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Regional Case Study

Impact of Electric Vehicle Transition Scenarios on Road Transport Emission in Semarang City

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Abstract

The transition from fossil-fueled vehicles into electric vehicles is considered to be a strategy that can significantly reduce emissions and improve urban air quality. This study aims to examine the impact of the battery electric vehicles growth in Semarang City on carbon emissions within the road transport sector. Projections were made to assess the long-term impact and contribution of this trend towards meeting government targets in 2030 and 2060. Low Emission Analysis Platform (LEAP) software was used to estimate carbon emissions based on amount of vehicle and vehicle kilometer traveled (VKT) data. Three scenarios were set: the BEV scenario, which focuses on the widespread use of electric vehicles, demonstrates a significant reduction, especially in PM_{10} emissions, highlighting the advantages of transitioning away from internal combustion engine vehicles. The EMX scenario, which emphasizes an energy mix plan to support electricity, does not demonstrate a significant reduction in emissions. The COM scenario, which combine the BEV and EMX scenarios achieves the lowest emissions overall, indicating that a comprehensive strategy is most effective for achieving long-term emission reductions. All scenarios indicate the need for more aggressive policies, technological innovations, and carbon capture strategies to achieve reduction targets, particularly in the road transport sector.

Keywords: electric vehicle; emission forecast; GWP100; LEAP

1. Introduction

Global greenhouse gas (GHG) emissions from the transportation sector in 2019 contributed up to 23% of global CO_2 emissions with road transportation contributing 70% (Calvin et al., 2023). Meanwhile, Indonesia's GHG emissions in 2021 reached 600 $MtCO_2e$, with the transportation sector accounted for 23%. Within this sector, road transportation was the predominant source, responsible for 90% of the emissions. The Ministry of Environment and Forestry (KLHK) estimates that based on the current policy, GHG emissions from the transportation sector in Indonesia will reach 145 $MtCO_2e$ by 2050 (IESR, 2023). Central Java Province ranks third in Indonesia for the number of vehicles, with the highest concentration in its capital, Semarang City (Korlantas Polri, 2024). This increasing vehicle density is expected to significantly impact emission levels, particularly from the road transport sector in Semarang City, where emissions were 1,350.7 $ktCO_2e$ in 2015. Under a business-as-usual scenario, these emissions are projected to rise to 2,093 $ktCO_2e$ by 2030 (Sofaniadi et al., 2022).

Following the Kyoto Protocol and the Paris Agreement, Indonesia has enhanced its Nationally Determined Contribution (NDC), increasing its emissions reduction target through domestic efforts (unconditional) from 29% to 31.89% by 2030, while the target with international assistance (conditional) has risen from 41% to 43.2%. Additionally, the country aims to achieve net-zero emissions by 2060. The NDC encompasses five key sectors responsible for reducing GHG emissions are energy, waste, industrial processes and production use (IPPU), agriculture, and forestry (Indonesia, 2022). The energy sector includes emissions from fuel consumption in motor vehicles. According to the Institute for Essential Services Reform (IESR), achieving the NDC targets by 2030 will require 13 millions two-wheeled electric vehicles and 2 millions for the four-wheeled (IESR, 2023). This policy also encourages the development of the electric vehicle (EV) industry in Indonesia. The transition to electric vehicles is believed as a strategy that not only reduces transportation sector emissions, but also improves urban air quality (Axsen et al., 2020; Board et al., 2022). Indonesia, which included within The Group of 20 together with Australia, Japan, South Africa, the United Kingdom, and other high emitter countries are responsible for about 76% of global greenhouse gas emissions (UNEP, 2023). Net zero means to reduce carbon emissions to a minimal level of residual emissions that can be effectively absorbed and permanently stored by natural processes and other carbon dioxide removal methods, resulting zero in the atmosphere (United Nations, n.d.).

The issuance of Presidential Regulation Number 79 of 2023 about the acceleration of the battery electric vehicle (BEV) program for road transportation, underscores the government's attention to the issue of global warming. However, by 2020, the adoption rates of electric vehicles remained low, with only 0.15% of the target of 150,000 four-wheeled vehicles (electric cars) and 0.18% of the target of 800,000 two-wheeled vehicles (electric motorbikes) being achieved (IESR, 2020). The government's commitment to promoting electric vehicles is further demonstrated by the provision of a subsidy of IDR 7,000,000.00 for the purchase of each two-wheeled electric vehicle. This subsidy has positively influenced public perception and interest in electric vehicles, as evidenced by the significant growth in their adoption. Research data indicates that the number of electric vehicles in Indonesia increased fifteenfold over two years, rising from 2,176 units in 2020 to 33,461 units in 2022 (Deloitte and Foundry, 2023).

The environmental benefits of BEVs are still a subject of debate, particularly because much of the electricity in many regions is generated by coal-fired power plants, which are among the most carbon-intensive fossil fuels ("Coal - IEA," 2023; Ordonez et al., 2021). Despite this, BEVs produce lower carbon emissions compared to internal combustion engine vehicles (ICEVs) over the same mileage (Poornesh et al., 2020; Veza et al., 2023; Wei et al., 2023). Various studies have demonstrated that electric vehicles are not only more economical than fossil fuel vehicles (Kumar et al., 2023; Moriarty and Wang, 2017) but also significantly reduce emissions (Dulău, 2023). Nevertheless, the maximum potential of electric vehicles must be supported by the availability of electricity from renewable energy sources (Moriarty and Wang, 2017). This research aims to assess the impact of the growing electric vehicle trend in Semarang City and to project its long-term effects and contributions toward achieving government targets—an area that has not been explored in previous studies. Several scenario options have been developed based on current regulations and government plans to assess their significance in reducing carbon emissions.

2. Methods

2.1. Framework

Low Emission Analysis Platform (LEAP) is a software tool designed for in-depth analysis of energy policies, environmental impact evaluations, and economic cost studies over the long term. By utilizing scenario-based modeling, it assesses different energy production and consumption patterns from multiple sources, ensuring the energy demand is met across various sectors of the economy (Rivera-González et al., 2020). One of LEAP's strengths is its integration capability with a wide range of data sources, which makes it valuable for detailed analysis of specific energy systems. A key motivation for employing LEAP in this study is the limited research on using the tool to evaluate road transport emissions in Semarang City, presenting an opportunity to explore new methodologies and innovative approaches (Al-Jabir and Isaifan, 2023). This study is using demand module on LEAP to enter the data of each scenario such as growth rate, fuel consumption, and emission factor as shown in Figure 1.

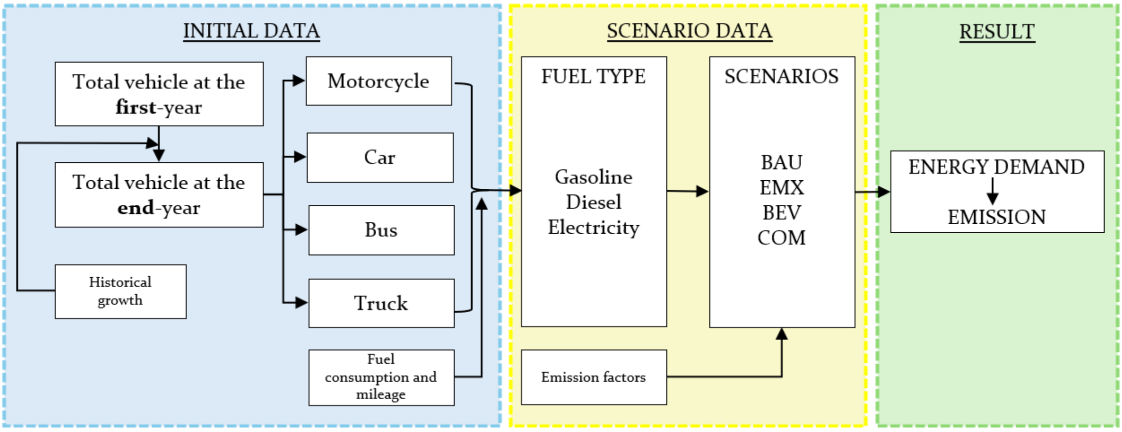

Figure 1. Data flow on LEAP

This study is subject to the following limitations: the transportation sector emissions analyzed are limited to road transport emissions from motor vehicles (motorcycles, cars, buses, trucks), based on fuel consumption and average annual mileage; projections are made up to the year 2060, using assumptions and scenarios developed in accordance with current government policies and planning. Sensitivity analysis also applied to the optimal scenario to assess the degree to which policy factors influence urban emissions (Saltelli et al., 2019).

2.2. Data Collection

Data from regional agencies have been collected for this study, including vehicle counts categorized by type (motorcycle, car, bus, and truck) and fuel type (gasoline, diesel, and electric). Additionally, secondary data from relevant literature, such as average vehicle kilometers traveled (VKT) and average fuel consumption, have been incorporated. In the LEAP model, emissions for each vehicle type will be calculated based on the energy consumption (EC) of each vehicle, in accordance with its respective fuel type, as outlined in Equation (1) (Rivera-González et al., 2020):

$$EC = \sum (TV_a \times VKT_a \times FE_{ab}) \quad (1)$$

where TV is the total number of vehicles of type a, VKT is the average distance traveled by vehicle a (km/year), and FE is the average consumption of fuel b of vehicles type a per unit distance traveled (liter/km).

Carbon emissions will be calculated following the methodology established by Intergovernmental Panel on Climate Change (IPCC), with results directly proportional to the amount of energy consumed. The carbon emissions calculations will be conducted using Equation (2):

$$Em = EC \times EmF_{bc} \times G_c \quad (2)$$

where EmF represents the emission factor for pollutant c under fuel type b, and G denotes the change in the pollutant c emission factor as the vehicle ages. The value of G is set to 1, based on the assumption that any decline in engine performance due to aging is offset by improvements in fuel quality, which enhance combustion efficiency. The input data utilized in these calculations are summarized in Table 1 and the emission factor in Table 2 is following national regulation.

Table 1. Data Input for LEAP

Vehicle Type	*VKT* (km/year)	*FE* (liter/km)
Motorcycle	7300[a]	0.023[a]
Car (gasoline)	15330[b]	0.083[c]
Car (diesel)		0.069[c]
Bus	15700[d]	0.100[a]
Truck	32689[d]	0.133[e]

Source: [a](Sukarno et al., 2016); [b](Rahayu et al., 2023); c(Erahman, Reyseliani, Purwanto, & Sudibandriyo, 2019); [d](Arief Budihardjo et al., 2021); [e](Thaheer et al., 2019)

Table 2. Vehicle emission factors for large cities in Indonesia based on vehicle category

Category	Emission Factor				
	CO (g/km)	NO_x (g/km)	PM_{10} (g/km)	CO_2 (g/kg fuel)	SO_2 (g/km)
Motorcycle	14	0.29	0.24	3180	0.008
Car (gasoline)	40	2	0.01	3180	0.026
Car (diesel)	2.8	3.5	0.53	3172	0.44
Bus	11	11.9	1.4	3172	0.93
Truck	8.4	17.7	1.4	3172	0.82

Source: Regulation of the Minister of Environment and Forestry No.12/2010

2.3. Scenarios

This study examines four scenarios: business-as-usual (BAU), government BEVs target (BEV), energy mix plan (EMX), and a combination of BEV target and energy mix (COM). The base year, used for historical data, is set to 2018, according to the number of vehicles data obtained from the Regional Revenue Management Agency of Central Java Province. The first year of scenario analysis beginning in 2024 and extending to 2060 as the end year. The evaluation focuses on the results for 2030 and 2060, aligning with targets set by the Indonesian government. The percentage share of each vehicle type remains constant, following the actual data in 2023. Several assumptions were made to limit this study and are explained in each scenario.

2.3.1. Historical

This section simulates data from the period 2018-2023 to analyze historical trends in vehicle growth and energy consumption. The results will provide insights into these trends and help identify the associated challenges.

2.3.2. Business-as-Usual (BAU) Scenario

Once a model is built using historical data, forecasting the future trends in transportation and their related emissions becomes more achievable (Rivera-González et al., 2020). This scenario will generate projections for the number of vehicles and their emissions in 2030 and 2060. The growth rates for ICEVs and BEVs are derived from the average growth rates observed in historical scenarios. Additionally, current conditions, including the energy mix with 72,72% coal domination (Kementerian ESDM, 2021), charging stations growth, and related policies of BEV acceleration in Presidential Regulation Number 79 of 2023, have not undergone significant changes and are therefore considered negligible.

2.3.3. BEV Target (BEV) Scenario

The target for the number of BEVs in Indonesia by 2030 is 13 million units for two-wheelers (motorcycles) and 2 million units for four-wheelers (cars) (IESR, 2023). To estimate the target for Semarang City, assumptions are made based on the percentage of BEVs currently in the city, compared to the total number in Indonesia—25,782 motorcycles and 7,679 cars (Deloitte and Foundry, 2023). Another assumption is that the growth rate of ICEVs will decline, influenced by factors such as BEV purchase subsidies, predicted decreases in battery prices (IESR, 2023), and a public interest shift, with up to 22% of ICEV owners expressing intent to switch to BEVs (Indonesia Automotive Team, 2023). Meanwhile, the condition of the energy mix, infrastructure and related policies have not significantly changes.

2.3.4. Energy Mix (EMX) Scenario

Government Regulation Number 79 of 2014 on National Energy Policy sets a target for the optimal energy mix, aiming for a composition of at least 23% new and renewable energy (NRE) by 2025 and at least 31% by 2050. Accordingly, the 2021-2030 electric power supply business plan projects that the energy mix in the Java, Madura, and Bali (Jamali) regions will include 16.1% NRE by 2030, which comprises hydro, geothermal, and other sources such as solar, wind, waste, and biomass. This represents an 8.5% increase over the past decade, with the energy mix reaching an estimated 10% in 2023. These changes will impact the emission factor of electricity, which is currently 0.89 tCO_2e/MWh, and is projected to decrease to 0.78 tCO_2e/MWh by 2030 (Kementerian ESDM, 2021). Additionally, the growth of ICEVs and BEVs is assumed to follow the BAU scenario, with infrastructure and other policies remaining largely unchanged, allowing these factors to be disregarded in the analysis. The growth in the number of BEVs for motorcycles and cars is assumed to follow the BAU scenario, but BEV buses and trucks are expected to increase, with Semarang City projected to need at least 150 electric buses by 2030 (3% of total buses). Given that Semarang has yet to commit to public transport electrification and lacks fiscal incentives from local authorities to support electric bus adoption, this target is set for the end of the scenario period (Anam, 2024).

2.3.5. Combination (COM) Scenario

This scenario integrates the two previous scenarios: the growth rate of battery electric vehicles (BEVs) aligns with the established target, the optimization of the energy mix adheres to the planned strategy, and the possibility of bus electrification.

3. Result and Discussion

The LEAP calculations project the number of vehicles through 2060, as Figure 2 shows a steady increase in vehicle numbers across all scenarios, with a noticeable diversification in fuel types over time. The projected number of vehicles remains consistent across all scenarios, aligning with the current growth rate of 3.44%. The percentage distribution of each vehicle type is also kept constant: motorcycles at 80.8%, passenger cars at 14.3%, buses at 0.2%, and trucks at 4.7%. The key differentiating factor among the scenarios is the percentage of ICEVs and BEVs, as detailed in the research methodology section.

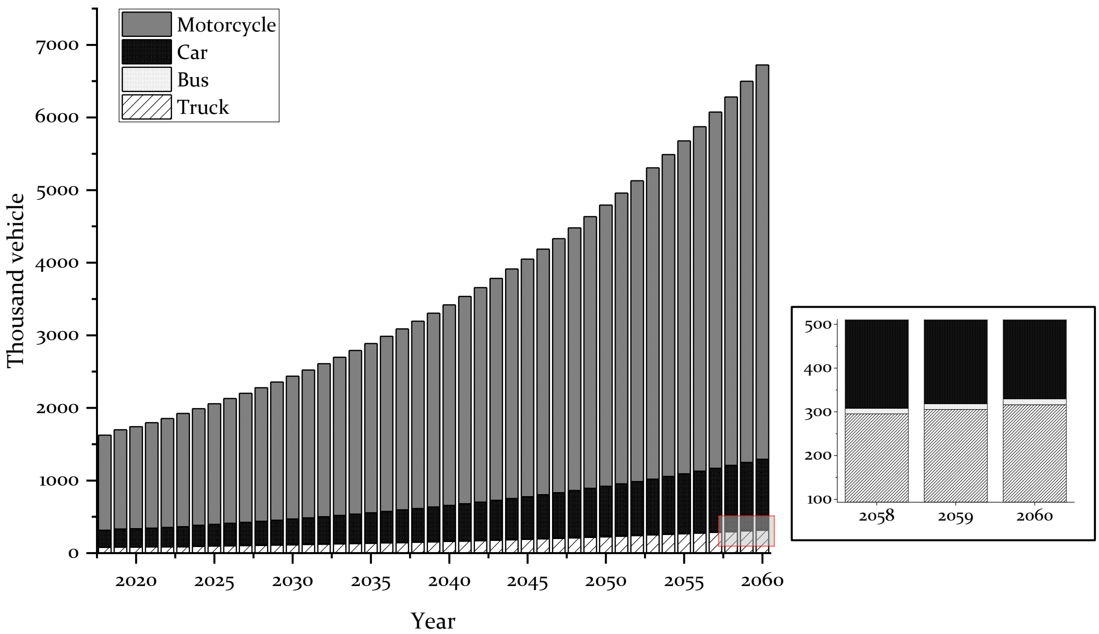

Figure 2. Annual total amount of vehicles by type

Motorcycles remain the most prevalent vehicle type, largely due to their suitability for daily activities, and their effectiveness in navigating traffic congestion in large cities (Huu and Ngoc, 2021). In particular, Semarang City, where public transportation facilities are limited and residential areas are often far from transit stops, exhibits a notably high rate of motorcycle ownership. Passenger cars occupy the second position, driven by the large population and the limited availability of public transportation, which also contributes to the high rate of car ownership. Trucks rank third, and buses are the least.

3.1. Forecast of Emissions

Fuel combustion from road transport between 2023 and 2060 results in varying levels of atmospheric pollutant emissions, depending on the scenario. The analysis is divided into two sections: (1) GHG emissions contributing to global warming, quantified by the global warming potential over 100 years (GWP100), and (2) pollutant gas emissions that degrade air quality (Rivera-González et al., 2020).

3.1.1. GHG Emission

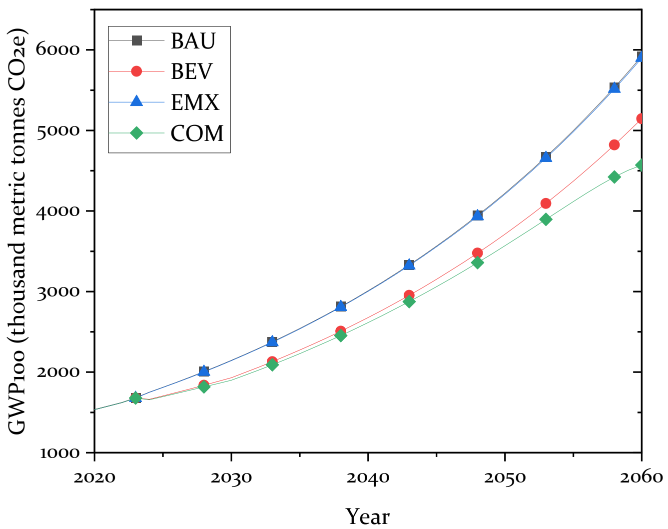

Figure 3. GWP100 of each scenario

Greenhouse gas (GHG) emissions for all scenarios presented in Figure 3 are expressed in terms of the global warming potential over 100 years (GWP100), measured in CO_2-equivalents (CO_2e). By 2030, the BEV and COM scenario shows the lower emissions compared to another two, suggesting the effectiveness of adopting electric vehicles in reducing CO_2e emissions by this time. In 2060, the BAU scenario shows the highest emissions, indicating that without significant intervention, emissions will continue to rise dramatically. The BEV scenario shows a considerable reduction in emissions compared to BAU, results in emissions that are 22.4% lower than BAU in 2030 and 29.3% lower in 2060, underscoring the long-term benefits of transitioning to electric vehicles. The COM scenario emits the lowest emissions among all, with reductions of 22.5% 2030 and 36.5% in 2060. There is a significant difference compared to the BEV scenario in the last 10 years (2050-2060), indicating that the scenario becomes effective during this period. This scenario shows that a combination of strategies is the most effective in reducing emissions in the long term. Meanwhile, the EMX scenario, although indicating a reduction in emissions, does not exhibit a significant deviation from the BAU scenario over the projected period, with emissions only 0.5% lower by 2060. It is less effective than the COM scenario, suggesting that focusing solely on emissions mitigation without integrating electric vehicles may not be sufficient.

The differences between scenarios become significant by 2060. This suggests that the long-term adoption of electric vehicles and comprehensive strategies (COM) is crucial for substantial emission reductions (Alanazi, 2023; Zhao et al., 2023). The BEV scenario consistently shows lower emissions across all years, emphasizing the importance of electric vehicles in reducing CO_2e emissions. However, the COM scenario, is the most effective, indicating that a holistic approach is necessary for achieving the most significant emission reductions.

3.1.2. Other Emission

Figure 4 illustrates that Nitrogen oxide (NOx) emissions under the BAU and EMX scenarios remain relatively similar, with no significant differences observed through 2060. However, there is a notable reduction in NOx emissions under the BEV scenario, which is nearly equivalent to the COM scenario by 2030. By 2060, NOx emissions in the COM scenario are 23.6% lower than BAU scenario and 2.4% lower than BEV scenario.

The increase in emissions across all scenarios corresponds to the growing number of ICEVs. This trend is also observed in PM_{10} emissions (Figure 5), which are exclusively produced by ICEVs. By 2030, the BAU scenario, representing a continuation of current practices without significant intervention, shows the highest emissions, emphasizing the need for policy changes or technological shifts to mitigate emissions effectively. The BEV and COM scenarios show a reduction in NOx emissions compared to BAU and EMX, suggesting that the adoption of battery electric vehicles and a combined approach, possibly including stricter emissions regulations or other technological interventions, start to have a more substantial impact on reducing NOx emissions.

The divergence among the scenarios becomes most pronounced by 2060, reflecting the long-term impacts of different strategies. The BAU scenario shows the highest NOx emissions, indicating that without significant changes in policy or technology, NOx emissions are projected to increase dramatically over the long term. The EMX scenario, which likely focuses on emission mitigation measures without a strong emphasis on electric vehicles, shows a reduction in emissions, but it is not as effective as the BEV or COM scenarios. The BEV scenario, where a significant shift to electric vehicles is assumed, shows a considerable reduction in NOx emissions, underscoring the effectiveness of transitioning away from internal combustion engines in reducing NOx emissions. The COM scenario demonstrates the lowest emissions, indicating that a comprehensive approach is most effective in significantly reducing NOx emissions by 2060. The long-term projections show substantial differences in NOx emissions among the scenarios. This suggests that significant emission reductions require sustained and comprehensive efforts over several decades (Bode, 2006; Kurokawa and Ohara, 2020). The BEV scenario shows a marked reduction in NOx emissions by

2060, illustrating the critical role that electric vehicles can play in mitigating NOx pollution. However, the COM scenario, which likely integrates BEVs with other emission-reduction strategies, is the most effective, indicating that a multifaceted approach yields the best results.

The EMX scenario does not significantly impact vehicle emissions, as BEVs do not produce NO_x, PM_{10}, or other related compounds directly. By 2030, the BEV and COM scenarios begin to show modest reductions compared to BAU, reflecting the initial benefits of electric vehicle adoption and combined mitigation strategies. By 2060, the differences between the scenarios become significant, with the BAU scenario showing the highest PM_{10} emissions, and the COM scenario showing the lowest. The BAU scenario projects the highest PM_{10} emissions, suggesting that without significant policy changes or technological advancements, emissions will continue to increase substantially over time (Freitag et al., 2021). The EMX scenario shows a reduction but is not as effective as the BEV and COM scenarios, indicating that emission mitigation strategies alone may not be sufficient to achieve substantial reductions. The BEV scenario, which emphasizes the adoption of electric vehicles, shows a significant decrease in PM_{10} emissions, underscoring the potential benefits of transitioning away from ICEVs. The COM scenario demonstrates the lowest emissions, suggesting that a holistic approach, both electrification and less fossil energy is most effective in achieving long-term reductions.

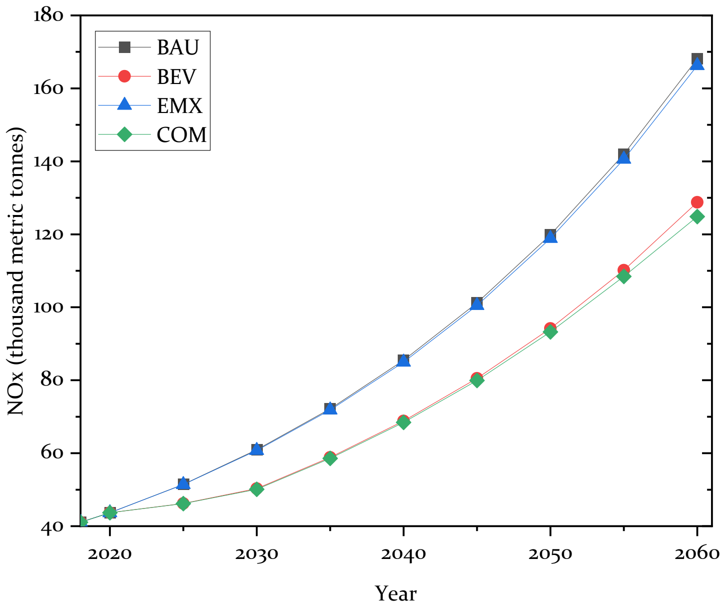

Figure 4. Nitrogen oxides (NOx) emissions of each scenario

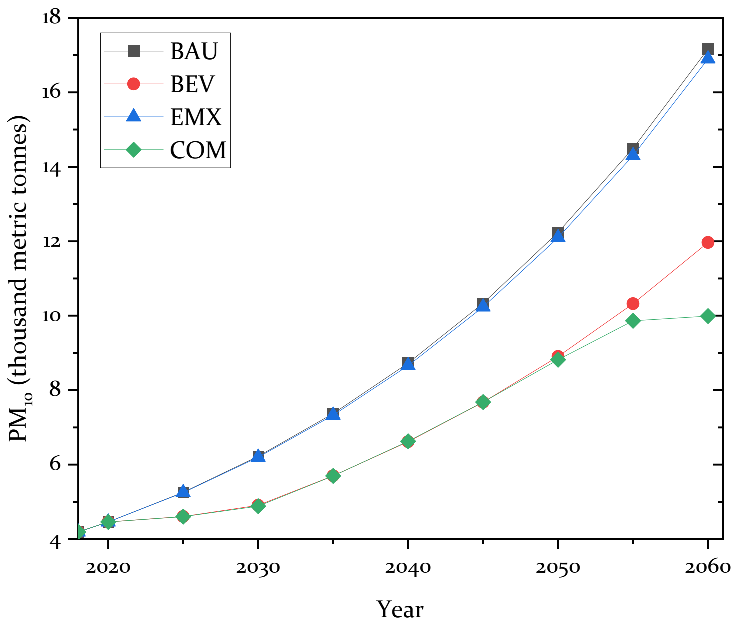

Figure 5. Particulate matter (PM_{10}) emissions of each scenario

3.1.3. Sensitivity Analysis

The optimal scenario based on the results above is COM, which includes policy changes in both the BEVs target and the energy mix plan. An analysis was conducted on changes to the BEV target and the composition of renewable energy (RE) with projections up to 2060. The amount of BEVs target is set to be 50% and 75% higher than the COM scenario, while the RE composition is set at 50% and 75%. Each change was also combined to assess its sensitivity. The analysis results are presented in Table 3, where a 50% increase in the BEVs target proves to be more effective in reducing emissions, achieving nearly a 15% reduction, compared to a 50% increase in the RE composition, which only achieves a 5% reduction in emissions.

Table 3. The emission reduction by 2060 based on the sensitivity analysis of the COM scenario

GWP100 (thousand metric tonnes CO_2e)		Energy Mix		
		Actual scenario	**RE 50%**	**RE 75%**
BEV	Actual scenario	4569.93	4331.22	3899.50
	Amount of BEVs increased by 50%	3890.64	3538.02	2893.00
	Amount of BEVs increased by 75%	3564.44	3146.62	2390.97

3.2. Energy Demand Projections

Figure 6 shows that cars and motorcycles consistently represent the largest shares of energy demand in all scenarios, with their demand peaking in the BAU scenario. The BEV and COM scenarios show a substantial reduction in energy demand for motorcycles and cars by 2060, highlighting the impact of transitioning to electric vehicles and comprehensive strategies. A significant difference in energy demand between motorcycles and cars is observed in 2060 under the COM scenario, where, despite the substantially higher number of motorcycles (Figure 2), their energy demand is lower than cars. This is because the motorcycle fleet in the COM scenario is predominantly composed of BEVs. A similar trend is observed for cars, but due to their higher energy consumption, the total energy demand remains substantial. The growth in buses and trucks across all scenarios shows no significant variation, resulting in low energy demand for these vehicle types.

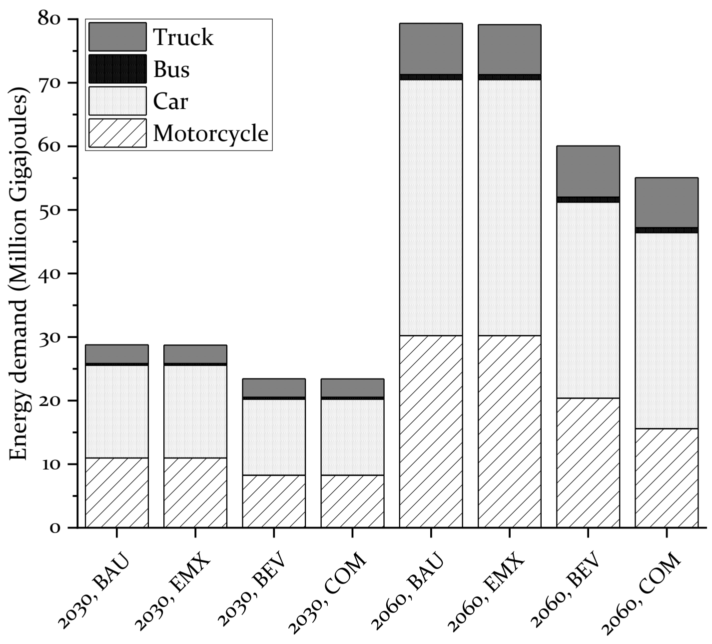

Figure 6. Projections of energy demand of each scenario by vehicle type

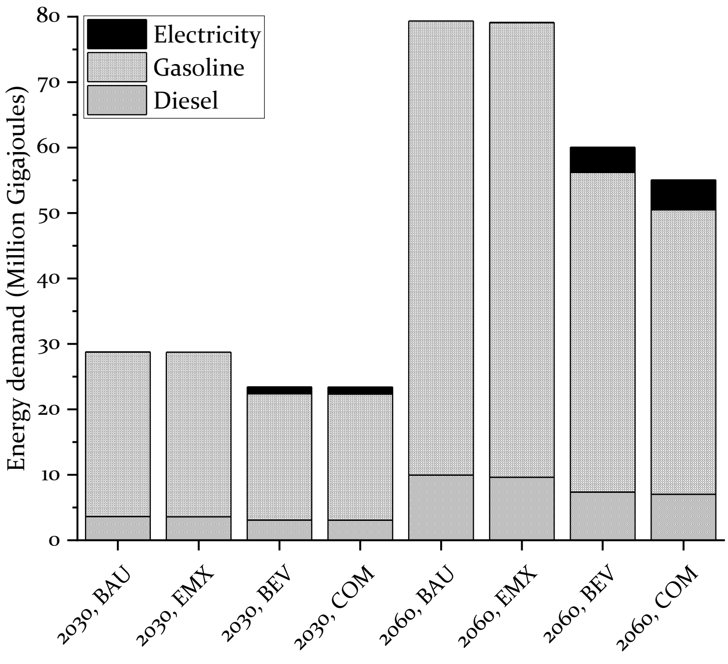

Figure 7. Projections of energy demand of each scenario by fuel type

Gasoline is consistently the dominant fuel type in all scenarios up to the end year as shown in Figure 7. Diesel remains a minor component in all scenarios, with only slight increases over time. Electricity plays a more significant role in the 2060 scenarios, especially in the BEV and COM scenarios, where its share of the total energy demand increases markedly compared to earlier years. The significant growth in electricity demand in the BEV and COM scenarios by 2060 underscores the potential impact of electric vehicle adoption on overall energy consumption patterns. Policymakers should consider these projections when planning infrastructure investments, grid enhancements, and regulatory frameworks that support increased electrification of transportation and other sectors. This result provides valuable insights into future energy demand by fuel type, emphasizing the need for strategic planning and proactive policies to manage the transition to a more sustainable energy system.

3.3. Contribution to Emission Target

Based on the GHG emissions calculations presented in Table 3, emissions increase under all scenarios up to 2060. The largest increase in emissions from 2023 to 2030 occurs in the BAU scenario, with a rise of 27.7%, while the decrease is observed in the BEV and COM scenario, at -0.9% and -1.1% respectively. Even in this most optimistic case, the reduction is modest, indicating that additional measures may be necessary to meet the full scope of Indonesia's Enhanced NDC (ENDC) ambitions, especially if aiming for the 41% reduction target with international support. However, the COM scenario achieves a 36.5% reduction in emissions compared to the BAU scenario by 2060.

Table 3. Increased emission of all scenarios (thousand metric tonnes CO_2e)

Scenario	2023	2030	2060
BAU	1681.57	2146.58	5291.10
EMX		2141.65	5899.76
BEV		1931.28	5145.75
COM		1898.89	4569.93

This trend contrasts sharply with the emission reduction targets outlined in the ENDC, especially considering the net zero emission goal for 2060. None of the scenarios achieve net zero emissions by 2060 based on the result. The BEV and COM scenarios show the most significant reductions, suggesting a strong move towards electrification and a diversified energy strategy. However, these scenarios still project substantial emissions, implying that more aggressive policies, technological innovations, and potentially carbon capture and storage will be necessary to achieve the net zero target.

4. Conclusion

Although emission levels remain relatively stable across different scenarios in the short term, substantial differences emerge by 2060. This indicates that achieving significant emission reductions require long-term and sustained efforts. The projections highlight the critical need for early and consistent interventions to mitigate the environmental and health impacts associated with NOx emissions. The significant differences observed in the 2060 projections underscore the importance of implementing proactive policies to effectively mitigate future emissions, such as the adoption and promotion of BEVs, and incorporate additional emission reduction strategies to maximize long-term benefits.

Regarding energy demand of all scenarios, gasoline remains the predominant fuel type through the end year, while electricity's role grows significantly by 2060, particularly in the BEV and COM scenarios. These projections highlight the importance of strategic planning and policy decisions in supporting the shift towards a more electrified and sustainable energy system. All scenarios still project significant emissions, highlighting the need for more aggressive policies. These could include increasing the adoption of BEVs through higher subsidies and large-scale infrastructure development, such as expanding charging stations to support their widespread mobility (Mclaren et al., 2016). Additionally, further research and technological advancements are needed to produce more environmentally friendly vehicles. Carbon capture and storage may also be essential for achieving both ENDC and net-zero targets, particularly in the road transport sector. While other sectors may have greater potential for emission reductions, the contribution of the transportation sector is crucial for achieving overall emission reductions within the energy sector.

Acknowledgement

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