Long-term Planning of the Fuel System in Indonesia using Optimization

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Abstract. Biofuel has been considered as an option to substitute petroleum fuels and reduce dependence of fossil fuel importation and greenhouse gases emissions. Current Indonesia’s biofuel blending mandates are cannot achieved due to technical, price and financial aspects. The objectives of the study are to obtain the optimum fuel supply mix by considering the fuel quality standard, production capacity and resource availability. Long-term fuel system optimization by minimum total system cost up to 2050 is carried out using TIMES-VEDA. The results showed that if governement does not upgrade the quality of diesel up to EURO 4 and adapted EURO fuel specification with adjustment, the optimal fuel supply mix are FAME 50%-Diesel 50% in 2020-2030 and mix of FAME 47%-HVOSMR 53% in 2035-2050. For adapted EURO specification with adjustment except the sulphur content has fuel supply mix of HVOSMR 30%-Diesel 70% in 2020, FAME 20%-Diesel 80% for 2025-2030 and FAME 47%-HVOSMR 53% for 2035-2050. For gasoline, the optimum supply mix is Ethanol 5%-Gasoline 95% in 2020 and Ethanol-Ethanol2G 20%-Gasoline 80% in the 2025-2050. The utilization of biofuels can reduce the diesel and gasoline consumption for about 67-79% and 19% and reduce carbon intensity by 65-78% and 27%, respectively.

1. Background

The dependence on fossil fuels and the continuous increase of energy use in the many sector have brought attention to biofuels as a potential alternative fuel for petroleum-based fuels. The main roles of biofuels are to mitigate climate change and to enhance energy security however currently only contribute a small share of the energy supply for the transport sector. The lack competitiveness with fossil fuel in the market is one of the reason development biofuel not significantly increase, financial factor due to high production cost and feedstock also become barriers against sustainably producing bioenergy. Incentive and technology support from government with the good oriented planning can be one of solution. Several governments and intergovernmental organizations have declared policy targets which can lead to a significant increase in transport biofuel utilization. In the EU, energy from renewable sources in the transport sector should reach at least 10% by 2020 [10].

In Indonesia, the government has declared the blending-biofuel mandate targets for transportation, industry and power generation sectors through MEMR Regulation 12/2015 until 2025 [16] to increase the use of renewable energy by biofuel utilization and reducing fuel imports. The two most commonly use biofuel types are biodiesel and bioethanol because currently those two liquid biofuels are commercially available. Indonesia should reach biodiesel consumption 4.73 billion liter in 2020 and 9.52 billion liters in 2025 but currently the blending target proves difficult to meet. The total consumption in 2018 at 3.65 billion liters or comprised only 12.7% of total diesel consumption [16, 32, 33]. The high percentage of unsaturated bonds in the fatty acids structure causes biodiesel or Fatty
Acid Methyl Esthers (FAME) to be more prone to oxidation compared to diesel, which decreases its long-term stability properties [45,58] can lead to microbiological contamination, sludge, filter clogging and tank corrosion in the vehicle [42, 43]. Therefore, it is necessary to improve the quality of biodiesel or substitute by other biofuels. Highly paraffinic fuels such as biomass-to-liquid (BTL) or FT-diesel and hydrotreated vegetable oil (HVO) have emerged as alternative diesel fuels with some outstanding diesel properties, mainly cetane number and heating values, that offer potential to reduce fuel consumption, and thus CO$_2$ emissions, and harmful emissions of diesel vehicles [17]. Moreover, these fuels have been claimed to be fully compatible with current engine technologies [1, 3, 37, 47]. In the HVO processing, hydrogen is used to remove oxygen atoms and double bonds from the structure of triglycerides via decarbonylation, decarboxylation, and hydrodeoxygenation. Propane, water, carbon monoxide and carbon dioxide are the side-products produced [27, 29, 40]. Hydrogen is an energy carrier and not a source of energy. It can be produced from a wide variety of energy sources. Historically, hydrogen has been predominantly produced from fossil sources such as steam methane reforming (SMR) from natural gas and in a low-carbon energy future, hydrogen offers new pathways to valorise renewable energy sources such as water electrolysis and less mature pathways are biomass gasification and pyrolysis [20].

In this study various hydrogen production has been considered such as from fossil and renewable sources as a potential approach to mitigate the effects of climate change and security of energy supplies. Indonesia’s Fuel Grade Ethanol (FGE) consumption has remained zero since 2010 due to lack of financial support and constraint on raw materials to run the blending program and a mandate that was never enforced. Ethanol production are currently used for the non-fuel sector such as perfumes, cosmetics, pharmaceutical, chemical solvents industries and export [16,32]. Therefore, the government needs to provide adequate incentives if the domestic demand is to be fulfilled by 2025 [16,32,33]. This study focuses on long-term fuel system optimization by minimum total system cost up to 2050 applying fuel quality standard, production capacity and resource availability. The future optimal fuel supply mix uses biofuel first and second generations with fossil fuels to reduce fossil fuels consumption.

2. Methods and Data
In this section explain the methodological approach is presented, including a general description of the optimization model, main input data assumptions and scenarios.

2.1. Fuel Demand Projection
The first step is projecting the fuel demand for diesel and gasoline. Fuel demand projected based on an econometric model use GDP growth and demand elasticity. Projected fuels demand required population projection were collected from the Central Bureau of Statistics [6,7] and GDP growth also collected from the same resource and Ministry of Industry Indonesia [6,34]. The projections are obtained using GDP growth until 2050.
2.2. Fundamental model assumptions

The general outline of the models constructed based on utilization domestic biomass, renewable and fossil sources in Indonesia and through different types of energy conversion technologies to fulfill fuel demand is presented in Figure 1. Optimization of long-term fuel system used TIMES-VEDA [12,14,15,28] energy system model with GAMS Software package with the objective function minimize the total system cost and time horizon of 2020 to 2050 divided in 5-year model periods. In this study, most energy carriers are represented on an annual basis and a discount rate of 10% is used. The limited supply of biomass resources constitutes and fuel quality specifications are important model constraint.

Bottom-up technology data include technology costs and performance data such as operation and maintenance costs, investment costs and conversion efficiencies for technologies in all parts of the energy system are available in [9,13,18,19,44,52,55]. Investment cost or capital expenditure can be estimate by the technology learning rate which is the percentage reduction of future capital expenditure for each cumulative production of biofuel which can get from [2,8,53]. In the model also need feedstock or commodity cost which have obtained by empirical approach from ratio average of crude oil price from US Energy Information Administration [55] and feedstock price based on [21,41].

![Figure 1. General overview of the flow of energy system](image)

A prime assumption of the proposed models for biofuel production based on domestic renewable and biomass sources should not be at the expense of domestic food and other sector non fuel supply. Crude palm oil (CPO) as a renewable sources for HVO and FAME processing projected based on fresh fruit bunches (FFB) growth obtained from [30,41] and molasses for bioethanol first generation (ETOH) processing projected based on historical data on molasses production compared to sugarcane production. Sugarcane production estimate by sugar cane plantation growth from [31].

The empty fruit bunch (EFB) as biomass resource for FT-diesel and bioethanol second generation (ETOH2G) processing projected by the area of oil palm growth based on data from [30,41]. EFB also use for hydrogen production by gasification along with other generation technology from natural gas and photovoltaic (PV) with batteries as co-reactants for HVO processing. The existing capacity of petroleum refineries is not modeled, the prices of diesel, gasoline and natural gas are assumed as commercial prices from [43].

2.3. Fuel properties

The first and second-generation biofuels are included in the study: ethanol, biodiesel (FAME), hydrotreated vegetable oil (HVO), and Fischer Tropsch diesel (FT-diesel). For petroleum fuels, CN1
48 (Solar) and CN 53 (Pertadex) are represented as existing diesel, RON 90 (Pertalite), RON\(^2\) 92 (Pertamax) and RON 98 (Pertamax Turbo) are represented as existing gasoline in Indonesia. Biodiesel exhibits a strongly different property set compared to the paraffinic diesel [35,48]. Therefore, HVO may be an ideal blending alternative to biodiesel as it does not deteriorate the quality of petroleum diesel but rather improves it [27,38]. FT-diesel is similar to fossil diesel regarding its energy content, density, viscosity and flash point. It's a high quality and clean transportation fuel with favourable characteristics for application in diesel engines. FT-Diesel has also characteristics that are almost the same as HVO, so the principle of the mixing process is the same as HVO [23,30,34,22,46]. An overview of the differences properties of biofuels and petroleum fuels are given in Table 1 and 2.

### Table 1. Properties of different types of renewable diesel [3,35,43,46]

| Parameter | FAME | HVO | FT | CN 48 (Solar) | CN 53 (Pertadex) |
|-----------|------|-----|----|---------------|------------------|
| CN        | 53   | 75  | 80 | 48            | 53               |
| Density (kg/m\(^3\)) | 880 | 780 | 770 | 840          | 830              |
| Viscosity (mm\(^2\)/s) | 4.4 | 3.21 | 3.1 | 3.25         | 3                |
| HHV (MJ/kg) | 40  | 47  | 48 | 39            | 42.9             |
| Sulphur Content (ppm) | <5  | <1  | <1 | 2500          | 300              |
| Lubricity (micron) | 186 | 650 | 650 | 350          | 330              |
| Water content (mg/kg) | 375 | 40-42 | 19 | 100          | 50               |
| Efisiensi Energi (%) | 98  | 80-88 | 41 |               |                  |
| Emisi CO\(_2\) (g CO\(_2\)-eq/MJ)\(^a\) | [22,26] | [35,36] | [35,36] | [11] | [11] |

\(^a\)well to wheel

### Table 2. Properties of different types of renewable gasoline [32,43,54]

| Parameter | ETOH | ETOH2G | RON 90 (Pertalite) | Ron 92 (Pertamax) | RON 98 (Pertamax Turbo) |
|-----------|------|--------|--------------------|-------------------|------------------------|
| RON       | 111  | 111    | 90                 | 92                | 98                     |
| Density (kg/m\(^3\)) | 794 | 794    | 740                | 740               | 740                    |
| HHV (MJ/kg) | 26.8 | 26.8   | 42.4               | 42.4              | 42.4                   |
| Sulphur Content (ppm) | 7 | 7     | 500                | 500               | 50                     |
| Aromatic (%v/v) | 5 | 5     | 50                 | 42-50             | 50                     |
| Benzene (%v/v) | 0.25 | 0.25   | 5                  | 5                 | 5                      |
| Emisi CO\(_2\) (g CO\(_2\)-eq/MJ)\(^a\) | 48  | 44     | 89[11]             | 89[11]            | 89 [11]                |

\(^a\)well to wheel

In this study the ethanol mixture is limited to not more than 50% due to several issue [54]. The emission factors based on well-to-wheel were obtain from [11,22,26,35,36,50,51] which can use to evaluate the carbon intensity of fuel supply mix in the model result. Carbon intensity is obtained by dividing the total emission factor for each fuel by the throughput of the optimization results.

### 2.4. Scenarios

For the analysis, there is three scenarios for roadmap of fuel development in Indonesia summarized in Table 3 below.

### Table 3. Overview of scenarios

| Scenario  | Description |
|-----------|-------------|
| IND–EURO  | This scenario represents if Indonesia does not have planning to upgrade the quality of current diesel up to EURO 4 and implemented EURO fuel specification with adjustment by current situation which in 2020 applies EURO 2 standard use CN 48 (Solar) mix with RON 90 (Pertalite), EURO 4 standard in 2025 to 2030 use CN 53 (Pertadex) mix with RON 92 (Pertamax) and EURO 5 standard use CN 53 |
Scenario Description

(Pertadex) mix with RON 98 (Pertamax Turbo) in 2035 to 2050.

Adjustment Parameters for diesel supply mix:
EURO 2 = Cetane Number, Water Content, Density, Viscosity, Sulphur
EURO 4 = Water Content, Density, Viscosity, Sulphur
EURO 5 = Sulphur

Adjustment Parameters for gasoline supply mix:
EURO 2 = Benzene, aromatic dan sulphur
EURO 4 = Benzene, aromatic dan sulphur
EURO 5 = Benzene, aromatic dan sulphur

EURO-SULPHUR IND This scenario represent if Indonesia does not have planning to upgrade the quality of current diesel up to EURO 4 and implemented EURO fuel specification except sulphur content which in 2020 applies EURO 2 standard use CN 48 (solar) mix with RON 90 (Pertalite), EURO 4 standard in 2025 to 2030 use CN 53 (Pertadex) mix with RON 92 (Pertamax) and EURO 5 standard use CN 53 (Pertadex) mix with RON 98 (Pertamax Turbo) in 2035 to 2050.

The scenario applies fuel specification based on the specification of the fuel mixture with the maximum and minimum values are presented in Table 4-7

Table 4. Diesel fuel specifications IND-EURO scenario [57]

| Parameter          | IND Euro 2 | IND Euro 4 | IND Euro 5 |
|--------------------|------------|------------|------------|
| CN                 | Min        | Max        | Min        | Max        | Min        | Max        |
| Density (kg/m³)    | 815        | 860        | 815        | 860        | 815        | 840        |
| Viscosity (mm²/s)  | 2          | 2          | 4          | 4          | 4          | 4          |
| HHV (MJ/kg)        | 35         | 35         |            |            |            |            |
| Sulphur content (ppm) |           | 2500       | 300        |            |            |            |
| Lubricity (micron) |            | 460        | 460        |            |            |            |
| Water content (mg/kg) |            | 500        | 200        |            |            |            |

Table 5. Diesel fuel specifications EURO- SULPHUR IND scenario [57]

| Parameter          | Euro 2 - Sulphur IND | Euro 4 - Sulphur IND | Euro 5 - Sulphur IND |
|--------------------|----------------------|----------------------|----------------------|
| CN                 | Min        | Max        | Min        | Max        | Min        | Max        |
| Density (kg/m³)    | 815        | 850        | 815        | 840        | 815        | 840        |
| Viscosity (mm²/s)  | 2          | 4          | 2          | 4          | 4          | 4          |
| HHV (MJ/kg)        |            |            |            |            |            |            |
| Sulphur Content (ppm) |           | 2500       | 300        |            |            |            |
| Lubricity (micron) |            | 460        | 460        |            |            |            |
| Water content (mg/kg) |            | 200        | 200        |            |            |            |

Table 6. Gasoline fuel specification IND-EURO scenario [57]

| Parameter          | IND Euro 2 | IND Euro 4 | IND Euro 5 |
|--------------------|------------|------------|------------|
| RON                | Min        | Max        | Min        | Max        | Min        | Max        |
| Density (kg/m³)    | 715        | 770        | 715        | 770        | 715        | 770        |
| Parameter     | IND Euro 2 | IND Euro 4 | IND Euro 5 |
|---------------|------------|------------|------------|
|               | Min | Max | Min | Max | Min | Max |
| HHV (MJ/kg)   | 32  | _   | _   | _   | _   | _   |
| Aromatic (%v/v) | 50  | _   | 50  | _   | 40  | _   |
| Benzene (%v/v) | 5   | _   | 5   | _   | 5   | _   |
| Sulphur (mg/kg) | 500 | _   | 500 | _   | 50  | _   |

Table 7. Gasoline fuel specification EURO –SULPHUR IND scenario [57]

| Parameter     | Euro 2 -Sulphur IND | Euro 4 - Sulphur IND | Euro 5 - Sulphur IND |
|---------------|---------------------|----------------------|----------------------|
|               | Min | Max | Min | Max | Min | Max |
| RON           | 91  | _   | 95  | _   | 98.99 | _   |
| Density (kg/m³) | 715 | 770 | 715 | 770 | 715 | 770 |
| HHV (MJ/kg)   | 32  | _   | _   | _   | _   | _   |
| Aromatic (%v/v) | 40  | _   | 35  | _   | 35  | _   |
| Benzene (%v/v) | 2.5 | _   | 1   | _   | 1   | _   |
| Sulphur (mg/kg) | 500 | _   | 500 | _   | 50  | _   |

3. Results and Discussion

3.1. Energy supply mix for IND-EURO scenario

In this scenario the Indonesian government does not upgrade the quality of diesel up to EURO 4 and implemented EURO fuel specification with adjustment by Indonesian government by considering the resource availability. The optimization results show that hydrogen for HVO processing comes from steam methane reforming (SMR) and this result applies to all scenarios. The optimum fuel supply mix are 50% FAME with 50% petroleum diesel in 2020-2030 for the EURO 2 and 4 diesel specifications. In the years 2035 to 2050 by applying the EURO 5 standard, the fuel supply mix are FAME 47% and HVO-SMR 53%. CN 48 and CN 53 not appear in the model result due to the fuel quality standards not meet requirement (Figure 2). FT-Diesel in the form of synthetic diesel not appear in the model results due to higher production cost compare with FAME and HVO.

Figure 2. Model result diesel supply mix IND-EURO scenario
The optimum results for a gasoline supply mix are shown in Figure 3.

The optimum fuel supply mix are 5% of first generation bioethanol (ETOH) with 95% of gasoline in 2020 for the EURO 2 qualification standard, the second generation bioethanol (ETOH2G) appear in the model result with ETOH in the 2025-2030 totally 20% and 80% of gasoline for the EURO 4 qualification standard filled by ETOH of 1.47 -1.56% and ETOH2G of 18.44-18.53% due to limited supply of molasses. The same results are also shown in 2035-2050 for the EURO 5 qualification standard which are filled by ETOH 1.31-1.38% and ETOH2G 18.62-18.69%. The production capacity profile is shown in Figures 4 and 5.
Figure 4 shows the existing and new refinery of FAME based on the fuel supply mix of Figure 2. The current existing capacity is 11,357 million liters and for new capacity required is 9,789.9 million liters in 2020 and will continue to increase until 2050 by 36,057 million liters. The possibility for CPO imports is utilized from 2035 up to 2050 due to demand for FAME production. Meanwhile, diesel imports will occur only in 2030. Indonesia currently does not have HVO refineries so that the required new capacity of HVO refinery is 35,568 million liters in 2035 and will increases up to 44,489 million liters in 2050 (Figure 4). Figure 5 showed, new capacity of ETOH must required in 2020-2045 around 2,020-5,432 million liters due existing capacity for biorefinery of ETOH in Indonesia does not exist while the required new capacity for ETOH2G is 26,295 million liters in 2025 and continues to increase up to 40,550 million liters in 2050. In this scenario, the possibility for molasse imports is not required due substitute by empty fruit bunches (EFB) as a commodity of ETOH2G but gasoline import must required around 10,596 million liters throughout the year due to the domestic gasoline production not have enough resources. The investment costs for biorefinery of diesel and gasoline for the IND-EURO scenario are illustrates (Figure 6) the investment cost for biorefinery of FAME is 0.25-0.50 billion USD in 2020-2030 with a capacity as described in Figure 4. The investment cost increase in the model year 2035 to 2050 due to addition of biorefinery of HVO with a total investment of USD 5.49 billion USD to 6.79 billion USD. The investment cost for biorefinery of ETOH is 1.04 billion USD in 2020 with a capacity as described in Figure 6. The refinery investment costs will increase in 2025-2050 due to the dominating new technology of ETOH2G with the required capacity being quite high with a total investment cost of 9.11-13.26 billion USD.
3.2. Fuel Supply Mix for EURO-SULPHUR IND Scenario

This scenario has implemented EURO fuel specification without adjustment except for the sulfur content by Indonesian government adjustment and also not upgrade the quality of diesel up to EURO 4. The optimization results show fuel supply mix are HVO-SMR 30% with petroleum diesel 70% for the EURO 2 qualification standard. Compare with previous scenario (IND-EURO) adjustment parameter of water content affect in the model result which is limited to a maximum of 200 mg/kg cannot be meet specification for other biofuels besides HVO and FT-Diesel. However, HVO selected to appear in the model rather than FT-Diesel because the high production cost of FT-Diesel made this technology not appears in model. The model year 2025 to 2030 for the EURO 4 qualification standard fuel supply mix of FAME 20% and petroleum diesel 80% appear in the model result and the same results with previous scenario (IND-EURO) for the model year 2035 to 2050 (Figure 7). Regarding the optimal fuel supply mix of gasoline, the results also have same with the previous scenario (Figure 3).

Figure 8 shows the new biorefinery of HVO required 13,425 million liters in 2020 due the fuel supply mix (Figure 7). The current existing capacity of FAME is 11,357 million liters and new capacity of FAME can be required in 2030 of 1,182.7 million liters because in 2025 still can be fulfilled by existing refineries but diesel imports will occur in 2025-2030. The model year 2035 to 2050 have same results with previous scenario (IND-EURO) and for required capacity of ETOH, ETOH2G and gasoline also have same result with previous scenario (Figure 5). The required investment cost for those biorefinery shown in Figure 9 while for gasoline it is the same as Figure 6. The high investment cost in 2020 affected by biorefinery of HVO which is 1.9 billion USD with a capacity as described in Figure 8. In the year of 2025-2030, the low almost zero investment cost appears due to utilize existing biorefinery of FAME and same total investment cost as the previous scenario (Figure 6) in the 2035 up to 2050 while the investment cost for the biorefinery of ETOH and ETOH2G has the same result as the IND-EURO scenario (Figure 6).
3.3. Fuel Oil Reduction

Biofuel utilization can reduce petroleum fuel consumption significantly (Figure 10). The reduction of diesel and gasoline is reviewed by comparing the optimization results of each scenario with projections following historical trends fuel consumption without fuel quality standard constraint. A significant reduction in diesel consumption occurs in 2020-2030 averagely 50% and 23% for the IND-EURO and EURO-SULPHUR IND scenario respectively. Biofuel utilization reached 100% in 2035-2050 for all scenario and affected zero diesel consumption during that time horizon, while for gasoline consumption can be reduced around 20% in 2025-2050. Overall, the average reduction in diesel and gasoline consumption for the IND-EURO scenario are 79% and 17% or around 50,608.73 million liters of diesel and 10,229.2 million liters of gasoline. In the EURO-SULPHUR IND scenario, the reduction in diesel and gasoline consumption are 67% and 17% in 2020-2050 with the average are 44,968 million liters of diesel and 10,229.2 million liters of gasoline.
3.4. Fuel supply mix costs

The production costs of the fuel supply mix are shown in Figures 11. The costs of blending using a new biofuel technology are quite high. The production cost of fuel supply mix of FAME 47% and HVOSMR 53% in 2035-2050 for IND-EURO and EURO-SULPHUR IND scenario are 16,264 IDR/liter up to 19,715 IDR/liter. The difference price of biodiesel (CN48) and Pertadex (CN53) affected by the higher production costs of CN53 due to the desulphurization processing compared with CN48. The cost of the 50% FAME with 50% petroleum diesel can able to compete with CN 48 and CN 53, but for other fuel supply mix with HVO still too high to compete. The production costs of gasoline blends (Figure 11) are obtained the high price of gasoline blended fuels due to the large production costs of ETOH and ETOH2G. RON value affected the selling price of gasoline due to the differences of production cost. Pertamax Turbo (RON 98) has a higher selling price compare with other gasoline (RON 90 and 92) but still more cheaper rather than gasoline blended fuel with 20% Bioethanol as consequence by the high production cost of ETOH2G but for gasoline blended fuel with 5% ETOH in 2020 can compete with gasoline price.
3.5. The CO₂ equivalent emission

The CO₂ equivalent emission factor for each technology as input data can be seen in Tables 1 and 2 with the assumption being reviewed is well to wheel (WTW) shows that the total emissions for the IND-EURO and EURO-SULPHUR IND scenario in 2035-2050 has the lower emission due to fuel supply mix dominated by biofuel. However, totally emission still high because fossil emissions from natural gas for hydrogen processing and dominated fossil fuel for gasoline supply mix. The CO₂ equivalent intensity for the EURO-SULPHUR IND scenario is relatively higher because dominated by the use of diesel and gasoline in 2025-2030.

The CO₂ equivalent intensity in 2035-2050 obtained same result due to has same fuel supply mix with average is 0.63 CO₂-eq/kg for diesel and 2.6 CO₂-eq/kg for gasoline each scenario. In 2025 to 2030, average total fuel system carbon intensity for IND-EURO scenario has reduced 7% compare with EURO-SULPHUR IND due to diesel blending rate more dominated and in 2020 has reduced 24% compare with IND-EURO scenario due to emission factor HVO more lower than FAME. Gasoline carbon intensity for both scenario in 2025-2030 has more lower rather than diesel, even utilization biofuel for diesel supply mix higher but ETOH and ETOH2G has lower emission factor. Average diesel carbon intensity for both scenarios are 1.57 and 1.54 CO₂-eq/kg and gasoline are 2.57 CO₂-eq/kg. The CO₂ equivalent intensity each scenario in 2020 to 2050 for diesel and gasoline are 65-78% and 27%, respectively.

4. Conclusion

The optimal fuel supply mix for IND-EURO scenario are FAME 50% and Diesel 50% in 2020-2030 and mix of FAME 47%-HVOSMR 53% in 2035-2050 which implemented EURO specification with adjustment by Indonesian government such as water content, sulphur content, viscosity, cetane number and density. For adapted EURO specification without adjustment except the sulphur content as EURO-SULPHUR IND scenario has fuel supply mix of HVOSMR 30% and Diesel 70% in 2020, FAME 20% with Diesel 80% for 2025-2030 and FAME 47%-HVOSMR 53% for 2035-2050. Utilization biofuel for this model result can reduce consumption diesel around 79% and 67% or equal with 50,608.73 million liter and 44,968 million liter each scenario, respectively. For gasoline type supply mix are Ethanol 5% and Gasoline 95% in 2020, combination Ethanol and Ethanol 2G totally 20% with Gasoline 80% in the 2025-2050 for all scenario with adjustment by Indonesian government such as aromatic, benzene and sulphur content for IND-EURO scenario and only sulphur content for
EURO-SULPHUR IND. Utilization of biofuels in this model result can reduce consumption gasoline up to 19% or equal with for 10,229.2 million liter each scenario. Average diesel carbon intensity for both scenarios are 1.57 and 1.54 CO$_2$-eq/kg, regarding gasoline carbon intensity which has same result for all scenario is 2.76 CO$_2$-eq/kg. This result showed that with implemented standard fuel quality for fuel system in Indonesia can increase biofuel utilization even the costs of second generation biofuels are currently still higher than those of the fossil fuels but we can utilize our biomass and renewable resources, mitigate climate change, and export petroleum fuel in the future.

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