WORKING PAPER 2 – 2020

UTILIZING AND MANAGING BIOFUEL (BIODIESEL): LESSONS LEARNED AND BEST PRACTICES FROM OTHER COUNTRIES

2020

TRACTION ENERGY ASIA

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Abstract

The world's biggest producer of Crude Palm Oil (CPO), Indonesia has a large potential to develop biofuels as an alternative sources of energy from this commodity. Indonesia has been developing biodiesel as an alternative fuel since 2006. However, there is growing concern that using CPO for biofuel, in addition to its use in a multitude of food and cosmetics products, risks further deforestation to develop more palm oil plantations to meet the additional demand. Therefore, Indonesia needs to heed the lessons and follow the best practices of other countries who have also developed biofuel, especially regarding biofuel governance. International experiences show that the utilization of biofuels as new and renewable energy sources can be optimized. This working paper identifies at least four important aspects that Indonesia can learn from, namely (1) institutionalization, (2) ensuring sustainable feedstock, (3) social and economic inclusion, and (4) mitigating the competition for palm oil between the food and energy sectors.

Keywords: New and Renewable Energy, CPO, Biofuel, Crude Palm Oil (CPO), and Biodiesel

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1. Introduction

Energy independence is one of the measures of a country's national resilience. The continuity and progress of a country's development is determined by the level of energy available to drive the wheels of its economy. Currently, Indonesia is faced with the threat of a fuel deficit in the future, and therefore, the development of biofuels, particularly CPO-based biodiesel, is considered a highly strategic aspect. With consistent implementation, the expansion from B20 to B30 will save Rp63 trillion of Indonesia's foreign exchange (CNBC Indonesia, 2019), so that through the implementation of mandatory CPO-based biodiesel use policy, Indonesia is expected to achieve a surplus trade balance.

Countries in the Southeast Asian region have great potential to develop first-generation, and even second-generation, biofuels[1] given the abundant availability of palm oil as feedstock (Chanthawong and Dhakal, 2015). Currently, the main biofuel-producing countries in Southeast Asia are Thailand, the Philippines, Indonesia, and Malaysia (Abdullah et al., 2009; Sheng Goh and Teong Lee, 2010). However, there have been rising concerns on the impact of biofuel development on food security, land use change, and increasing greenhouse gas (GHG) emissions. Since the beginning of the 21st century, international debates on the pros and cons of biofuel development have been discussed at nearly 10 international meetings on sustainable development (Dubois, 2008; FAO, 2008a; FAO, 2008c in Finco and Doppler, 2011).

Efforts to develop and utilize new and renewable energy sources, such as biofuels, are not only carried out by developed countries, but also developing countries. The production of biofuels, particularly biodiesel, as a renewable energy source, has increased rapidly over the past decade as countries around the world develop and utilize biodiesel as an important channel for reducing greenhouse gas emissions (Borugadda and Goud, 2012), increasing energy resilience, promoting technological innovation, creating job opportunities, and developing regional economies (Official Journal of the European Union, 2009; Haberl et al., 2012; Kochaphum et al., 2013).

As the largest CPO-producing country in the world, Indonesia should take lessons learned and best practices from the experiences of various countries in managing biofuels, particularly biodiesel, for the purpose of achieving Indonesia's greenhouse gas emission reduction target in accordance with its commitment in the National Determined Contribution (NDC).

[1] The production of biofuels from raw materials that are also used as a food commodity is called first-generation biofuels. Second-generation biofuels are produced from plants and plant parts that are not used for food, such as agricultural and forest waste. Third-generation biofuels are produced from non-food feedstock and agricultural waste, such as algae. See: https://academic.oup.com/af/article/3/2/6/4638639

2. Biodiesel Management in Thailand

Biodiesel development in Thailand began in 1989 as a community-based project initiated by the Kingdom of Thailand. Gradually, the development of biodiesel for various specific purposes was supported by the government. The use of biodiesel as a commercial vehicle fuel was first introduced at the end of 2004. At the time, the blending of 2% biodiesel with diesel fuel (B2) used by local minibuses in Chiang Mai Province was cheaper by ฿0.50 (US$0.0124) per liter—or 3.43% lower—than standard diesel fuel prices. At a later stage, Bangchak Petroleum Public Company Limited started to sell B5 at several gas stations in Bangkok, which eventually expanded to other areas.

In February 2008, PTT Public Company Limited started to sell B5 nationally at 1,289 gas stations under their management. This brief overview shows the strong commitment of the Thailand Government to the development of biodiesel industry by encouraging the production and consumption of domestic biodiesel (Nupueng et al., 2018).

2.1. Thailand's Biodiesel Policy

The Thailand Government fully controls the development of biodiesel industry by issuing a biodiesel blending rate policy, determining the selling price, preparing a national strategic plan to encourage production and consumption of biodiesel, providing loans and tax incentives, and encouraging feedstock production. The development and implementation of biodiesel policy in Thailand involves cross-ministerial efforts (Nupueng et al., 2018).

Table 1. Renewable Energy Development Program (REDP) Master Plan 2008–2022 (Thailand's Biodiesel Roadmap)

<table>
<tr><th>Year</th><th>08</th><th>09</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th></tr>
<tr><td>Biodiesel demand (million ltr/day)</td><td>1.35</td><td>1.35</td><td>1.35</td><td>3.02</td><td colspan="5">3.64</td><td colspan="6">4.50</td></tr>
<tr><td>Government's budget (million THB)[2]</td><td>129.75</td><td>37.4</td><td>29.4</td><td>19.4</td><td colspan="5">450</td><td colspan="6">330</td></tr>
<tr><td rowspan="2">Biodiesel market</td><td colspan="3">B2 mandated</td><td colspan="12">B5 mandated nationally</td></tr>
<tr><td colspan="3">B5 as alternative</td><td colspan="12">B10 as alternative</td></tr>
<tr><td rowspan="4">Biodiesel production</td><td colspan="15">From palm oil and palm stearin</td></tr>
<tr><td colspan="15">Standardizing quality control system</td></tr>
<tr><td colspan="15">Promoting and developing community-based biodiesel production process</td></tr>
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<tr><td colspan="4">BTL/BHD/algae oil</td><td colspan="11">BTL/BHD/algae oil production</td></tr>
<tr><td></td><td colspan="3">Planting and distancing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

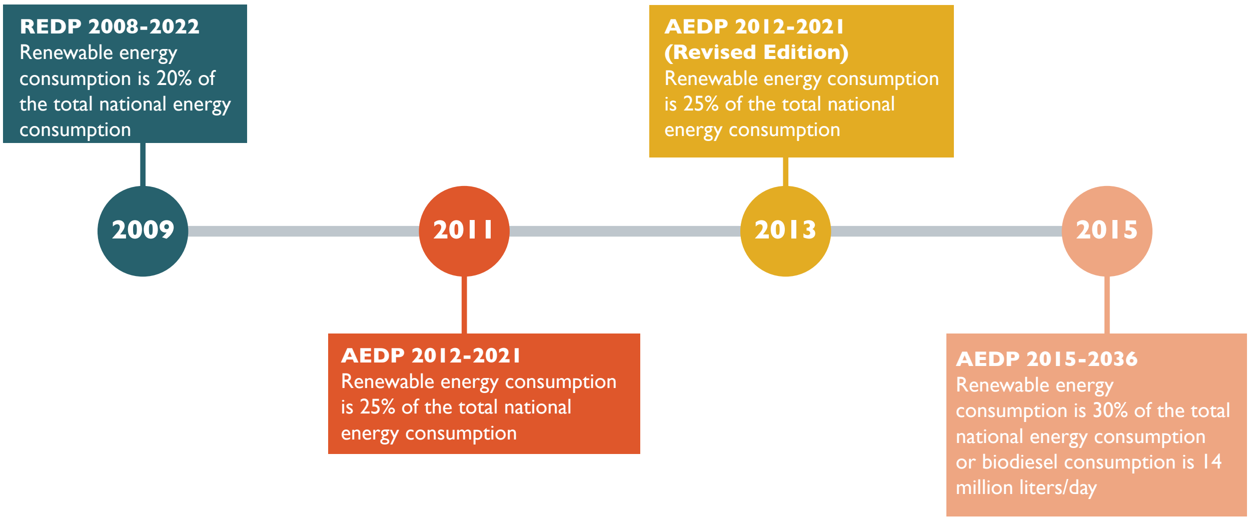
Source: http://www.dede.go.th Notes: *1 rai is equal to 0.16 hectare

[2] Exchange rate of Thailand Baht (THB/฿) to Indonesian Rupiah (IDR/Rp) and US Dollar (USD/US$) in 2020: ฿1 = Rp468.49/US$0.033

Thailand's Ministry of Energy developed an integrated national alternative energy master plan with three main objectives: creating energy resilience, maintaining economic balance to ensure economic growth, and minimizing the negative impact on the environment and society (Suksri et al., 2008). In addition, the Thailand Government also prepared a Renewable Energy Development Plan (REDP) 2008–2022 with the purpose of developing low-carbon fuels and promoting the use of alternative energy (B2), including research and innovation activities on the value added biodiesel by-products, such as glycerin. The objective of this plan is to achieve B10 nationally by 2022, or to create a biodiesel demand of approximately 4.50 million liters per day.

In the course of time, the REDP Master Plan 2008–2022 was refined into the Alternative Energy Development Plan (AEDP) 2012–2021, which was issued in 2012 and revised in 2013. The revision includes increasing the target for renewable energy consumption from 25% to 30% of the total energy consumption and adjusting REDP time frame to 22 years (2015–2036). In accordance with the AEDP 2012–2021, the Thailand Government set a target for biodiesel consumption at 7.2 million liters per day, while the target for ethanol production is at around 6 million liters per day by 2021. The plan focuses on the supply and demand of biodiesel.

Figure 1. REDP and AEDP Transformation



Source: Department of Alternative Energy Development and Efficiency, Thailand's Ministry of Energy (2016)

On the supply side, the government has set a target of 5.5 million rai (880,000 ha) for palm oil plantation expansion in 2021. Average production is estimated to reach 3.2 million tons per rai (20 million tons per hectare), while the rate of CPO yields must be above 18% by 2021. On the demand side, the government anticipated the provisions for meeting the biodiesel production by creating a domestic supply of palm oil. In the plan, the government will conduct trials on the use of B10 or B20 biodiesel blends for trucks and fishing vessels. The Energy Policy and Planning Office (EPPO) in Thailand's Ministry of Energy is the most important and vital institution in formulating national policies and plans for sustainable energy.

2.2. Biodiesel Production and Consumption

Biodiesel production and consumption in Thailand is supported by the increased production of fresh fruit bunches (FFB) and expansion of plantation land in the regions (Kumar et al., 2013). The table below illustrates the rapid growth of biodiesel production, from 68 million liters in 2007 to 1,210 million liters in 2015, and consumption, from 62 million liters in 2007 to 1,200 million liters in 2015.

Table 2. Thailand Biodiesel Production, Consumption, and Feedstock, 2007–2015

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Biodiesel (million liter)									
Initial stock	0	6	7	8	22	12	22	32	22
Production	68	448	610	660	630	900	1.060	1.170	1.210
Import-export	0	0	0	0	0	0	0	0	0
Consumption	62	447	609	646	640	890	1.050	1.180	1.200
Production Capacity									
Number of bio-diesel plants	5	9	14	13	13	10	10	10	12
Capacity (million liter)	475	840	1.970	1.970	1.450	1.450	1.450	1.450	1.630
Used capacity (%)	14,32	53,33	30,96	33,50	43,45	62,07	73,10	80,69	74,23

Source: Preechajarn and Prasertsri (2015)

2.3. Biodiesel Feedstock

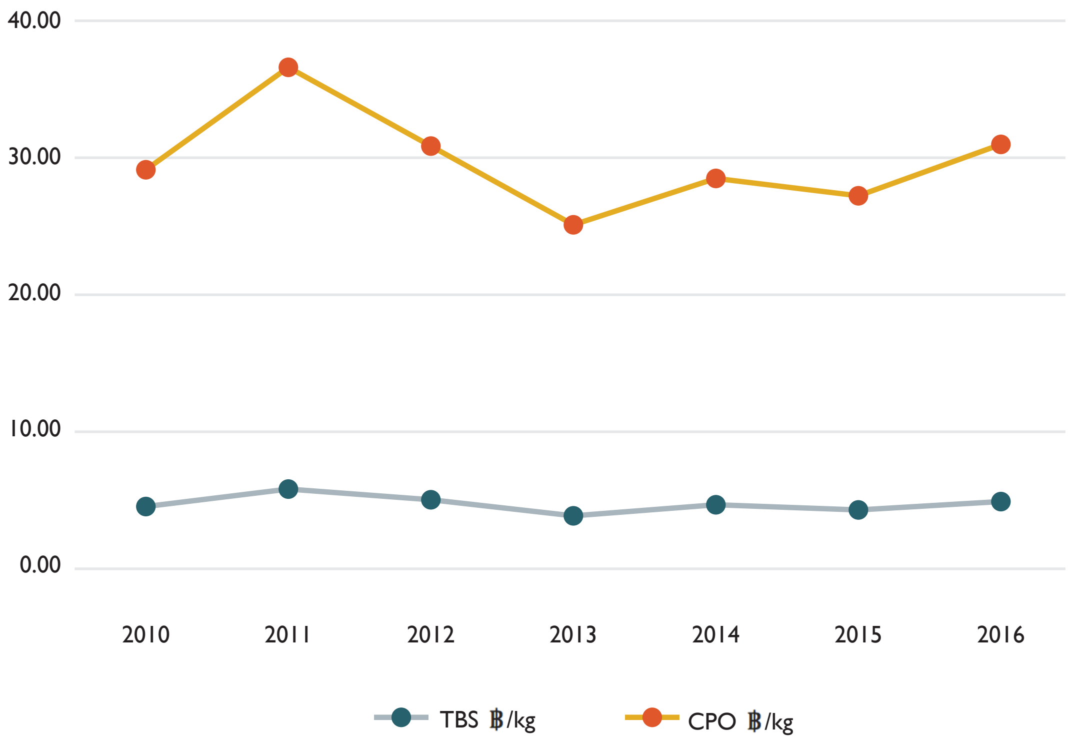
Biodiesel can be produced from various types of raw materials, such as animal fats and oils, as well as food crops, such as jatropha, palm oil, soybean, cotton, etc. In Thailand, the most used raw material in biodiesel production is palm oil. According to Thailand's Ministry of Trade, in 2014 and 2015, 45% of CPO produced in Thailand was used as feedstock for biodiesel production, while the rest (55%) was used for cooking oil production.

The Ministry of Agriculture and Cooperatives holds an important role in planning and supporting the cultivation of biodiesel feedstock by promoting palm oil cultivation and encouraging farmers to increase the efficiency of their FFB production. FFB produced by farmers will be processed in palm kernel processing plants and CPO refineries to produce CPO, stearin, and Refined Bleached Deodorized (RBD). In 2015, Thailand's FFB production reached 11,016 million tons, which was processed into 2,068 million tons of CPO. Currently, total production capacity of palm kernel processing plants is 1,155 million liters of CPO per day. Biodiesel processing plants, which are distributed in the south, east, and central regions of Thailand, purchase feedstock from approximately 84 palm kernel processing plants and refined palm oil distributors.

Nevertheless, feedstock availability for biodiesel production has not met the government's target. Feedstock supply for pure diesel fuel or CPO was estimated to grow to 2.2 million metric tons, assuming normal weather conditions and a continuous increase of harvest. Dry weather in all regions of Thailand in 2014 and early 2015 was expected to affect palm oil production in 2015. Unfavorable weather condition will not only harm FFB production, but also has the potential to reduce overall oil extraction rate (Preechajarn and Prasertsri, 2015).

The cost of providing feedstock is the largest expenditure in biodiesel production process, which is around 50–70% (Anuar and Abdullah, 2016). Therefore, the key factors that ensure the success of biodiesel production in Thailand are price stability, availability of FFB and CPO feedstock supplies, as well as competitive prices of biodiesel production. It must be noted that the price of feedstock fluctuates following the price of palm oil, which is between ฿ 25.24–36.59 per kg CPO and between ฿4.16–6.02 per kg FFB in the period of 2010–2016, or equivalent to Rp8,610–Rp11,829 per kg CPO and between Rp1,344–Rp 1,946 per kg FFB.[3]

Figure 2. Average Prices of FFB and CPO in Thailand, 2010–2016



Source: Thailand's Ministry of Trade

2.4. Biodiesel Market

Thailand owns 12 licensed biodiesel processing plants with a total production capacity of 4,635,800 liters of biodiesel per day. The standardization of biodiesel production process from palm oil follows the guidelines for developing biodiesel standards for APEC countries (TISTR, 2009). To achieve the biodiesel blending policy goal, the Thailand Government allocated a monthly biodiesel quota for each plant based on the estimated demand in the market. Thailand's biodiesel production increased from 1,170 million liters and the initial stock of 32 million liters in 2014 increased to 1,210 million liters in 2015. During this period, Thailand did not import and export biodiesel. Meanwhile, the distribution of biodiesel or B5-B7 blended fuel was carried out by 10 fuel distribution companies.

In 2015–2016, when the growth of biodiesel consumption was very low due to the growing use of diesel, the Thailand Government issued a number of policies to protect the domestic palm oil industry. With fewer FFB supply and the soaring price of CPO in early 2015, the government also reduced the biofuel blending obligation from B7 to B3.5 from 17 February 2014 to 16

[3] Using the average THB to IDR exchange rate from 2010 to 2016, i.e. Rp323.3

April 2015. The mandatory use of B7 was reinstated on 17 April 2015 after the increase of FFB harvest and CPO production.

2.5. Thailand Biodiesel Industry

2.5.1. Economic Actors

The major economic actors in Thailand's biodiesel industry are palm kernel processing plants, CPO refineries, traders, warehousing companies, and the government. The vertically integrated biodiesel industry in Thailand is dominated by several biodiesel processing plants which rely on a large number of suppliers and distributors. The main problem of Thailand's biodiesel industry is the high production cost compared to diesel production cost. In 2016, B100 selling price was ฿35.11 (Rp13,201/US$0.98) per liter, CPO price was ฿31.91 (Rp11,998/US$0.89) per liter, whereas diesel price was ฿19.50 (Rp7,332/US$0.54) per liter.[4]

The biodiesel sector is regulated nationally, and therefore, the import of biodiesel is limited to maintain a balance in palm oil supply. The government plays a central role in this sector and uses political measures to regulate the production and use of biodiesel. Their strategy is based on their commitment to achieving the objectives of the policies and the dynamic conditions in FFB and CPO markets. Business activities must adhere to the constantly changing government regulations. Changes in biodiesel blending percentage policy has a direct impact on CPO supply and is reflected in FFB price and farmers' income. In Thailand, independent smallholders have no negotiating power in the biodiesel market. For example, Krabi Palm Oil Community Cooperative Ltd., the largest farmer cooperative in Thailand, was unsuccessful in producing biodiesel independently due to the change in government regulations. Fluctuations in FFB and CPO prices, which directly affect palm oil refineries and RBD market, are believed to be the cause of the cooperative's failure, as the cooperative normally sells its FFB as feedstock to CPO processing plant.

Meanwhile, these economic actors seem to not pay much attention to the environmental impacts. They agree that sustainability in the palm oil industry is important, but FFB and CPO price stability is much more important. The Head of Biodiesel Producers Association, the main actor in promoting sustainable palm oil, supports the adoption of Roundtable on Sustainable Palm Oil (RSPO) scheme for smallholders. However, the certified palm oil products are not sent to the biodiesel industry.

2.5.2. Policy Actors

The implementation of biodiesel policies in Thailand is integrated with the palm oil sector, and both are supported by the government in many aspects. Ministries involved in the palm-oil-based biodiesel industry include Ministry of Energy, Ministry of Industry, Ministry of Agriculture and Cooperatives, Ministry of Trade, and Ministry of Finance. In this context, all relevant ministries carry out their tasks and authorities in accordance with the policies formulated by the National Palm Oil Policy Committee (NPOPC).

The Ministry of Energy plays an important role in determining the percentage target for biodiesel blends, as well as in planning and collaborating with the Ministry of Industry in

[4] Using the average THB to IDR exchange rate in 2016, i.e. Rp376

managing biodiesel production by taking into consideration the availability of feedstock, the demand for palm cooking oil, and diesel prices. The role of the Ministry of Industry is to control the production process, environmental management, and work safety in biodiesel processing plants. The role of the Ministry of Agriculture and Cooperatives is to prepare the supply of palm oil feedstock by promoting efficiency in palm oil production and to formulate policies aimed at overcoming the shortage or excess supply of FFB and its impact on biodiesel blends. The role of the Ministry of Trade is to determine and control the price of FFB and CPO used as feedstock in cooking oil production. The role of the Ministry of Finance is to provide support and financial assistance for biodiesel production, such as providing subsidies for biodiesel producers, managing taxes as a policy instrument, and offering loans to the Special Purpose Vehicle (SPV) committee for the promotion of palm oil and biodiesel production.

Thailand's government promotes, supports, and intervenes in the biodiesel industry so that the industry can help increase the income of independent palm oil farmers. At the same time, the government protects the consumption of palm-oil-based cooking oil. When the palm oil and cooking oil markets are in a normal condition, biodiesel production is the most efficient domestic resource for reducing fuel imports.

The Thailand government's commitment can also be seen when the Prime Minister attended the Climate Change Conference (COP 21) in Paris in December 2015 and where he ratified the Paris Agreement in 2016. This ratification demonstrates Thailand's active involvement in the global efforts to mitigate the impact of climate change. Promoting the use of alternative energy is Thailand's main commitment in its mission to achieve a low-carbon future. For this purpose, the biodiesel promotion policies and climate change mitigation efforts are carried out convergently.

2.5.3. Social Actors

There are only several social organizations involved in Thailand's biodiesel industry. The NGOs and civil organizations involved (e.g. Thai Center for Development Foundation, Thai Biodiesel Producer Network, Thai Alternative Energy Group) are more focused on the production of community-based biodiesel. They promote the recycling of used household cooking oil or animal fats into feedstock for biodiesel production to reduce living costs and to make a long-term positive impact on the community. They are less involved in the development of commercial biodiesel, considering that the production is highly dependent on government regulations.

On the other hand, the actors in biodiesel and CPO industries have close interactions. Both sectors involve many public and private actors, material and non-material requirements in production, policymakers, lawmakers, and regulators, as well as production and marketing of biodiesel.

3. Biodiesel Social Inclusion in Brazil

In 2004, the Brazilian Government launched a cross-ministerial program called *Programa Nacional de Produção e uso do Biodiesel* (PNPB) or National Program for Biodiesel Production and Use,[5] which was designed based on the scenario of high oil prices, increased demand for fuels from renewable energy, and the comparative advantage of Brazil's natural resources (Nass et al., 2007). In principle, the idea of launching the PNPB is based on three arguments: economic, environmental, and social. The economic argument behind the launch of PNPB is the fluctuation of oil prices and reducing dependence on diesel. From the environmental point of view, PNPB is expected to help reduce fuel exhaust emissions that contribute to the increase in the greenhouse effect, whereas the social argument of PNPB is the opportunity to reduce regional disparities between regions (Silva et al., 2014a and 2014b).

As a cross-ministerial program, the main purpose of PNPB is to increase the production and use of biodiesel while focusing on social inclusion and regional development. In addition, PNPB has several special objectives, which include implementing sustainable program and promoting social inclusion; ensuring competitive prices, quality, and offers; and producing feedstock for biodiesel from various types of vegetable oils.

Furthermore, the management of PNPB that is directed and mutually agreed by all stakeholders at various levels of government, business actors, and communities, is believed to have had a positive impact on (i) the economy, by increasing employment and increasing the income (welfare) of independent farmers, which leads to reducing economic disparities between regions in Brazil (César and Batalha, 2010; Finco and Doppler, 2011; Rathmann et al., 2012; Silva et al., 2014a), and (ii) the creation of social inclusion, by guaranteeing the purchase of agricultural yields of independent farmers as feedstock for biodiesel production (Langevin, 2011; Silva et al., 2014b; Cardoso et al., 2017).

In the following section, the 4 major instruments of social inclusion management in Brazil are described. These programs are able to ensure sustainable biodiesel management and favor the participation of small (family) smallholders, namely the launch of National Program for Biodiesel Production and Use (PNPB), the formulation of Social Fuel Seal (SFS), the implementation of national biodiesel auction, and efforts to commercialize biodiesel.

3.1. National Program for Biodiesel Production and Use (PNPB)

In 2003, Brazil organized a cross-ministerial meeting to discuss the feasibility of biodiesel use as an alternative energy source. The resulting recommendations include integrating biodiesel into the national energy agenda as well as adopting social inclusion principle and regional development as a reference for government's follow-up action. The meeting also concluded that Brazil's agro-energy policy should not give preferential treatment to the use of technology-intensive activities (industrial process), primary raw materials (agricultural production), and industrial production scale. All of the recommendations were based on the fact that Brazil has abundant availability of various vegetable oil sources.

With the institutional framework for the production and use of biodiesel already in place, Brazil's first step was to formulate a government regulation. By virtue of Interim Executive Decree No. 214 of September 2004, biodiesel was officially included in the national energy

[5] See: https://www.sciencedirect.com/science/article/abs/pii/S1364032115000386

matrix. The decree also delegated competencies and rights to the national oil, gas, and biofuel agency (ANP) to take steps to promote, regulate, issue permits, recruit, and monitor the production and commercialization of biodiesel in Brazil (Brazil, 2004 in Finco and Doppler, 2011). Subsequently, the Brazilian Government officially launched the National Program for Biodiesel Production and Use (PNPB) in December 2004.

Lessons learned from the establishment of PNPB:

1. PNPB is the manifestation of a cross-ministerial initiative in formulating a basic energy problem.
2. At the macro level, PNPB is built on the international scenario of increasing demand for renewable energy sources and Brazil's potential to meet this demand.
3. At the micro level, PNPB seeks to generate employment and income in rural areas, particularly through the integration of independent farmers into the biodiesel supply chain, which leads to an increase in the family smallholders' standard of living and a reduction in regional disparities in Brazil.
4. PNPB promotes the implementation of sustainable biodiesel production, which focuses on social inclusion and regional development, while still prioritizing environmental and cultural preservation efforts.
5. PNPB increases the importance of other vegetable oils' existence and diversity as feedstock for biodiesel production, which aims to avoid overexploitation of feedstock and to provide opportunities for independent smallholders in several regions to produce different feedstocks for industries other than biodiesel..

In short, PNPB has significant differences with its 1970–1980 predecessors in Brazil. Apart from biodiesel production and use, PNPB pays special attention to social inclusion and takes into account the environmental aspects of biodiesel production. In addition, the Brazilian Government also established a series of instruments to support PNPB, such as fiscal exemptions, financial subsidies, special credit lines, and Social Fuel Seal (SFS).

3.2. Social Fuel Seal (SFS)

In line with the official recognition of biodiesel as an important element in the national energy matrix, the Brazilian Government established the Social Fuel Seal (SFS) by virtue of Decision No. 5.297 dated 6 December 2004. Law No. 11.097 of 2005 has also proposed another incentive mechanism to encourage the participation of independent smallholders in the National Program to Strengthen Family Farming (PRONAF), which encourages biodiesel production in underdeveloped (poor) regions of Brazil. In other words, SFS plays an important role in ensuring improvements in Brazil's underdeveloped areas (Garcez and Vianna, 2009).

The tangible manifestation of SFS is the certificate given to biodiesel companies that purchase feedstock from independent smallholders. In accordance with Normative Instruction No. 1 dated 19 February 2009, biodiesel companies in Brazil are required to purchase a minimum of 10% of total feedstock from independent smallholders in the North and Central-West Regions, and a minimum of 30% of total feedstock from independent smallholders in the South, Southeast, and Northeast Regions of Brazil.

In addition, biodiesel companies that purchase feedstock from independent smallholders will receive a tax exemption for biodiesel products (PIS/PASEP and COFINS)[6] by virtue of Law No. 11.116 dated 18 May 2005. Biodiesel companies with SFS also receive an additional facility, namely financial support from Brazil's National Bank for Economic and Social Development, or *o Banco Nacional de Desenvolvimento Econômico e Social* (BNDES).

SFS performance is monitored by the Ministry of Agrarian Development (MDA). To receive their right on tax exemption and maintain SFS ownership, biodiesel companies must enter into contracts with independent smallholders; guarantee the estimated market price or minimum price of feedstock purchased (for a period of 36 months in average), sales and distribution; and provide seeds and technical assistance. The difference in taxes between biodiesel products and gasoline, diesel, and ethanol products can be seen in the following table.

Table 3. Biodiesel Tax in Brazil

Feedstock/Primary Material	Region	Agricultural Type	PIS/PASEP (R$/m³)	COFINS (R$/m³)	Total Tax (R$/m³)
All types	S; Tg, BT	All types	31.75	146.20	177.95
Jatropha/coconut	U; TL; SK	All types	27.03	124.47	151.50
All types	S; Tg, BT	Family Farming	12.49	57.53	70.02*
All types	U; TL; SK	Family Farming	0.00	0.00	0.00*

Source: Garcez and Vianna (2009)
Notes: *refers to the companies with SFS
S=South, SE=Southeast, N=North, NE=Northeast, CW= Central-West, SA=semiarid

The table above shows the high tax imposed on biodiesel products that do not include family farming. The main objective of the Brazilian Government is to encourage biodiesel production in the country's North Region, which mainly consists of Amazon rainforest and Cerrado biomass forest, and Northeast Region, which mainly consists of Cerrado and Atlantic biomass forests, particularly through the production of Jatropha (*Ricinus communis*) and African palm oil (*Elaeis guineensis*) (Arcez and Vianna, 2009). It should be noted that the tax incentive does not apply to soybean crops cultivated in Brazil territory. However, biodiesel tax is still lower than the tax on gasoline, diesel, and ethanol, which also receive tax exemption as they are also considered renewable energy sources, like biodiesel.

Table 4. Tax on Fuel, Diesel, and Ethanol in Brazil

Type of Tax	Fuel (R$/m³)	Diesel (R$/m³)	Ethanol (R$/m³)	
			Importer/Producer	Distributor
CIDE*	280.00	70.00	0.00	0.00
PIS/PASEP	46.58	26.36	23.38	58.45
COFINS	215.02	121.64	107.52	268.80
Total Tax (R$/m³)	541.60	218.00	103.90	277.25

Source: Garcez and Vianna (2009) Notes: *regional economic intervention

[6] PIS is a social integration program, PASEP is an old-age public insurance, and COFINS is a social security financing contribution. Both are implemented in the national level.

From the table above, it can be seen that the tax (CIDE + PIS/PASEP + COFINS) on gasoline and diesel are higher than biodiesel tax, even for crops that are not produced and cultivated by independent smallholders. Tax on ethanol (for importer/producer) is the same as the tax on biodiesel, showing that despite the different rules and norms for the production of the two renewable energy sources (ethanol production is based on *Programa Nacional do Álcool*, or widely known as *Pró-Álcool*), both tax collection schemes follow the same trend. In other words, the two renewable fuel types have similar tax exemption compared to the tax on other fossil fuels.

3.3. National Biodiesel Auction

After the issuance of Regulation No. 11.097 of 2005 on mandatory biodiesel market that aims to regulate biodiesel commercialization in Brazil, the Ministry of Mining and Energy (MME) established national auction guidelines for biodiesel acquisition by virtue of Presidential Order No. 483 dated 3 November 2005. In this context, the regulation on national auction was established as a mechanism to include renewable fuels into the national energy matrix and to solve various supply, logistics, and distribution problems.

Biodiesel auction at national level is conducted openly and organized by ANP in 2 phases. The first phase will auction 80% of the total biodiesel that will be commercialized and specifically for companies with SFS certification, and the second phase will auction the remaining 20% of national biodiesel and is open to companies with and without SFS certification. In the auction, participants provide information on the volume and acquisition status of biodiesel, participation status, producer accreditation, and proposal for electronic money transfer. ANP also provides the estimated maximum price per unit of biodiesel to be used as a reference for companies submitting their bids. The auction winner is selected from the lowest price proposed by the company for each volume of biodiesel auctioned. The winner is responsible for producing renewable fuels within the time period specified by ANP.

It should be noted that in this national auction, Petrobas is the sole buyer of biodiesel. Therefore, it can be concluded that the Brazilian biodiesel market is characterized by a pure monopsony condition. Once the biodiesel is purchased, Petrobas allows fuel distributors to collect the product in the industry. All biodiesel sold in the national auction is considered free on board (FOB), which means that the distributors should be responsible for shipping costs. Subsequently, distributors will blend biodiesel with diesel, while refineries are allowed to produce and deliver biodiesel blends to the distributors.

Another important note in this biodiesel commercialization process is that the renewable fuel should adhere to the technical specifications issued by ANP. When biodiesel producers commercialize their final products, they should be able to show that their certificate of traceability is in accordance with the national quality specifications. In short, it can be seen that the Brazilian Government is trying to adopt norms and regulations that are different from the implementation of PNPB.

3.4. Biodiesel Commercialization

After the issuance of the Interim Executive Order No. 214 dated 13 September 2004, ANP began conducting public consultations to determine the technical specifications regarding the blending percentage of biodiesel and diesel. At the time, ANP set a voluntary consensus of 2% biodiesel as a fuel mixture called B2. When the Interim Executive Order was changed into Law No. 11.097 dated 13 January 2005, the central government chose to make the voluntary biodiesel blending consensus into a mandate. The percentage of biodiesel blends and the duration of the commercialization process can be modified any time according to the availability of the feedstock, industrial capacity, and participation of family farms in biodiesel supply chain.

In this context, the central government determined that the voluntary consensus of 2% biodiesel in fuel oil blends prior to 2008 became mandatory in January 2008. According to Garcez and Vianna (2009), the main reason behind the change is Brazilian Government's desire to participate in Kyoto Protocol's Clean Development Mechanism (CDM) through carbon credit. However, in 2008, the percentage shifted to 3% (B3), to 4% (B4) in 2009, and finally to 5% (B5) in 2010. Since 1 March 2018, the applicable mandatory biodiesel use is 10% for all types of mineral diesel fuel consumed. National Energy Policy Council (CNPE) Resolution No. 16 of October 2018 recommended increasing biodiesel blends by 1% per year, from B11 in June 2019 to B15 in March 2023, for use in diesel engines.

4. Low-Carbon Fuels in the United States

There are two main low-carbon policies in the United States (US), namely the US Renewable Fuel Standard (RFS2) and the California Low-Carbon Fuel Standard (LCFS). RFS2 regulates renewable fuels (biofuels) across US, whereas LCFS regulates renewable and non-renewable fuels in California. Both RFS2 and LCFS use life cycle analysis (LCA) as a tool to regulate fuels by combining greenhouse gas (GHG) emissions from indirect land use change (ILUC) in their framework. Besides LCFS and RFS2, various efforts are being carried out to regulate regional low-carbon fuel standards in the Northeast and Mid-Atlantic regions, as well as in Midwestern. The three regional initiatives were established after adapting California's LCFS (ICCT, 2011).

4.1. US Renewable Fuel Standard (RFS2)

RFS2 is a volumetric standard which aims to significantly increase biofuel use in the US to 36 billion gallons by 2022. US Environmental Protection Agency (EPA) estimates that this policy will reduce GHG by 138 million metric tons by 2022 although there is uncertainty regarding GHG emissions from ILUC. US produced approximately 13.5 billion gallons of biofuel in 2010, consisting of biodiesel and corn ethanol at 0.3 billion gallons and 13.2 billion gallons respectively.

The year 2011 is the second year of RFS2 implementation by EPA. Every year, all fuel, diesel, and mixed fuel refineries and importers are required to meet the volumetric target for four types of commodities: renewable fuels, cellulose biofuels, plant-based biofuels, and next-generation biofuels. The biofuels are categorized based on the type of raw materials/technology used in the production and the minimum threshold for GHG reduction. The standard requirement for GHG threshold differs between renewable fuels (20%), next-generation biofuels (50%), plant-based diesel (50%), and cellulose biofuels (50%).

Volumetric targets are tracked through Renewable Identification Numbers (RIN), a unique identification number assigned to each gallon of biofuel, containing information on how and where it was produced. The RIN value associated with each gallon of biofuel depends on the energy content and is calculated based on its ethanol equivalent. For example, 1 gallon of plant-based diesel has an RIN of 1.7. Every year, all fuel, diesel, and mixed fuel refineries and importers must produce a certain minimum amount of RIN by producing or purchasing renewable fuels. RIN can be traded between said parties with other parties, such as renewable fuel producers. Information about the RIN creation and transaction is submitted to EPA using the EPA Moderated Transaction System (EMTS).

In November each year, EPA will determine the amount of cellulose biofuels produced to be used in the transportation sector the following year. EPA predicts the availability of cellulose biofuels based on projections of fuel and diesel use released by the US Energy Information Administration (EIA) and a survey of the production capacity of the US biofuel industry. However, the volumetric standard for plant-based biofuels has not been determined.

In the latest RFS2 regulation, EPA has calculated the amount of GHG emissions for several specific plant-based biofuels, such as corn ethanol, sugarcane ethanol, cellulose biofuel from corn cobs and straws, and soybean biofuel. Recently, EPA has included canola-oil-based biodiesel in biomass-based biodiesel and next-generation biofuels categories. Other biofuels being considered are palm oil, sorghum, and wood biomass.

After the issuance of the latest RFS2 in 2010, EPA has made several amendments to the RFS2, particularly on matters related to RIN and compliance requirements, which include:

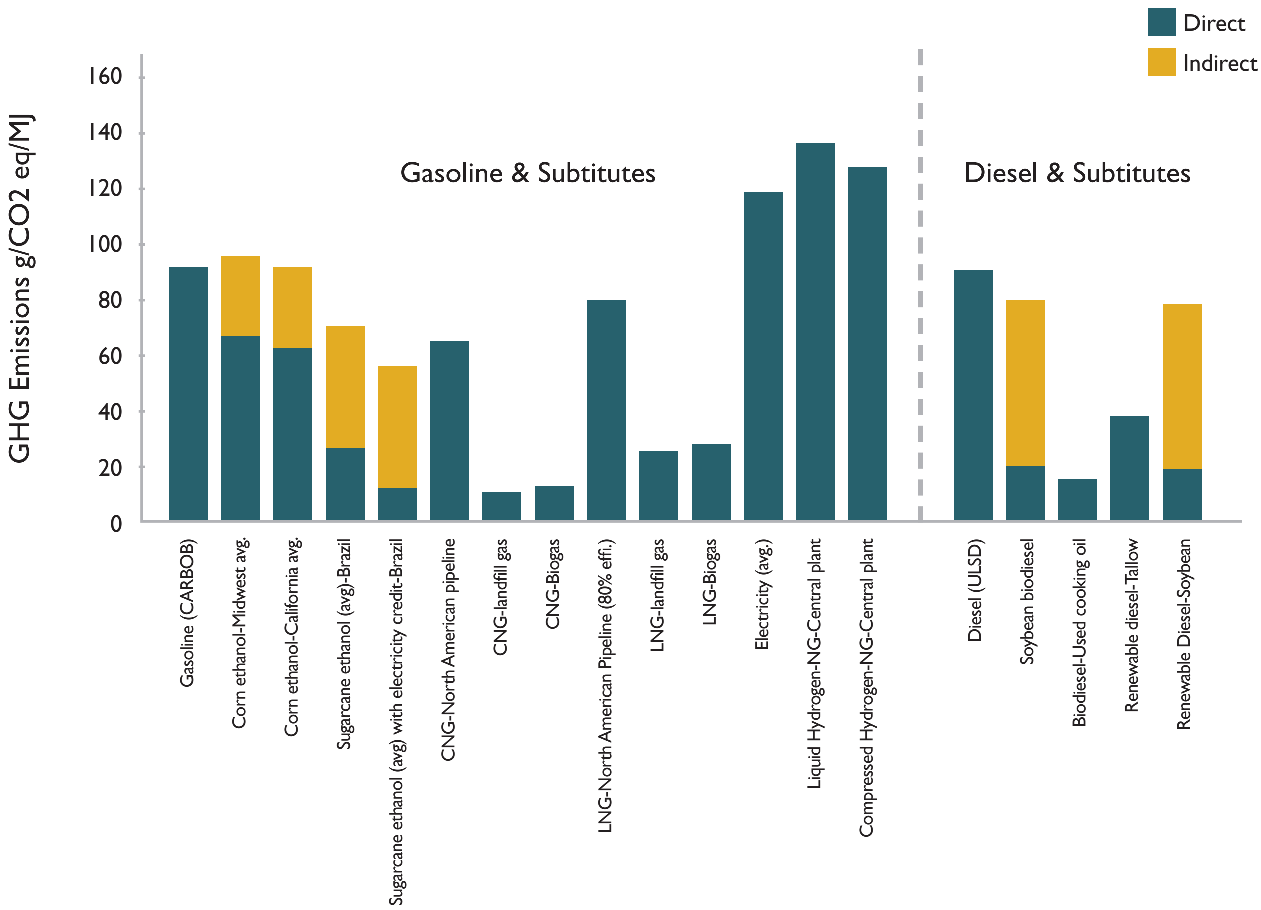
- Determining the "allowed capacity"
- Technological requirements for new types of ethanol in RIN creation
- Clarifying RIN information channel to EPA

4.2. California's Low Carbon Fuel Standard (LCFS)

Low Carbon Fuel Standard (LCFS) is a carbon-based fuel standard which aims to reduce GHG emissions from the transportation sector in California by 10%, or approximately 16 million metric tons per year, by 2020. LCFS regulation follows market mechanisms, particularly credit trading and banking mechanisms.

In 2011, California's LCFS mandated fuel producers and importers, including the owners or sources of alternative fuels, to reduce carbon intensity by an average of 1% per year until 2020. The California Air Resources Board (CARB) has calculated carbon intensity generated by various fuel pathways and sub-pathways and presented the result in a table. In calculating carbon intensity, the amount of GHG emissions is adjusted to the efficiency level of the vehicles using energy economy ratio (EER). For example, electric trains are considered 3 times more efficient than conventional gasoline engines.

Figure 3. Carbon Intensity Values of Certified Pathways, LCFS



Source: ICCT (2011)

LCFS uses a credit system. If the carbon intensity of the available fuels is higher than the target set for a particular year, it will result in a deficit. On the contrary, if the carbon intensity of the available fuels is lower than the determined target, it will result in a credit. Total credit or deficit is determined by calculating the amount of unused fuel energy (gasoline or diesel) as well as the difference between the actual carbon intensity and the targeted carbon intensity of the fuels in a particular year. The amount of unused energy is calculated using EER method. Parties affected by the rules can trade the credit or obtain a credit bank based on their compliance with the rules.

Currently, there is no standard credit trading scheme/mechanism. California is in the process of creating a credit trading mechanism. The California market has started to differentiate fuels with high and low carbon intensity. For example, corn ethanol with a carbon intensity of about 90 g CO_2 e/MJ will receive 2 to 3 cents more than corn ethanol with carbon intensity of 98 g CO_2 e/MJ.

Based on the determination of carbon intensity generated from various pathways, fuel producers and importers will provide information (quarterly and annually) regarding the volume and carbon intensity of each type of fuel they manage to CARB, using the online LCFS Reporting Tool. This tool will calculate the amount of credit and deficit generated from each type of fuel.

In 2010, CARB established LCFS Expert Working Group to give recommendations on ways to improve the estimation accuracy of ILUC GHG emissions from biofuels and indirect impacts of other fuels using the Global Trade Analysis Project (GTAP) model. CARB then formed smaller groups to discuss detailed aspects of the GTAP model, such as elasticity value, joint product credit, land cover, time calculation, direct emission, etc. In December 2010, the working group presented the short-, mid-, and long-term results of their analysis.

To evaluate the progress of LCFS implementation, CARB established an advisory board consisting of 40 members from academia, NGOs, and industries (including representatives from ICCT). The advisory board meets bi-monthly to review LCFS implementation and identify areas of concerns to be submitted to CARB as recommendations by the end of 2011.

4.3. Northeast and Mid-Atlantic LCFS

A consortium of eleven states in the Northeast and Mid-Atlantic regions is working on the standardization of low-carbon fuels. The governors from these states signed an MoU to reduce GHG emissions from transportation sector and fossil fuel use. Based on the MoU, the framework for the standardization of low-carbon fuels that have an impact on the economy and environment will be developed by also taking into account the indirect land use change.

Economic impact analysis is an important consideration in the development of LCFS framework. This analysis is carried out to find the most effective way to reduce carbon intensity by taking into consideration the availability and potential of existing fuel, as well as the capacity to meet various targets for reducing carbon intensity, including GHG emissions, by 10%.

The Northeast States for Coordinated Air Use Management (NESCAUM) is tasked with conducting an economic impact model analysis which takes into consideration three scenarios that combine biofuels, natural gas, and electricity to meet the 10% GHG emission reduction target. Fossil fuels are the type of fuel most widely used by the transportation sector in Northeastern states. Therefore, LCFS pays more attention to fossil fuels. If the participating states choose to implement LCFS, the legalization of the framework and its key elements can be done through the legislative authorities in each state.

4.4. Low-Carbon Fuel Policy in Midwestern States

Midwestern Governors Association (MGA), which consists of ten states in the Midwestern region, has also initiated a low-carbon fuel policy (LCFP). For this purpose, MGA established a low-carbon advisory board in 2009 to formulate federal and regional LCFP recommendations. The advisory board designed and developed the federal and regional LCFP recommendations in accordance with four principles: creating incentives for low-carbon fuels in the Midwest, reducing the carbon intensity of transportation fuels, exploiting industrial and agricultural potentials while protecting natural resources, and complementing existing policies. The advisory board felt that an integrated federal LCFP was the best choice, but also prepared regional LCFP considering policy/regulation uncertainties at the federal level. The recommendations of the advisory board are summarized in the report titled “Energy Security and Climate Stewardship Platform for the Midwest.”

In general, the federal LCFP is designed based on science and available data, and is quite consistent and flexible to achieve the targets through market mechanisms. The federal LCFP also sets realistic yet progressive GHG reduction targets and is able to demonstrate increasing benefits of GHG reduction. Based on the recommendation of the advisory board, federal LCFP does not have to include ILUC until more empirical evidence and magnitudes are found.

As for the regional LCFP, the advisory board recommended the same framework as California's LCFS, namely a target of minimum 10% carbon intensity reduction as compared to the carbon intensity of oil blends in Midwestern in 2005 by using LCA to calculate carbon intensity score of various fuels (including renewable and non-renewable fuels), cost effective and flexible in adjusting to credit trading and banking regulations, and should apply to all fuel types if ILUC is to be included in the calculation. Prior to designing the regional LCFP, the advisory board requested MGA to conduct an economic impact analysis of the policy for the Midwestern region.

5. Biofuel Production from Used Cooking Oil in the UK

The transportation sector in the UK accounted for around 23% of the total GHG emissions in 2013, with land transportation sector being the main contributor (DECC, 2015). Therefore, GHG emission reduction efforts from the transportation sector were carried out to mitigate the impacts of climate change. There were at least four strategies to choose from for reducing GHG emissions in transportation sector, namely the use of sustainable and renewable transportation fuels, improving the efficiency of vehicle fuels, reducing demands for transportation by switching to other transportation modes, and improving logistics. In the following section, only matters related to the first strategy are discussed.

The use of biofuels for the transportation sector in European Union countries is supported by two policies, namely Renewable Energy Directive (RED), which mandates the use of 10% renewable energy by 2020, and Fuel Quality Directive (FQD), which mandates a 6% reduction in GHG emissions from fuels by 2020 as compared to 2010. Both policies do not explicitly mention biofuels. However, in practice, biofuels—particularly biodiesel and bioethanol—have been the most widely used renewable energy sources in the transportation sector.

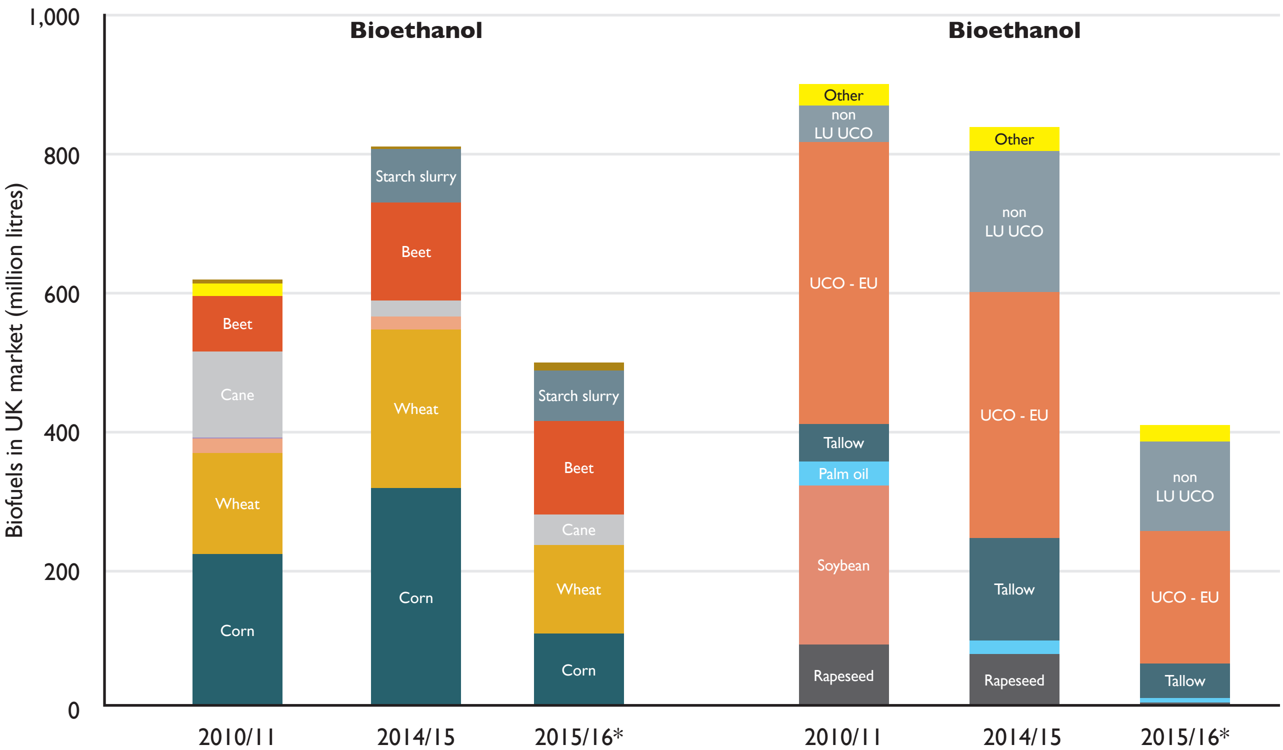
RED and FQD also include ILUC directives, which drive the use of feedstock with the assumption that limiting the share of biofuels produced from food crops to a maximum of 7% of the total energy consumption in transportation sector by 2020 will result in a better GHG emission reduction. In addition, the directives are considered better through the double counting of biofuels produced from waste, residues, and lignocellulosic raw materials to achieve the 10% RED target (Hamelinck and Zabeti, 2016). Instead of using single-counted biofuels (often plant-based), the double counting method is intended to encourage the use of next-generation biofuels and waste-based biodiesel. It means that, in theory, the 10% target can be met with only 5% supply of waste-based biofuels.

Currently, the UK is focusing on the development of double-counted UCO-based biodiesel, or biodiesel produced from used cooking oil, to meet the 10% target that is included in the 7% limit. Most of the UCO produced in the EU is categorized as waste, which by definition cannot be used or exported to other countries as animal feed. For this reason, UK Department for Transport (DfT) defines UCO as oil and fats from plants or animals that have been used by restaurants, caterers, or household kitchens, to cook food for human consumption.

For 2020, DfT is considering the option of limiting the use of plant-based biofuels for the transportation sector to 5%, 3%, or even 1.5%. At the same time, DfT is expanding the role of UCO- and fat-based biodiesel. This approach is based on concerns about the increasing effects of ILUC.

In recent years, UCO feedstock from outside EU continues to increase and is estimated to increase until 2020. However, UCO from outside EU should not become EU's waste, although there is no regulation that definitively prohibits the use of UCO for animal feed. UCO-based biodiesel does not have high carbon emission potential as the carbon footprint from its previous use is not calculated.

Figure 4. UK's Biofuel Market, 2010/11–2014/15



Source: DfT website

The figure above shows that between 2010 and 2015, the double-counting fraction for Used Cooking Oil Methyl Esther/UCOME-based biodiesel in total biofuels sales was 30% to 34%. In other words, around 45% to 46% of the UK's commitment to RED policy was supported by UCOME. In addition, the largest share of used cooking oil in the UK comes from non-EU countries. This is a major problem, considering that UCO from third countries often cannot be clearly categorized as waste. For the record, in 2014/15, UCO from non-EU countries mostly came from the US (40%), followed by Saudi Arabia and South Korea (10% each).

When UCO is used further, it cannot be categorized as waste. If UCO is used as feedstock for biodiesel, it can create indirect carbon emissions. In the EU, UCO can be used for various purposes, from animal feed to illegal uses, and therefore, the monitoring analysis for UCO that comes from the EU is quite straightforward. However, non-EU countries do not treat UCO in the same way as EU countries, so it does not make sense that UCO imported from non-EU countries is categorized as waste. Therefore, the utilization of domestic UCO will be of great benefit to the UK.

6. Food-Crop Biofuel in the European Union

6.1. Biofuel, Land Use Change, and Palm Oil

The role of food-crop biofuels in the climate change mitigation policy has long been a subject of controversy due to its impacts on food prices and land use. This type of biofuel is deemed to be less effective in reducing GHG emissions compared to petroleum, because the feedstock for the biofuels must be cultivated beforehand. Therefore, the land use is associated, both directly and indirectly, with increased GHG emissions. If forests were cut down and the land was used to cultivate food crops as feedstock for biofuels, the GHG emission reduction from the use of this type of biofuels would not make up for the amount of carbon released by the crops and land used in a certain period of time. This premise serves as the basis for biofuel management policies in the EU and the US that prohibit direct land use change in forests for producing food crops as feedstock for biofuels.

Direct land use change would not occur if the crops used for biofuels were harvested from existing agricultural land. However, it will still have indirect effects. For instance, if the harvest from 1 hectare of rapeseed (also known as canola in North America) plantation was to be converted into biofuels, the market value for agricultural products would be reduced by 1 hectare worth of products. This would result in a shortage of rapeseed supply in the market, increase competition, and eventually lead to increase in prices. Other rapeseed farmers in the market would observe the price increase, and the following year, they would clear more forest land near their plantation area to produce more rapeseed because this would be profitable to them, considering the high price. However, clearing forests would severely disrupt the ecosystem and soil, resulting in high GHG emissions. Although the rapeseed used for biofuel does not come directly from the cleared forest land, but the land use change of forest land into plantation still counts in the biofuel production chain. This would result in indirect land use change (ILUC) emissions.

The expansion of rapeseed plantation would result in fewer rapeseed being purchased in the market due to its higher price. Subsequently, farmers would invest by making new irrigation system to increase crop yields on their land. After the rapeseed is processed and the oil is used for biodiesel, the biofuel producers would sell the processed residue and oil products to other farmers as animal feed. Then, the farmers would plant less corn and soybean for animal feed in the following year.

The net effect from all these changes is that the production of rapeseed from the 1 hectare converted forest land would be smaller than the production of 1 hectare land area that is fully dedicated for biofuels. Despite the long debate about the relative size of the effects, it is evident that all plant-based biofuels produce some amount of ILUC emissions and still have a GHG impact (Malins et al., 2014). Land use change due to biofuel production would be a huge concern when it involves palm oil, as the commodity is commonly used for food. Currently, over 80% of the world's palm oil are cultivated in Indonesia and Malaysia (Abdullah et al., 2009; Sheng Goh and Teong Lee, 2010; FAOSTAT, 2017).

When farmers expand their palm oil plantation, most of their new plantation land will be converted from tropical forest land, which is rich in biodiversity and carbon stock. One third of the whole palm oil area expansion takes place on peatlands. Peatland is a waterlogged soil that is low in oxygen, which conserves organic matters that have been formed for thousands of years (Miettinen et al., 2012). Palm trees won't be able to grow properly in soggy soils.

Therefore, farmers would construct ditches to drain the peatlands when expanding their plantations. Peatland drainage would expose the organic matters to oxygen, resulting in the decomposing of the thousand-year-old peat and the release of carbon dioxide (CO_2) in large amounts (Page et al., 2011). Consequently, when the ILUC emissions for palm oil are included in the calculation, palm-oil-based biodiesel has a worse impact on the climate, even when compared to petroleum (Valin et al., 2015).

6.2. Vegetable Oil Substitution

Santeramo (2017) conducted an empirical study using econometric techniques on the possible impact of changes in the price of one commodity on the supply of other commodities, namely soybean oil, rapeseed oil, sunflower oil, animal fat, and palm oil. The research found that the increased price of rapeseed oil in the European Union (EU) and soybean oil in the United States (US) led to increased imports of palm oil to these regions. In addition, the production of rapeseed-based biodiesel in the EU and soybean oil in the US were considered to have contributed significantly to the high emissions caused by land use changes related to palm oil expansion. This fact hindered, or even nullified, the impact of various policies that support the development of food-crop biodiesel on the climate.

The detailed explanation of the empirical study conducted by the EU shows that the increased price of rapeseed oil resulted in increased supplies of rapeseed oil and palm oil. The increased price of rapeseed oil was predicted to lead to an increase in its supply. With its price being higher, farmers in the EU would be incentivized to cultivate more rapeseed due to its profitability. Moreover, traders would also tend to sell more rapeseed oil domestically and export less of it due to the increasing profit in the EU market. However, the increased price of rapeseed oil would also lead to an increased supply of palm oil. The most logical explanation for this is that palm oil serves as a substitute for rapeseed oil in the EU market. For instance, restaurants would switch to the less-expensive palm oil as rapeseed oil becomes too expensive, which would in turn lead to increased imports of palm oil to the EU.

In the case of the US, the result of Santeramo's analysis (2017) shows that the increased price of soybean oil coupled with the small increase of its supply led to an increase in palm oil supply. This means that palm oil has replaced the use of soybean oil in the US. The increase in soybean oil supply that was responding slowly to its increase in price indicates the weak influence of the increase in soybean oil prices on the increase in its supply.

A significant difference between the EU and the US cases is the fact that rapeseed oil accounts for two-thirds of the total value of rapeseed production in the EU, while soybean oil only accounts for one-third of the total value of soybean production in the US. In the case of the former, rapeseed oil is the most valuable product processed from rapeseed, making it the driving force in the decision to produce rapeseed. Meanwhile, the decision to produce soybean is more likely to have been influenced by the change in price/value of products processed from soybean.

The most logical explanation is that other types of oil, such as rapeseed oil in the US and sunflower oil in the EU, are used for unique/specialty products that tend to be slower/harder to replace by other types of products. Products that are less sensitive to differences in oil properties, such as animal feed, would logically have the lowest production cost and be more price-sensitive.

Currently, palm oil is the least expensive oil in the US and EU markets. At the same time, soybean oil is less expensive than rapeseed oil in the US, while it is the other way around in Europe. As the least expensive and most dominant oil in the US is derived from soybean, and in the EU is derived from rapeseed, while both also serve as the most dominant feedstock for biodiesel in the US and EU, it is natural that the two are closely related in the vegetable oil substitution dilemma.

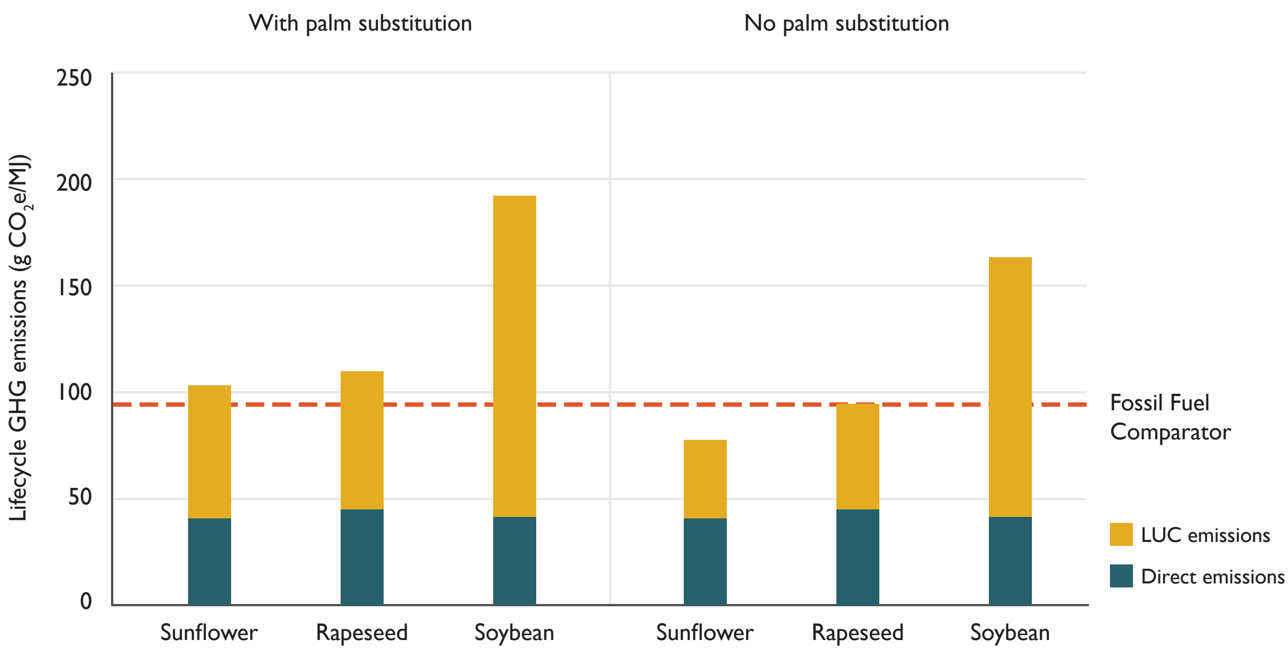
6.3. Palm Oil Substitution

Vegetable oil substitution has a significant impact on the estimated ILUC emissions from biodiesel feedstock. ILUC is calculated by using a balance model that represents the whole global economy or the main sectors within it. This model calculates the impact of changes in prices of several commodities in response to biofuel policy and predicts where land use change will occur in the world.

A study using GLOBIOM method was conducted by the European Commission to assess the impact of EU's biofuel policy (Valin et al., 2015 in Searle, 2017). The study shows that the ILUC emissions generated by all types of biodiesels is expected to be very high, and even rapeseed-based or sunflower-based biodiesel produced in the biorefinery are not able to reduce GHG emissions compared to petroleum. Furthermore, soybean- and palm-oil-based biodiesel also have a worse impact on the climate compared to fossil fuels.

If substitution of palm oil as feedstock for biodiesel is not allowed, the change in emissions due to land use change for biodiesel would be lower, namely around 40% for sunflower, 25% for rapeseed, and 20% for soybean. These figures are enough to change the understanding of the impacts the various biofuel feedstocks have on the climate. For instance, if it is believed that palm oil substitution will not occur, then GHG emission reduction from sunflower-based biodiesel will be lower than from fossil fuels (petroleum). In contrast, if palm oil substitution is allowed, all types of biodiesels will generate much higher GHG emissions compared to the GHG emissions generated from petroleum.

Figure 5. Life cycle of GHG Emissions from EU Biodiesel



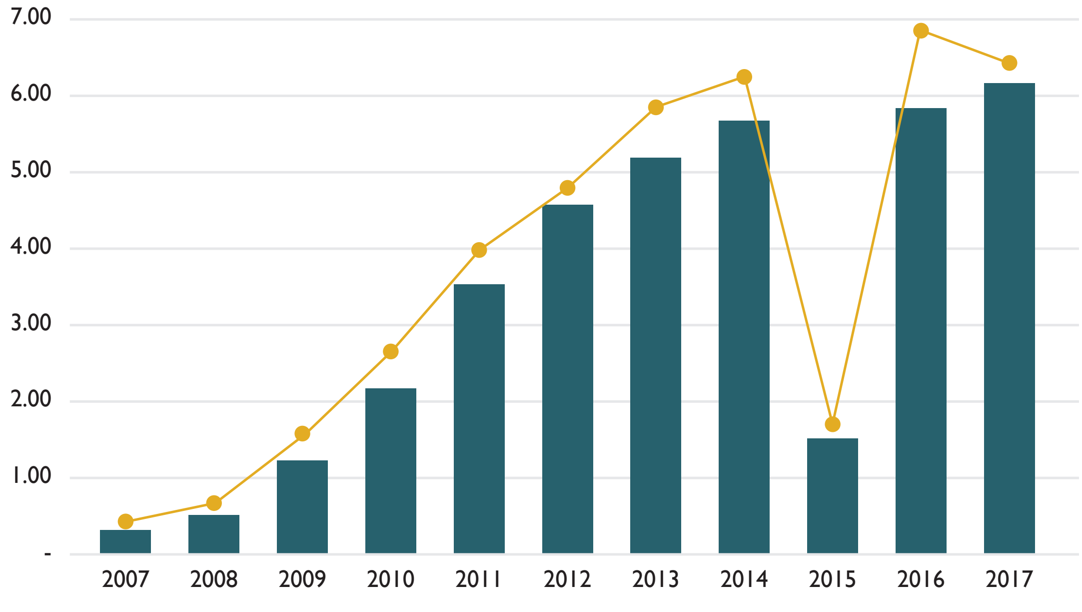
Source: Valin et al., 2015 in Searle (2017)

Another lesson learned from this is that without palm oil substitution, ILUC emissions from other biodiesel feedstocks in the EU remained high. Sunflower-based biodiesel could only contribute 20% to GHG reduction, whereas rapeseed-based biodiesel has similar impact on the climate and soybean-based biodiesel generates much worse GHG emissions compared to petroleum. Despite the strong empirical evidence regarding the practice of vegetable oil substitution, it is important to note that ILUC emissions substantially limit the benefits for the climate (GHG emission reduction) that are expected from the various policies that support the use of food-crop/plant-based biofuels.

7. Palm-Oil-Based Biodiesel in Indonesia

As a country that requires a huge supply of energy sources, Indonesia is developing biodiesel to replace diesel fuel, which in part still needs to be imported. The type of biodiesel developed in Indonesia is palm-oil-based, or produced from crude palm oil (CPO). The Indonesian Government started developing biodiesel in 2006 and exporting biodiesel in 2008 (Abdullah et al., 2009). The policy on CPO use as feedstock for biodiesel is inseparable from economic considerations, namely to reduce CPO imports and create new jobs. With the availability of abundant raw materials, the biodiesel industry in Indonesia can be scaled up to an export-oriented industry or scaled down to a domestic-market-oriented industry (Susila dan Munadi, 2008). With massive utilization, biodiesel industry is expected to be a source of foreign exchange earnings and encourage the use of clean energy to reduce carbon emission pollution. In 2008–2015, Indonesia's biodiesel production and exports consistently increased with growth rates of 16.46% and 13.26% respectively. This led to an increase of 20.65% in domestic biodiesel supply, which can also be used domestically as a biofuel (Purba et al., 2018).

Figure 6. Energy Consumption and Use of Biodiesel in Indonesia, 2007–2017 (%)



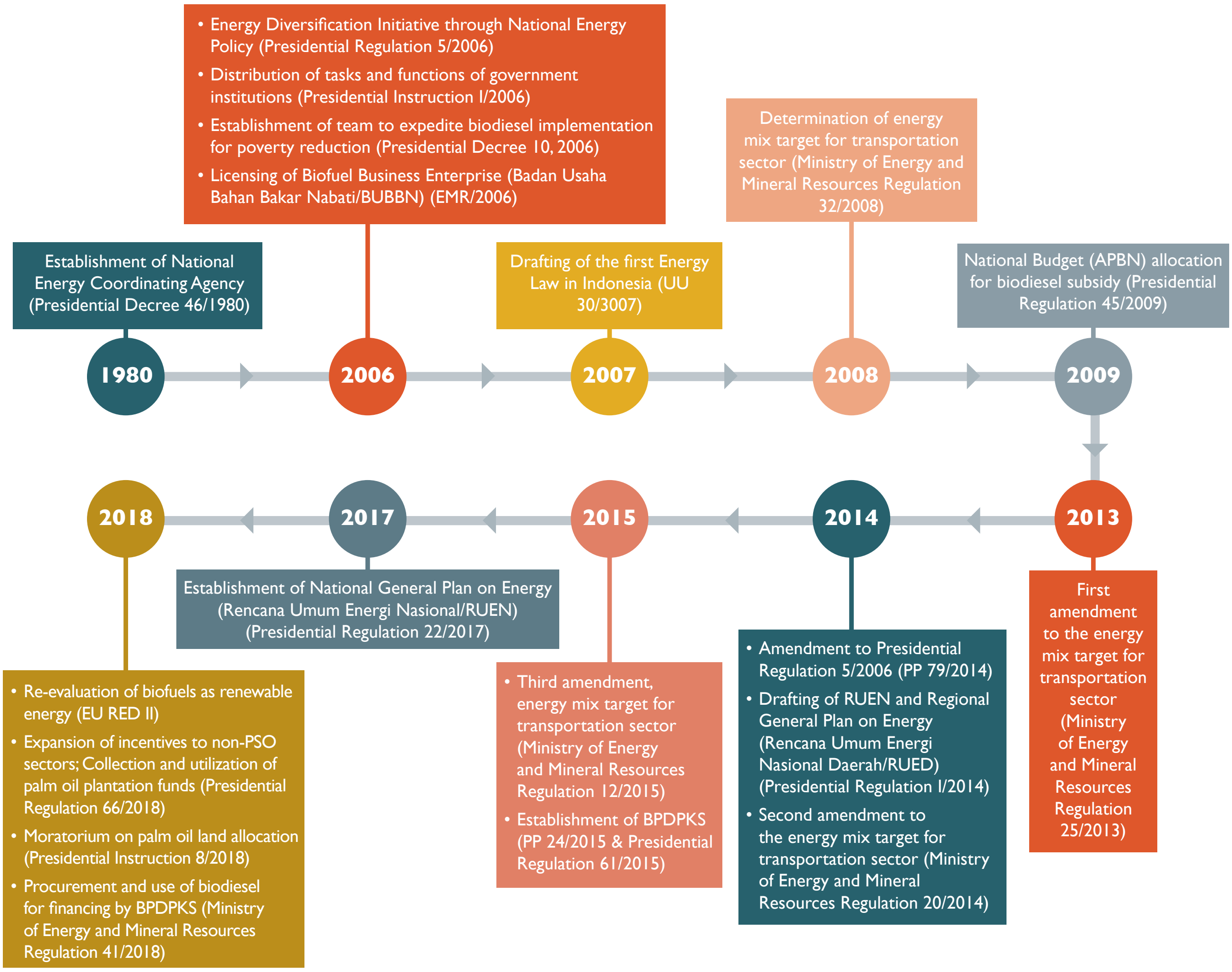
Source: Ministry of Energy and Mineral Resources, Katadata (2018)

According to the Ministry of Energy and Mineral Resources, in general, biodiesel energy consumption in 2017 reached 79.43 million barrels oil equivalent (BOE), or an increase by 5.4% from the previous year. The amount is equivalent to 6.44% of total national energy consumption, which reached 1.23 billion BOE. Meanwhile, petroleum still accounted for the largest share in the national energy consumption, which reached 356.33 million BOE, or 28.88% of total energy consumption, followed by biomass at 306.25 million BOE, or 24.82% of total consumption.

7.1. Biodiesel Policy in Indonesia

Biodiesel development policy is very closely related to the policy on new and renewable energy (NRE) development. The effort to develop energy mix began with the issuance of Presidential Decree No. 46 of 1980 on National Energy Coordination Agency (*Badan Koordinasi Energi Nasional*/BAKOREN). The decree was still focused on the effort to cut down on petroleum use and expand the role of coal in the national energy mix. In 1981, BAKOREN issued the General Policy on Energy (*Kebijakan Umum Bidang Energi*/KUBE), which was amended in 2003. The Presidential Decree on BAKOREN has been amended three times, the latest of which was based on Presidential Decree No. 23 of 2000.[7]

Figure 7. Biodiesel Policy in Indonesia



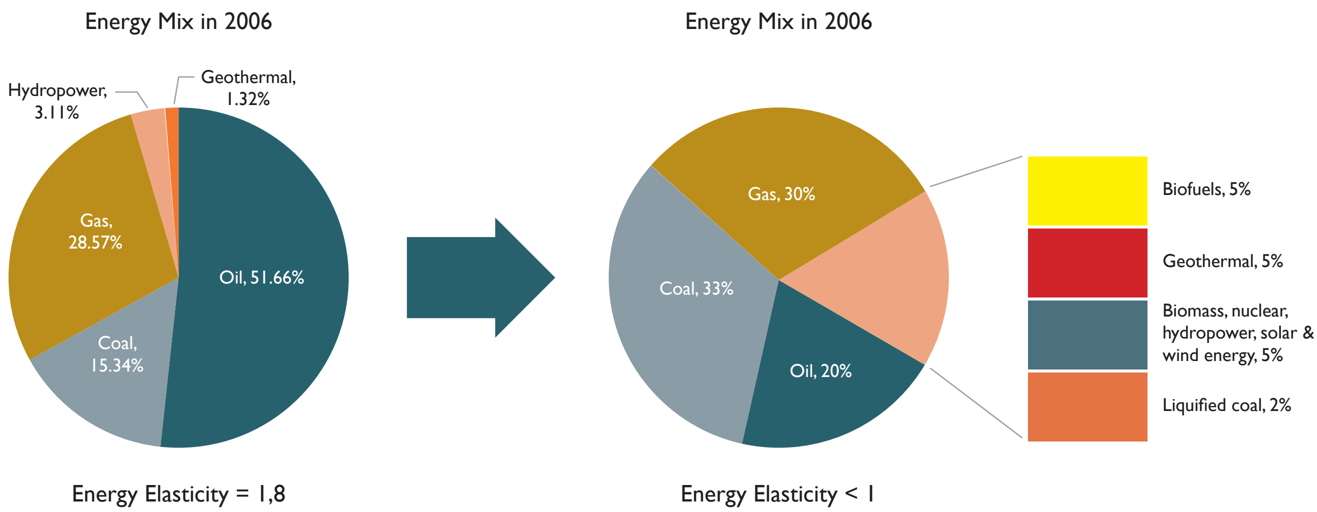
Source: Analysis by the writer, 2019.

[7] Edited from Dharmawan et al. (2018)

Next was Law No. 30 of 2007 on Energy, the first law to specifically and comprehensively governs the energy sector in Indonesia (Indrarto et al., 2018). The Law also includes the drafting of National Energy Policy (NEP). Considering the importance of establishing an energy management agency to, among others, manage the diversification and availability, Presidential Regulation No. 26 of 2008 on the Establishment of National Energy Agency (*Dewan Energi Nasional*/DEN) was issued. DEN is an independent national institution that is responsible for monitoring the implementation of national energy policies.

In 2014, policy on energy mix and NRE development was strengthened by the issuance of Government Regulation No. 79 of 2014 on NEP, which replaced Presidential Regulation No. 5 of 2006, stating that the fulfillment of national energy requires an improvement in national energy mix, implementation of energy conservation, and acceleration of power plant construction. More specifically, through the Government Regulation, the government targets an increased use of biofuels, which are parts of bioenergy. Government Regulation No. 79 of 2014 contains energy mix policy, in which the share of renewable energy is targeted to reach 23% in 2025 (4.7% for biofuel in particular) and increase to at least 31% in 2050 as long as the economic value is met. As the implementing regulation for the Government Regulation, Presidential Regulation No. 1 of 2014 on the Composition of National General Plan on Energy (RUEN), Regional General Plan on Energy for Provinces (RUED-Provinsi), and Regional General Plan on Energy for Regencies/Municipalities (RUED-Kabupaten/Kota) was issued. In March 2017, RUEN was stipulated through Presidential Regulation No. 22 of 2017.[8]

Figure 8. Energy Mix Target in 2025



Source: Presidential Regulation No. 5 of 2006.

RUEN consists of numerous short- and long-term programs to achieve the targets in NEP. RUEN targets 15.6 million kiloliters (KL) of biofuel production in 2025 and 54.2 million KL in 2050, as well as blending target of 30% biodiesel and 20% bioethanol. In the development of biofuels to replace petroleum in transportation and industry sectors, the programs formulated in RUEN are as follows:[9]

[8] *Ibid.*

[9] *Ibid.*

1. Conversion of the use of petroleum to biofuels in transportation, industry, and power plant sectors.
2. Increased production and use of biofuels.
3. Special allocation of lands for energy plantations (plantations that are specifically prepared to be planted with trees for their use of energy by converting former mining areas and critical lands).

The policies on blending targets began with the issuance of Presidential Instruction No. 1 of 2006 on the Provision and Utilization of Biofuels as Alternative Fuels. To support the utilization of biofuel and ensure biodiesel use in Indonesia, the government issued Minister of Energy and Mineral Resources Regulation No. 32 of 2008 on the Provision, Utilization, and Trading System of Vegetable Oils as Alternative Fuels, which has been amended three times, the latest being the Minister of Energy and Mineral Resources Regulation No. 12 of 2015. The three amendments are known as the mandatory use of biofuels and the acceleration of biodiesel use in the transportation, industry, commerce, and power plant sectors.

In the first amendment, Minister of Energy and Mineral Resources Regulation No. 25 of 2013 Article 3 Point 2 determines the stages in utilizing biofuels as alternative fuels. In the third amendment, Minister of Energy and Mineral Resources Regulation No. 12 of 2015 stipulates the mix of biofuels to diesel fuels to reach 20% by 2016 and 30% in 2020 for the non-Public Service Obligation (PSO) transportation. This policy aims to reduce dependency on fossil fuel imports, establish national energy independence, and save up on foreign exchange earnings.

Table 5. Stages of Minimum Mandatory Use of Biodiesel (B100) as Oil Fuel Blend

Sector	April 2015	January 2016	January 2020	January 2025	Description
Household	-	-	-	-	Undetermined
Micro business, fishery, agriculture, transportation, and PSO	15%	20%	30%	30%	Against total demand
Non-PSO transportation	15%	20%	30%	30%	Against total demand
Industry and commerce	15%	20%	30%	30%	Against total demand
Power plant	25%	30%	30%	30%	Against total demand

Source: Minister of Energy and Mineral Resources Regulation No. 12 of 2015

Before the full substitution takes place, biodiesel production will be carried out by blending in stages. There are several reasons behind the strategy to use blended biodiesel. First, the economic value of biodiesel production has not yet been met. In this context, government support is still necessary to help the biodiesel industry continue to operate and grow. Second, the limited capacity of biodiesel production and the lack of realization of the production (Legowo, 2008).

The American Society for Testing and Materials (ASTM), an international institution that determines the specification standards of biodiesel, defines biodiesel as a mix between biodiesel fuel and fossil diesel fuel (Stauffer and Byron, 2007 in Wibowo et al., 2019). The implementation of biodiesel standards is indicated by the Indonesian National Standard (SNI) label, which was formulated to comply with the World Trade Organization (WTO) Code of Good Practice: openness, transparency, consensus and impartiality, effectiveness and relevance, coherence, and development dimension. A study by Tyagi et al. (2010) shows that the quality requirements for biodiesel are necessary for the issuance of production license, as well as quality and liability assurance for biodiesel distribution. Even the feedstocks for B20 (biodiesel and diesel fuel) must meet these standards before the mixing.[10]

Based on the identification carried out through SNI Information System, currently there are two SNIs regarding biodiesel. The first one is SNI 7182:2015, which consists of 19 main parameters (cetane number, specific weight, viscosity, sulfur content, distillation, flash point, pour point, carbon residue, water content, FAME content, copper strip corrosion, ash content, sediment content, strong acid value, total acid value, visual, color, lubricity, oxidative stability) for the B100 biodiesel standard. The second is SNI 8220:2017, which consists of 17 parameters (cetane number, density, viscosity, sulfur content, distillation, flash point, pour point, carbon residue, water content, copper strip corrosion, ash content, sediment content, strong acid value, total acid value, visual, color, lubricity) for pure CN 48 diesel standard (Wibowo et al., 2019).

Another policy to spur biodiesel development is the provision of subsidies. Prior to 2014, the government provided biodiesel subsidies through the allocation of the State Budget (APBN). In 2015, the government issued Presidential Regulation No. 61 of 2015 on the Collection and Utilization of Palm Oil Plantation Funds, or known internationally as CPO Fund. The amount of levy for CPO is US$50 per ton, of which some is used to incentivize biodiesel producers.[11]

In 2018, the regulation was replaced by Presidential Regulation No. 66 of 2018, which covers the expansion of incentives to include non-PSO sector. The implementation of this Presidential Regulation was supported by the massive implementation of the mandatory B20 program in every sector. In support of the B20 mandatory program, the Ministry of Energy and Mineral Resources issued Minister of Mineral and Energy Resources Regulation No. 41 of 2018 on the Provision and Utilization of Biodiesel Type of Biofuels in the Context of Financing by the Oil Palm Plantation Fund Management Agency. In the same year, President Jokowi issued Presidential Instruction No. 8 of 2018 on the Suspension and Evaluation of Palm Oil Plantation Permits as well as Increasing the Productivity of Palm Oil Plantations, known as the Moratorium. The moratorium policy on palm oil plantation permits is valid for 3 years from September 2018 with the aim of improving the governance of palm oil plantations.

7.2. Biodiesel Management Institutionalization

Institutionally, the government's support in the development of biofuels is the establishment of the National Biofuel Development Team in July 2006. The main duty of the team is to formulate sources of biofuels, including those from palm oil. The National Biofuel Development Team describes the biofuel development by using the concept of triple track strategy, which includes pro-growth, pro-job, and pro-poor. In this context, pro-job means that the biofuel development will create new jobs. Pro-poor is to ensure that low-income community's access to energy sources is improved through the policy to substitute kerosene with biofuels, whereas pro-growth means that biofuel development will increase economic activities, which in turn would lead to economic growth.

In July 2015, the government established the Palm Oil Plantation Fund Management Agency (*Badan Pengelola Dana Perkebunan Kelapa Sawit*/BPDPKS), a Public Service Agency (*Badan*

[10] *Ibid.*

[11] *Ibid.*

*Layanan Umum/*BLU) under the Ministry of Finance. This agency manages export levy funds paid by exporters of CPO and its derivatives, based on Presidential Regulation No. 61 of 2015 with the aim of human resource development, palm oil research and development, palm oil plantation promotion, palm oil plantation replanting, infrastructures and facilities construction, and biodiesel provision. To support biodiesel development, BPDPKS also entered into a Memorandum of Understanding with the Ministry of Agriculture, Ministry of Energy and Mineral Resources, and Ministry of Environment and Forestry.

Next, as part of the biodiesel trading system, biodiesel producers in Indonesia formed an organization called the Indonesian Biofuel Producers Association (*Asosiasi Produsen Biofuel Indonesia*/Aprobi). Aprobi became a government partner in formulating policies related to biodiesel development in Indonesia, especially the palm-oil-based biodiesel.

7.3. Conception of Palm-Oil-Based Biodiesel

As a country “rich” in natural resources, Indonesia has abundant supply of renewable and new energy sources, both in quantity or type. This means that, in addition to CPO, biodiesel can also be produced by using other feedstocks, such as used cooking oil (UCO) and agricultural/plantation waste.

Currently, the government’s decision to use CPO as the single feedstock for biodiesel is meant to absorb CPO oversupply. With that, the biodiesel program is a solution to maintain the stability of CPO prices and tap into domestic potential in the effort to realize energy resilience.

Positioning CPO as the only feedstock for biodiesel is actually quite risky, if one of the aims of the biodiesel program policy is to promote the use of clean energy or low-emission fuels. Compared to fossil fuels, palm-oil-based biodiesel may indeed have a relatively lower pollution rate (TEA, 2019). However, there is a threat in the form of palm oil plantation expansion to meet the increased demand for CPO if CPO is still used as a production input for the food sector on top of the increased demand of CPO for biodiesel due to the increasing use of biodiesel based on the policy. This would translate into threats of environmental disasters and increased greenhouse gas emissions from the upstream activities.

This concern is reasonable, given that many independent smallholders in Indonesia have yet to implement a proper and sustainable palm oil plantation business model. In addition, there is a strong mindset and assumption that in order to increase fresh fruit bunches (FFB) yields, expansion of plantation land is necessary.

Due to this phenomenon, the existence of palm oil in the international biodiesel trading system has been perceived negatively by non-palm-oil exporting countries, especially members of the European Union. These countries are trying to control palm oil imports by implementing high import tariff policies, as well as anti-dumping duties. If this issue is not anticipated, it is very likely that India and China—big importers of world’s palm oil—will follow the protective measures (OECD/FAO, 2015).

In 2016, Indonesia supplied 61% (36 million tons) of the world’s total palm oil. The Indonesian Government also aspires to produce around 60 million tons of CPO in 2045. However, the government should be cautious in taking steps and responding to this target, considering the logical consequences to forests and peatlands, especially in the case of land extensification. It is worth noting that from 1995 to 2015, Indonesia has lost around 2.3 million hectares of forest area to palm oil plantations. To achieve the 2045 palm oil production target, an additional of 8.2-hectare land (roughly estimated to be the size of Papua Island) is needed (Saleh et al., 2018).

In response to the assumption that Indonesia's palm oil plantations have not complied with sustainable principles and criteria, the government formulated CPO governance guidelines in the form of National Action Plan for Sustainable Palm Oil (*Rencana Aksi Nasional Kelapa Sawit Berkelanjutan*/RAN KSB) 2018–2023, which targets that at least 70% of the country's palm oil production in 2020 must be sourced from sustainable plantations (FoKSBI, 2017). To achieve this target, the government set a moratorium policy on palm oil plantation permits to suppress deforestation through Presidential Instruction No. 8 of 2018.

Moreover, the government also promotes intensification practices in an effort to increase the productivity of palm oil plantation businesses, particularly independent smallholders, whose productivity level is still below private- and state-owned plantation companies. Through the institutionalization of intensification practices in plantation businesses, it is hoped that the national productivity level can be maintained while also complying with the principles of sustainability and environmental conservation in palm-oil-producing regions.

Having observed the importance of inclusion and implementation of sustainability principles and criteria in palm-oil-based biodiesel program and trading system, a number of parties are currently lobbying the government to place independent smallholders as an actor of CPO supply chain in the biodiesel trading scheme. The reasoning behind this is, first, independent smallholders are business actors on the upstream side whose level of productivity still has to be boosted and a lot of them have not yet implemented a good and sustainable plantation business model.

Second, independent smallholders are actors on the upstream side that can be involved in the institutionalization of good and sustainable plantation business practices. Based on the BPS data on Indonesian palm oil statistics in 2018, smallholder plantations accounted for 38.26% of the country's palm oil production. Next, based on the data of Directorate General of Plantation, Ministry of Agriculture, the number of palm oil plantation households in 2019 is 2,740,747. Third, independent smallholders can be invited to contribute to the realization of proper and sustainable biodiesel production.

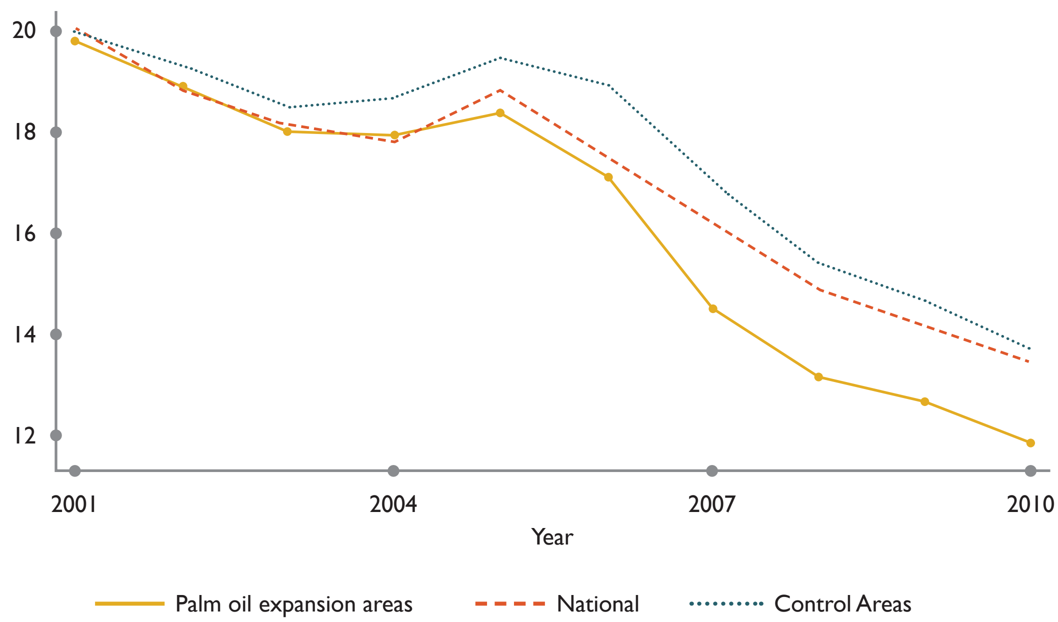
Besides the need for structuring the governance of palm oil industry, a beneficial scheme for palm oil independent smallholders is also necessary within the palm-oil-based biodiesel program, so that they could also enjoy the added economic value from the use of palm oil as feedstock for biodiesel. The scope of such scheme should include improvement of regulatory framework, collaboration between stakeholders along the palm oil supply chain, and capacity increase of independent smallholders in Indonesia.

7.4. Palm-Oil-Based Biodiesel and Poverty Reduction Program

Biodiesel program is an energy issue and developed as a solution to strengthen the country's fiscal capability (by reducing the volume of fossil fuel imports). On the other hand, palm-oil-based biodiesel program can also be directed to support the poverty reduction program. It is worth noting that, based on the profile and distribution pattern, apart from existing in urban areas, poverty is also present in rural areas that serve as centers for agricultural, plantation, and livestock activities. A study by ADB (2004) and Hussain (2005) in Asian Pacific countries concluded that for every 10% growth in the agricultural sector, the number of poor people in the rural areas would decline by 1.5-12%, or 7% in average.

Palm oil is a commodity produced by a basic sector. One of the defining characteristics of a basic sector is the ability to create jobs or absorb a high quantity of workforce. The CPO-based biodiesel trading system consists of upstream activities (production and supplying of feedstock) and downstream activities (distribution and marketing of biodiesel). According to Bappenas Chairperson, palm oil industry was able to absorb 16.2 million of workforce, consisting of 4.2 million direct workforce and 12 million indirect workforce, in 2018. Out of this figure, according to the Ministry of Agriculture data, the amount of workforce absorbed by the upstream side of palm oil plantation sector was 4.4 million people (Directorate General of Plantation, 2018). Compared to the downstream side, the upstream side is more prone to poverty caused by external changes, such as price fluctuation, demand fluctuation, and trade policy. Meanwhile, the business actor most vulnerable to poverty on the upstream side is palm oil independent smallholders.

Figure 9. Palm Oil Expansion Areas Experiencing a More Rapid Poverty Reduction Compared to Other Areas



Source: Asmanto and Adji (2019)

The influence of the dynamics of the upstream activities on poverty rate has been the subject of many studies. A study by Asmanto dan Adji (2019) describes the impact of palm oil industry expansion on poverty and the socioeconomic aspect in Indonesia. Combining palm oil production data from the Ministry of Agriculture and poverty data from National Socioeconomic Survey (Susenas) 2015, the analysis concludes that palm oil industry expansion influences or contributes to poverty reduction. Rural areas with larger shares of palm oil plantations in particular recorded higher reductions in poverty compared to other areas.

7.5. Challenges and Opportunities in Biodiesel Development

7.5.1. Challenges in Biodiesel Development

In Indonesia, the petroleum industry is placed under the central government's jurisdiction or authority. The performance indicator for this sector's goals and objectives is ensuring domestic availability at affordable prices. In this context, petroleum is a strategic commodity whose governance and trading system are managed by the state (government).

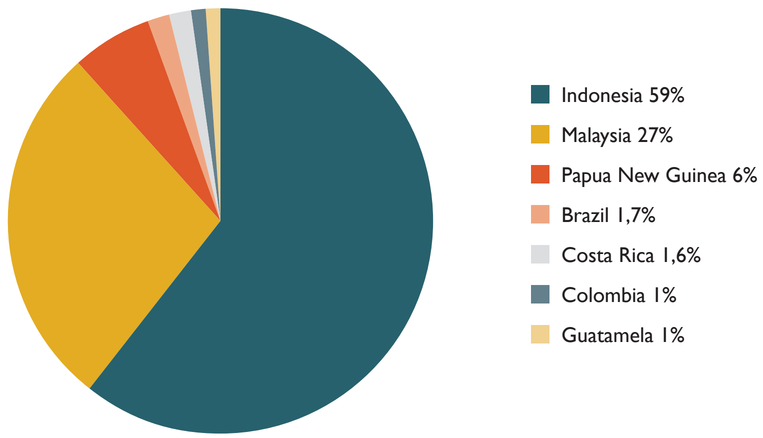
Based on the definition above, palm-oil-based biodiesel development faces challenges on the upstream and downstream sides. The first challenge on the downstream side is that biodiesel must be produced with a basic production cost that allows for an affordable selling price. Therefore, the challenge faced by the government is the ability to achieve the economic price of biodiesel production at the lowest level. Second, palm-oil-based biodiesel developed in Indonesia must be able to meet the quality standards perceived by the market, particularly consumers in the transportation sector. Currently, there is still an assumption that palm-oil-based biodiesel is not compatible with the specifications of diesel car engines. According to them, biodiesel reduces engine performance, which means that the cost for car maintenance will be higher (CNN Indonesia, 2018).

Meanwhile, the first challenge on the upstream side of palm-oil-based biodiesel development is the perception of global market that Indonesia has not used feedstock from proper and sustainable plantations for biodiesel production. European Union countries judge Indonesian biodiesel to be environmentally-unfriendly and lead to deforestation. Secondly, to minimize land expansion driven by an economic motive, biodiesel development program must place independent smallholders in the biodiesel supply chain, so that they could enjoy the added economic value of the utilization of CPO as biodiesel feedstock.

At the international level, regulations on sustainable palm oil (SPO) products have been issued and implemented through the Roundtable on Sustainable Palm Oil (RSPO) Certification, which plays the role in bridging palm-oil-producing countries with palm-oil-consuming countries regarding the fulfillment of environmental and sustainability aspects of CPO production governance. RSPO is an association that was established on 8 April 2004 by virtue of Article 60 of Swiss Civil Code as a rule with international standards in the sustainable and continuous palm oil plantation management. RSPO aims to promote sustainable palm oil production and utilization through partnership along the supply chain and open discussions with the stakeholders.

In response to such demand and to show commitment to proper biodiesel production, Indonesia restructured its CPO governance and trading system through the issuance of the mandatory Indonesian Sustainable Palm Oil certification, in accordance with Minister of Agriculture Regulation No. 11 of 2015. The regulation contains seven principles, namely legality, plantation management, protection of primary forests and peatlands, environmental management and monitoring, responsibility to workers (HSE), social responsibility and community empowerment, and sustainable business growth.

Figure 10. Shares of Countries Producing Certified Sustainable Palm Oil, 2017



Source: Directorate General of Plantation, 2017

The implementation of sustainable palm oil (SPO) is mandatory for palm oil plantation actors to ensure their business continuity, as some importers, such as Western European countries, have imposed RSPO standardization in accepting processed palm oil products. Oftentimes, the importers refuse to purchase products that do not comply with SPO in the production process. Indonesia is a producing country of certified sustainable palm oil with a share of 59%, followed by Malaysia at 27%, and Papua New Guinea at 6%.

7.5.2. Opportunities in Biodiesel Development

The awareness of using clean, low-carbon energy source has become a necessity and is practiced in both developing and developed countries. This step is taken as an effort to mitigate the threats of global warming due to increased greenhouse gas emissions worldwide. The international campaign on the use of clean energy is believed to be able to reduce global greenhouse gas emissions.

As a country with a vast amount of biofuel feedstock, Indonesia has the opportunity to develop biodiesel intensively. This means that to accelerate energy transition from the use of fossil fuels in a larger proportion to a smaller proportion by substituting them with biofuels, Indonesia has the opportunity to develop biodiesel by using various types of feedstocks, including second-generation ones such as used cooking oil.

7.6. Necessary Palm Oil Policie

Currently, biodiesel being developed in Indonesia is palm-oil-based. Considering its status as a single feedstock, there are two issues that should be focused on. First, maintaining the continuous supply of CPO feedstock, namely the fresh fruit bunches from palm oil plantations. Second, ensuring that the fresh fruit bunches used for CPO production are sourced from proper and sustainable plantation practices.

Therefore, the governance of palm oil plantation that must be implemented in Indonesia, in addition to increasing the productivity of palm oil plantations, is also directed to improve the standards of transparency and traceability of palm-oil-based biodiesel feedstock supply.

The problems of structuring the governance of palm-oil-based biodiesel trading system in Indonesia still revolve around the upstream side, particularly the small-scale business actors, the independent smallholders. The problems include low productivity, use of uncertified seeds, the need to replant most crops, and lack of good agricultural practices (GAP) implementation. Indonesia needs a policy to increase palm oil productivity through the Smallholder Palm Oil Plantation Replanting (*Peremajaan Sawit Rakyat*/PSR) with a public-private partnership (PPP) scheme, especially with Large Private Companies (*Perusahaan Besar Swasta/*PBS).

The sustainable increase of Indonesia's palm oil production and productivity requires serious management and support from all stakeholders. Some of the policies urgently needed to be implemented are:

1. Acceleration of smallholder palm oil plantation replanting.
2. Settlement of land legality (1.7 million hectares of smallholder plantations and 0.8 million hectares of corporate plantations are indicated as forest areas).
3. Improvement and acceleration of ISPO certification.
4. Strengthening of independent palm oil smallholder institutionalization.
5. Institutionalization of partnership programs between independent palm oil smallholders and palm oil companies.
6. Distribution of funds from palm oil export levy to local governments (for, among others, infrastructure repair in palm-oil-producing regions).
7. Mentoring/guidance for independent smallholders.
8. Structuring of sustainable palm oil plantation governance.

8. Lessons Learned in Biofuel (Biodiesel) Management

Biofuel (biodiesel) has become one of the priorities in the development of renewable energy, due to its large resource potential. As an agricultural country with various types of vegetable oil crops, Indonesia is highly suitable to support biodiesel development. However, biodiesel development in Indonesia is still facing numerous issues and requires more efforts to turn this potential into an actual advantage.

To date, Indonesian Government has issued various policies and regulations that aim to support biofuel development, including policy on mandatory biofuel use targets, implementation of B20 biodiesel processing standards, and CPO fund, which was started to be collected from 1 July 2015. However, many weaknesses still remain in the biofuel (biodiesel) sector in Indonesia, which caused the policy implementation to be less effective and the development is still way below target.

In the palm-oil-based biodiesel market, there is a conflict of interest between biodiesel consumers who, on one side, want affordable biodiesel prices, and palm oil companies on the other who seek a much faster way to profit by just exporting raw CPO. After all, converting CPO into biodiesel requires considerable investment and more effort. Consequently, annual biodiesel production remains at 75% of total production capacity (Murtinigrum and Firdaus, 2015). Therefore, it is necessary for the government to take a better strategic measure to boost biofuel (biodiesel) development in Indonesia.

Based on the international experience of countries that develop biofuel and biodiesel, there are at least four crucial aspects that have been identified and can be used as lessons for Indonesia in managing and utilizing biofuel (biodiesel), namely aspects of institutionalization, sustainable feedstock, social and economic inclusion, and competition between food source and energy source.

8.1. Institutionalization

Institutionalization and policies are two things that influence each other. A good policy without a strong institutionalization would not result in a maximum development output. Likewise, a good institutionalization without a good policy would also make it hard to achieve the desired development goals. Past events show that development failure often was a result of the state or government failure in drafting and implementing a good policy, as well as neglecting the institutional aspect, which should be the foundation of all development processes, from social, economics, and politics to technology and natural resources. In short, the government needs to have good governance.

The experience of several countries that are successful in managing biodiesel shows the importance of state commitment, as well as the active support and participation of all stakeholders. In relation to the national energy policy, energy independence would be achieved when based on the three basic principles: fairness, sustainability, and environmental insight. Therefore, it is important for Indonesia to position biofuel, or biodiesel in particular, as one of the transitional energy sources. This means that the sourcing of energy should be carried out in stages by moving on from fossil fuels while increasing the utilization and management of low-carbon renewable energy.

The repositioning of biofuel sector as one of transitional energy sources must be contained in a roadmap for biofuel bioenergy development, particularly palm-oil-based biodiesel, as the agreed-upon work guidelines. The roadmap would be crucial for determining the various outcome indicators of renewable energy—especially biodiesel—development in Indonesia.

Development of biodiesel or other biofuels must involve stakeholders from different sectors. Based on the lessons learned from various countries, as discussed in the previous sections, Indonesia needs a dedicated institution responsible for the national development and management of biofuel (biodiesel). This institution would serve as a guide that coordinates and ensures convergent cross-sectional efforts on biofuel development and management. The following are the various stakeholders of biofuel development in Indonesia:

- Policymakers (Government): Coordinating Ministry for Economic Affairs, Ministry of Energy and Mineral Resources, Ministry of Agriculture, Ministry of Environment and Forestry, Ministry of Industry, Palm Oil Plantation Fund Management Agency, and Local Governments at Province and Regency/Municipality levels;
- Business actors: PT. Pertamina, Biofuel Business Enterprises (*Badan Usaha Bahan Bakar Nabati/* BUBBN/biodiesel producers), Petroleum Business Enterprises (*Badan Usaha Bahan Bakar Minyak*/BUBBM), Indonesian Biofuel Producers Association (APROBI), as well as Banking and other financial institutions;
- Producers (upstream): Independent palm oil smallholders, palm oil companies, and palm oil factories;
- Other related institutions: NGOs and academics.

8.2. Sustainable Feedstock

At the micro level, CPO is one of the most readily used and feasible biofuel feedstock in short-medium term. Sustainability standards are necessary as a safeguarding framework to measure the fulfillment of biodiesel industry. However, the scope is limited to the upstream sector and there is yet to be a standard that covers the whole process of biodiesel business at the moment.

The lesson learned from the United States is that every biofuel producer should have Renewable Identification Number (RIN). RIN is a unique identification number assigned to every gallon of biofuel, which contains information on how and where the biofuel was produced, and could be used to trace the achieved volumetric target. Meanwhile, the lesson from Thailand is the importance of Indonesian Government to maintain the stability of FFB and CPO prices. In theory, sustainable increase of food (palm oil) productivity would increase the income of farmers, even more so if the prices of FFB and CPO in the market remain stable. Price stability is expected to give assurance to palm oil smallholders to increase their production and productivity to provide sustainable feedstock.

Therefore, the agenda for Indonesia to ensure sustainability, traceability, and transparency of palm oil products as the main feedstock for biodiesel are:

- Ensuring the transparency and traceability of feedstock (palm oil) distribution scheme/supply chain in biodiesel trading system through comprehensive data collection;
- Refinement (strengthening and acceleration) of ISPO palm oil sustainability standardization;
- Replanting of plantations to optimize productivity without clearing more lands.

8.3. Social and Economic Inclusion

Community welfare can be achieved if the government carries out equitable development across all regions and life aspects. This includes social and economic inclusion, which requires all development efforts to take into account the sustainable welfare of environmental resource actors and owners at individual and collective levels.

Future biofuel development will become one of the important determining factors for the development performance and welfare of (palm oil) farmers in general. However, the socioeconomic dimension of agricultural business in Indonesia has not been properly identified. Therefore, the government should make fundamental changes to the policies by giving more attention to palm oil smallholders. The solution is to make policies that pay attention to and prioritize independent smallholders as a CPO supplier for biodiesel feedstock. This step can be carried out through a partnership program between independent smallholders and palm oil companies or factories.

Furthermore, mentoring and other special interventions can also be carried out, such as guarantee to purchase palm oil products. It is necessary to have a special policy to spur the growth of domestic palm oil sector for biodiesel's main feedstock because the biodiesel industry can be scaled up to an export-oriented business or scaled down to a domestic-market-oriented industry.

8.4. Competition between Food Source and Energy Source

Development of CPO biodiesel industry in Indonesia is inevitable. The government needs to formulate proper measures so that the industry can grow efficiently with minimum negative impact, particularly in relation to food and energy resilience.

Agricultural development in the future will be even more challenging, and full of risks and uncertainties, especially if the performance of production and consumption are not properly planned and controlled. At the same time, energy development, particularly from agricultural commodities, urgently needs to be carried out through integrated steps, from research and development, policy formulation, and policy implementation to the monitoring and evaluation of the implemented policies.

Currently, the global recommendation is to use second- or even third-generation biofuels as energy sources considered most sustainable. The use of first-generation biofuels, which are produced from agricultural/plantation products, is considered unsustainable because it creates competition in the use of agricultural products for food source and energy source. As previously mentioned, besides producing first-generation biofuels (biodiesel, FAME), palm oil also produces considerable amount of second-generation biofuel (biomass). Based on the study conducted by ICCT and Traction Energy Asia (2020), some of the residues from palm oil plantation are potentially able to be processed into second-generation biofuel feedstock. Such residues include empty fruit bunches, shells, fruit fiber, palm trunks, and palm fronds.[12]

Another potential for second-generation biofuels in Indonesia is through the development of used cooking oil (UCO) biodiesel. From the environmental point of view, the absorption of UCO as biodiesel feedstock can reduce the need to clear new lands to meet biodiesel production, as well as reduce negative impacts on water channels, groundwater, and soil fertility caused by the disposal of used cooking oil. Moreover, the development of UCO for biodiesel can prevent recurring use/consumption of cooking oil, which is harmful to human health (Kharina et al., 2018). Therefore, the efforts to promote active participation of educational and research institutions, as well as to involve independent smallholders and the private sector in innovating the development of second- and even third-generation biofuels, are necessary.

[12] The result of this study will be published soon at https://tractionenergy.asia following the publication of this working paper.

Table 6. Summary of Lessons Learned in Biofuel Management Across the World

Country	Aspect			
	Institutionalization (Policy)	Sustainable Feedstock	Social and Economic Inclusion	Competition between Food Source and Energy Source
Indonesia	National energy mix policy and mandatory use of biofuel. Establishment of National Team for Biofuel Development (July 2006), APROBI (December 2006), and BPDPKS (July 2015).			Two SNIs concerning biodiesel, namely SNI 7182:2015 on 19 standard parameters for B100 biodiesel and SNI 8220:2017 on 17 standard parameters for pure CN 48 diesel.
Thailand	Biodiesel development roadmap. Cross-ministerial involvement under the direction of National Palm Oil Policy Committee (NPOPC).	Feedstock diversification policy. Biodiesel is produced from various types of feedstocks, such as animal fat and oil, as well as food crops like jatropha, palm oil, soybean, and cotton.		Palm-oil biodiesel standardization is based on Guidelines for the Development of Biodiesel Standards for APEC countries.
Brazil	Implementation of the National Program for Biodiesel Production and Use (PNPB).		Purchase guarantee of agricultural products cultivated by independent smallholders as the main feedstock for biodiesel (social fuel seal).	Promotion of the use of biodiesel feedstock from various types of biofuels.
United States	Low-carbon fuel policy.	RIN as an instrument to trace volumetric targets of biofuels.		
United Kingdom	Policy to reduce plant-based biofuels with the aim to reduce the use of petroleum and to mitigate GHG.		Promoting the utilization of domestic used cooking oil.	Focus on waste-based biofuel development, including from used cooking oil.
European Union	Biofuel development policy on the prohibition of forest land use change for biofuels.			Land use change from palm oil expansion is estimated to lead to high GHG emissions.
Lessons Learned	It is important to make an integrated policy that places biofuel (biodiesel) as one of the transitional energy sources.	Improvement of sustainability standards should include the entire supply chain of biodiesel and incentivize independent smallholders.	More attention should be paid to independent palm oil smallholders through various partnership schemes, as well as mentorship and other special interventions.	Involvement of independent smallholders and private sector in the development of second- and even third-generation biofuels.

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