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Policy Paper

The Impact of Biofuel Intensification on Integrated Climate-Land-Energy-Water System

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ABSTRACT

Producing biodiesel using a mixture of palm oil is one of the main policies today. This paper studied the interactions among climate, land, energy, and water in a model to address national biofuel intensification policies and identified biofuels' role in fulfilling energy needs, the trade balance, and reducing greenhouse gas emissions. The integrated climate land energy system (CLEWs) model was employed here. The model simulated the implementation of B30 in 2020 (B30/20), B40/25, and B50/30. The results showed that the implementation of the B30/20, B40/25, and B50/30 scenarios requires 15.30, 20.20, and 25.10 million tons of Crude Palm Oil (CPO), respectively. In terms of land, implementing the B30/20, B40/25, and B50/30 scenarios needs an additional 8.36, 69.33, and 80.38 thousand km2 of oil palm plantations, respectively 2030. In terms of emission, implementing the B40/25 and B50/30 policies can reduce 160 MTon and 320 MTon CO2-eq, respectively by 2030. There is no irrigation system needed in oil palm plantations. The paper recommended that the biofuel incentives or need price mechanism formulation and land allocation policies by using marginal/critical land for new oil palm plantations. The policy should be used to improve the yield or crop productivity of palm oil plants.

Keywords: biofuel, intensification, implementation, emission, and plantations.

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1. Introduction

The economic driving sectors of a country are very important to support the prosperity of human life through a series of measurable activities that are interrelated. However, due to climate change driven by environmentally-unfriendly development activities, poor environmental quality will have a global adverse impact on the material and value balance in the development production process (Zhou et al., 2013; 2016). The massive use of fossil energy in developing countries is also a key contributor to the formation of global CO_2 emissions. The Association of South-East Asia Nations (ASEAN) is currently in the medium-term predictions due to its dependence on coals and natural gases. Between 2005 and 2030, it is estimated that energy consumption will increase by almost three times, whereas CO_2 emissions will rise fourfold (Kumar, 2016). In this condition, Indonesia is still heavily dependent on fossil fuels and traditional biomass to maintain household energy needs in rural areas. However, Indonesia also shows concerns about the issue of CO_2 emissions and starts to find alternatives, such as using its new and renewable energy (RE) sources compared to other countries in ASEAN (Handayani et al., 2019; Kumar, 2016).

The current energy status in Indonesia

The commitment of Indonesia to the National Determined Contribution (NDC) is to reduce unconditional greenhouse gasses (GHG) emissions by 29% and a conditional reduction target of up to 41 % from the Business As Usual (BAU) scenario by 2030 (Amheka & Higano, 2015; Government of Indonesia, 2016; Siagian et al., 2017). This covers energy, agriculture, industry, waste, and forestry sectors. In the energy sector, electricity use is expected to reduce significantly by 605 and 645 million tons by 2030, which is higher than the BAU and ambitious RE target scenario by 2050 (Reyseliani & Purwanto, 2021). However, the current RE in the Indonesia primary energy mix is still very low at around 11.7% in 2021 (Ministry of Energy and Mineral Resources [MEMR], 2022). To achieve a 23% energy mix in 2025, the gap is still large and needs to be closed by around 11.3% within the upcoming three years. This consequently makes concrete actions and strategies necessary. Nevertheless, Indonesia has a large potential for RE utilization, as identified in Table 1.

Table 1. Indonesia's RE Potential and Utilization

No	Energy type	Potential (GW)	Installed capacity (MW)	Utilization (%)
1	Geothermal	23.36	2,276.9	9.747
2	Water	94.62	6,601.9	6.977
3	Bioenergy	56.90	1,920.4	3.375
4	Solar	3,294.4	195.4	0.006
5	Wind	154.9	154.3	0.100
6	Others (Ocean energy)	59.90	0.6	0.001

Source: Ministry of Energy and Mineral Resources, 2022

The massive use of RE needs to be promoted and implemented with various approaches involving various entities (national and local engagement). Critical points of the system and representation are highly needed. Indonesia has unique characteristics because it is an archipelagic country covering more than 17,000 islands. All recorded RE potentials are the accumulation of various potentials that exist in archipelagic areas within Indonesia. The challenges here are not only preparing the basic infrastructure for RE development but also stimulating the active involvement, i.e., facilitating communication and interactions within a transdisciplinary context, in which the interactions are more refined on smaller geographical scale contexts (Ramos et al., 2021). Related to internal aspects, the data availability and accessibility become the main baseline in carrying out various RE policy optimizations in Indonesia besides the main foothold through INEP targets, as shown in Table 2.

Table 2. Indonesia's National Energy Policy (INEP) Targets

No	INEP Targets	Units	2015	2020	2025	2050
1	Primary energy supply	Million TOE	-	-	> 400	>1.000
2	Energy Mix target					
	a. Renewable Energy	%	-	-	> 23	>31
	b. Crude oil	%			< 25	< 20
	c. Coal	%	-	-	> 30	>25
	d. Natural gas	%	-	-	> 22	> 24
3	Provision of electricity generation	GW			> 115	> 430
4	Electrification ratio	%	85	100	100	100
5	Utilization of primary energy per capita	TOE	-	-	1,4	3,2
6	Utilization of electricity per capita	kWh			2.500	7.000
7	Energy elasticity		-	-	< 1	
8	Decrease in energy intensity	%	1% per year			
9	Household gas usage ratio	%	85			

Source: Indonesia National Energy Policy [INEP], 2014

As an archipelagic country with a population of 271 million (Biro Pusat Statistik [BPS], 2021), Indonesia has plenty of natural resources and the potential for a primary energy mix. With a large population, it is important to manage energy consumption thoroughly. In 2021, it was recorded that the national electrification ratio was 99.45% (MEMR, 2022). The most significant final energy mix consumption is still non-RE at 63%, while the rest is for RE and supply for national electricity. This condition is a challenge. If solved, it can be a stepping stone towards the fulfillment of national energy policy targets by maximizing the use of EBT in accordance with the potential natural resources, economic values and social impacts for local and national communities. The implementation of the development and use of biodiesel using a mixture of palm oil is one of the main policies of the Indonesian government today (Prananta & Kubiszewski, 2021) in addition to finding sustainable energy as well as encouraging the national economy. Although there are negative impacts of developing biofuel production on food security, land use change, and CO2 emissions (Acheampong et al., 2019), there are also some positive impacts on the social, economic and environmental aspects.

Today, oil palm plantation areas in different provinces of Indonesia have grown at different rates. Some provinces have changed some land functions from plantations to residential areas, industrial zones, and many more. The average growth of the oil palm area by provinces in Indonesia between 2017 and 2021 was 0.91% (Directorate General of Plantation, 2019). This is important baseline information for the government if the palm oil-based biodiesel intensification policy is to be applied. Today, the world has developed and utilized biodiesel as an important channel for reducing CO2 emissions (Borugadda & Goud, 2012), improving energy security, promoting technological innovation, creating jobs, and developing regional economies (Haberl et al., 2012; Kochaphum et al., 2015).

Currently, the main producers of biofuels in Southeast Asia are Thailand, the Philippines, Indonesia and Malaysia (Kumar, 2016). The biofuel producers were primarily motivated to enhance energy security by reducing energy imports (Aviso et al., 2015). A mandatory blending of biodiesel has been carried out in several countries. For example, Indonesia requires a mixture of diesel and diesel fuel with a composition of 30% diesel and the rest being diesel fuel called B30, 40% of diesel and the rest being diesel fuel called B40, and so on (Prananta & Kubiszewski, 2021). The Malaysian government has successfully involved all key components of local stakeholders as well as one of the backbones of the national economy (Zulqarnain et al., 2020). However, it is necessary to carefully ensure the level of profit for the overall green economy aspect (Gasparatos et al., 2017). Increasing the economic scale in the utilization and development of bioenergy to achieve national energy independence can be quite optimal in a concrete way with the existence of chain benefits starting from the upstream to the downstream side, including the political economy of oil supply in Indonesia (Rahman et al., 2021). Aviso et al., (2015) observed the economic impacts of climate change on the implementation of mandatory biodiesel blending. Directed implementation of research and development of bioenergy in relation to risk has been carried out (Benjamin et al., 2015) in industrial parks, and its strategies are implemented within industrial complexes (Tan et al., 2016).

Exemption toward biofuel investment has been reported (Prananta & Kubiszewski, 2021), but it provides an opportunity to continue investing with certain limitations to palm oil intensification and its relationship to climate change (Aviso et al., 2015) as well as various comprehensive assessments on the optimization of the bioenergy technology used (Song et al., 2015). The Australian government has made a great deal of effort through a comparative environmental performance of biodiesel produced by Moringa Oleifera oilseeds which can significantly reduce the impacts of global warming on the environment (Biswas, 2008). This gives added value to the diversification of raw materials for biofuel mixtures as the potential of each region.

Energy system modelling

Urban et al., (2007) assessed several energy models by comparing the models based on the characteristics of developing countries to get an insight into present-day energy models. However, they could not find any correlation between differing results and the availability or unavailability of certain method parts. Welsch et al., (2014) have used the General Circulation Model (GCM), Water Evaluation and Planning (WEAP), Long-Range Energy Alternatives Planning (LEAP), and Agro-Ecological Zoning (AEZ) models, and integrated them into a CLEW approach to capture their interlinkages to find out consistent strategies for countries that aim to implement integrated policies with potential implications for multiple resource systems. Timmons et.al. (2019) simulated scenarios consider of electricity from RE case study Mauritius and its related including demand-side management and costs of electricity generation approach to get effective cost for fully RE in the nation. Hermann et al. (2012) had originally developed targets and implications for CLEWs resources focusing on the intensification of agricultural production and the potential introduction of Jatropha as a biofuel. The focus of the global CLEWs model was the development of a compact and easily understandable tool (Weirich, 2013). Under the Scopus database by using key words "climate," "land," "energy," and "water" or "CLEWs," there is no research or assessment found related to the CLEWs strategies in Indonesia. Research on the energy system in Indonesia is also rare. Prambudia & Nakano (2012) examined specific challenges and possible policies for the Indonesian economy, i.e. coal, oil, and gas, and its regulatory environment (impacts of fossil fuel exploitation on Indonesia's environment) to get an insight into how a better utilization of Indonesia's RE potential could help achieve CO2 and pollution reduction targets. Kumar & Madlener (2016) estimated and analyzed the RE potential in the energy mix and its CO2 emission for Indonesia and Thailand. Until now, no work has been done with the integrated CLEWs model of Indonesia. This work became the first study focusing on the Indonesia's CLEW system.

Purwanto et al. (2015) developed a multi-objective optimization model and analyzed the adequacy of energy sources, economic and environmental concerns to support future Indonesia's long-term electricity demand. They said that RE could play a significant role in supporting a more sustainable electricity system in Indonesia; hence, identifying optimal solutions is mandatory. Yoo & Kim (2006) investigated the causality between electricity generation and economic growth covered the 1971–2002 period. The results show that there has been a rapid growth in electricity generation for the consumption of households and industries, especially factories and commercials sectors. Rachmatullah et al. (2007) made a simple scenario to devise a long-term electricity supply plan for the Java–Madura–Bali electricity system. Schmidt et al. (2013) investigated the RE based village grids in Indonesia for specific reasons by using a quantitative and qualitative approach. They suggested that reforming the national renewable and electrification policies is needed. Wijaya & Tezuka (2013) analyzed the electricity consumption characteristics in two cities under specificities of different cultural characteristics linkages to the impact of education levels on electricity consumption awareness. Gunningham (2013) attempted to manage a complex Indonesia 'energy trilemma' involving competing demands of energy security, climate change mitigation, and energy poverty. He argues that more natural gas and LNG plants should be built, whereas oil-based power plants should be converted into gas rather than coal-orientated. A transition to a low carbon economy is expected to be achieved through credible governance strategies.

Setiawan & Cuppen (2013) investigated stakeholder perspectives on carbon capture and storage in Indonesia by using the Q methodology. Igos et al. (2015) observed modeling systems to analyze the environmental impacts of bioenergy policies for sustainability. The rest of the paper is organized as follows. First, an introduction and detailed literature review are provided related to the use of biodiesel at the global, national and regional scale. It is then followed by a methodology that integrates the CLEW system with the development of the scenarios and is linked to palm oil plantations and NDC policy. After that, results and discussion that accurately link all aspects assessed in this work are discussed. Finally, conclusions, recommendations, and policy implications are presented.

2. Methodology

The study used the integrated CLEWs model as a basic methodology. The model is based on a bottom-up representation of physical systems given the interrelationships among climate, land, energy, and water systems. Each component is described based on its technical and economic characteristics, allowing cost-effective strategies for each policy scenario and result to be identified. OSeMOSYS – an open-source energy modeling tool – is the engine to model all the resource systems to understand the interaction among climate, land, and water and address energy policy change related to NDC. In general, the structure is divided into energy, land, crop production, and water supply. It is a linear optimization model with a modeling period from 2015 to 2030.

The energy system model consists of demands for energy in the end-use sectors (i.e., industrial, residential, commercial, transportation, and others), commodity trading (export/import), transformation in the power sector, and domestic energy resources. The structure is modified to represent Indonesia as an archipelagic country. The power sector model is developed by the five big regional system, covering Sumatera-Java-Bali, Kalimantan, Sulawesi, Maluku Islands, and Papua, by considering the existing transmission dan distribution planning. However, in the model, the demand and supply of energy is calculated at the national level. Energy balance from the Handbook of Energy and Economic Statistics of Indonesia is used to develop a base year projection. Projection of energy demand is driven mainly by GDP, and the population refers to the scenario used in the Grand Strategy Energy study.

The reference energy system of Indonesia with all energy flows as well as the technologies that use and produce these energies are illustrated in Figure 1. Traditional biomass is still utilized by the residential sector, particularly in rural areas. In 2019, the share of biomass in the primary energy consumption was less than 4%. Most of the energy consumption in Indonesia comes from domestic resources (MEMR, 2022). Indonesia is one of the biggest exporting countries of coal. Around 75% of Indonesian coal production is exported, mostly to China and India. In the domestic setting, coal is the most widely used energy source in power generation. Coal generates more than 60% of electricity production in Indonesia (MEMR, 2022). Indonesia is also a natural gas producer and one of the LNG exporting countries. The current policy of Indonesia is to prioritize natural gas production for the domestic markets. However, Indonesia has a high dependency on oil imports. Almost 60% of the domestic oil consumption comes from imports due to the low domestic oil production. An ambitious target has been set by 2030, namely to reach one million barrels per day of oil production and 12 TCF per day of gas production (MEMR, 2022).

Multiple strategies have been introduced by the Indonesian government to reduce domestic oil consumption. Mandatory use of biofuel is one of the key policies to reduce oil consumption in the country. In 2020, the portion of biodiesel in diesel consumption rose to 30% from 20% in the previous year. The mandatory biofuel use was first implemented in 2008 with a biodiesel content of 2,5% (MEMR, 2022). Gradually, the biodiesel portion increased to 7,5% in 2010. Between 2011 and 2015, the biodiesel content increased again from 10% to 15%. Then, from January 2016, 20% of biodiesel shares was utilized in all relevant sectors. The B30 program has also helped reducing diesel imports, saving Indonesia's foreign exchange about Rp. 63 trillion, and increasing domestic demands for Crude Palm Oil. Moreover, the government has planned to increase the biodiesel portion to 40% and 50% (MEMR, 2022).

Biofuel intensification is chosen as the main scenario in the study not only because it is one of the government's strategic programs but also covers key sectors in CLEWs, i.e., land, water, and energy. Land and water are naturally needed for palm oil production. Figure 1 shows the climate, land, energy, and water system interrelation supporting the demands for energy in agriculture, commercial, industry, residential, transportation, and exports.

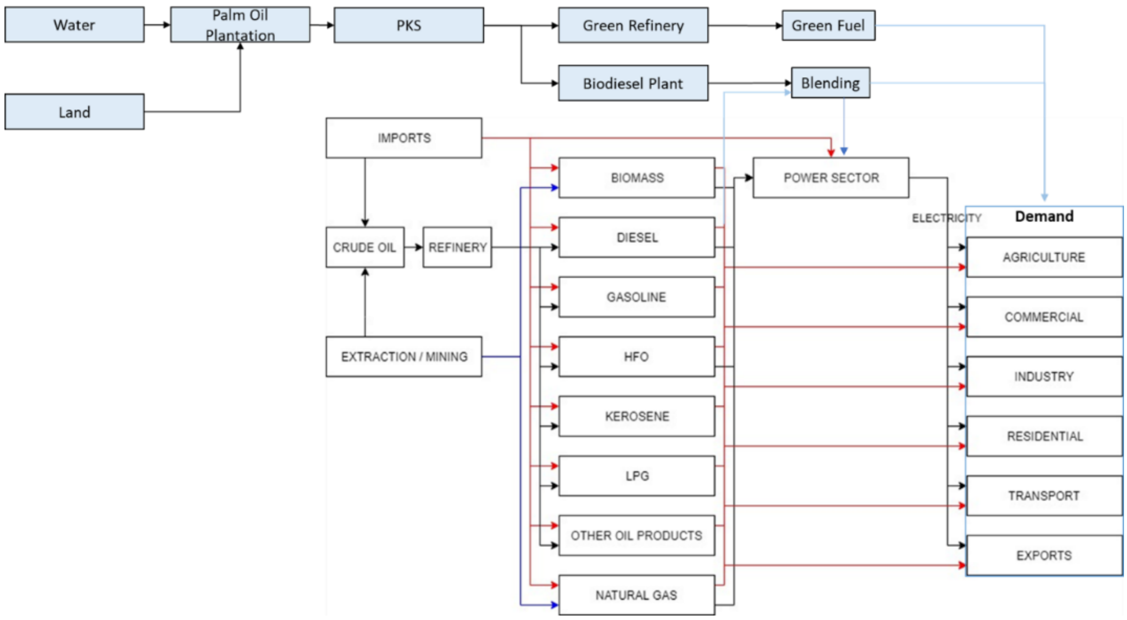


Figure 1. Reference of Energy System of Biofuel on the CLEWs Model
Source: CLEWs Modelling

Water dominantly comes from irrigation tunnels in palm oil plantations. Regularly fertilized lands also contribute to maintaining the productivity of palm oil plants. The government's plan to increase the portion of biofuel to 40% and 50% is considered an alternative scenario in the current study to better understand the interaction and the implications of the biofuel intensification program on emission reduction, land needs, and water usage.

B30/20 is the baseline scenario referring to the existing biofuel mandatory policy, namely the Minister of Energy and Mineral Resources Regulation No. 12/2015 that requires 30% of biodiesel to be blended with diesel in all end-use sectors starting from the 1st of January 2020. The second scenario is B40/25, in which 40% of biodiesel should be blended with diesel oil by all sectors starting from 2025. The third scenario is B50/30, in which the implementation of 50% Biodiesel shall start from 2030. The scenarios will include the use of biodiesel and the use of 0.1 million KL of green gasoline from 2022 to 2030.

Currently, the mandatory biodiesel program is to blend diesel with biodiesel (B100) that is conventionally produced through transesterification of Crude Palm Oil (CPO) fats with methanol. Fresh fruit bunches from a palm oil plantation are collected and transported using trucks to CPO Plant or *Pabrik Kelapa Sawit* (PKS) to be ground, compressed, and extracted to Crude Palm Oil (CPO). This CPO product can be directly used as the feedstock of the Biodiesel Plant through the transesterification process and produce Fatty Acid Methyl Ester (Biodiesel). The CPO to FAME conversion rate is one million tons of CPO, which is equal to 32,7 PJ of FAME. Further, FAME mixed with diesel oil in the blending facility will result in BXX (Alkabbashi et al., 2009).

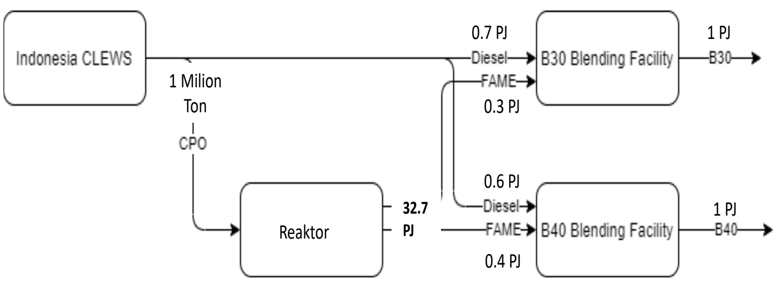


Figure 2. Integration of Indonesia CLEWs with Biofuel Processing
Source: CLEWs Modelling

However, to increase the biofuel content to more than 30%, diesel should not be only blended with FAME but also mixed with green diesel (D100). Green diesel is made by refining CPO in a dedicated refinery or by refining the CPO derivatives in a single process. Before the green diesel refinery process, CPO must be refined, bleached, and deodorized until it becomes Refined Bleached Deodorized Palm Oil (RBDPO). This study considered two different green diesel processing technologies, namely stand-alone refinery and co-processing refinery. The main difference between the two in this model structure is that green diesel is made using co-processing technology, whereas the RBDPO and oil stream (residue/diesel/kerosene) are produced in the existing oil refinery. In stand-alone technology, the RBDPO is the only feedstock on converting to green diesel. In this model, the input-output ratio for co-processing technology is 0,6 million tons of CPO which is equal to 1,2 PJ of green diesel, and 1,64 million tons of CPO which is equal to 0,5 PJ of green gasoline. For the stand-alone technology, we add a green fuel refinery as a new technology in the model structure to allow 100% RBDPO to react with hydrogen using a specific catalyst, generating green gasoline and green diesel. The input-output ratio for the stand-alone refinery is one million tons of RBDPO, which is equal to 3,46 PJ and 1,97 PJ of green diesel and green gasoline, respectively (M. Yusuf, personal communication, April 23, 2019).

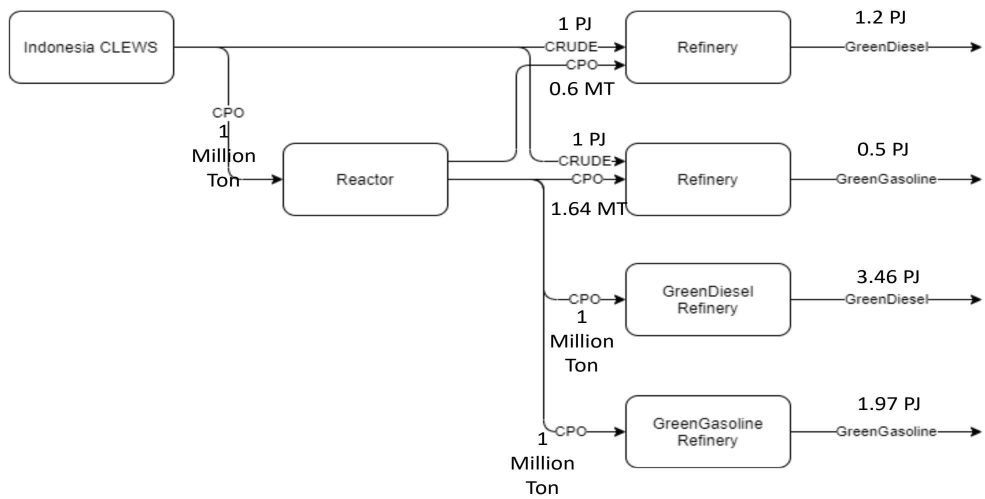


Figure 3. Integration of Indonesia's CLEWs model with Advanced Biofuel Processing
Source: CLEWs Modelling

The land-and-water model is developed based on spatial analysis data taken from Agro-Ecological Zoning (AEZ) by considering the types of crops and water supply. The land-and-water model is divided into seven regions, namely Java, Kalimantan, Maluku Islands, Papua, Sulawesi, Sumatera, and Nusa Tenggara.

3. Results and Discussion

The simulation results and analysis of the CLEWs model of Indonesia are divided into three main groups: energy, land, and climate. The water system in the model is not discussed in this paper, considering that the water supply of oil palm plantations in Indonesia does not use a specific irrigation system. Several studies on oil palm plantations in Indonesia concluded that plants mostly use water in the zone above the plant roots, which means they will only use rainwater and surface water. It is also mentioned that the water footprint of Indonesian palm oil is quite effective. Low agricultural productivity, poor efficiency in water use, and lack of improved technology can cause higher water footprints in primary crop production (Shrestha et al., 2013). As a tropical country with fairly high precipitation, Indonesia has more than enough rainwater to meet the water needs of oil palm plantations.

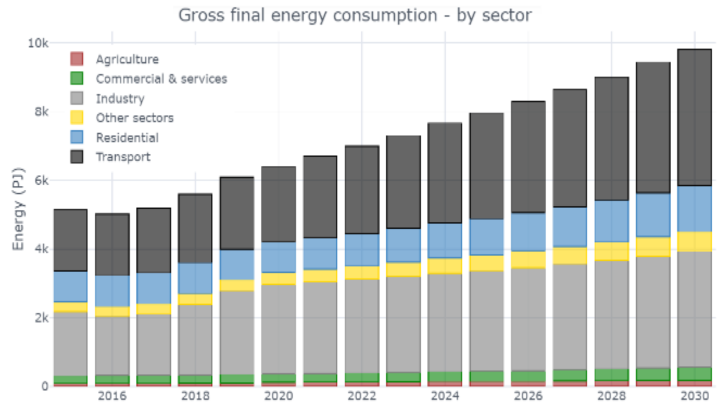


Figure 4. Final Energy Consumption
Source: CLEWs Modelling

The simulation result (Fig.4) shows that the final energy consumption by sectors grows by 4.9% per year. In 2030, the energy demand is estimated to reach 9,800 PJ or increase to almost double from 2015. The transport sector is the second-largest final energy consumer after the industry, which is around 40% of the total final energy consumption. The main strategy to reduce oil fuel consumption is to promote the use of public transport and electric vehicles and shift to biofuels.

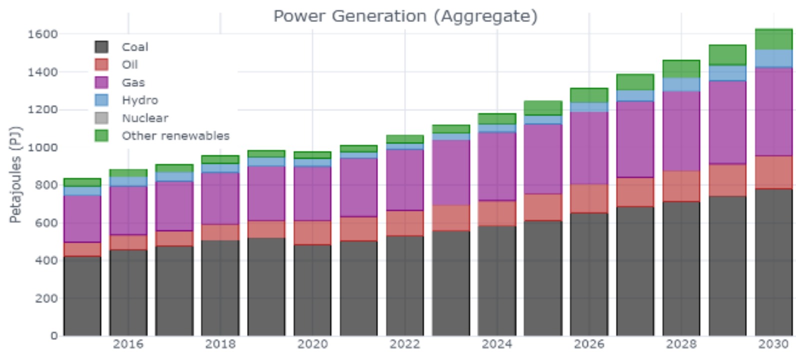
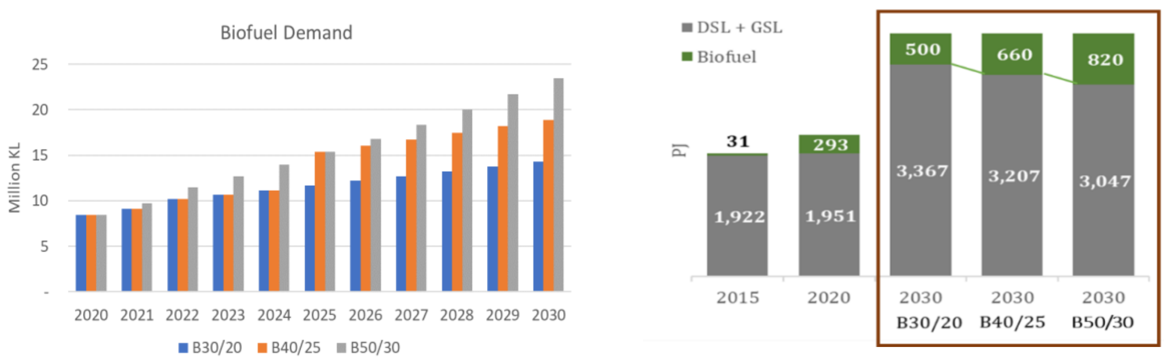


Figure 5. Electricity Production
Source: CLEWs Modelling

Fig.5 illustrates the average electricity growth after 2020, which is 5.3% annually, dominated by the production from coal power plants. Diesel power plants still produce less than 6% of total electricity production. In the future, one of the policies needed to be made is using biofuels in diesel power plants to reduce oil fuel consumption. The scenario developed for biofuels in the transport sector and power generation is similar to the one described in the methodology.



(a) (b)

Figure 6. Biofuel Demands: (a) total fuel demands (b) total biofuel demands
Source: CLEWs Modelling

Figure 6 shows the biofuel demands in the 2015-2030 period. The average growth of biofuel demand is 5.5% under the B30/20 scenario, 8.8% under the B40/30 scenario, and 10.9% under the B50/30 scenario. When the B40/30 scenario implementation starts in 2025, there will be a significant surge in demand for biofuels. This needs to be anticipated to avoid the problems related to the availability of CPO feedstock. Therefore, the implementation of this policy is expected to start 2 or 3 years in advance. In 2030, biofuel demand under the B50/30 will become 24% higher than the B40/25 scenario, and 64% higher than the B30/20 scenario. With the implementation of the current policy, the total demand for biofuel will reach 13% in 2030. Meanwhile, the implementation of the B40/30 scenario will increase the demand by 17%, and by 21% under the scenario B50/30.

The intensification of biofuels under the three scenarios will help reduce oil fuel imports, as shown in Figure 7. The implementation of B40/25 and B50/30 will help decrease oil imports by around 3.7 million KL by 2025 compared to the current policy scenario (B30/20). Under the B40/25 scenario, oil imports will drop by about 4.6 million KL (equal to USD 2 billion saving), whereas under the B50/30 scenario, the imports are estimated to decline by 9.2 million KL (equal to USD 4 billion saving) in 2030. The implementation of the scenario of B50/30 in the long term has the potential to eliminate fuel imports.

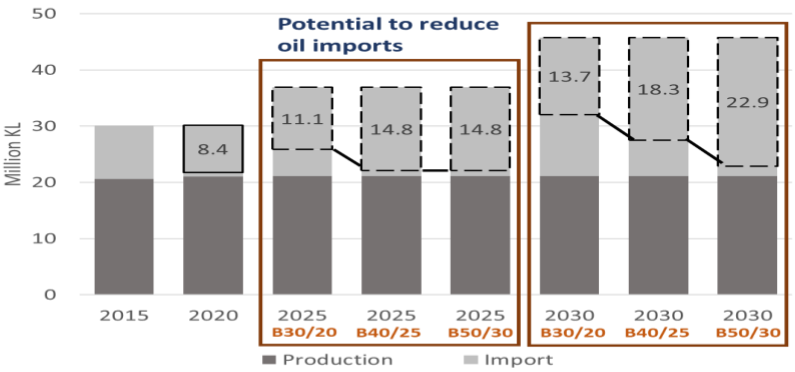
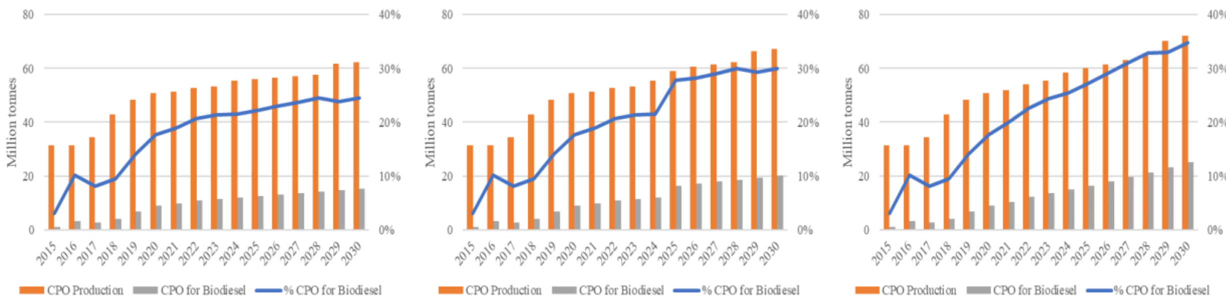


Figure 7. Oil Import Reduction
Source: CLEWs Modelling



(a) B30/20 (b) B40/25 (c) B50/30

Figure 8. CPO Production vs. Biofuel Demand
Source: CLEWs Modelling

Figure 8. highlights the shares of CPO needed to produce biofuel. In 2030, to produce 14.3 million KL of biofuel, 15.3 million tons of CPO or equal to 25% of total CPO production are needed under the current policy. Meanwhile, under the B40/50 scenario, 20.2 million tons of CPO are required (30% of total CPO production) to produce 18.9 KL of biofuel to meet the demand. Under the B50/30 scenario, 25.1 million tons of CPO (35% of the total CPO production) are needed to meet 23.5 KL of biofuel demand. The share growth of CPO for biofuel in the scenario of B50/30 seems to continue to increase sharply compared to other scenarios. In the long term, this can be an issue and needs to be studied further, so that it will not interfere with the need for CPO for other purposes and with the CPO price.

One of the issues of concern in this study is the government's policy for a moratorium on land clearing or expansion of oil palm plantations in the future. It is expected that the increase in the demand for biofuel and other CPO needs will not significantly increase the plantation areas. A strategy to reduce CPO exports is thus required to solve the issue.

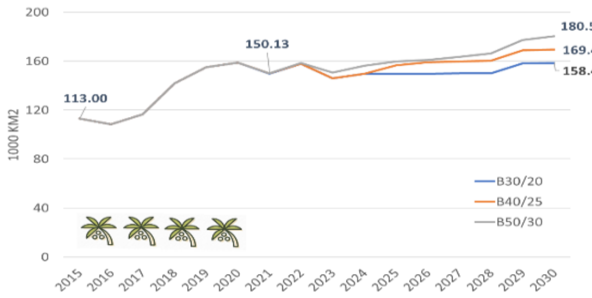
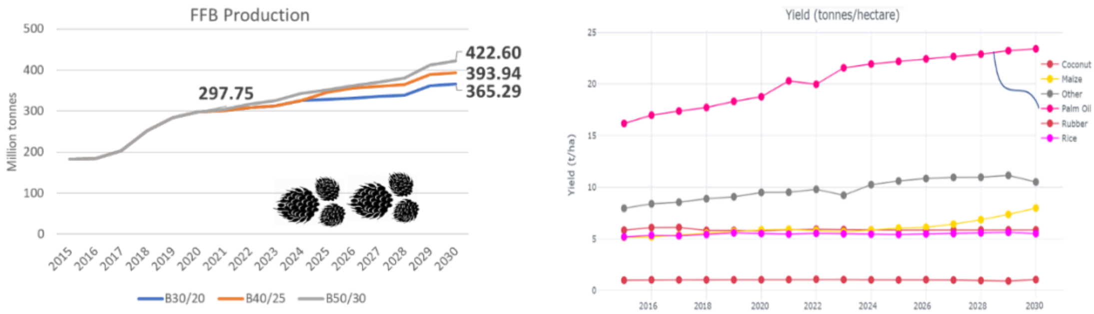


Figure 9. Oil Palm Plantation Areas
Source: CLEWs Modelling

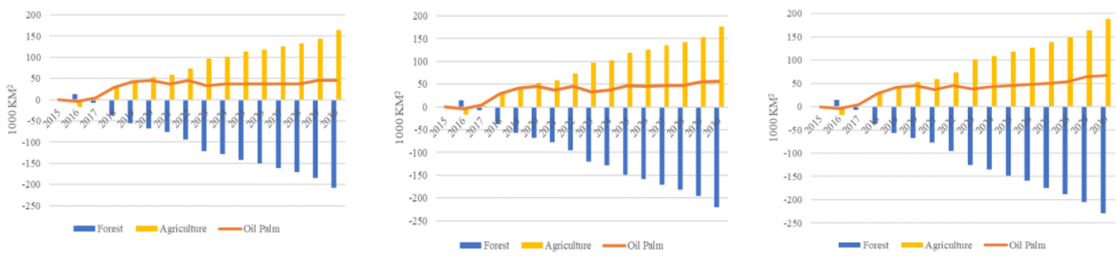
Figure 9. shows the areas of oil palm plantations needed to meet the future CPO needs. By 2030, an area of 8.36 km^2 will be required under the B30/20 scenario, 69.33 km^2 under the B40/25 scenario, and 80.38 km^2 under the B50/30 scenario, compared to the current policy's scenario. If all plantation areas were assumed to have the same productivity, the increased proportion of land demand can be used as a reference to calculate the number of CPO exports that must be reduced if there is no more expansion. Thus, to meet domestic needs, including the need for biofuels, CPO exports must be reduced by 7% in 2030 under the scenario of B40/25 and 14% under the scenario of B50/30 to the total national production of CPO.

In 2030, oil palm production is predicted to increase by about 7.8% under the scenario of B40/25 and 15.7% under the scenario of B50/30, compared to current policy as shown in Figure 10a. There is no significant difference in plantation productivity in the three scenarios. They also have slightly similar trends of yields (Figure 10b). To avoid land expansion for oil palm plantations under the B40/25 and B50/30 scenarios, palm oil yield (FFB) on the existing oil palm plantations shall be increased to above 28 tons/Ha in 2030.



(a) FFB Production (b) Plantation Productivity

Figure 10. Production and Productivity of Oil Palm Plantations
Source: CLEWs Modelling



(a) B30/20 (b) B40/25 (c) B50/30

Figure 11. Accumulation of Forest Diversion
Source: CLEWs Modelling

The results of model simulations related to forests show that most of forest diversion is used for agricultural area expansion (~ 75–80% of forest diversion), as shown in Figure 11 in all scenarios. Under the current policy, 22% of the forest diversion will be used for additional oil palm plantations by 2030. From Figure 11a., it can be seen that in the 2019–2030 period, there are relatively no additional areas of oil palm plantations, which is in line with the government's policy of moratorium on oil palm plantation expansion. Meanwhile, under the B40/25 scenario, 26% of the forest diversion will be utilized for oil palm plantation expansion, and 30% under the B50/30 scenario by 2030. However, land expansion is still important to meet biofuel needs in the B40/25 and B50/30 scenarios. In terms of water needs, there is no irrigation system required in oil palm plantations; thus, the water system in the biofuel intensification scenario is not specifically discussed in the study.

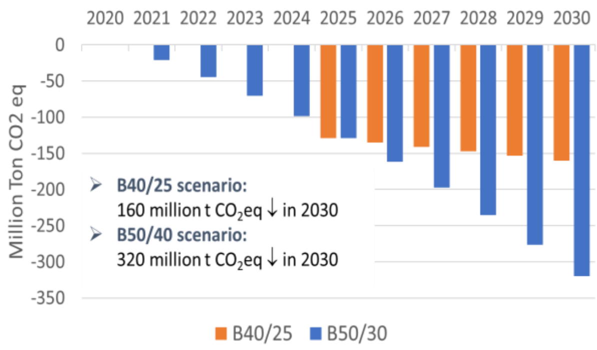


Figure 12. GHGs Emission Reduction
Source: CLEWs Modelling

The implementation of the B40/25 and B50/30 scenarios will help reduce GHGs emissions from fuel combustion by around 160 MTon CO2-eq and 320 MTon CO2-eq respectively by 2030, as shown in Figure 12. However, the emissions from forest diversion to oil palm plantations are not considered in this study. The implementation of the B50/40 scenario can fully meet Indonesia's NDC target commitments from the energy sector for the CM1 (unconditional mitigation scenario) or 80% of commitments for the CM2 (conditional mitigation scenario).

Conclusions

Biofuel intensification in Indonesia, as simulated by the model, can help reduce the country's dependency on fuel imports and increase domestic consumption of CPO. It will also increase energy security and protect the environment as GHGs emissions are also reduced. However, some factors need to be considered before implementing this biofuel intensification. If the cost of biofuel production is higher than the cost of diesel/ gasoline production, there will be some financial issues for the government. Diversion of more forests to oil palm plantations can also be an issue. At the same time, carbon sink areas will decrease. To avoid land expansion for additional oil palm plantations, the yield of FFB or land productivity on the existing oil palm plantation should be increased.

Recommendation

The government needs a policy of biofuel incentives or price mechanism formulation, a policy of land allocation using marginal/critical land for a new oil palm plantation, and a policy to improve the yield or crop productivity of oil palm plants.

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