Reducing CO\textsubscript{2} Emissions from Land Transport Sector in
Indonesia: Case Study Automobiles Sector

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Abstract. Indonesia land transportation sector has the largest share of final energy consumption, which is 88\%, followed by air transportation 9\%, sea transportation 2\%, river transportation 1\%, and the rest is rail transportation that is still very little. This paper presents policy mix analysis which can contribute for achieving 29\% of CO\textsubscript{2} reduction target in Automobiles Sector up to 2030. The result showed that by 2030, automobiles unit in operation (UIO) will achieve 32 million units and emit 114 mega ton CO\textsubscript{2} emission. By introduction of policy mix such as aged vehicle reduction, alternative fuel vehicle (AFV) promotion, Biofuel promotion and low carbon emission vehicle (LCEV) promotion, it can reduce up to 29.6 mega ton, which is around 26\% reduction from total.

1. Introduction

Historically, indigenous oil, gas and coal reserves have played an important role in Indonesia’s economy. Indonesia’s vast reserves and resources of these three commodities have allowed extensive utilization as sources of energy, industrial raw material and national income. With the continued growth of Indonesia’s economy and the increase of population growth, demand of these fossil fuels has also increased and with it, a higher energy demand. Total Indonesian energy consumption in the year 2000 was 777,925,086 BOE. Within 11 years, this increased to 1,114,766,960 BOE. Meanwhile, oil production decreased 0.2\% annually from 2010-2012 due to depletion of reserves and lack of investment for exploration and development [1].

The transportation sector consumes over 60\% of Indonesian oil whereas 70\% of which attributed to road transportation. Summarizing, road transportation, the main contributor of energy consumption in transportation sector, will account for 88 \% of the total transport energy demand by 2030. The Asia Pacific Energy Research Centre predicts that the number of passenger vehicles will increase from 3.4 million units in 2002 to 13.9 million units by 2030 thus drastically increasing oil demand [2].

Automotive industry, including the suppliers and material industry contribute to 6\% of the GDP in 2016 and is the biggest manufacturing industry in Indonesia. As a total, the industry created more than 400,000 job opportunities, including jobs in production, parts, material supply, logistics and sales activity. Beyond the domestic consumption, automotive vehicles are also the priority commodity for export expansion. Today, vehicles and automotive parts, like engine, are exported from Indonesia to more than 80 countries, which contribute to trade profitability. Moreover, continuous investments
from foreign countries could boost national science and technology level and as well as human resources development.

IMF predicted that Indonesia would be the fourth largest economy in 2050, a jump from the eighth largest economy in 2016. This is supported by rich natural resources and the large population of over 280 million, mainly consisting of young and productive generations. Figure 2 displays vehicle ownership per 1,000 people and GDP per capita, we can see that Indonesia’s ownership level is 87 units/1,000 people. There is still a gap with some other developing countries. With the increase of economic growth, Indonesian automotive market is expected to continuously grow and expand and may even double in size over the next 10 years.

![Figure 1. GDP per capita/Automotive Market (2003 - 2017)](image_url)

![Figure 2. GDP per capita/Vehicle per 1,000 Population (2015) [3]](image_url)

In 2015 Paris Climate Conference (COP21), President Joko Widodo mentioned Indonesia’s commitment to reduce CO2 emission by 29% without international support, or 41% with international support by 2030. This reduction will involve Energy, Forestry and Marine Sectors. Compared to the forestry and energy sectors, transportation sector might not emit CO2 as much, but it has the potential to be one of the biggest contributors in the future. Hence, we believe automotive industry should also
be responsible in reducing CO$_2$ emission to help achieving the national CO$_2$ reduction target. Not only from the environmental risk, energy condition is also affecting Indonesia to take action, Indonesia’s trade balance is under deficit situation and one of the reasons is excessive oil import level, the burden may get heavier, as vehicle numbers increase in the future. Indonesian government recognized this issue and it announced the “Energy Mix” in RUEN. Based on that plan, in 2016, almost half of Indonesia’s energy supply relied on Oil (46%), the government is determined to reduce the use of conventional fossil fuels to 25% in 2025 and 20% in 2050. Instead of using oil, the government has high intention to promote renewable sources of energy use in future. The share of renewable energy is estimated to be 23% by 2025 and 31% in 2050.

Based on above descriptions, the researchers consider it necessary to do a study a policy mix proposal for land transport sector, especially related to Automobiles Sector, which can reduce the CO$_2$ emission and at the same time reduce the fossil fuel consumption.

2. Method
As the first step, we are going to calculate the CO$_2$ emission based on vehicles UIO. The calculation will only focus on the automobiles vehicles. The calculation will use UIO data with vehicle age, segment difference, engine size and fuel type and fuel emission data of each target vehicle. Based on actual UIO, we will develop the 2030 based UIO as the calculation database.

In the second step, based on the national reduction target, we are going to calculate the amount of emission to be afforded by automobiles vehicle. We are going to breakdown the national target to industry target, transportation type target and finally to automobiles vehicles target.

In the third step, we are going to make suggestion of policies for automotive industry to promote CO$_2$ emission reduction and analyze each policy’s impacts to the market and CO$_2$ emission. As for the output of step 1 to step 3, we are going to provide comprehensive policy advice along with the data set to the government to support the policy decision. We are going to calculate how much CO$_2$ can be reduced based on each policy and as a total. The stepping of this study as described in figure 4 are:

1. Automobiles vehicles CO$_2$ emission calculation
2. CO$_2$ reduction target setting
3. Policy suggestion and CO$_2$ reduction impact calculation
2.1. CO₂ Emission Calculation
The calculation formula is shown above in Figure 5. The CO₂ emission equals to the accumulation of the multiplications of vehicle number (by different indicators) and CO₂ emission (by different indicators) and average annual driving distance as listed in table 1. In making the calculation model, we identified the following indicators of automobiles as the key indicators:
1: Vehicle age
2: Vehicle segment (Engine size)
3: Vehicle segment (Body type)
4: Vehicle Category (Passenger Vehicle (PV), Commercial Vehicle (CV)
5: Fuel to use (Gasoline, Diesel)

Table 1. Average Annual Mileage (Km Travel) by Type of Vehicle [5]

| Type of Vehicles | Number of Days per month (day) | Average Km Travel per Day (km) | Average Km Travel Annually (km) |
|------------------|-------------------------------|-------------------------------|-------------------------------|
| Passenger car    | 28                            | 55                            | 18,480                        |
| Bus              | 15                            | 200                           | 36,000                        |
| Truck            | 20                            | 150                           | 36,000                        |

Foreign automotive companies entered Indonesia in 1960s. Some vehicles have been produced from late 1960s and even today, we can still see some vintage vehicles on the road. This is due to the lack of scrapping regulation in Indonesia. Vintage vehicles are still using old engines that emit more CO₂ than today’s model. In addition, segment and engine size are also some of key indicators affecting the CO₂ emission, heavier body type and bigger engine size have direct relationship with CO₂ emission amount.

For example, 3-row MPV emits more CO₂ compared to H/B vehicles with the same engine size due to its heavier weight. Commercial vehicles CO₂ emission is also different compared passenger vehicles. When we make the calculation model, we need to clarify the CO₂ emission efficiency by different segment vehicles. The type of fuel used is also one of the indicators to consider. The fuel efficiency of
gasoline and diesel is different; gasoline emits 2.322 kg-CO2/L, but diesel emits 2.619 kg-CO2/L [6]. The efficiency of thermal is also different. These factors are considered into our calculation model.

Based on the indicators listed above, we collected the sales data from 1975-2016 and including vehicle age, segment of vehicle, engine size with vehicle and type of fuel to use in Indonesia. In order to calculate unit in operation (UIO), we are going to sum up the sales number of each year with considering the abolishment ratio. Even though Indonesia does not have the regulation to stop aged vehicle from running, their number of units would decrease naturally theoretically. Based on the interview with the third party consultant and insurance company, we received the information that the abolishment ratio in Indonesia is around 0.5%-1.5%. After further discussion, we decided to use 1% as the abolishment ratio to calculate total UIO.

Based on market distribution at the end of 2016, we developed the future sales estimation as well. We made an assumption that if the government does not make any change to the current policy, and request any technological improvement, the market segment distribution would be the same as 2016’s, with market size grow up. As the conclusion, Indonesia’s automobiles vehicle market reached 1.2 million in 2014, but due to the macroeconomic situations, the automotive market drops to 1.03 million in 2015 but made a comeback to around 1.07 million in 2016. Based on the estimation of our regression analysis, as can be seen in Figure 6, Indonesian automotive industry is expected to reach 1.26 million in 2020 and reach 2 million in 2030.
From model calculation, Figure 7 showed the total number of UIO and CO2 emission. In 2016 the total UIO of Indonesia automobile is 14 million units. The UIO number will increase to 18 million in 2020 and reach to 32 million (+129%) in 2030. The CO2 emission in 2020 will be 69 megaton and CO2 emission in 2030 will be 114 megaton (+107%), which is 55 megaton in 2015. UIO number will increase from 14 million to 32 million units (+129%).

Table 2, is the estimations for UIO Distribution and CO2 Emission Distribution in 2030 which is visualized by vehicle age and segment. Vehicle segment in these figures is categorized into two sections, CV and PV. Moreover, we identified that vehicle age consists of “New Vehicles (1-9 years)”, “Matured Vehicle (10-19 years)” and “Aged Vehicle (20- years). According to the data, out of the 32 million UIO, new vehicles, which will be sold from 2021-2030 in total will reach 14.5 million units or 44.8%, which take up the highest proportion. Matured Vehicles will be 10.2 million or 31.4%. Aged Vehicles will be 7.7 million or 23.8%. It also shows the CO2 emission distribution, in total automobiles would emit 114 megaton in 2030, New Vehicles occupy 42.2% of the total emission. Whereas, Aged Vehicles occupy 27.4% and Matured Vehicles occupy 30.4%. The highest CO2 emitting groups are New PV and Matured PV, with 32.1% and 21.7%. We also can conclude that the aged vehicles contribute more CO2 emission compared with new and matured vehicles. This is because aged vehicles use old engines that emit more CO2. The regulation for aged vehicle should be the higher priority to be considered.  

![Figure 7. UIO and CO2 Emission Growth](image)
Table 2. UIO Composition and CO2 Emission Base

| UIO Composition | CO2 Emission Base |
|-----------------|-------------------|
| PV   | CV   | PV  | CV  |
|------|------|-----|-----|
| New  (1-9 yrs) | 44.90% | 42.20% | 36.40% | 8.50% | 32.10% | 10.10% |
| Matured (10-19 yrs) | 31.49% | 30.40% | 24.20% | 7.20% | 21.70% | 8.70% |
| Aged (20-29 yrs) | 12.89% | 14.10% | 8.50% | 4.30% | 8.40% | 5.70% |
| Aged (30 yrs –) | 11.19% | 13.30% | 7.90% | 3.20% | 8.70% | 4.6% |

2.2. CO2 Reduction Target Setting

According to Ministry of Environment and Forestry report, the total GHG emission level by 2030 is supposed to reach 2,869 megaton. Based on the discussion with MOEF, we are going to use this number as the starting point. Indonesia is targeting to reduce 29% of CO2 emission, which can be calculated as 832 megaton. Based on First National Determined Contribution Report, Energy & Transportation Industry is the second highest CO2 emitting industry, taking up 37.7% that equals to around 314 megaton. While, Transportation Industry itself takes up 85 mega ton, which is 27% out of 314 megaton.

Among the different means of transportations, land transportation’s emission is the highest. It is 85% of the whole transportation industry’s emission, which is 72 megaton. Land transportation could also be further categorized into 2- and automobile (automobile) and others, such as trains. Based on the government interview, we set the calculation condition as 2- and automobile emission is the most significant contributors, as they occupy 88% of the total, amounting to 65 megaton. Inside the 2-wheel, automobile calculation, we found that automobile occupies 48% of the total emission and 2 wheel occupies 52% of total emission. This emission composition is calculated from the number of 2-wheel, automobile vehicles and fuel efficiency of the 2-wheel, automobile vehicles. In conclusion, our calculation result shows that to achieve the national reduction of 832 megaton, automobile transportation should take the responsibility of reducing 31 megaton CO2, which is 27.3% of the total CO2 emission.
2.3. Policy suggestion and CO2 reduction impact calculation

According to step 2, automobiles transportation sector should contribute 27.3% of CO2 reduction, which is equal to 31 megaton emission reduction. Since the target is relatively high, it might be hard to achieve when only relying on a certain policy or a vehicle group. We need to introduce various different automotive vehicle policies as the “Policy Mix” aiming to reduce CO2 emission. We developed the draft image for each policy. The categorization of the policies, and the target vehicle groups are shown in Figure 9. Targeting aged vehicle, we propose the introduction of policy that will encourage owners to replace their high emission vehicles with low emission vehicles. The idea is to provide the incentive for aged vehicles replacement, for example by government providing incentive through tax reduction for owners who are willing to replace their aged vehicles for new vehicles.

Alternative fuel vehicles introduction, like CNG vehicles and BEV would be an effective idea to reduce CO2 emission. Considering the necessary infrastructure to make the station, this policy would only be targeting New CV. On the other hand, we would suggest introducing the policy to promote fuel-efficient vehicle penetration especially to target PV. We are going to propose a new tax scheme based on CO2, and the local production incentive for not only LCGC, but also for the next generation, “Electrifies Vehicles”.

![Figure 8. Transportation Sector CO2 Reduction Target](image)

![Figure 9. CO2 Emission Amount (2030 BAU vs 2030 Target)](image)
Considering Indonesia’s economic level, and future development of the automotive industry, we would like to make sure that the “Electrified Vehicles” policy would only target vehicle models that can be built locally. Finally, the efforts for Bio Fuel Promotion should be considered as well. Indonesia is rich with natural resources, especially bio fuel, with the country being one of the biggest bio diesel producers and exporters. Other than bio diesel, bio ethanol introduction is also one of the possible methods to reduce the CO2. There are two advantages for biofuel introduction. Firstly, Indonesia is already the producer of biofuel, making it easy to find the resources. Secondly, biofuel introduction will benefit all units of operation in Indonesia. Thus, we can expect a big impact towards CO2 emission reduction through this policy. Some policies will affect total UIO volume, and some policies will affect CO2 emission efficiency. Therefore, considering the calculation convenience and to avoid unnecessary mistake, we would like to start the calculation from the policy that affects UIO volume first. After discussion and brainstorm, the policy calculation order would be as described in figure 10.

![Figure 10. Policy Mix Categorization](image-url)

### 3. Result and discussion

From model calculation, if the policy mix can be execute, there would be a total reduction of 29.6 megaton of CO2 by 2030, which is 26.1% of the total CO2 reduction as in figure 11. For achieving the original target of CO2 reduction, we still have remaining 1.3 megaton to reduce, we might need to modify the policies or expect other policy or measure to support reduction. Based on the discussion result, we would be expecting the mass transportation development to reduce the driving distance, and believe this would reduce the remaining 1.3 megaton. Starting from 2016, there are some serious mass transportation infrastructure development, such as MRT around Jabodetabek area. Considering the policy impact, we believe biofuel could make the biggest impact for CO2 emission reduction, because the policy is affect UIO for all vehicles aged. Followed by the fuel efficient vehicle promotion as CO2 tax introduction, and by aged vehicle reduction and alternative fuel vehicle introduction.

However, we are not going to conclude with fuel improvement as the most prioritized policy. As we mentioned in the previous section, the reduction of 27.3% is quite a challenging target and we need to introduce various different policies as “Policy Mix” to solve the big social issue together. The various policies introduction requires different government body and stakeholders to work together as “one team”. For example, for introducing the E10, the government needs to secure enough supply of raw material, which will require the support from agricultural stake holders. Alternative fuel vehicle like CNG and BEV also need the strong support from energy and infrastructure stakeholders, like gas and Electricity Company. Fuel efficient vehicle introduction policy also requires the cooperation of automobile companies understand the direction and make additional investment in Indonesia, for
introducing the new CO2 tax, we need road and transportation sector to support to prepare the new testing facilities.

![CO2 Emission Reduction Amount](image)

**Figure 11. CO2 Emission Reduction Amount in Total**

4. Conclusion
The research reveals that the in order to achieve 29% of CO₂ reduction as targeted by Indonesian Government need a policy mix which can implement effectively with the support of all stakeholders. Without end of life vehicle policy in place, the biggest challenge is how effectively create a policy which have an impact to all unit in operation (UIO). Biofuel policy and fuel efficient vehicle promotion are very effective policies for achieving reduction of CO₂ and at the same time can also reduce the consumption of fossil fuel.

5. References
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