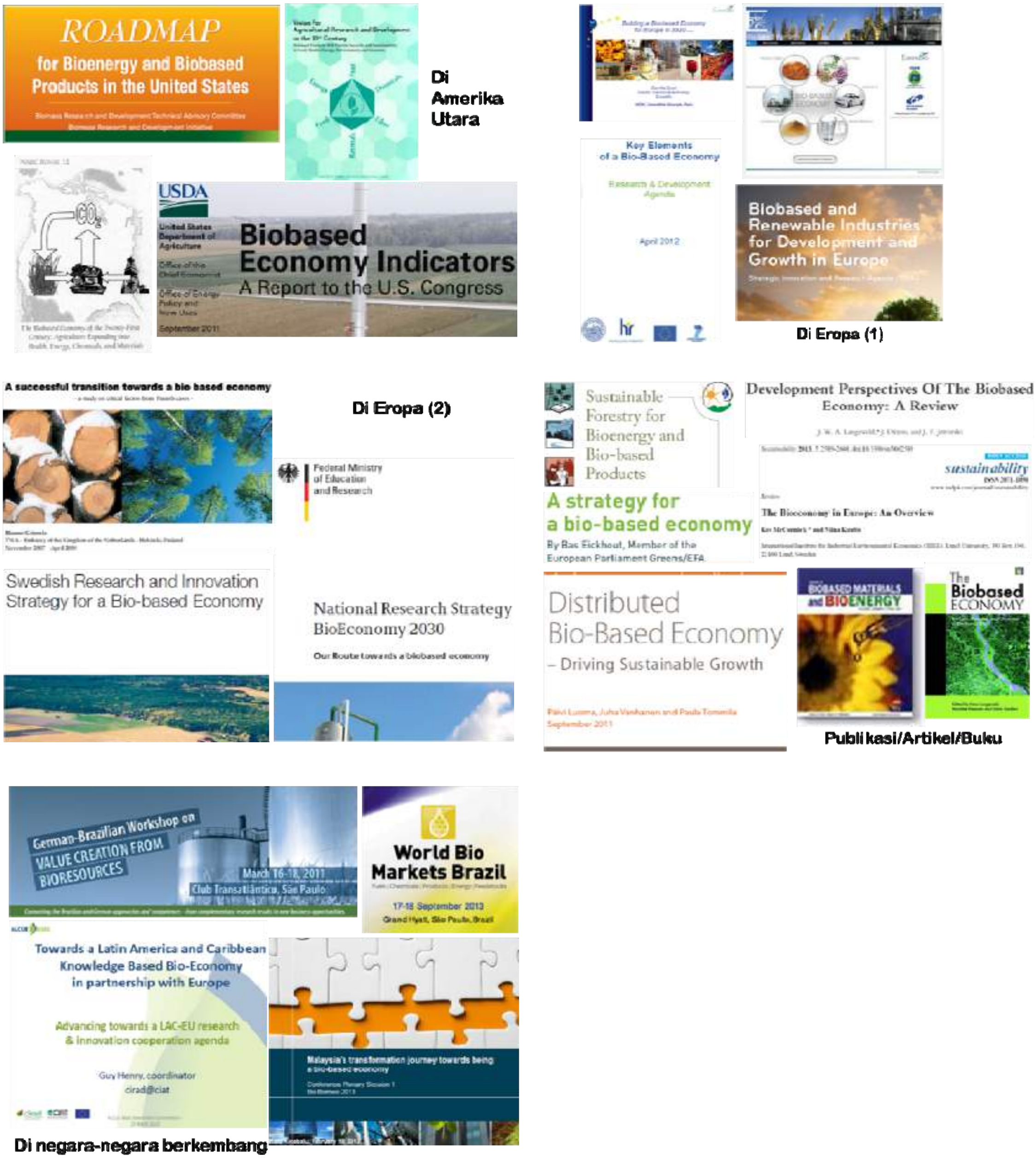
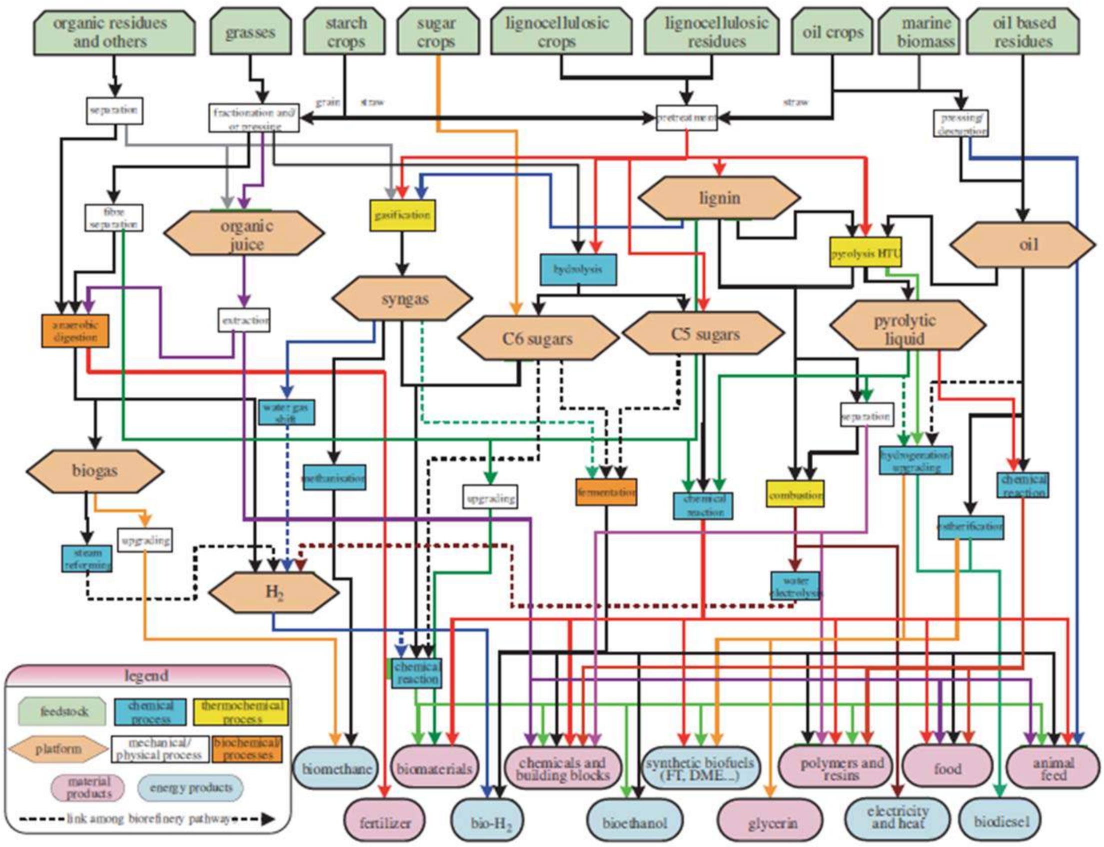


Diagram 1.1 shows a glimpse of products and symbols from various activities around the world that indicate the world is transitioning into a bio-based economy. Further investigation on the internet will provide stronger conclusions still above emergence of the bio-based economy.

1.3 Biofuels industry as the main pillar of the bio-based economy

In a bio-based economy, bio resources are the key resources not only for food and animal feed, but also for energy and industrial products. Diagram 1.2 shows a guideline of transformation routes or processing of various bio resources into products for industrial and public consumption.

Diagram 1.2: Flowchart of Bio Resource Usage in the Bio-based Economy



Source: Cherubini dkk. *(2009)*

In the bio-based economy era, there are four groups of commodities that become the key pillars of the economy. Based on their production volume, the four pillar commodities are categorised into two main pillars and two supporting pillars. The two main pillars are:

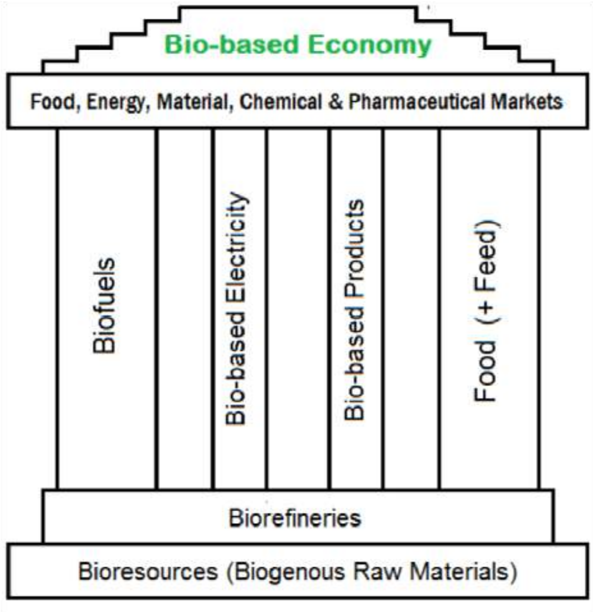
- Food (plus animal feed); and
- Biofuels.

Whereas the two supporting pillars are:

- Bio-based electricity and
- Bio-based chemical products and materials.

Diagram 1.3 shows the schematic structure of a bio-based economy. The four pillar commodities are produced and supplied by bio-refineries, which will one day replace today's petroleum refineries. It is important to bear in mind that although electricity is the main commodity needed by the society, electricity power generation from bio resources (i.e. bio-based electricity) is not as big as the biofuels production volume, because the majority of electricity will be supplied by other (renewable) resources, i.e. geothermal, hydropower, solar power, wind power, and ocean power. In the energy sector, bio resources has an irreplaceable primary function (which becomes its niche), namely as an alternative to fuel, because other renewable energy can only produce electricity and not fuel.

Diagram 1.3: Bio-based economic structure



1.4 A golden opportunity for Indonesia

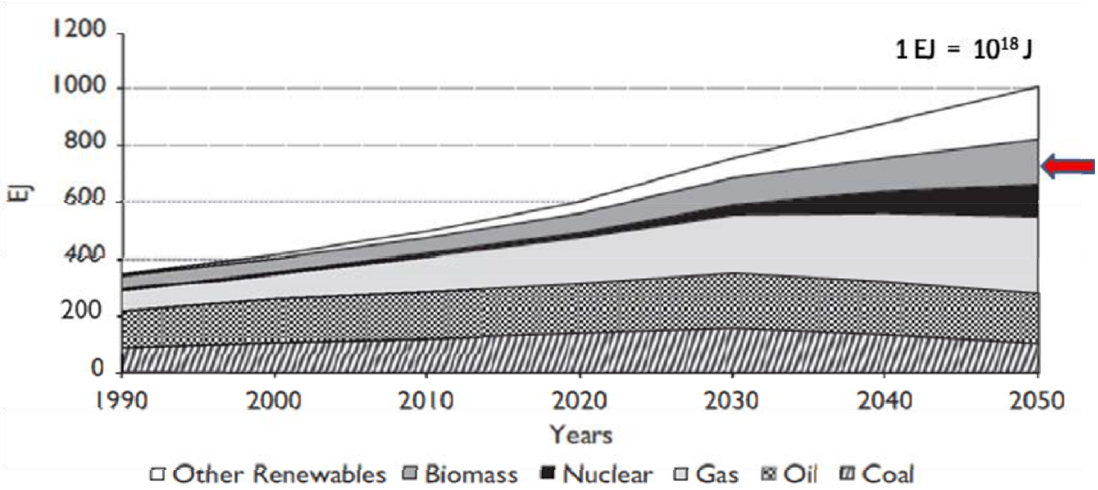
The world's progression towards bio-based economy is a golden opportunity for Indonesia, because Indonesia is a tropical country with vast potential with large stretches of land and rich biodiversity (Indonesia's land biodiversity is the second richest in the world after Brazil, but it is the richest in the world when combined between land and sea biodiversity). Trees grow quicker and larger in Indonesia than in other developed countries (that have four seasons); and various types of multifunctional plants enrich the country's biodiversity.

This golden opportunity must be optimally utilised if Indonesia is not to be left behind. As a country with huge resources far more than most countries, Indonesia must not only follow the currents, but should be the leader in the production, marketing, and R&D of bio products and their processing technologies to obtain added value from the rich potential of its bio resources, to strengthen economic development and to develop food and energy resilience.

Due to the fact that the biofuels industry has not yet bloomed over the past century, but is one of the two main pillars in a bio-based economy, the development of the biofuels industry is the responsibility of the government and Indonesia must not fail in this task. In order to achieve this, the growth and strengthening of the domestic biofuels industry must be factored in as one of the key performance indicators of the government.

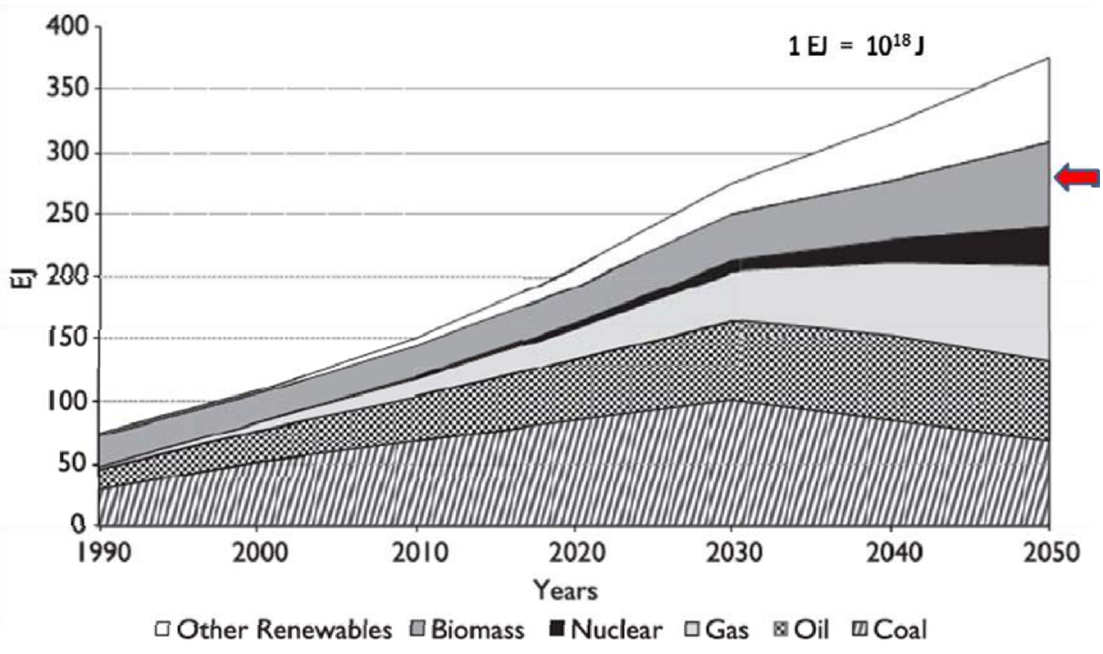
Further confirmation on the relevance of building a strong and dynamic biofuels industry can be concluded from sustainable development scenarios in the energy sector. Diagrams 1.4 and 1.5 show the projections of total primary energy consumption at the global level and in Asia according to the International Energy Agency's (IEA) sustainable development vision scenario.

Diagram 1.4: Projections of total global consumption of primary energy



Source: International Energy Agency. Sustainable Development Vision Scenario, (2003).

Diagram 1.5: Projections of total consumption of primary energy in Asia



Source: International Energy Agency. Sustainable Development Vision Scenario. (2003).

Diagram 1.4 shows that in terms of global projections, the proportion of biomass based energy consumption (i.e. bioenergy, which includes biofuels + bio-based electricity), the area indicated by the red arrow, is about half of the total consumption of total renewable energies (biomass area + other renewables). Diagram 1.5 shows an even greater proportion of bioenergy vis-á-vis total renewable energy consumption in Asia. Therefore, based on these projections we can draw a conclusion that if Indonesia fails to develop its bioenergy industry (a major proportion of which is the biofuels industry), the country will also fail in its objective of developing its renewable energy industry. In the bigger scope of development, this will also mean this country will fail to comply with the development pattern agreed by all other countries around the world, i.e. sustainable development. It is therefore very clear that in order to avoid such failures, Indonesia must succeed in developing its bioenergy energy production (particularly its biofuels industry).

2. Overview of Liquid Biofuels Types and Their Production Technology

2.1 Introduction

Among all forms of final energy forms (electricity and high-quality fuels), liquid fuels is the best and most strategic form of final energy, for a number of reasons:

- Easy and safe storage for long periods of time (reliable as a sources of fuel in emergency situations);
- Portable and easily transported including over long distances;
- High energy density (energy per volume unit); and
- Relatively easy to be ignited (compared to solid fuel), but not highly explosive (compared to gas fuel).

These advantages are factors that have allowed oil and petroleum fuels to dominate the energy economy from the start of the 20th century until today. As a consequence of these facts, today we find that:

1. All engines and technology is available to convert petroleum fuels into electricity; and
2. The transportation sector is highly reliant on petroleum fuels or liquid fuels (fully converting transportation vehicles to be electrically powered is not easy and may take decades to complete).

Due to the fact that the components that compose petroleum fuels are chemical substances that are called hydrocarbons, petroleum fuels can also be called fossil hydrocarbon fuels. Three types of fossil hydrocarbon fuels that are most important in the transportation sector are diesel and gasoline for land transport, and jet fuel for air transport.

Taking into consideration the above, then among the varieties of biofuels available, liquid biofuels are the most important. The most valuable of them are liquid biofuels that can substitute for diesel or gasoline or jet fuels. This chapter introduces those types of important liquid biofuels, their basic production technology and feedstock that have already been utilised by industries or could potentially be developed.

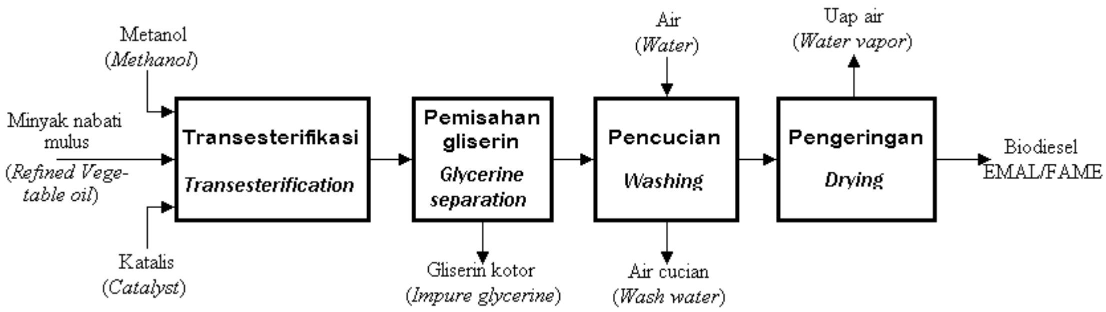
2.2 Generation 1 biofuels

2.2.1 Generation 1 biodiesel

The scientific definition of biodiesel is fuel for automotive diesel engines made from bio / vegetable resources. The commercial product called biodiesel by industries and as known in the market today is actually called EMAL (*Ester Metil Asam-asam Lemak*) or FAME biodiesel (*Fatty Acids Methyl Ester*), also known as generation 1 biodiesel. From the chemical compound perspective, this type of fuel consists of at least 96.5% of fatty acids methyl ester. The government, through the Directorate General of Renewable Energy and Energy

Conservation (Ditjen EBTKE) of the Ministry of Energy and Mineral Resources (Kemen ESDM) now regulates that EMAL/FAME biodiesel product marketed in Indonesia. This product must fulfil certain quality requirements elaborated in SNI 7182: 2012. The most common type of feedstock used to produce EMAL/FAME biodiesel is refined vegetable oil, and the common method of production used is called the transesterification process. Diagram 2.1 shows a basic flowchart of the steps to produce generation 1 biodiesel.

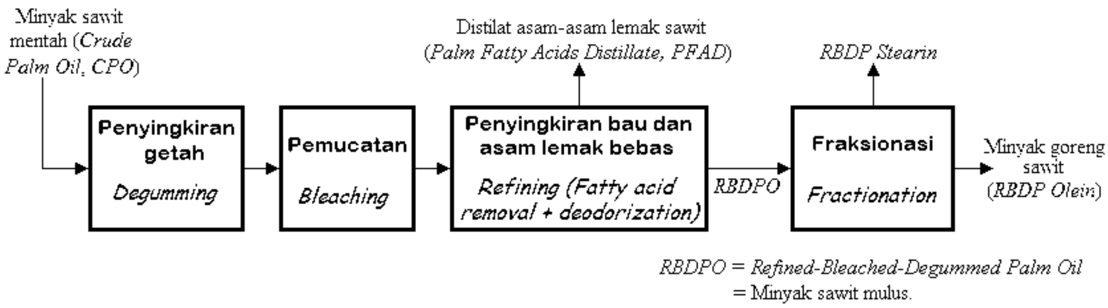
Diagram 2.1: Simple flowchart of EMAL/FAME biodiesel of generation 1 biodiesel production process



Source: Author

The feedstock that is currently most common to be found in Indonesia to produce biodiesel is refined palm oil or RBDP Olein. Diagram 2.2 shows a simple flowchart of the process to produce these two types of feedstock from crude palm oil or CPO. To produce frying oil, most raw vegetable oils (for example raw soybean oil or canola oil) only needs a refining process; palm oil needs an additional fractionation process because they are half solid [CPO and RBDPO are half solid, RBDP Stearin is solid and RBDP Olein is liquid].

Diagram 2.2: Simple flow chart of palm oil refining and fractionation process



Source: Author

Indonesia's biodiversity stores within it various trees and plants species that can potentially produce inedible vegetable oils that can be developed into inedible feedstocks for EMAL/FAME biodiesel. The most prominent ones being the pongam oil tree (*Pongamia pinnata*), nyamplung (*Callophylum innophylum*), neem tree (*Azadirachta indica*) and *sunan candlenut* (*Reutealis trisperma*). Pongam oil tree also grows in (north) Australia, and Australia is undertaking a massive program to develop its plantations. One US Company is also trying to build a plantation in Florida. A brief description about pongam oil trees and the three other trees can be found in the appendix.

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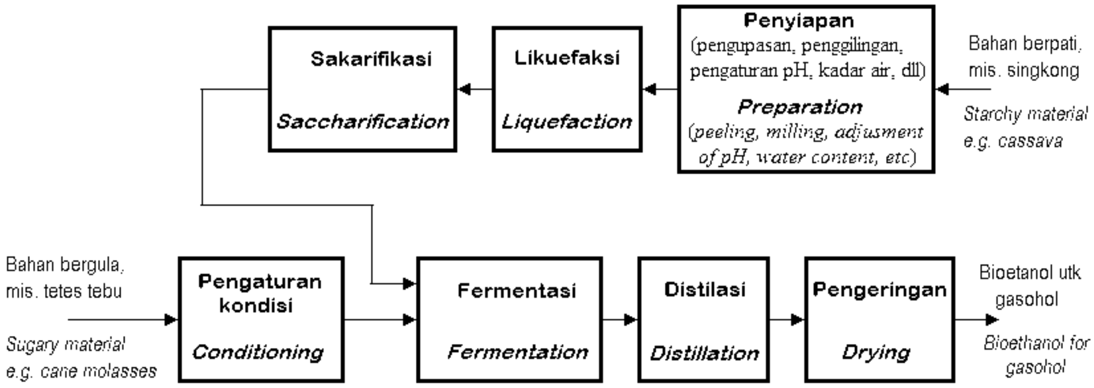
EMAL/FAME biodiesel can be categorised into the oxygenated fuel (i.e. fuel that contains oxygen) category; its mix with hydrocarbon fuels produces lower car emissions.

2.2.2 Generation 1 bioethanol

Bioethanol, or ethanol made from bio-resources, is a substitute for gasoline; in order for it to blend perfectly with gasoline; the water content in bioethanol for gasohol (gasoline-alcohol mixture) must be very low, maximum of 0.5% of weight. The Indonesian Government, through Ditjen EBTKE – Kemen ESDM specifies that bioethanol products marketed in Indonesia must fulfil certain quality requirements elaborated in SNI 7390: 2012. Generation 1 bioethanol is made from sugary or starchy materials (currently commonly produced by the agriculture/plantation sector for food production). Diagram 2.3 shows a flowchart of bioethanol production processed from sugary or starchy materials.

Diagram 2.3: Flowchart of bioethanol production processed from sugary or starchy materials



Source: Author

The diagram shows that the stages in bioethanol production process using sugary materials are fewer than when using starchy materials. Therefore, bioethanol plants using sugary materials will require less investment and smaller operational cost per produced volume. This means bioethanol plants using starchy materials can only compete if the price of feedstocks is relatively cheap.

The most popular sugary material used as feedstock for bioethanol production is cane molasses, a thick black liquid with around 50% sugary content which is a by-product of sugarcane product. Other sugary materials that can be developed in Indonesia include: nipa juice, sweet sorghum juice and sugar palm juice. There are quite a few ethanol plants in Brazil that are combined with sugar factories; the feedstock used for production can be obtained from cane molasses or a combination of nira and cane molasses.

Apart from cassava that has been planted/cultivated by farmers for a long time, sago is another starchy material that can become a great value for Indonesia and worthy to be further developed.

2.3 Biohydrocarbon fuels from vegetable oils and fats

The molecules in vegetable oils and fats consist of 85-90% hydrocarbon. This fact drives the invention of technologies to convert vegetable oils and fats into a mix of hydrocarbon-renewable liquid hydrocarbon (or liquid biohydrocarbon) that can be further processed with common technologies used in oil refineries (crackling, isomerisation, distillation, etc.) to produce renewable biohydrocarbon fuels, namely: *bio-hydrofined diesel* (BHD) or *green diesel*, *jet biofuel*, or even *biogasoline*; all three of them are substitute of diesel, jet fuel and gasoline. The basic stages of their processing can be seen in Diagram 2.4.

Diagram 2.4: Outline of the processing production flow of various renewable biohydrocarbon fuels from vegetable oils and fats

Green diesel or biohydrofined diesel (BHD) production utilises hydrodeoxygenation technology [Eco-Resources Consultants *(2012)*]. Production through hydrodeoxygenation technology with common vegetable oils and fats (e.g. palm oil, canola oil, soybean oil, sunflower oil) as its feedstock will produce a small amount (around 18%) of jet biofuel, apart from the main product, which is BHD. If we only want to produce jet biofuel, we will need to use lauruc type oils and fats, such as coconut oil, palm kernel oil, cinnamon seed oil, and aromatic litsea (*Litsea cubeba*) seed oil, which are endemic to Indonesia. The commercial use of jet biofuel will be carried out in the next few years, due to the following reasons:

- The IATA (International Air Transport Association) has set a target to achieve neutral-carbon growth starting in 2020. This means that the pace of growth in aviation biofuel consumption (the majority of which is jet biofuel) in civilian aviation industry must be equal to the growth of the aviation industry itself (including in Indonesia); and

- The European Union and the United States have already started to implement Emission Trading Schemes (ETS) in the aviation industry, which forces airlines such as KLM and Lufthansa to start using jet biofuel.

In order to respond to this development, the relevant authorities in Indonesia (i.e. Garuda, Lion Air, Angkasa Pura, Air Transportation Directorate General, Ditjen EBTKE, Indonesian Bioenergy Experts Association) have met several times to discuss the preparation for producing and utilising jet biofuel to reduce emissions in the air transportation sector.

Today, there are at least five hydrogenated biofuel plants (i.e. those that use hydrodexygneation technology) around the world; one of them is located in Singapore and produces around 850 thousand tons/year of renewable hydrocarbon fuels utilising Indonesian palm oil as feedstock (1 million ton/year). The plant, which is owned by Neste Oil (Finland), was initially going to be built in Batam, Indonesia, but it is relocated to Singapore because the Singaporean Government offered a 10 year tax holiday facility.

Biogasoline production at large quantities on the other hand, can utilise oil-fat catalytic crackling technology, very similar to the fluid catalytic cracking (FCC) that has been commonly applied in oil refineries (Al-Sabawi dkk, 2012). A simple version of this technology has actually already been applied in China in the 1940s (during World War II) to produce gasoline from tung oil (in the same family as *sunan* candlenut oil) (Chang and Wan, (1947). Today many research institutes around the world operate oil-fat crackling pilot plants to verify and further develop this technology for modern commercial use. As shown in the flowchart of Diagram 2.4, apart from the main product of biogasoline, the FCC process will also produce around 33% of light cycle oil that can be used to as a mixing component for green diesel.

Renewable liquid hydrocarbon materials have the advantage of being able to be mixed in various percentages (hence its name, drop-in fuel) with their relevant fossil hydrocarbon fuels (this is because the fuels share similar molecules, the only difference being one is made from fossil materials and the other is made from vegetable materials). On the other hand, oxygenated biofuels such as bioethanol and EMAL/FAME biodiesel can only be mixed at a certain percentage (because a larger percentage will require modification in the vehicle’s engine). As an additional note, aircraft manufacturers, civilian airlines, and biofuels developers agree that only drop-in biofuels can be used for air transportation.

The special characteristics of vegetable oils and fats allow them to be relatively easy to be processed into EMAL/FAME biodiesel, renewable liquid hydrocarbon fuels, and pure plant oil (PPO), or straight vegetable oil (SVO) (a type of biofuel that can be used in low cycle stationary diesel engines); this has driven Western countries to seriously cultivate trees that can potentially produce inedible oils and fats in their countries, for example tobacco and camelina, despite their annual production is not more than 1½ ton/ha/year. As a comparison, the annual potential production of these types of trees in Indonesia (i.e. *mabai* (pongam oil tree), *nyamplung* (laurelwood), *nimba* (nimtree) and *sunan* candlenut (tung tree) is more than 2½ ton/ha/year, hence if Indonesia truly makes the effort to develop these commodities, Indonesia will become amongst the biggest producers of both food and inedible oils and fats.

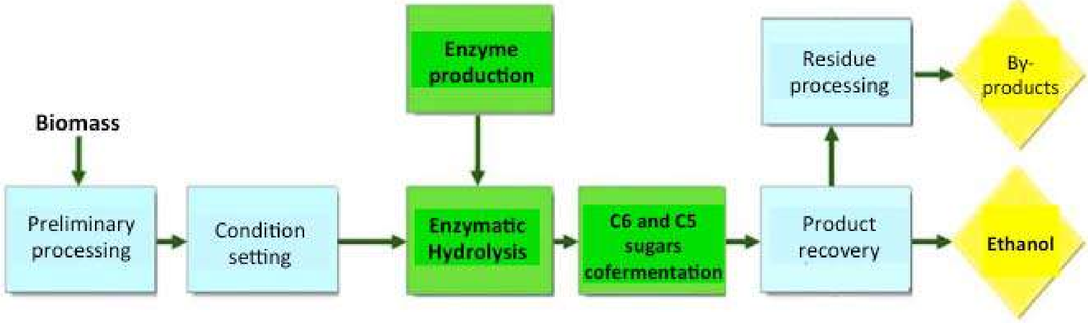
2.4 Generation 2 biofuels

Generation 2 biofuels are liquid biofuels that are made from lignocellulose. The material known as lignocellulose, or sometimes known as whole biomass, is the structural part of trees. For examples: palm oil’s empty husk, sago tree bark, hay, sugarcane bagasse, sweet sorghum bagasse, corn stalk and cob, wood, bamboo, grass, etc. Lignocellulose is not considered as food material, but is produced in large quantity by trees, particularly those planted/cultivated for food. Thus, the production of biofuels using lignocellulose materials will not compete with, but rather can potentially complement food production, because it adds value to materials that are normally disposed of as waste during harvesting and food processing.

2.4.1 Generation 2 bioethanol

Lignocellulosic materials are composed of two carbohydrate matrix (cellulose and hemicellulose) that are strongly bound by lignin (non-carbohydrate material) with a composition of 30-50% of cellulose matter, 15-35% hemicellulose matter, and 13-30% lignin matter. The two carbohydrates inside lignocellulose materials are the ones that can be processed using biotechnology into bioethanol.

Diagram 2.5: Flowchart of generation 2 bioethanol production process



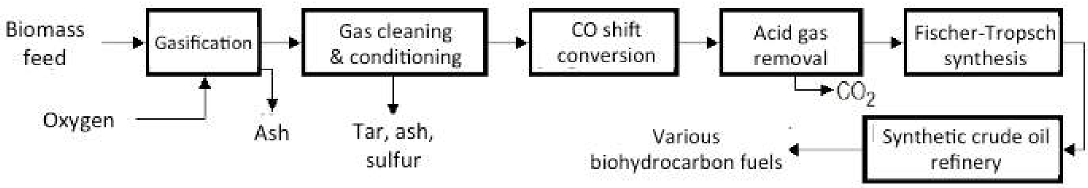
The production of bioethanol from lignocellulose materials (Diagram 2.5) has more complicated stages compared to the production of bioethanol from starchy materials as illustrated in Diagram 2.3, because it also incorporates the pre-treatment process to release the cellulose and hemicellulose from the lignin strain. The technologies are currently being developed by R&D agencies in several countries, and some have already reached the demonstration plant stage, therefore hopefully it can go commercial by the second half of this decade.

At some future time when generation 2 bioethanol can be produced at a competitive price, it can also be converted into biogasoline using technologies similar to ExxonMobil's Methanol-to-Gasoline (MTG) technology *(2009)*, which has been proven to be commercially viable.

2.4.2 Generation 2 biodiesel

Unlike generation 1 biodiesel that consists of fatty acids methyl ester (FAME), generation 2 biodiesel, or also known as Biomass-To-Liquids (BTL) or F-T (Fischer-Tropsch). Generation 2 biodiesel is a renewable liquid hydrocarbon fuel like biohydrofined diesel (BHD) but made of lignocellulose by combining biomass gasification technology with Fischer-Tropsch synthesis. Diagram 2.6 illustrates the stages in producing generation 2 biodiesel.

Diagram 2.6: Flowchart of BTL liquid hydrocarbon production process



German-based company CHOREN has managed to develop BTL technology up to the demonstration stage since 2008 and its demonstration plant is located in Freiberg, Germany. However, the technology and commercial plant do not yet appear to be economically viable. CHOREN itself has gone bankrupt and has sold its technology to another German company called Linde Engineering. Nevertheless, today the European Union is financing several similar demonstration plants. It is predicted that this BTL diesel technology will only be commercially available after 2020.

2.5 Summary: Biofuels classification and their technology commercialisation

In the previous sub chapters we have discussed the two classes of biofuels, namely:

- Oxygenated biofuels can only be mixed at a limited percentage (10-20% of volume) with fossil fuels, because a higher percentage mix will require modification in the vehicle's engine, but has better emission rates than for pure hydrocarbon fuels.

- Drop-in biofuels are biofuels that have hydrocarbon chemical structures and therefore can be mixed with the corresponding fossil fuels in any percentage (up to 100%).

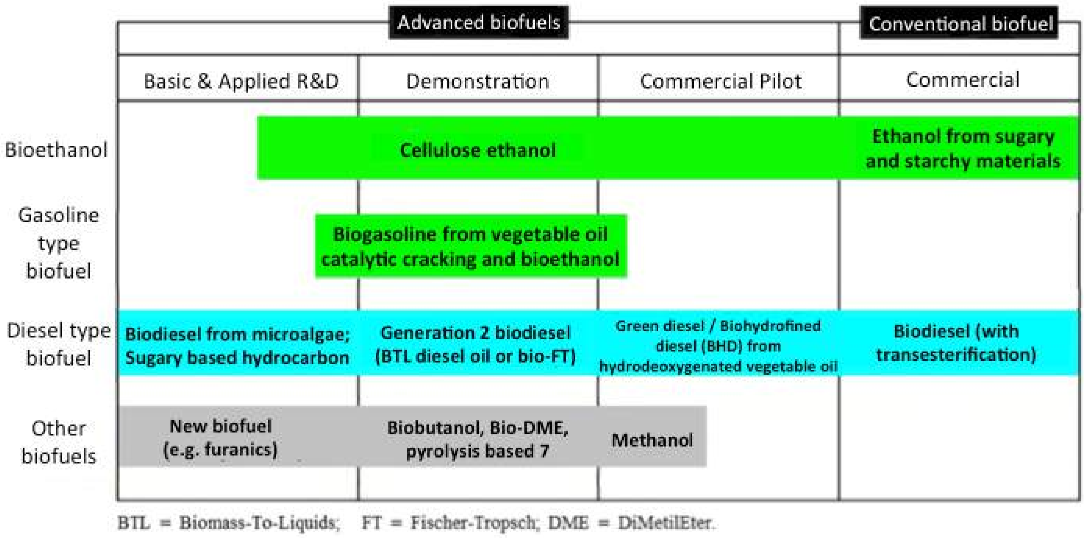
Table 2.1 below shows a summary of biofuels types categorised into those two classes.

Table 2.1: Classes and Types of Biofuels

Corresponding fossil fuels	**Biofuels**	
	Oxygenated	**Drop-in**
Diesel	Generation 1 Biodiesel (EMAL/FAME* Biodiesel)	Bio-Hydrofined Diesel (BHD) or Green diesel and generation 2 Biodiesel (or BTL biodiesel or F-T biodiesel)
Gasoline	Generation 1 and 2 Bioethanol	Biogasoline or Green gasoline
Jet fuel	-	Bioavtur or Jet biofuel

Diagram 2.7 shows a summary of the status of commercialisation of various biofuels that have been explained in the previous sub chapters, as well as other biofuels that are (still) less important.

Diagram 2.7: Commercialisation status of various biofuels



Source: modified from IEA (2011)

3. Evaluation of Liquid Biofuels Industry Development and their Development Policies

3.1. Introduction

The Indonesian economy has suffered recent stresses. Despite a relatively high economic growth (around 6% per year), import volumes have dramatically increased, while export volumes have decreased and net capital investment flows have shown periodic weakness. This has caused the overall balance of payment and foreign exchange reserves to come under stress, which has led to recent weakness in the exchange value of the Rupiah.

To tackle these instabilities, the Indonesian government on 23 August 2013 released an economic policy package; with one of the items included in the package stipulating a planned reduction of fuel imports through increasing the consumption of domestically produced biofuels, considering that fuel imports are one of the main contributors to the trade deficit. On 28 August 2013 the government also put into effect Permen ESDM No. 25/2013 that stipulates new targets and timelines for the mandatory use of biofuels, which were previously regulated in Permen ESDM No. 32/2008. The new targets and timelines can be seen in Table 3.1. below.

Table 3.1: Targets and timelines for mandatory use of biofuels according to Permen ESDM No. 25/2013 (minimum percentage versus total consumption)

Bio-fuel	Sector	Sept. 2013	Jan. 2014	Jan. 2015	Jan. 2016	Jan. 2020	Jan. 2025
BIODIESEL	PSO transportation*	10 %	10 %	10 %	20 %	20 %	25 %
	Non PSO transportation	3 %	10 %	10 %	20 %	20 %	25 %
	Industrial & Commercial	5 %	10 %	10 %	20 %	20 %	25 %
	Electricity generation	7.5 %	20 %	25 %	30 %	30 %	30 %
BIOETHANOL	PSO transportation	-	0.5 %	1 %	2 %	5 %	20 %
	Non PSO transportation	1 %	1 %	2 %	5 %	10 %	20 %
	Industrial & Commercial	-	1 %	2 %	5 %	10 %	20 %
PPO	Industry	1 %	5 %	10 %	20 %	20 %	20 %
	Sea transportation	-	5 %	10 %	20 %	20 %	20 %
	Electricity generation	1 %	6 %	15 %	20 %	20 %	20 %

* PSO = *Public Service Obligation*, PPO = *Pure Plant Oil* = Minyak Nabati Mumi (MNM)

The short term goal of Permen ESDM No. 25/2013 is to reduce fuel imports as soon as possible (within 2014) by 100,000 barrels/day (5.73 million kL/year).

This chapter provides a quick assessment of biodiesel and bioethanol industry development in Indonesia, to assess if the targets scheduled in Permen ESDM No. 25/2013 and illustrated in Table 3.1 can technically be fulfilled, as well as to identify which policies need to be taken by the government to develop the existing domestic biofuels industry to ensure the smooth implementation of the mandatory biofuels usage program.

3.2. Mapping of producers and installed capacity of biodiesel and bioethanol industry and access to feedstock

Table 3.2 provides information on the identity, plant location, and installed capacity of existing biodiesel producers in Indonesia. All biodiesel plants today use Refined-Bleached-Degummed Palm [RBDP] Olein/Oil/Stearin.

Table 3.2: List of biodiesel producing companies in Indonesia

No.	Company	Location	Installed capacity, ton/yr	Access to feedstocks
1	PT Pelita Agung Agrindustri	Duri, Riau	200,000	Market*)
2	PT Musim Mas	Medan + Batam	800,000	Own plantation
3	PT Wilmar Nabati	Gresik	1,300,000	Market
4	PT Wilmar Bioenergi	Dumai	1,300,000	Market
5	PT Nusantara Bioenergi	Aceh	50,000	Pure market
6	PT Multi Biofuels Indonesia	South Kalimantan	160,000	Pure market
7	PT Indo Biofuels Energy	Merak	60,000	Pure market
8	PT Eterindo Wahanatama	Gresik	240,000	Pure market
9	PT Darmex Biofuels	Bekasi	150,000	Pure market
10	PT Ciliandra Perkasa	Dumai	250,000	Market
11	PT Cemerlang Eka Perkasa	Dumai	250,000	Market
12	PT Sumi Asih	Bekasi	100,000	Pure market
13	PT Damai Sentosa CO	Surabaya	73,000	Pure market
TOTAL			**4,933,000 (5,670,115 kL)**	

*) Market: business unit has a plantation unit. Pure market: business unit does not have any plantation unit.
Source: APROBI (Indonesian Biofuels Producers Association)

Among the thirteen companies, only PT Musim Mas has its own palm oil plantation (integrated with a palm oil plantation); the other companies must purchase their feedstock from RBDP producing companies. Nevertheless, five out of 12 companies (with access to "Market" for feedstocks) have better feedstock supply guarantee, because their business units have an RBDP producing company incorporated, whereas the rest of them (those that buy their feedstocks from "pure market") has no such inter-company access.

Table 3.3 shows a list of companies that produce gasohol grade bioethanol (fulfils technical specifications to be mixed with gasoline), including PT Energy Agro Nusantara, the subsidiary of PT Perkebunan Negara X (PTPN X), whose plant has just been completed in August 2013. With the exception of PT Medco Ethanol Lampung, the plants are designed to produce bioethanol with cane molasses as its feedstock. PT Medco Ethanol Lampung was originally designed to produce bioethanol using cassava (from pure market) as its feedstock, but changed to cane molasses due to difficulty in securing the feedstock.

Table 3.3: List of gasohol grade bioethanol producers in Indonesia

No.	Company	Location	Installed capacity, ton/yr	Access to feedstock
1	PT Molindo Raya Industrial	Malang	7,900	Pure market*)
2	PT Medco Ethanol Lampung	Lampung	7,900	Pure market
3	PT Energi Agro Nusantara	Mojokerto	23,700	Market
4	PT Acidatama	Surakarta	25,952	Pure market
TOTAL			**65,452 (82,850 kL)**	

*) Market: business unit has a plantation unit. Pure market: business unit does not have any plantation unit
Source: APROBI

The data presented in Table 3.2 and Table 3.3 shows that the total installed capacity of biodiesel and bioethanol plants in Indonesia today is 5.75 million kL. As long as the entire production from these companies can be absorbed to substitute the use of fossil fuels in the country, the target to reduce fuel import by 400,000 barrels/day (5.73 million kL/year) by 2013 can technically be achieved.

3.3. Analysis on the availability of domestically produced biodiesel and bioethanol and their potential growth

3.3.1. Biodiesel

The current state (2013) of Indonesia's CPO production is around 26 million tons/year with an estimation of increase to 40 million per year by 2020. From the current state of 26 million tons/year, 5 million tons are consumed by the domestic food industry/sector, another 5 million tons are consumed by the biodiesel industry (if the plants are fully operational with maximum capacity), and the remaining 16 million tons is exported as CPO.

The abovementioned overview of CPO domestic production and export indicates a great potential for the growth of domestic biodiesel industry. The availability of domestically produced biodiesel can also be ensured, as long as the established buying price of biodiesel by the government is sufficiently attractive for the producers to produce. Table 3.4 below presents the details of additional domestic production of biodiesel that can be expected from one to three years ahead based on known production capacity expansion plans of current and future producers. The listed data on this table indicates that the availability of domestically produced biodiesel in the immediate years ahead (until 2015) is rather reassuring.

Table 3.4: Additional production capacity of biodiesel to the end of 2015

No.	Companies	Location	Planned capacity, ton/year	Ready for operation target
1	PT Pelita Agung Agrindustri	Duri, Riau	+ 140,000	Dec 2014
2	PT Nusantara Bioenergi	Aceh	+ 44,000	Dec 2014
3	PT Multi Biofuels Indonesia	Kalsel	+ 120,000	Mar 2014
		Sulut	160,000	Jun 2014
4	PT Indo Biofuels Energy	Merak	+ 100,000	Jan 2014
		Jambi	160,000	Mar 2014
		Sulsel	160,000	Jun 2014
		Kalbar	100,000	Aug 2014
5	PT Eterindo Wahanatama	Gresik	+ 150,000	Jan. 2014
6	PT Darmex Biofuels	Bekasi	+ 100,000	Jan.2014
		Kaltim	401,500	Jul 2015
		Riau	401,500	Jul 2015
7	PT Oleokimia Sejahtera Mas	Riau	500,000	Dec 2015
8	PT BITs Energi	Kaltim	100,000	Dec 2014
9	PT Nusa Energi	Kaltim	100,000	Aug 2014
TOTAL			**2,737,000 (3,145,977 kL)**	

Source: APROBI

3.3.2. Bioethanol

Most of bioethanol plants in the world (and all bioethanol plants in Indonesia) produce gasohol grade bioethanol (with a maximum water content of 0.5%–weight) by drying industrial grade bioethanol (or azeotropic bioethanol) that contain around 5%–volume (or around 6%–weight) of water. This bioethanol product with azeotropic grade is produced through distillation (refer to Figure 2.3 in Chapter 2) and is sold to meet the needs of chemical, pharmaceutical and beverages industries. Table 3.5 below presents the list of industrial grade bioethanol producers with large installed capacity.

Table 3.5: List of industrial grade bioethanol producers

No.	Company Name	Location	Installed capacity ton/yr
1	PT Medco Ethanol Lampung	Lampung	47,400
2	PT Molindo Raya Industrial	Malang	39,500
3	PT Indo Acidatama	Solo	39,500
4	PT Energi Agro Nusantara	Mojokerto	23,700
5	PT Indonesia Ethanol Industry	Lampung	63,300
6	PT Indo Lampung Distillery	Lampung	47,400
7	PSA Jatiroto (PTPN XI)	Jatiroto	5,530
8	PSA Palimanan (PT RNI)	Cirebon	5,530
9	PT Madubaru	Yogyakarta	5,530
10	PT Molasindo Alur Pratama	Medan	3,950
11	PT Basis Indah	Makassar	3,950
TOTAL	**(361.100 kL/th)**		**285,290 ton/th**

Source: ASENDO (Indonesia Ethanol Association)

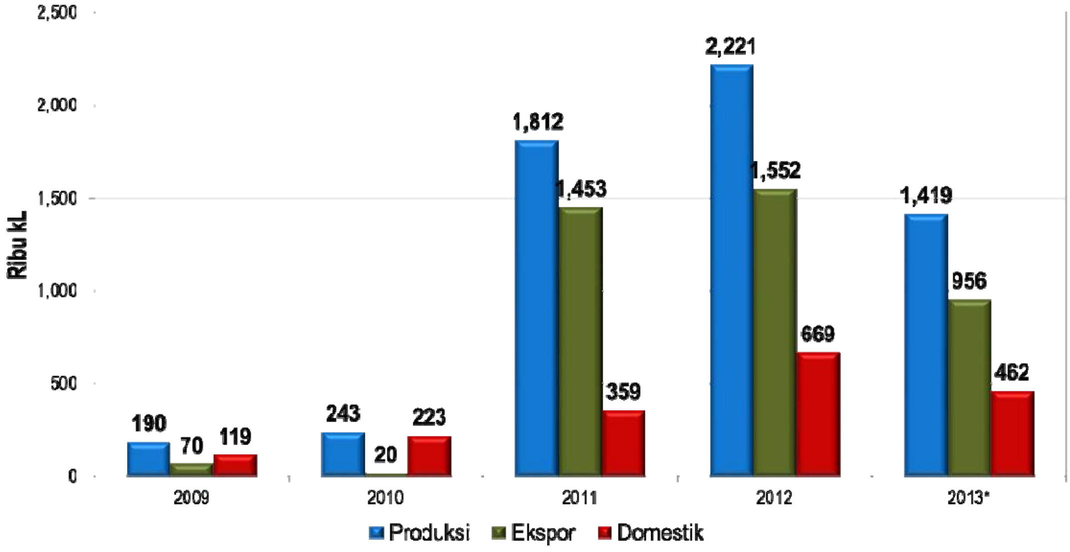
The comparison of total capacities stated in Table 3.3 and 3.5 shows that currently in Indonesia, the production capacity of gasohol grade bioethanol does not amount to a quarter of total bioethanol production capacity (industrial grade). This indicates that if the price of gasohol grade ethanol could attract the interest of producers, they could quite likely install ethanol drying installations (which would take less than a year) and produce and domestically market gasohol grade bioethanol. In fact, the total capacity of companies that plan to and are ready to produce gasohol grade bioethanol and have obtain biofuel license from the Bioenergy Directorate of the Ministry of Energy and Mineral Resources is at 328,800 tons/year (416,200 kL/year). Even so, the analysis in section 3.4.2 below indicates that gasohol grade bioethanol production capacity from 2014 to 2016 will not be able to meet projected demand over this period.

3.4. Analysis of domestic sales and exports as well as the valuation of the determining factors

3.4.1. Biodiesel

The biodiesel mandatory use target in 2014, as stated on Table 3.1, is 10% each for transportation, industry and commercial and 20% for power plants. According to the estimation by the Bioenergy Directorate of the Ministry of Energy and Mineral Resources, biodiesel demand to meet those targets is equal to 2.734 million kL with 1.644 kL used by PSO transportation. This number is far below the national production capacity which is 5.67 million kL, of which the industry still has the capacity for export. Figure 3.1 shows the data of production, export and domestic sales volumes of biodiesel from 2009 to 2013.

Figure 3.1: Biodiesel production, domestic consumption & exports, 2009 to 2013



*) Until 29 August 2013.
Source: Bioenergy Directorate, Directorate General of New, Renewable and Conservation of Energy (EBTKE), Ministry of Energy and Mineral Resources

The above data indicates that the realisation of biodiesel domestic production so far has always been far below the total installed capacity (that, in fact, has reached 3.9 million tons/year in 2009). This is due to two following reasons:

1. The established price

The price set by the government for the purchase of biodiesel by PT Pertamina is considered very low which creates reluctance of the producers (especially those with relatively low production) to produce and supply biodiesel for the domestic market. Table 3.6 below presents the data of discrepancy between mandatory biodiesel use target stipulated in the Ministerial Decree no. 32/2008 and its realisation.

Table 3.6: The realisation of mandatory use of biodiesel.

	2009 (kL)	2010 (kL)	2011 (kL)	2012 (kL)	2013 (kL)
Mandatory for all sectors	775,941	1,76,051	1,297,000	1,641,000	2,017,000
Mandatory for PSO transportation	349,175	484,225	590,650	694,440	1,202,250
Realisation*)	119,348	223,041	358,812	669,398	570,901
Percentage (against PSO)	34.2 %	46.1 %	60.8 %	96.4 %	47.5 %

*) Realisation in 2013 until 23 September 2013.
Source: Directorate of Bioenergi, the Ministry of Energy and Mineral Resources

2. Export Constraints

Large producers such as Wilmar and Musim Mas initially expected to export biodiesel. However, allegations of dumping, non-environmentally friendly product (due to production on plantations that were formerly thick peat lands), etc. has hindered export growth. Many producers that are members of Association of Indonesian Biofuel Producers (APROBI) actually prefer to sell domestically if the price is realistically set.

Even when in 2014 the producers are projected to export, for example 2 million kL, with a total production capacity of 5.67 million kL and domestic consumption to meet the mandatory use target at 2.734 million kL, there is still idle capacity at 0.936 million kL. Thus, it is evident that the bottleneck to the presently unattainable mandatory biodiesel use target is not due to the lack of production or export capacity, but due to improper pricing policy from the government.

3.4.2. Bioethanol

The low bioethanol price set by the government has made the realisation of the biofuel mandatory use constantly come to nothing since 2009. Producers have preferred to trade industrial grade bioethanol produced (which has a more competitive price) rather than producing bioethanol for gasohol.

If the price were able to encourage industry to produce and sell gasohol grade bioethanol, the mandatory use target in 2013 (1% from total consumption of non-PSO transportation, Table 3.1) could easily be achieved, because the demand is only around 12,000 kL (in fact, it is only 3,000 kL because it was only one quarter according to the 2013 data), while the national installed capacity is at 82,850 L (Table 3.3). However, in 2014, the demand will increase to around 165,000 kL with the commencement of the bioethanol mandatory use target of 0.5% for PSO transportation whose consumption volume is far larger (around 25 times) than the non-PSO transportation. The demand in the following years will continue to grow (a minimum of 330,000 kL in 2015 and 660,000 kL in 2016), due to the constant increase of bioethanol mandatory use target towards PSO transportation. Thus, even if the price negotiation arrived at a satisfactory result for the producers, the targets for 2014, 2015, 2016 will remain extremely difficult to achieve on time, because the fulfilment will require a very large addition of new production capacity.

3.5. Analysis of existing policies that support the production and use of biodiesel and bioethanol in Indonesia and valuation of capacity to expedite production and domestic use

The main policies that have been established by the government to support the production and use of biodiesel in Indonesia are as follows:

1. Presidential Decree (Perpres) no. 5 of 2006 on National Energy Policy set a 2025 target of domestic use of biofuel to reach a minimum of 5% of the national energy mix. According to the estimation of the Bioenergy Directorate of the Ministry of Energy and Mineral Resources, to achieve this target in 2025 the biodiesel and bioethanol domestic use should reach 9.52 million kL and 3.45 million kL, respectively. Further elaboration on the long term strategy and policy needed to implement this target can be found in section 3.8 below.

2. President Instruction (Inpres) no. 1 of 2006 on the Procurement and Use of Biofuel as alternative fuel stipulate instructions to all relevant ministers, governor and regent/mayor to take steps in order to expedite the procurement and use of biofuel.

3. Law no. 30 of 2007 on Energy mandates the procurement and use of new and renewable energy (including biofuel) as priorities.

4. Energy and Mineral Resources Ministerial Decree (Permen) no. 32 of 2008 on the Procurement, Use and Trade System of Biofuel stipulates the mandatory use of biofuel for transportation, industry, commercial sector and power plants, which was amended / expedited by the Energy and Mineral Resources Ministerial Decree no. 25 of 2013.

5. The allocation of biofuel subsidies on top of the Market Price Index (MOPS, *Mid-Oil Platts Singapore*) in the State Budget (APBN).

6. Energy and Mineral Resources Ministerial Decree (Kepmen) no. 0219K/12/MEM/2010 on the Market Price Index (HPI) of petroleum fuel and biofuel that is mixed to certain type of petroleum fuel, stipulates that:

    - Biodiesel Market Price Index (HPI) = HPE x 870 kg/m^3

   HPE is the Biodiesel Export Standard Price (FAME) from palm oil that is set monthly by the Minister of Trade. Since biodiesel is made from refined palm oil (especially RBD olein) and RBD Olein is made from CPO (please refer to figure 2.1 and 2.2 in Chapter 2), HPE of palm oil FAME is consequently higher from HPE of RBD Olein and HPE of RBD Olein itself is higher than HPE of CPO.

    - Bioethanol Market Price Index (HPI) = (Argus Price) x 788 kg/m^3 x (1 + 0,05)

   (Argus Price) is ARGUS published price for average FOB Thailand bioethanol during the period of the previous month and 0.05 (=5%) is the domestic production balancing factor.

   As the above biodiesel Market Price Index is considered too low, especially by low capacity producers, it becomes the bottleneck of biodieseul use as a mix to PSO transportation fuel. On the other hand, the stagnation of biodiesel use in non-PSO transportation, industry, commercial and power plants is due to the lack of firm socialisation and mandatory use of biodiesel in those sectors, including penalties for non-compliance.

   The main reason for the stagnation of bioethanol use is the abovementioned bioethanol Market Price Index that has been set, which is considered unattractive. Our current domestic bioethanol industry remains less competitive to other producers abroad (e.g. Thailand and Brazil). Recalling the abundant potential domestic bio resources for bioethanol (in addition to cane molasses and cassava, there are buckwheat, sugar palm, nipa palm, etc. that need to be developed), the government is advised to carry out nurturing programmes for these industries, through pricing policies that provide good incentives first but which are then gradually tightened in order to push for the growth of the industry with stronger competitiveness.

   The industry itself has recommends that in the current condition, factor 0.05 should be changed to 0.32 which then could be followed by a negotiation to agree on the schedules for tightening/reduction of this factor over time. With regard to the nurturing programme, in order to allow the industry to grow through the process of ‘learning by doing’ within a seven year period (which is sufficient time to build competitiveness), the government should consider setting a factor value of 0.35 in the first year and to then gradually lower / tighten this factor value by 0.5 points for every following year.

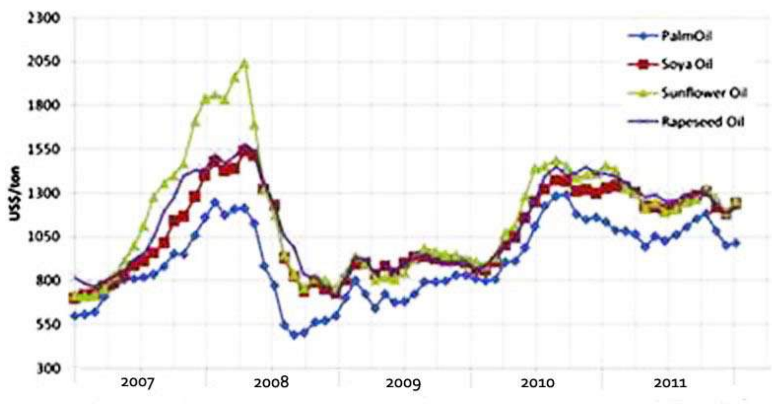
7. The Ministry of Finance has enacted Minister of Finance Regulation (PMK) no. 21 of 2010 on the provision of tax and customs for the use of renewable energy resources activities. Although there are benefits to this facility, the biofuel producers prefer the government to waive any value added tax applied to the selling of products, similar to the way it waived the tax towards petroleum fuel.

3.6. Analysis on impact, price setting and production profitability of domestic liquid biofuel, including deliberations on domestic and international prices from the feedstock of liquid biofuel production

3.6.1. Biodiesel

Figure 3.2 shows the trend of main biofuels' (palm, soybean, sunflower, and rapeseed) international price and indicates that palm oil has always been the cheapest which makes it the most competitive feedstock for biodiesel production.

Figure 3.2: International price movements of main biofuels



Source: Prussi et al (2013)

As previously elaborated in chapter 2 (section 2.2), the conversion of CPO to biodiesel includes two separate production processes:

- CPO refining to become RBDPO followed by its fractionation to become RBD Olein and RBD Stearin costs around USD35/ton (Rp300 – 400/kg is the cost range of normal processing of CPO into RBDP Olein); and

- The conversion of RBDP Olein/Oil/Stearin to biodiesel; the quality of biodiesel that meets Indonesia's product quality standard the most, can be attained when RBDP Olein is used as the feedstock (the ones made from RBDP Oil/Stearin often violates the clout point requirement; the Indonesia's National Standard requirement is for a maximum of 18^{o}C).

  The processing costs of RBDP Olein to biodiesel ranges around USD120 – USD130 per ton; theoretically, 1 kg of olein will produce 1 kg of biodiesel. Thus, the Market Price Index of biodiesel that ranges between USD120 – USD130 above the price of RBDP Olein can be deemed reasonable by producers (they can optimise it by mixing a small amount of RBDP Oil/Stearin, which is cheaper in cost, into the RBDP Olein and produce biodiesel that meets Indonesia's National Standards). A literature review (Duncan, 2003, Haas, 2006, Marchetti dkk, 2008, You dkk, 2008, Kiss dkk, 2010) indicates that the processing cost of refined biofuels to become biodiesel ranges between USD110/ton for plants with larger capacity than 100.000 ton/year and USD168/ton for plants with a capacity of 8,000 ton/year.

3.6.2. Bioethanol

The most common feedstock for ethanol production in Indonesia is cane molasses and cassava. Cane molasses is a thick black liquid that is a by-product of sugar cane factories which contains 42%-55% sugar. Cassava contains around 42% starch (substance that can be converted into bioethanol). The following data is extracted from http://www.thaitapiocastarch.org/article24.asp: “Ethanol Industry, an Open Market for Farmers”, December 2011:

- Conversion factor of cane molasses to ethanol: 4.17 kg/litre [sugar content in cane molasses is at 42.09%];
- Conversion factor of fresh cassava to ethanol: 6.55 kg/litre [starch level is at 24.12%];
- The cost of conversion to biodiesel from cane molasses: 6.125 baht/litre [Rp 2,240/litre]; and
- The cost of conversion to biodiesel from fresh cassava: 7.107 baht/litre [Rp 2,600/litre].

If the unit price of cassava and cane molasses can be identified, the production cost of ethanol from both of these feedstocks can be calculated. For example, if the price of cane molasses is Rp 1,000/kg (recent market price), then the cost of ethanol production = (4,17) (1,000) + 2240 = Rp 6,410/litre. If the price of fresh cassava is at Rp 8,000/kg (the actual current price), then the cost of ethanol production would be = (6.55) (800) + 2,600 = Rp 7,840. Based on these calculation samples, it can be concluded that the current buying price of bioethanol set by the government (which is around Rp 6,000/litre) will continue to be unattractive for the producers to produce and supply bioethanol for gasohol.

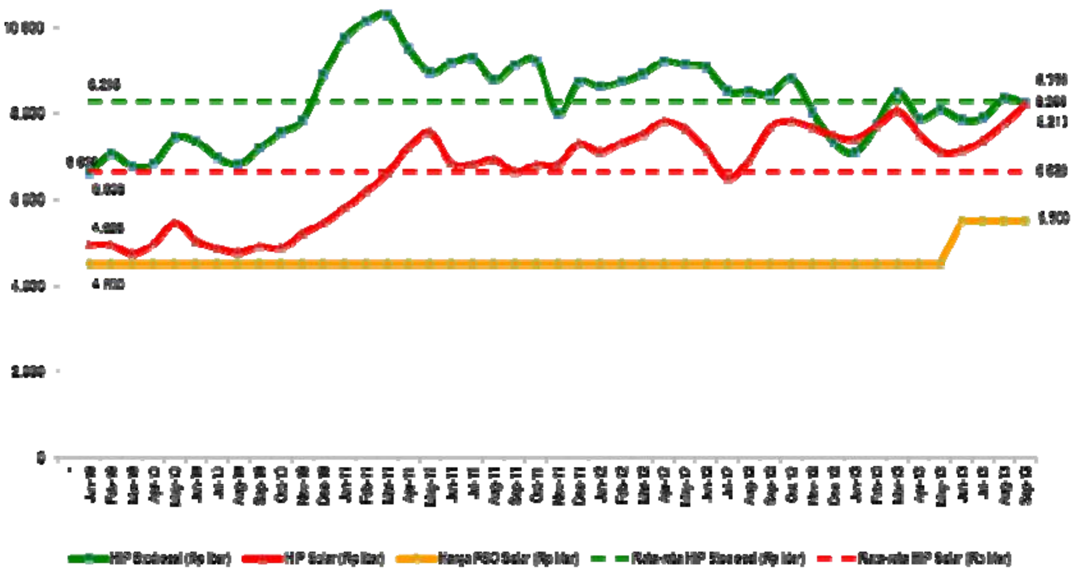
3.7. Impact analysis on the increase of domestic liquid biofuel production to other sectors such as forestry, land use as well as its implications to greenhouse gas emission and subsidy to energy and fuel.

3.7.1. Biodiesel

The Bioenergy Directorate of the Ministry of Energy and Mineral Resources estimates that the domestic use of biodiesel by 2025 will have to reach 9.52 million kL. Looking at the current capacity of national biodiesel production that stands at 5 million tons/year, an additional capacity of 4.5 million tons will be needed by 2025. With the current surplus in Indonesia’s production (of which Indonesia exports are not less than 16 million tons CPO/year), the addition to domestic capacity will not create any impact to the forestry and land use sectors (unless Indonesia increases its exports on CPO and its by-products including biodiesel).

According to calculations of the Indonesian Palm Oil Board (DMSI) and the Ministry of Agriculture, the use of 1 kL biodiesel as a replacement of 1 kL of diesel will have an impact of a 56% reduction in emissions which is equal to 1.456 tons of CO_2/kL. These calculations have taken life-cycle assessment starting from land clearing to the biofuel production into account (Ministry of Agriculture, 2012). Therefore, if Indonesia succeeded in using 5.7 kL of biodiesel in 2014, it will have the impact of an 8.3-ton-CO_2 reduction in emissions. Furthermore, if Indonesia succeeded in increasing the use of biodiesel to 9.52 million kL in 2025, the emission reduction will reach 13.86 million tons of CO_2 and accumulatively, from 2014 to 2025 there would be a reduction of approximately 130 million tons of CO_2.

Figure 3.3: Price trends that indicate the increasing competitiveness of biodiesel price against diesel price



Source: Directorate of Bioenergy, the Ministry of Energy and Mineral Resources

Figure 3.3 shows that in recent years the price of biodiesel was higher than diesel fuel, but the price has tended to decrease; on the other hand diesel prices have tended to go up and therefore in the next few years diesel fuel could potentially become more expensive than biodiesel. This means that the current price of biodiesel indeed warrants consideration of greater subsidies than diesel fuel (or in other words it warrants a subsidy on top of the MOPS diesel price). However, in the coming years these subsidies can be expected to become smaller than the subsidised diesel fuel. Moreover, the diminishing amount of subsidy for biodiesel could be accompanied by regional/national economic growth as a result of the growing biodiesel industry.

3.7.2. Bioethanol

Table 3.7 displays cane molasses production-export-consumption data in Indonesia for the year 2010 to 2012. Indonesia's export of cane molasses is around 300-400 thousand tons/year. If all of these exports were diverted domestically for the production of bioethanol, it will produce 72-96 thousand kL. Added to the national installed capacity (that currently exists) of 82,850 kL, the outcome is around 155-179 kL. This would only be enough to provide for the mandatory use of bioethanol in 2014, whereas the plant to convert the cane molasses has not yet been built. Therefore, it is clear that national bioethanol needs within the context of the implementation of mandatory biofuel use as stated in the Energy and Mineral Resources Ministerial Decree No. 25/2013 cannot be fulfilled on time, at least for the next few years. This also means that in the short term Indonesia is unable to rely on cane molasses as the main feedstock.

If in the near future the growth of sugar production (which would produce cane molasses as by-products) does not take place domestically, then the alternative feedstock that is sufficiently available is cassava. Among the plants listed in Table 3.5, only PT Medco

Ethanol Lampung (47,400 kL) and PT Indonesia Ethanol Industry (63,300 kL) utilise cassava for their production, but because they did not have their own cassava plantation, the two plants often experience difficulty in obtaining feedstock at a time when demand from the food sector for cassava is soaring. Looking ahead, the existence of integrated bioethanol plants with cassava plantations should be facilitated by the government.

Table 3.7: Production and export of sugarcane molasses (tons)

	2010	2011	2012
Production	755,280	740,570	858,120
(Net) Exports	362,910	471,640	285,680
Consumption	392,370	268,930	572,440

Source: Indonesia Cane Statistics 2012, Central Bureau of Statistics.
Production is calculated from the production of sugar by the conversion factor of 0.33
Net exports = the difference between exports and imports. Consumption = net Production deducted by Exports.

Through calculations using Life Cycle Assessment (LCA), starting from land clearing to bioethanol production, the California Air Resource Board (CARB, 2012) obtained results that the greenhouse gas emissions (GHG) produced from creating bioethanol from sugarcane in Indonesia is 29.19 kg CO_2-e/GJ. Because the GHG emission is 67.2 kg CO_2-e/GJ for gasoline and the heating value of bioethanol is 21.03 GJ/kL, therefore the use of ethanol to substitute gasoline would have an impact on emission reduction by 56.6% or 0.8 tons of CO2-e/kL.

3.8. Strategy and policy options for development of biofuel industry post-2016

Although the mandatory use targets for bioethanol in 2014-2016 seems very hard to reach it will still be possible to achieve the target post-2016 through good planning. This can be said because of the availability of potential resources of sugar and starch materials that have not been fully utilised, such as nipa palm (*nypa fruticans*), sago, buckwheat and sugar palm. To increase the use of these commodities, the government needs to provide incentives (e.g. financing feasibility study, tax holidays, etc.) as well as creating an attractive purchase price of bioethanol. Government incentives are needed to encourage the growth of:

- Bioethanol industries based on nipa palm and agroforestry plantations (HTI) of sago; and
- Bioethanol industries based on buckwheat and sugar palm plantations.

Furthermore, the government should also encourage and facilitate industrial R&D and cooperation with research institutes with the aim of developing and implementing commercially generation 2 bioethanol technology (i.e. made from lignocellulose feedstock, please refer to Section 2.4.1 for explanation).

Apart from efforts to solve the problems of the domestic production of bioethanol for the reasons described above, necessary strategies and policies are also required to anticipate and/or cope with the following trends:

- Gasohol ethanol that contains more than 10%–volume can only be used by gasoline based vehicles with modified engines, in which the machine is adapted to the nature and characteristics of the gasohol fuels. The use of gasohol in conventional gasoline vehicles (those are commonly available today) would have negative impacts. To overcome this challenge, Brazil for example 'forces' automobile factories to produce flexible fuel vehicles (FFV) that are capable of processing gasohol fuels with any grade of bioethanol, ranging from zero to 100 %;

- Although various trials conducted domestically and abroad show that EMAL/FAME biodiesel can be used with diesel vehicles at up to 20% volume levels (see the Energy and Mineral Resources Ministerial Decree No. 25/2013, Table 3.1), the diesel cars factories actually objected when the vehicles they produce are using biodiesel EMAL/FAME grade diesel greater than 10% volume biodiesel;

- The existing experiences and projections that are presented in Table 3.8 show that the consumption of gasoline, diesel and avionic fuel in Indonesia is growing very rapidly every year. Given that the crude oil production capacity in the country is not encouraging, therefore if no actions are carried out by Indonesia, the rapid growth of consumption will certainly result in an increase in the import of petroleum fuel or crude oil (provided new refinery capacity is built domestically) which other things equal will lead to balance of payments pressures. For example, as a caution, an energy research consulting firm Wood Mackenzie International recently announced that if Indonesia keeps doing 'business as usual, Indonesia will be the largest gasoline importer in the world by 2018 (420.000 barrels/day or 24.1 million kL/year).

Table 3.8: Selected projected needs of liquid fuels for transportation (thousand kL)

	Sources	2010	2015	2020	2025	2030
Diesel Fuel	EMR	25,080	30,120	34,610	37,300	43,090
	BPPT	20,010	26,380	34,450	50,250	74,900
	USDA-FAS		28,130	35,640		
	Actual	28,650				
Gasoline	EMR	26,450	36,750	45,500	54,310	64,320
	BPPT	20,360	28,790	38,960	53,610	74,200
	USDA-FAS		36,040	48,230		
	Actual	23,860				
Avionic Fuel	EMR	3,400	4,720	6,630	9,270	11,529
	BPPT	3,980	7,160	13.91	21,860	39,750
	USDA-FAS		6,810	9,140		
	Actual	3,530				

Source: Executive Summary of Indonesian Refinery Development Studies Going Forward 2008 (EMR), Indonesia Energy Outlook 2012 (BPPT), Indonesia Biofuels Annual 2013 (USDA-FAS), Handbook of Energy & Economic Statistics, 2012 (Actual).

The path towards addressing the three abovementioned problems simultaneously is in fact accessible, due to:

- Indonesia's power as the world's largest producer and exporter of palm oil;

- The availability of hydrodeoxygenate technology or fluid catalytic cracking (refer to section 2.3) to convert vegetable oils and fats into drop-in fuels such as bio-hydrofined diesel (BHD), bio-gasoline and bio-avionic fuel, and

- The availability of potential inedible vegetable oil fats-producing trees such as *Mabai* or *Pongam* (*Pongamia pinnata*), *Nyamplung* or *Bintangur* (*Callophylum innophylum*), *Neem* (*Azadirachta indica*) and *Sunan* candlenut (*Reutealis trisperma*), which are very feasible to be processed to produce inedible vegetable oil fats (as a substitute/supplement of palm oil) for the production of renewable hydrocarbon fuels mentioned above (please refer to the descriptions in the Appendix).

If the Indonesian government and people are committed, the three abovementioned facts can be utilised to maintain the import volumes of petrol and diesel at constant values/levels (i.e. that they will not increase further) after the year 2016. This can be achieved through:

- Continuing development of the biofuel oxygenate industry (bioethanol and biodiesel of the first generation); and

- Building a drop-in biofuels industry (i.e. bio-gasoline, green diesel, bio-avionic fuel).

Several scenarios of how biofuels can contribute towards controlling fuel imports are presented separately in Chapter 4.

4. Scenarios of Biofuel's Contribution to Controlling Fuel Imports

4.1. Rationale

1. Increase in fuel consumption due to economic growth including growth in the transportation sector.

2. However, as the productivity of domestic refineries has yet to increase substantially, increases in fuel consumption will be compensated by increased imports.

3. EMAL/FAME biodiesel and bioethanol would reduce the increase of gasoline and diesel imports, but only up to 10-20%. The remainder would still need to be imported thus, imposing a hefty burden to the balance of payments and the budget while subsidies continue (if the issue is not addressed budget and external deficits and devaluation of the Rupiah will occur periodically).

The solution to address this particular issue is to substitute imported fuel (gasoline and diesel fuel) with the production of bio hydrofined diesel (BHD) and bio gasoline as drop-in bio fuels which would complement other bio fuels, namely first generation bio ethanol and EMAL/FAME biodiesel.

4.2. Target Scenarios

Considering that the construction of drop-in bio fuel plants/refineries will roughly take three years (or could be completed in 2017 if the scenarios were to be consistently implemented from 2014), the target of the scenarios is to maintain the volume of gasoline and diesel imports at a constant value/level after 2016.

4.3. Assumptions of scenarios

1. Domestic petroleum fuel consumption, i.e. gasoline, diesel fuel and avionic fuel, will grow according to the projections stated on Table 4.1. The projection was derived from several forecasts that have been elaborated on Table 3.8.

2. As a reference of feedstock availability: 16 million tons (2013) – 21 million tons (2020) of CPO (which if not domestically utilised, will be exported abroad).

3. Generation 1 bio ethanol industry can be supported to fulfil the required amount of the scenario.

4. Hydrodeoxygenated as well as FCC (or Fluid Catalytic Cracking) of oils and fats refinery/plant has an optimal capacity of roughly 8,000 BPSD (Barrels per Standard Day) oils and fats feedstock which requires investment of around USD 300 million for each plant. Production of 1 kL of biogasoline would require 2.05 tons of oils and fats, while the production of 1 kL of green diesel would require 1.17 tons of oils and fats. These assumptions have been derived from various study and literature reviews (Gary, et al., 2005, Nextant Inc., 2006, Pearson, 2011, Kangvansaicol, 2012 and EcoResources Consultants, 2012).

Table 4.1: Projection of petroleum fuel consumption, i.e. gasoline, diesel, avtur on slow and rapid growth assumption (in million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Slow growth consumption :							
Gasoline	26,769	28,720	30,820	32,860	34,890	36,930	38,960
Diesel	29,250	30,120	30,990	31,850	32,720	33,580	34,450
Avtur	4,340	4,720	5,100	5,480	5,870	6,250	6,630
Rapid growth consumption :							
Gasoline	34,450	36,750	39,050	41,340	43,640	45,930	48,230
Diesel	29,020	30,120	31,220	32,330	33,430	34,540	35,640
Avtur	6,340	6,810	7,280	7,740	8,210	8,670	9,140

Assumption number 2 (the availability of CPO as a temporary primary feedstock) indicates the urgent need of large scale development of domestic potential inedible biofuel resources, including *Pongam, Nyamplung, Nimba, Sunan candlenut, Kapok*, etc., to provide inedible vegetable oil substituting for CPO as feedstock.

4.4. Conformable Scenario of Energy and Mineral Resources Ministerial Decree 25/2013

The projections of domestic petroleum fuels production namely gasoline, diesel and avtur (which values are constant as there is no increase in domestic refinery capacity) are obtained from Pertamina. Bioethanol and EMAL biodiesel supplies are adjusted to the percentage determined in Energy and Mineral Resources Ministerial Decree No. 32/2013 (Table 3.1). Gasoline and diesel fuel imports are going to be constant after 2016 with the introduction of domestic bio gasoline and green diesel.

Calculation results, particularly the projection of the required drop-in biofuels as well as the requirement of oils and fats feedstocks in line with the number of refinery/plants that need to be built, and for the case of consumption growth, both rapid and slow, are presented on Table 4.2a and 4.2b for gasoline and Table 4.3a and 4.3b for diesel fuel.

Table 4.2a: Projection of gasoline consumption and supply according to scenarios that correspond with the Energy and Mineral Resources Ministerial Decree No. 25/2013 on the condition of slow consumption growth (million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	26,760	28,790	30,820	32,860	34,890	36,930	38,960
Domestic production	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Bioethanol production	0,134	0,288	0,616	0,657	1,047	1,477	1,948
Biogasoline production	-	-	-	2,003	3,643	5,253	6,812
Gasoline Import	15,426	17,302	19,004	19,000	19,000	19,000	19,000

- Production of 2,003–6,812 million kL of *bio gasoline* would requires 4.2–14 million tons of CPO and 10–34 FCC refineries, with each at a capacity of 8,000 BPSD (Barrels Per Standard Day).
- Total investment: 34 x USD 300 million.
- Production of 2,003–6,812 million kL of gasoline would also yield 0,668–2,271 million kL of *light cycle oil* (diesel fuel mix).

Table 4.2b: Projection of gasoline consumption and supply according to scenarios that corresponds with the Energy and Mineral Resources Ministerial Decree no. 25/2013 on the condition of rapid consumption growth (million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	34,450	36,750	39,050	41,340	43,640	45,930	48,230
Domestic production	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Bioethanol production	0,172	0,368	0,781	0,827	1,309	1,837	2,412
Biogasoline production	-	-	-	2,313	4,131	5,893	7,618
Gasoline import	23,078	25,182	27,069	27,000	27,000	27,000	27,000

- Production of 2,313–7,618 million kL of biogasoline requires roughly 4,75–15,6 million tons of CPO and 12–38 FCC refineries, each at a capacity of 8,000 BPSD.
- Total investment: 38 x USD 300 million.
- Production of 2,313–7,618 kL biogasoline would yield 0,771–2,514 million kL of *light cycle oil* (diesel fuel mix).

Table 4.3a. Projection of diesel consumption and supply according to scenarios that corresponds with the Energy and Mineral Resources Ministerial Decree no. 25/2013 on the condition of slow consumption growth (million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	29,250	30,120	30,990	31,850	32,720	33,580	34,450
Domestic Production	20,000	20,000	20,000	20,000	20,000	20,000	20,000
EMAL biodiesel production	2,925	3,012	6,198	6,370	6,544	6,716	6,890
Green Diesel production	-	-	-	0,690	1,386	2,074	2,770
Diesel fuel import	6,325	7,108	4,792	4,790	4,790	4,790	4,790

- Production of 0.690–2.770 million kL of green *diesel* requires 0.807–3.24 million tons of CPO and 2–8 hydrodeoxygenated CPO refineries, each at the capacity of 8,000 BPSD.
- Total investment: 8 x USD 300 million.
- Production of 2,770 million kL green diesel will yield 499 thousand kL of bioavtur.

Table 4.3b. Projection of diesel consumption and supply according to scenarios that corresponds with the Energy and Mineral Resources Ministerial Decree no. 25/2013 on the condition of rapid consumption growth (million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	29,020	30,120	31,220	32,330	33,430	34,540	35,640
Domestic Production	20,000	20,000	20,000	20,000	20,000	20,000	20,000
EMAL biodiesel production	2,902	3,012	6,244	6,466	6,686	6,908	7,128
Green Diesel production	-	-	-	0,864	1,744	2,632	3,512
Diesel fuel import	6,118	7,108	4,976	5,000	5,000	5,000	5,000

- Production of 0.864–3.512 million kilo litres of green diesel requires 1.0–4.1 million tons of CPO and 3–10 hydrodeoxygenated CPO refineries, each at the capacity of 8000 B/PSD.
- Total investment: 10 x USD 300 million.
- Production of 0.864 – 3.512 million kilo litre of green diesel will yield 156 – 632 thousand kL of bioavtur.

The required oils and fats to produce biogasoline and green diesel in 2020 on the scenario of rapid growth equals to (15.6 + 4.1) = 19.7 million tons. This number is deemed critical as it is very close to the estimated amount of CPO that was potentially available as feedstock in 2010. The primary reason for this is that the high demand for the required oils and fats to produce biogasoline, which was at the level of 15.6 million tons. High demand can be suppressed if the bioethanol supply does not need to adhere to the Ministerial Decree no. 25/2013 (2% in 2016 and 5% in 2020), but accelerated / increased to 5% in 2017 and 10% in 2018. Bioethanol is a biofuel that is not made from oils and fats (but from feedstock that contains carbohydrates), so the increase of bioethanol content in gasolines up to 5% or E5 in 2017 and 10% or E10 (maximum) in 2018 will substantially reduce the production need of biogasoline as well as the feedstocks required for its production.

Considering that the use of biodiesel on a level greater than 10% (B10) will spur resistance from the automobile industries, it will be beneficial if further study is conducted to analyse the impact of retaining the biodiesel content on diesel fuel at 10% (B10) in 2016-2020 as opposed to increasing it from 10% in 2015 to 20% in 2016-2020 as stipulated in the Ministerial Decree. The alternative scenario that is based on these two important considerations is called E10B10 scenario.

4.5. E10B10 Scenario

The result of the calculations according to E10B10 scenario is presented in Table 4.4a and 4.4b for gasoline and Table 4.5a and 4.5b for diesel. The E10B10 Scenario estimated that the required oils and fats to produce biogasoline and green diesel in 2020 on a rapid consumption growth case is roughly at (10.7 + 8.3) = 19 million tons. Even though this figure is slightly less from the total needs according to the Scenario that corresponds with the Ministerial Decree no. 25/2013, it remains a better alternative to the latter.

Table 4.4a: Projection of gasoline consumption and supply according to E10B10 Scenario on the condition of slow consumption growth (in million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	26,760	28,790	30,820	32,860	34,890	36,930	38,960
Domestic production	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Bioethanol production	0,134	0,288	0,616	1,643	3,489	3,693	3,896
Biogasoline production	-	-	-	1,017	1,201	3,037	4,864
Gasoline import	15,426	17,302	19,004	19,000	19,000	19,000	19,000

- Production of 1,017–4,864 million kL of biogasoline requires 2.1–10.0 million tons of CPO and 5 – 25 CPO FCC refineries, each at the capacity of 8,000 BPSD
- Total investment: 25 x USD 300 million.
- Production of 1,017–4,864 million kL of biogasoline will yield 0,339–1,621 million kL of light cycle oil (diesel fuel mix)

Table 4.4b: Projection of gasoline consumption and supply according to E10B10 Scenario on the condition of rapid consumption growth (in million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	34,450	36,750	39,050	41,340	43,640	45,930	48,230
Domestic production	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Bioethanol production	0,172	0,368	0,781	2,067	4,364	4,539	4,823
Biogasoline production	-	-	-	1,073	1,076	3,191	5,207
Gasoline Import	23,078	25,182	27,069	27,000	27,000	27,000	27,000

- Production of 1,073–5,207 million kL of biogasoline requires 2.20–10,7 million tons of CPO and 6–26 CPO FCC refineries, each at the capacity of 8,000 BPSD
- Total investment: 26 x USD 300 million.
- Production of 1,07 –5,207 million kL of biogasoline will yield 0,358–1,718 million kL of light cycle oil (diesel fuel mix).

Table 4.5a: Projection of diesel consumption and supply according to E10B10 Scenario on the condition of slow consumption growth (in million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	29,250	30,120	30,990	31,850	32,720	33,580	34,450
Domestic production	20,000	20,000	20,000	20,000	20,000	20,000	20,000
EMAL Biodiesel production	2,925	3,012	3,099	3,185	3,272	3,358	3,445
Green Diesel production	-	-	-	3,875	4,658	5,702	6,215
Diesel fuel import	6,325	7,108	7,891	4,790	4,790	4,790	4,790

- Production of 3,865–6,215 million kL of green diesel requires 4.6–7.3 million tons of CPO and 11-18 hydrodeoxygenated CPO refineries, each at the capacity of 8,000 BPSD.
- Total investment: 18 x USD 300 million.
- Production of 3,875–6,215 million kL of green diesel will yield 0,698 – 1,119 million kL of bioavtur.

Table 4.5b: Projection of diesel fuel consumption and supply according to E10B10 Scenario on the condition of rapid consumption growth (in million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	29,020	30,120	31,220	32,330	33,430	34,540	35,640
Domestic production	20,000	20,000	20,000	20,000	20,000	20,000	20,000
EMAL Biodiesel production	2,902	3,012	3,122	3,233	3,343	3,454	3,564
Green Diesel production	-	-	-	4,097	5,087	6,086	7,076
Diesel fuel import	6,118	7,108	8,098	5,000	5,000	5,000	5,000

- Production of 4,097–7,076 million kL of green diesel requires 4.8–8.3 million tons of CPO and 12–20 hydrodeoxygenated CPO refineries, each at the capacity of 8,000 BPSD
- Total investment: 20 x USD 300 million.
- Production of 4,097–7,076 million kL of green diesel will yield 0.74–1.27 million kL of bioavtur

Projection of consumption and avtur supply according to E10B10 Scenario on the condition of rapid consumption growth is presented on Table 4.6. Production of bioavtur presented on the table below includes the production on green diesel refinery. Constructing additional hydrodeoxygenated lauric oil plants (coconut oil, palm kernel oil, etc.) may also serve as an alternative to boost additional biovtur production.

Table 4.6: Projection of avtur consumption and supply according to E10B10 Scenario on the condition of rapid consumption growth (in million kL)

Year	2014	2015	2016	2017	2018	2019	2020
Consumption	6,340	6,810	7,280	7,740	8,210	8,670	9,140
Domestic production	2,600	2,600	2,600	2,600	2,600	2,600	2,600
Bioavionic fuel production	-	-	-	0,737	0,916	1,095	1,274
Avionic fuel import	3,740	4,210	4,680	4,403	4,873	4,975	5,266

4.6. Final Evaluation and Conclusion

- Both scenarios suggest that suppressing the import of gasoline and diesel fuel from 2016 onwards is a significant challenge, however it is not impossible;

- The E10B10 Scenario is better than the scenario that corresponds with the Ministerial Decree 25/2013. The requirement of CPO in the E10B10 scenario is substantially less than the other scenario. If low cycle oil yielded from the production of biogasoline is counted as green diesel, the required amount of total oils and fats feedstocks will decrease substantially;

- According to E10B10 Scenario on the condition of rapid consumption growth, it is required to have at least six biogasoline plans/refineries via FCC and 12 BHD refineries/plants via hydrodeoxygenisation in 2017; this number increases to 26 biogasoline and 20 BHD refineries by 2020;

- As the investment cost for each refinery is estimated at around USD 300 million (or Rp 3.3 trillion), the total investment required to implement E10B10 scenario is roughly USD13.8 billion (or Rp 151.8 trillion). Even though the cost may seem very large, it is actually less than the current annual budget for fuel subsidies which have reached levels of Rp. 200 trillion. In addition, the total investment will be needed within a quite lengthy period of time (2014-2020) and can be diverted to the private sector while the cost of Rp. 200 trillion fuel subsidies would have to be sustained by public spending.

The development of the biofuel industry (both oxygenate or *drop-in*) as presented in the E10B10 Scenario possesses an important strategic value due to its potential to suppress fuel imports to a constant level. Accordingly, the government is urged to:

☑ Allocate funds or provide incentives (i.e. providing funds for feasibility studies, tax holiday, etc.) to encourage the construction and operation of hydrocarbon fuel production installations via hydrodeoxygenisation or Fluid Catalytic Cracking (FCC);

☑ Provide funds for research and development of inedible oil and plantations such as Pongam, Nyamplung, Nimba, dan Sunan candlenut [to 'push for' the commitment of the Ministry of Forestry and Ministry of Agriculture to devote their attention to developing agro-forestry and plantations of biofuel plants, the success of which should be one of the key performance indicators to assess the performance of the two Ministries];

☑ Provide funds to develop palm oil and other inedible oil catalytic cracking technology in experimental plants as pilot programmes so that commercial plants can be established in Indonesia in 2017 or 2018;

☑ Provide incentives (i.e. providing grant for feasibility study and tax holiday, etc.) to encourage gasohol grade bioethanol industry development, in order to achieve E5 in 2017 and E10 in 2018, and also other targets in the future. Bioethanol industry in this context refers to:

- Industries based on nipa palm agroforestry and/or plantations (HTI) of sago; and

- Industries based on buckwheat or sugar palm plantations.

5. Recommendations

The utilisation of domestically produced liquid biofuels and related industrial development has a strategic value, due to:

1. Reduced fuel imports (thus improving the country's balance of payments and budget position through the energy sector);

2. Indonesia has large capital resources to enable entry to the era of the renewable bio-based economy (the world economy is now transforming / transitioning from fossil-based to bio-based and the biofuels industry is one of the two major pillars of the bio-based economy; of which the other pillar is the food industry); and

3. Reductions in greenhouse gas emissions.

Therefore, the development of the biofuels industry in Indonesia should not be allowed to fail and the government is encouraged to nurture and foster the domestic biofuels industry in order for it to grow strongly and to become dynamic. Towards this end:

a. The government needs to have appropriate pricing policies for biofuels. The current price (especially in the case of bioethanol) is deemed as unattractive by biofuel producers. The government is advised to set a stimulatory pricing policy at the beginning and to gradually tighten it – so as to boost the growth of a strongly competitive biofuels industry (this includes developing technologies that are more effective and/or efficient). At the initial stage (for 2014), it is recommended that the price be set according to the Market Price Index (HIP), as follows:

   - Biodiesel Market Price Index (HIP) = Domestic olein price + USD120;
   - Bioethanol Market Price Index (HIP) = (Argus Price) x 788 kg/m^3 x (1 + 0.35)

   Price adjustments in subsequent years can be set following negotiations with biofuels producers and experts (consultations between Academic-Business-Government – ABG). Based on information from industrial players, the use of biodiesel and bioethanol using the above price formula will require an additional subsidy of not more than IDR 1,000/litre, on top of the existing fuel subsidy. This on-top subsidy could be fulfilled if the subsidised fuel price were to be increased by IDR 500/litre (in other words, diverting the subsidy from fossil fuels to biofuels). [The price of CPO (or CPO-based) derivative biofuels can be set below MOPS if the government can regulate their trade starting from feedstock up to the end product, considering the cost of goods manufactured for CPO is only around USD 400/kg].

b. The government's policy on the purchase biofuels through a bidding process is not effective as it will drive biofuels industries with relatively small capacity to bankruptcy, whereas these industries can help the government in fostering equal economic growth throughout Indonesia.

c. As per (a) above, the policy of "on-top" subsidy to biofuel from the MOPS price of petroleum fuel should be continued for the next few years, until eventually the biofuel price is reduced to a level below MOPS.

d. Producers of liquid biofuel materials should not be subject to the value added tax currently applied to the sale of the products.

e. The growth and strength of the domestic biofuels industry should be one of the key performance indicators of the Ministry of Energy and Mineral Resources (downstream), Agriculture and Forestry (upstream) as well as Marine and Fisheries (particularly in future years after research and development demonstrates the potential economic viability of biofuel production from macro- and micro-algae).

f. Governments provide various incentives (i.e. financing feasibility studies, offering giving tax holiday, etc.) to promote the growth of:

   - Bioethanol industry based on nipa palm agroforestry and plantations (HTI) of sago; and
   - Bioethanol industry based on buckwheat or sugar palm plantations.

   Furthermore, the government should also encourage and facilitate industrial R & D and cooperation with research institutes with the aim of developing and commercially implementing generation 2 of bioethanol technology.

g. To develop industrial capacity of biofuels both oxygenate and *drop-in* as shown by the E10B10 scenario in Chapter 4, in order to benefit from the strategic value of the benefits of suppressing imported costs of fuel to a constant level. In this regard the government should:

   - Apportion funds and provide incentives (such as finance feasibility studies, tax holidays, etc.) to encourage the construction and operation of plants producing hydrocarbon fuels and renewable hydrodeoxygenated technologies or even Fluid Catalytic Cracking (FCC);
   - Finance the research and development of inedible oils agroforestry or plantations such as from commodities of *Pongam*, *Nyamplung*, *Neem* and *Sunan* candlenut; and
   - Finance the development of catalytic cracking technology of palm oil and inedible oils in pilot plants so that commercial plants can be built in Indonesia in 2017 or 2018.

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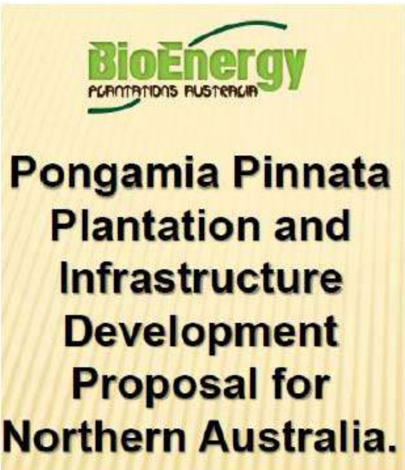
APPENDIX. Trees that are Potential Producers of Inedible Vegetable Oil

Mabai/Malapari (Pongamia pinnata)

- Widely known in India, found all across the Archipelago and in Northern Australia (it is currently being developed intensively).
- Local names: Malapari (Simeuleu), Mabai (Bangka), Ki Pahang Laut (West Java), Bangkong (Java), Kranji (Madura, East Java), Butis, Sikam (Timor), Asawali (Ambon), Hate hira (Ternate).
- A complete bioenergy tree.
- Included in a World Bank book titled "Bioenergy Development" (2010).
- Grows fast, firewood tree, short rotation coppice.
- Nitrogen-fixing tree, salt-tolerant.
- The seed kernel contains 22 – 38% inedible vegetable oil (with a production potential up to 5 ton/ha/year).
- The seed kernel/oil contains bioactive chemical substances (karanjin, pongamol, etc.) used for cosmetics, medicines, etc.



Pongamia pinnata as a shade street tree in Brisbane, Australia.

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Biofuels News

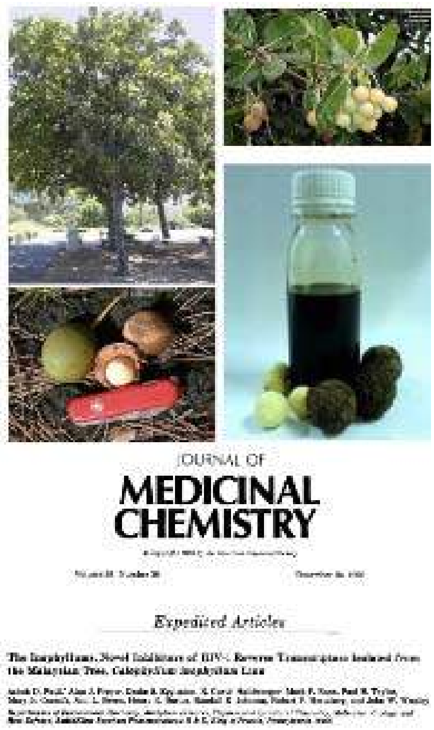
Pongamia being established in USA

Since 2009, TerViva Inc. (Oakland, California, USA) has been acquiring acreage in the states of Texas, Florida, Arizona, and Hawaii for the purpose of establishing farms of pongamia (*Milletia pinnata*, formerly known as *Pongamia pinnata*) trees. This nitrogen-fixing legume is native to Australia and India. The trees produce a nut crop that can be harvested annually by using conventional shakers, such as those used by growers of almonds and other nuts. The tree is frost tolerant, but not impervious to freezing. It grows in most soils, is drought tolerant, and has a productive life exceeding 50 years.

The seed has about 40% oil content, which can be converted to biodiesel or aviation fuel. The oil contains as much as 50% oleic acid, another possible and economically important market for the oil. The company claims that at maturity the trees can produce enough nuts to yield 400 gallons of oil per acre (3,700 liters/hectare) per year.

TerViva, along with Mason & Morse Farmland Group (a US real estate company), is promoting pongamia as a replacement crop for Florida citrus crops, which have been severely limited by greening disease. Caused by the bacterium "*Candidatus* Liberibacter asiaticus," which was first identified in the United States in 2005, greening disease has led to the abandonment of thousands of acres of Florida citrus land. 2

Nyamplung (Calophyllum inophyllum)



- Other names: Bintangur, Pade, Punaga.
- Does not grow fast but salt-tolerant and good for conservation/greening (i.e. wind barrier/breaker on the beach).
- The wood has good quality for construction.
- The seed kernel contains 40-73% oil; potential to produce up to 4.5 ton/ha/year.
- The oil is very thick and green coloured because it contains ≈ 15% resin
- The resin consists of bioactive chemical derivative of 4-phenylcoumarin (calophyllum inophyllum, etc.); has fast wound curing function (cicatrisation) and has a potential to become cancer and HIV/AIDS cures.

Nimba/Mimba (Azadirachta indica)

- International name: Neem.
- Grows fast, firewood tree, short rotation
- Nitrogen-fixing tree, salt–coppice tolerant.
- Has the ability to grow in arid land.
- The seed kernel contains ≈ 45% of inedible oil with bitter taste; potential to produce up to 2.6 ton/ha/year.
- The seed kernel/oil and leaves contain bioactive substances (azadirachtin, etc.) that are potential for bio insecticide, medicines, etc.

Sunan candlenut (Reutealis/Aleurites trisperma)

- A large tree from the candlenut/muncang (Sundanese name) family (Aleurites moluccana).
- Origin: the Philippines; name: bagilumbang/banu-calag.
- Previous name: candlenut/chinese muncang.
- It is a flowering plant.
- The fruit consists of 3 seeds which coats are not as hard and thick as regular candlenut, so that it is easier to extract the seed kernel. The seed coat 35-45%, the seed kernel 55-65%.
- The seed kernel contains ≈ 55 oil, some developing parties argued that it can produce oil more than 4 ton/ha/year.

Kapok/Randu (Ceiba pentandra)

- Kapok fibre producing tree, for mattresses, pillow, life vest fillings, etc. Vegetable fat oil is extracted from the seed (kernel).
- The trees are very well-known and many can be found all across the Archipelago.
- The seed kernel contains ≈ 40% oil, while the seed contains ≈ 25%.
- The oil has a potential as the feedstock for biohydrocarbon or renewable hydrocarbon.
- Has a positive reaction to Besson test.
- Currently being researched at ITB because with additional processing it has a high potential to become a feedstock for high performance biodiesel