Supporting E-mobility focusing on Electric Two- and Three-wheelers and Policies on Urban Traffic Integration in Indonesia

Baseline Assessment of 2&3W in Indonesia

The International Climate Initiative (IKI) is an important part of the German government's international climate finance commitment. Since 2022 the IKI is implemented by the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close cooperation with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Federal Foreign Office (AA). Through the IKI, the ministries jointly support approaches in developing and emerging countries to implement and ambitiously develop the Nationally Determined Contributions (NDCs) anchored in the Paris Agreement. This includes measures to adapt to the impacts of climate change and to conserve and rebuild natural carbon sinks, taking into account environmental, economic and social concerns. The IKI also supports its partner countries in achieving the goals of the Convention on Biological Diversity (CBD). The three ministries jointly agree on the basic IKI framework. This includes the instruments that help ensure and verify the values and responsibilities of the IKI, the various funding calls and external communication.

The activities from IKI projects range, for example, from advising policy makers on capacity building and technology partnerships to risk hedging through innovative financial instruments. It also includes studies, project preparation advice for infrastructure development, and investment instruments for climate change mitigation or biodiversity conservation.

To date, IKI has approved more than 950 climate and biodiversity projects in over 150 countries worldwide with a total funding volume of almost 6 billion euros (2008-2022).

The program management, evaluations and technical assistance of the projects, as well as the management of IKI media and communication are supported by the IKI Office at the government owned Zukunft - Umwelt - Gesellschaft (ZUG) gGmbH.

Institute for Transportation Development Policy (ITDP) is a non-profit organization that works in cities worldwide in realizing a sustainable urban transit system as a way to cut greenhouse gas emissions and improve the quality of urban life. Founded in 1985, the Institute for Transportation and Development Policy (ITDP) has become a leading organization in the promotion of environmentally sustainable and equitable transportation policies and projects worldwide. ITDP Indonesia has been providing technical assistance to the provincial governments of DKI Jakarta, Medan, Semarang, and other cities for more than ten years on mass public transportation, parking systems and improving pedestrian facilities.

Executive Summary

The transport sector significantly contributes to greenhouse gas emissions in Indonesia, prompting the government to prioritize emission reduction and energy efficiency. This includes promoting non-polluting transport modes such as walking and cycling, promoting public transport, and accelerating the adoption of cleaner vehicles, such as electric two- and three-wheelers (E2&3W). In the project titled *“Supporting E-Mobility Focusing On Electric Two-And Three-Wheelers And Policies On Urban Traffic Integration In Indonesia”* " the Institute for Transportation and Development Policy (ITDP) Indonesia supported by the United Nations Environment Programme (UNEP) developed three main outputs as follows:

1. **Baseline Assessment of Two- and Three-Wheelers in Indonesia**
2. **Development of National Policies And Standards on Two- and Three-Wheelers Electric Mobility Transition in Indonesia**
3. **Guidelines On The Integration Of Electric Two- and Three-Wheelers In Urban Traffic**

The "Baseline Assessment of Two- and Three-Wheelers in Indonesia" offers insights into the country's 2&3W fuel economy using GFEI methodology, E2&3W adoption's impact on fuel efficiency and emissions, and an overview of Indonesia's current ICE and renewable energy policies. Serving as the first of three reports, it lays the foundation for subsequent policy recommendations to enhance E2&3W integration and sustainability in Indonesia's transportation sector.

Indonesia's transportation landscape is predominantly shaped by motorized two-wheelers (2W), which account for 85% of the motorized vehicle market with around 113 million registered vehicles. The widespread preference for motorized ICE 2W is largely driven by affordability, convenience, and supportive policy frameworks, including tax incentives, low prices, financing options, and a lack of transport demand management measures.

Based on the assessment of the trends, sales figures, engine displacements, body types, and fuel economies of 2W vehicles in Indonesia between 2017 and 2021, Internal Combustion Engine (ICE) 2Ws show an overall increase in fuel consumption, reaching 1.94 l/100 km in 2021, worse compared to Vietnam's 2020 2W fuel economy of 1.76 l/100km and India’s 2018 2W fuel economy of 1.74 l/100km. Nevertheless, when compared to the light-duty vehicle (LDV) fuel economy in Indonesia at 8.1 l/100km in 2019, the 2W fuel economy still fares better.

The adoption of E2W has a significant impact on improving fuel economy and emissions. Despite a very low adoption rate (less than 1.5% market share in 2021), E2W improves national fuel consumption by 0.01 l/100km and lowers the fleet emission factor by 0.3% from 63.55 gCO_2/km to 63.34 gCO_2/km. Under the Business-As-Usual (BAU) scenario of vehicle growth and carbon density factor improvement target from the government, transitioning to 100% E2W penetration by 2035 could slash emissions by almost 50% compared to 2021 levels. The same result can be achieved without any additional E2W adoption only if the ICE fleet emission factor is improved by 44.8%. Nevertheless, to achieve a 2W emission factor of 20 gCO_2/km (65% improvement), the carbon intensity of the electricity network would have to be increased by 40% compared to the 2035 BAU scenario.

To seize this opportunity, policies must promote E2W adoption, enforce stricter emission standards, and address carbon intensity in electricity generation. However, certain policies, like high domestic content requirements, may hinder E2W adoption in the early market, necessitating temporary relaxation and reduced access barriers. Additionally, to accelerate E2W and E3W adoption, both fiscal and non-fiscal disincentives for ICE 2W and 3W vehicles are essential, including emissions-based taxes and stricter standards. Local-level vehicle disincentives, like those in Jakarta, frequently exempt 2W and 3W vehicles from traffic restrictions and other push policies. Therefore, providing preferential incentives for E2W and E3W compared to ICE 2W and 3W vehicles is challenging without reforming the current push policy framework. Navigating Indonesia's 2W sector demands a multi-faceted approach to achieve sustainable mobility goals, blending regulatory frameworks, technological innovations, and stakeholder partnerships for a cleaner, greener, and more efficient transportation future.

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Introduction

Context

Air pollution and greenhouse gas emissions have become global problems with very significant impacts. In Indonesia, 27% of the country's greenhouse gas emissions in 2020 were contributed by the transport sector[1]. Transport emissions are one of the main contributors - vehicle emissions increased rapidly between 2005 and 2016, at the rate of about 10% annually. While the exponential growth of vehicles, especially motorized 2Ws which is growing around 12% each year, is a major factor, the current use of poor quality fuels in most Indonesian cities in Indonesia also exacerbates transport sector emissions. Given Indonesia's commitment to reduce emissions (an unconditional 29% reduction in GHG emissions by 2030 compared to a business-as-usual scenario, based on Indonesia's Nationally Determined Contribution), emissions from the transport sector are one of the key sectors to be addressed.

Apart from reducing emissions, Indonesia is also seeking to improve fuel and energy efficiency in the transport sector. In 2019, the transport sector consumed nearly 200 million barrels of gasoline[2]. Two main approaches can be taken to reduce emissions and energy consumption in the transport sector: promoting the transition to non-polluting and energy-efficient modes of transport, such as walking, cycling and public transport, and promoting cleaner vehicles, such as through the adoption of stricter fuel emission standards, as well as accelerating the adoption of electric vehicles or other low-emission vehicles.

In the National Energy General Plan (Rencana Umum Energi Nasional/RUEN), Indonesia has set a target of 2.1 million E2W electric vehicles and 2,200 E4W by 2025, and to electrify 10% of the national public transport fleet. The plan goes hand-in-hand with the target to increase the country's new and renewable energy mix to 23% in 2025 and 31% in 2050 as well as reduce oil consumption to less than 25% in 2025 and 20% in 2050

[1] Climate Transparency. (2021). *Laporan Climate Transparency: Membandingkan Aksi Iklim G20 Menuju Net Zero.* [Online]. [Accessed 2022]. Available from https://www.climate-transparency.org

[2] Kusdiana, Dadan. 2021. *Kebijakan Energi Alternatif di Sektor Transportasi* [Webinar]. Indonesian Ministry of Energy and Mineral Resources.

Part A:
Baseline Assessment On 2&3 Wheelers in Indonesia

1. Current 2W Market in Indonesia

Motorized 2W is the most popular transport mode in Indonesia. There are 113 millions motorized vehicles currently registered in Indonesia, or around eighty-five percent of motorized vehicles registered as private and public vehicles (see Figure 1). At least 8 out of 10 Indonesian households have one motorized 2W. This number continues to grow at an annual rate of 4.5%. As a result, Indonesia is ranked as one of the largest growing markets for motorized 2W worldwide.

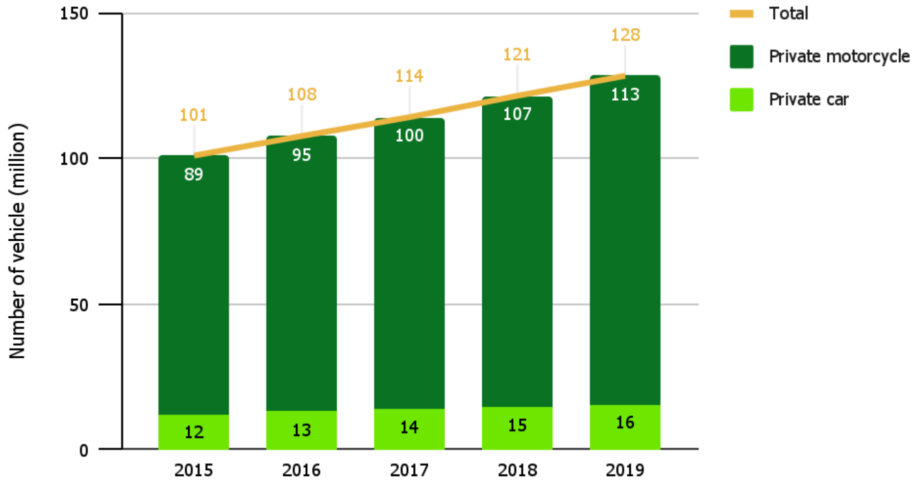


Figure 1. Private vehicle ownership in Indonesia, 2015-2019

Figure 2. New motorized 2W Sales in Indonesia

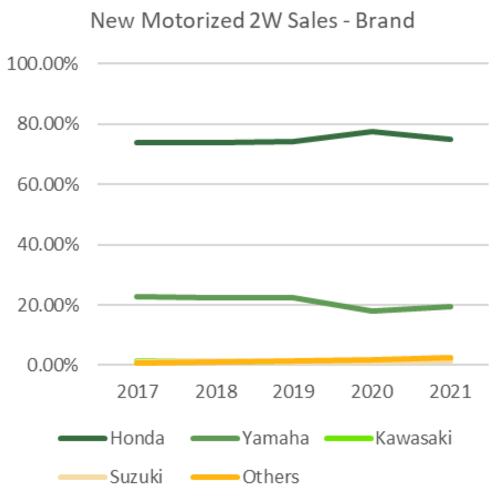
The total number of motorized 2Ws in Indonesia is directly related to the number of motorized 2Ws sold each year. The number of new motorized 2Ws sold domestically from 2017 to 2019 increased on an annual basis. In 2020, motorized 2W sales dropped significantly, possibly due to the impact of the COVID-19 pandemic, and sales fell by up to 44% year-over-year. Sales in 2021 are up, but lower than the annual sales of the last three years before the pandemic.

1.1. Brands

National sales figures[3] show that Honda dominates the motorized 2W market in Indonesia. Honda's annual market share has remained above 73% since 2017. Its closest competitor, Yamaha, hovers between 18% and 23%, with 2020 being the lowest.

1.2. Engine Displacement

From the engine displacement (capacity), even though the small motorized 2W segment below 150cc is shrinking year by year, it still dominates the market. On the contrary, big motorized 2Ws with displacements of 150-250cc and above are slowly gaining popularity, especially 150-250cc. Interestingly, the E2W is also gaining market share. E2W represents more than 1.5% of total sales in 2021, compared to less than 0.1% in 2017.



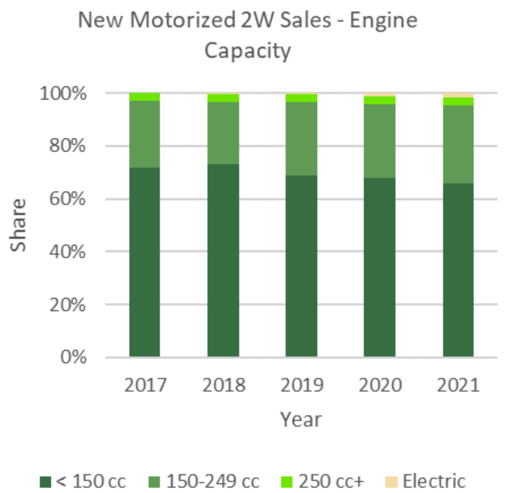


Figure 3 (left). New motorized 2W Sales Based on Brand

Figure 4 (right). New motorized 2W Sales Based on Engine Capacity

[3] Motorcycles Data. 2022. Electric Scooter and Motorcycles Archives - Motorcycles Data. [online] [Accessed 2 September 2022]. Available from https://www.motorcyclesdata.com

1.3. Body Type

Scooter-type motorized 2Ws using automatic transmission dominate the market, growing from 72.5% in 2017 to 83.7% in 2021. While manual transmission motorized 2Ws are steadily declining, underbone motorized 2W (with semi-automatic transmission) also continues to lose market share significantly. Its total share in 2021 is slightly lower than 5.5%, compared to 13.6% in 2017.

Figure 5. Motorized 2W Body Types From left to right: Underbone, Scooter, and Motorcycle (source: astra-honda.com)

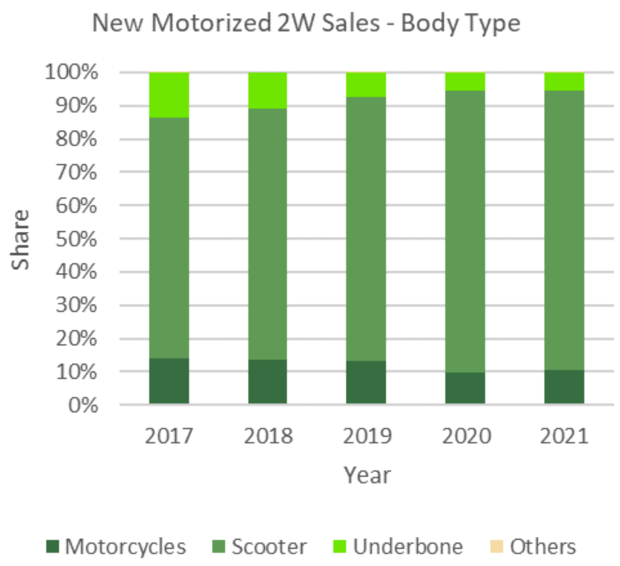


Figure 6. New motorized 2W Sales Based on Body Type

2. Methodology

2.1. GFEI Methodology

The Global Fuel Economy Initiative (GFEI) has developed a methodology to analyze trends in global average fuel consumption. The methodology has been established to standardize the calculation of baseline fuel consumptions in all countries. The formula for calculating the baseline fuel consumption according to the GFEI method is as follows:

$$FE = \frac{\sum_i^n Reg_i \times FE_i}{\sum_i^n Reg_i}$$

With:

$$FE = weighted\ average\ fuel\ economy$$

$$Reg_i = number\ of\ newly\ registered\ vehicles\ of\ type\ i$$

$$FE_i = fuel\ economy\ of\ vehicle\ of\ type\ i$$

Figure 7. GFEI Fuel Economy Calculation

Generally, the data required for this calculation are the number of newly registered vehicles, vehicle composition, fuel type, engine type, year of manufacture, emission technology, and energy efficiency rating (fuel economy) of each type of vehicle.

2.2. Data Collection

In developed countries, fuel economy baseline calculations are usually supported by an extensive publicly available fuel economy database for all vehicle segments. Meanwhile, in developing countries, data availability is often a major issue in monitoring and evaluation activities, including establishing fuel consumption baselines. In Thailand, for example, the baseline fuel consumption is calculated from the number of vehicles sold over a three-year period (from 2013 to 2015). Meanwhile, the Philippines' baseline is calculated from 2013 data only.

Indonesia is no exception: there is publicly available 2&3W sales data, including exports and imports between 2011 and 2020, but is limited at an aggregated level. Official sources such as the Ministry of Transport also do not have 2&3W data at the level of detail required for the GFEI calculation methodology. Therefore, while it is indeed ideal to have official national statistics to calculate baseline fuel economy, the data used in this calculation was obtained from a paid source (motorcycledata.com). The dataset contains the following information:

1. Vehicle brand
2. Vehicle model
3. 2&3W engine types (ICE or electric)
4. 2&3W engine displacement/capacity (cc)
5. 2&3W year of vehicle registration (2017-2021)

The scope of calculation in this report is to identify the fuel economy baseline of the national 2&3W fleet in Indonesia between 2017 to 2021.

2.3. Fuel Economy Baseline Calculation

To calculate fuel consumption, annual fuel efficiency data for selected motorized 2W electric models was first collected. The selected models are in the top 95% of motorized 2W sold in one year, exceeding the minimum of 85% required by the Global Fuel Economy Initiative (GFEI)[4]. The sales of the selected models, grouped by brand, are shown in the table below.

Table 1. Motorized 2W type for calculation sample grouped by brand

Number of Motorized 2W Sales					
Parameter	**Sales 2017**	**Sales 2018**	**Sales 2019**	**Sales 2020**	**Sales 2021**
Total Sales (unit)	5,930,698	6,452,156	6,627,203	3,734,047	5,182,787
Top 95% Sales (unit)	5,642,789	6,135,571	6,304,979	3,552,209	4,931,947
Top 95% Sample Breakdown					
Brand	**Sales 2017**	**Sales 2018**	**Sales 2019**	**Sales 2020**	**Sales 2021**
Gesits			22,600	26,522	45,561
Honda	4,285,689	4,667,429	4,805,428	2,836,058	3,783,514
Kawasaki	60,552	33,464	33,016	44,293	76,796
Piaggio					16,079
Suzuki	32,420	35,390	28,575	12,149	53,632
Viar	19,680	25,200			

[4]GFEI. Draft Guideline for Fuel Economy Baseline-Setting.[Online]. [Accessed 2022]. Available from: GFEI

Yamaha	1,244,448	1,374,088	1,415,360	633,187	956,365
Sample Percentage from Total	**95.15%**	**95.09%**	**95.14%**	**95.13%**	**95.16%**

	Is not part of the top 95% and thus not taken into account in the calculation

The annual fuel consumption of each model was collected from secondary data sources such as official brand websites, news websites, and review websites. Please note that measurement methods may vary between each model due to limited data sources. If available, official website or brand specifications are preferred. The ECE R40 Euro 3 compliant method is the most commonly used fuel economy test method.

The collected fuel consumption (km/l) of the selected model is respectively converted into fuel economy (l/100km) to get a better idea of the average energy required to drive a certain distance. The fuel consumption value is inverted and multiplied by 100 to get the l/100 km value. In order to obtain the average annual fuel economy, the weighted average method is adopted and the average value is calculated proportionally according to the sales volume of each model. The energy consumption of E2W in kWh/km is converted to l/km using a conversion factor, assuming that 1 liter of gasoline is equivalent to 8.9 kWh of electricity[5].

[5] Nrcan.gc.ca. 2022. Understanding the tables. [online]. [Accessed 2 September 2022] Available at: <https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/buying-electric-vehicle/understanding-the-tables/21383>

3. Fuel Economy Baseline of 2W in Indonesia

3.1. National 2W Fuel Economy Between 2017-2021

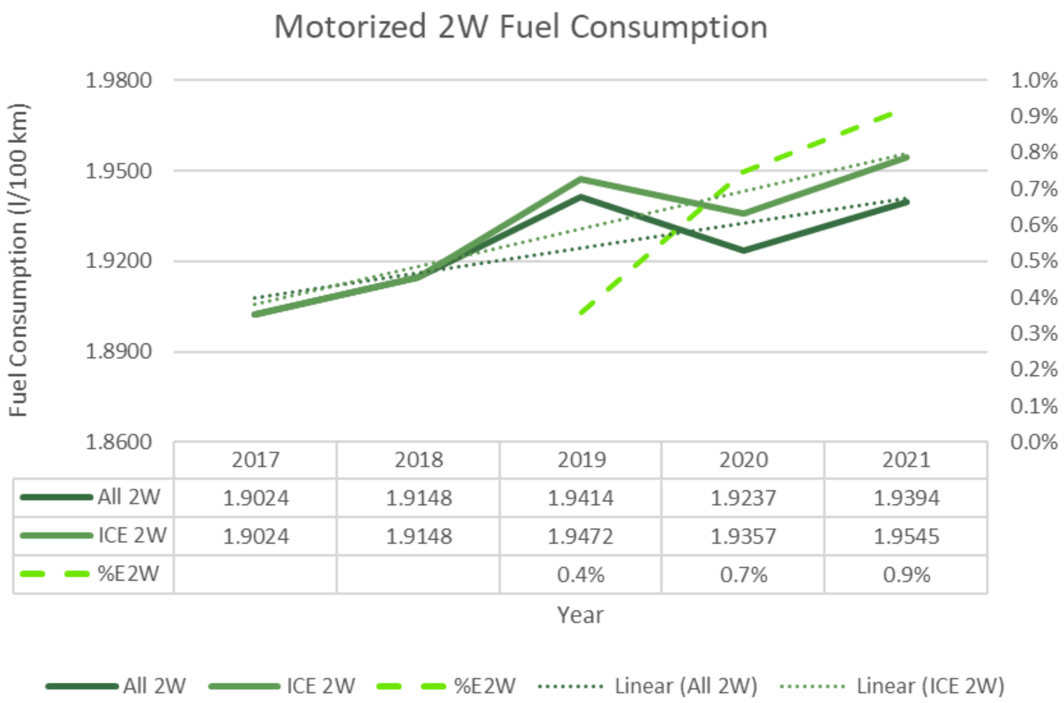


Figure 8. Motorized 2W Weighted Average Fuel Consumption

The national 2&3W fleet baseline fuel economy, as in the weighted average of the fuel economy of various 2W models, from 2017 to 2021 is presented above. Overall, the weighted average fuel economy of the motorized 2W (the ICE 2W in particular) continued to increase each year and only decreased in 2020. From 1.9 l/100 km in 2017, the fuel economy of the ICE 2W increased to 1.95 l/100 km in 2021 – a five-year increase of 2.7%.

Dividing the data into two groups, namely 1) a fuel economy baseline that only includes ICE motorized 2W data, and 2) a fuel economy baseline that includes E2W sales, clearly shows that the adoption of electric vehicles can improve fuel economy. In 2021, the adoption of E2W improved the national 2W fleet fuel economy has improved by 0.5%, although their market share has not even reached 1% of the top 95% sold models.

3.2. Fuel Economy By Brand, Engine Capacity, and Body Type

The fuel economy of small motorized 2W under 150cc 2W is second only to E2W, while the fuel consumption of 250cc 2W and above is the worst. However, the sales share of the small motorized 2W is gradually decreasing, although it still holds a market share of more than 65%. Conversely, sales of the 2W 150-249cc 2W increased substantially. Albeit there is also a year-on-year increase in 150-249cc 2Ws fuel economy, the overall annual fuel economy continued to increase.

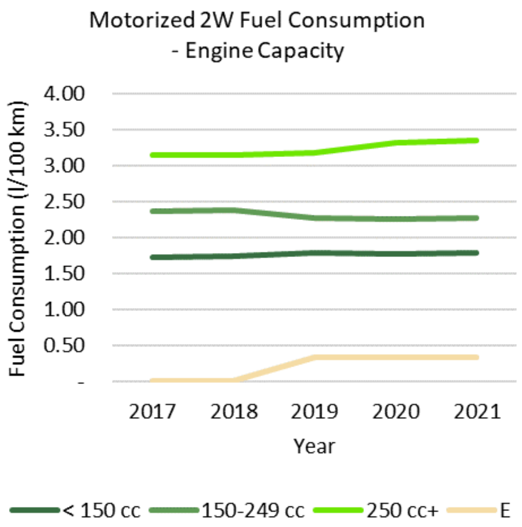


Figure 9. Motorized 2W Fuel Consumption Based on Engine Capacity

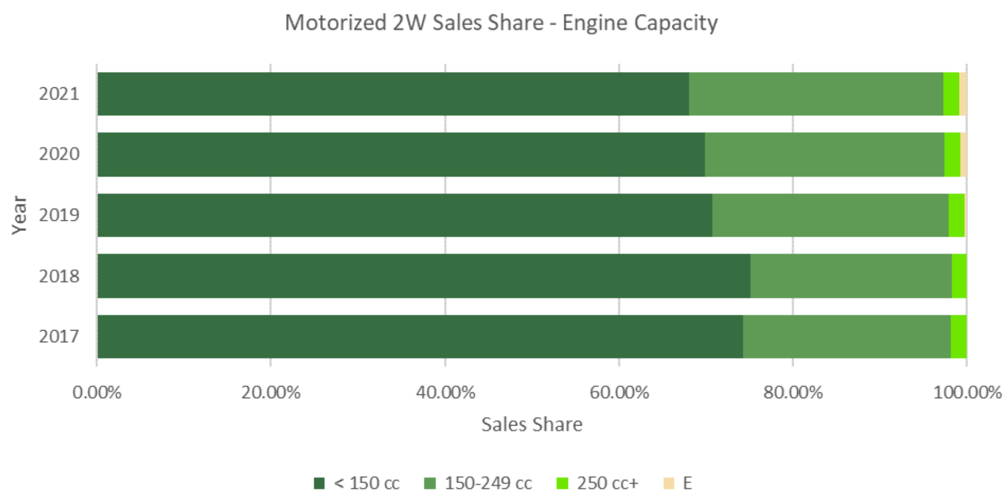
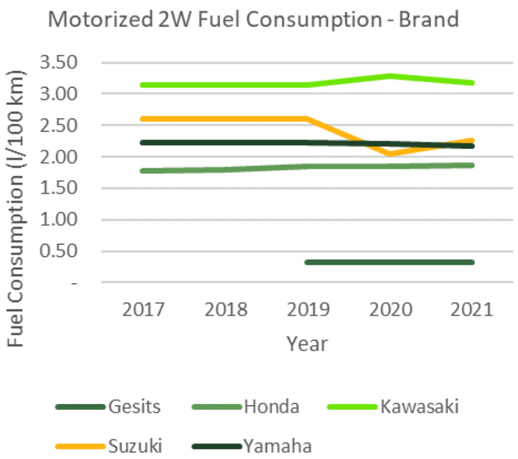


Figure 10. Motorized 2W Sales Share Based on Engine Capacity

It is worth mentioning that each brand and body type of motorized 2W has its own unique fuel economy. Honda has the lowest fuel economy of all brands, second only to Gesits which represents the E2W segment. Meanwhile, Kawasaki which mainly markets large motorized 2W has the highest average fuel economy.

Based on the body type, in 2017 scooters consume more fuel on average than the underbone motorized 2Ws. However, the fuel economy of the scooter segment continues to improve and became better than the underbone segment in 2021. At the same time, motorcycle type motorized 2Wa consume more fuel than other motorized 2W body types.



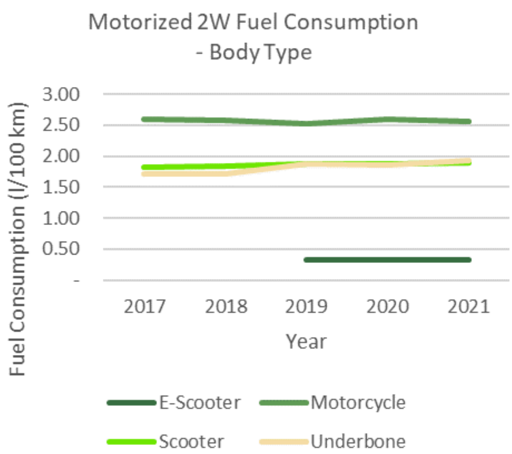


Figure 11 (left). Motorized 2W Fuel Consumption Based on Brand

Figure 12 (right). Motorized 2W Fuel Consumption Based on Body Type

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4. Motorized 2W Fleet Emission Factor

4.1. 2021 Emission Factor Baseline

To take the analysis a step further, the baseline GHG emissions of Indonesia's 2W motorized vehicle fleet were also estimated for 2021. To better represent CO_2 emissions from motorized 2W use, a life cycle analysis was used to track emissions from vehicle production to vehicle use.

For ICE motorized 2W, life cycle analysis includes vehicle production, fuel production, fuel combustion, and vehicle disposal. Slightly different, the E2W life cycle analysis begins with vehicle production, battery production, power generation, and vehicle disposal. Fuel consumption rates will determine emissions from fuel production and combustion, so better fuel consumption can lead to reduced emissions. Table 2 below presents the assumptions used for the life cycle emissions calculations.

Table 2. Energy and Carbon Assumption for Life Cycle Analysis

Life Cycle Stage	Emission or Energy Factor
Vehicle Production	41.8 MJ/kg vehicle[6]
Fuel Production	225 g CO2/litre[7]
Fuel Combustion	2416.8 g CO2/litre[8]
Battery Production	500 MJ/kWh[9]
Electricity Production	Vary between each year[10]
Vehicle Disposal	852 g CO2/kg vehicle[11]

[6] Sato, F. E., & Nakata, T. (2020). Energy consumption analysis for vehicle production through a material flow approach. *Energies*, *13*(9), 2396. https://doi.org/10.3390/en13092396

[7] ITDP Indonesia (2021). *Timetable and Roadmap for Ride Hailing Fleet Electrification.*

[8] Ibid

[9] Romare, Mia and Dahllöf, Lisbeth (2017). The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-Ion Batteries, *IVL Swedish Environmental Research Institute.*

[10] ITDP Indonesia (2021). *Timetable and Roadmap for Ride Hailing Fleet Electrification.*

[11] Ibid

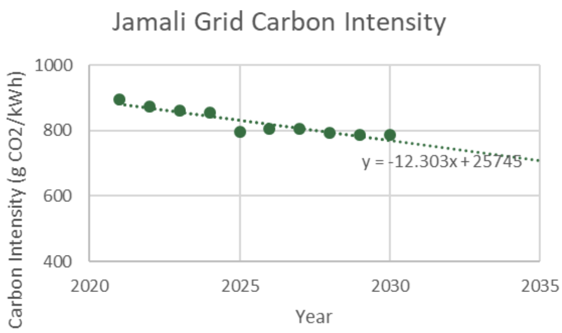

Figure 13. Regression for Jamali Electricity Grid Carbon Intensity to 2035

Emission factor of the energy source was firstly identified in order to calculate the emissions in the production stage. The energy mix of the electricity network is determined according to the forecasts of the RUPTL 2021-2030. Natural gas, coal, and oil are used as energy sources for electricity After 2030, carbon intensities are interpolated using linear regression, as shown in Figure 13.

Table 3 below shows the basic assumptions for the ICE 2W and E2W. Battery capacity assumptions are based on the current most popular model in Indonesia.

Table 3. Assumptions for motorized 2W Lifecycle Analysis

Assumptions	Value
General Variables	
Motorized 2W Lifetime	10 years
Annual VKT	10,620 km[12]
ICE motorized 2W Fuel Consumption Improvement	0.5% annually[13]
Electric motorized 2Ws	
Battery Capacity	1.44 kWh/battery[14]
Battery Replacement during Lifetime	3 times[15]

[12] Daily distance travelled of 36 km and 295 active days annually

[13] Kimura, S., Suehiro, S., & Doi, N. (2018). An Analysis of Alternative Vehicles' Potential and Implications for Energy Supply Industries in Indonesia. Economic Research Institute for ASEAN and East Asia

[14] Gesits. 2020. Gesits G1. [Online]. [Accessed 2022]. Available from: gesitsmotor.com

[15] Anshori, Luthfi. 2019. Setelah 3 Tahun, Baterai Gesits Bisa Ditukar Tambah. Detik.com. [Online]. [Accessed 2022]. Available from https://oto.detik.com/motor/d-4690998/setelah-3-tahun-baterai-gesits-bisa-ditukar-tambah

Assumptions	Value
Electric motorized 2W Fuel Consumption Improvement	0.2% annually[16]

For this calculation, the motorized 2Ws are categorized based on their body type and engine displacement class. Motorized 2Ws under 150 cc are defined as small motorized 2Ws and those beyond 150 cc are defined as large motorized 2Ws. Since it is assumed that the electric motorized 2Ws all have the same battery capacity, they do not have size classification as such. Table 4 below presents the classification and market share in 2021, as well as their characteristics to determine each group's emission factor.

Table 4. motorized 2W Classification Based on 2021 Data

Body Type	Class	Market Share	Average Weight (kg)	Weighted Average Fuel Consumption (2021)	
Scooter	E-Scooter	0.92%	94.5	0.029	kWh/km
	Small Scooter	65.6%	96.7	0.018	l/km
	Large Scooter	29.88%	129.8	0.023	l/km
Motorcyle	Large Motorcyle	8.79%	130.8	0.026	l/km
Underbone	Small Underbone	2.44%	105.9	0.017	l/km
	Large Underbone	2.36%	121.3	0.022	l/km

Table 5. Motorized 2W Emission Factor Calculation for 2021

2021		ICE variables		Electric variables		General variables		Emission factor
Body Type	Class	Fuel Prod.	Fuel Comb.	Battery Prod.	Electricity Prod.	Vehicle Prod.	Disposal	
Scooter	Electric	-	-	5.05	25.75	9.24	0.76	**40.79**
	Small	4.55	43.12	-	-	9.45	0.78	**57.90**
	Large	5.74	54.42	-	-	12.68	1.04	**73.89**

[16] Kimura, S., Suehiro, S., & Doi, N. (2018). An Analysis of Alternative Vehicles' Potential and Implications for Energy Supply Industries in Indonesia. Economic Research Institute for ASEAN and East Asia

2021		ICE variables		Electric variables		General variables		Emission factor
Body Type	**Class**	**Fuel Prod.**	**Fuel Comb.**	**Battery Prod.**	**Electricity Prod.**	**Vehicle Prod.**	**Disposal**	
Motorized 2W	**Large**	6.55	62.06	-	-	12.78	1.05	**82.44**
Underbone	**Small**	4.30	40.73	-	-	10.35	0.85	**56.23**
	Large	5.55	52.61	-	-	11.86	0.97	**70.99**
Weighted Average for All 2W (g CO2/km)								**63.34**
Weighted Average for ICE 2W only (g CO2/km)								**63.55**

Overall, the emission factor of the overall motorized 2W in 2021 reach 63.34 gCO_2/km. Meanwhile, if E2Ws are excluded from the calculation, the emission factor becomes slightly higher at 63.55 gCO_2/km. Although the E2Ws consist less than 1% of the market sample, their adoption brought the national fleet emission factor lower by 0.3%.

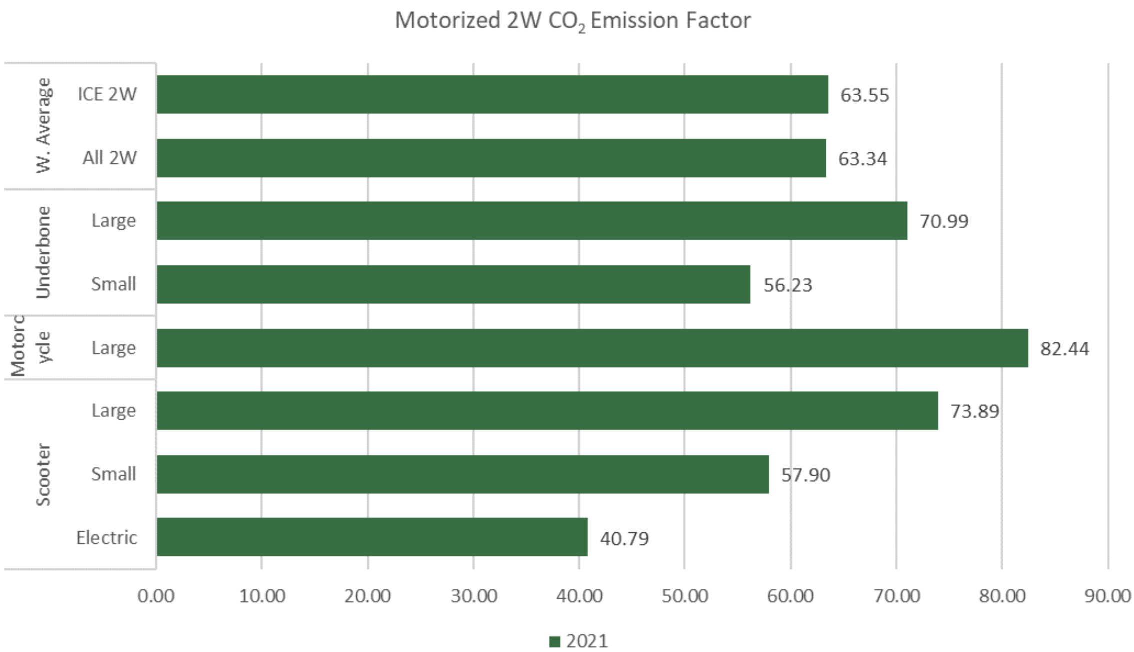

Figure 14. Motorized 2W Emission Factor by Body Type

From the life cycle emissions assessment, it appears that the emission factor of underbone 2Ws and small scooters, which are 56.23 and 57.9 gCO_2/km respectively, is second only to E2Ws. In contrast, large motorized 2Ws have the worst emission factor at 82.44 gCO2/km, 75% of which comes from fuel combustion. The E2W has the best emission factor at 40.79 gCO2/km, of which 63% comes from electricity production. Life cycle emission analysis of other types of motorized 2W shows that fuel combustion contributes around 73-75% of the emission factor. This clearly shows that the transition to a cleaner grid will have a significant impact on reducing 2W lifecycle emissions.

4.2. 2035 Emission Factor Projection

For emission factor calculations, the 2021 fuel economy was used and then projected to 2035, as the target year of a GFEI has a target to reduce 2W and 3W CO_2 emissions by 80% by 2035 compared to the reference from 2005.

4.2.1. Business-As-Usual (BAU) Grid Carbon Intensity Improvement

a. No improvement in E2W Adoption

Without any improvement in E2W adoption, BAU improvement in emission factor based on the RUPTL projection, and BAU improvement in fuel economy rate, the overall emission factor for the national motorized 2W is expected to increase from 63.34 gCO_2/km to 57.6 gCO2/km or only a 9% improvement compared to 2021.

Table 6. Motorized 2W Emission Factor Calculation for 2035

2035		ICE		Electric		General		Total
Body Type	**Class**	**Fuel Prod.**	**Fuel Comb.**	**Battery Prod.**	**Electricity Prod.**	**Vehicle Prod.**	**Disposal**	
Scooter	**Electric**	-	-	4.00	19.84	7.32	0.76	31.92
	Small	4.24	40.20	-	-	7.49	0.78	52.70
	Large	5.35	50.74	-	-	10.05	1.04	67.18
Motorized 2W	**Large**	6.10	57.85	-	-	10.13	1.05	75.14
Underbone	**Small**	4.01	37.97	-	-	8.20	0.85	51.03
	Large	5.17	49.04	-	-	9.40	0.97	64.59
Weighted Average ALL (g CO2/km)								**57.60**
Weighted Average ICE (g CO2/km)								**57.84**

b. 100% E2W Penetration

The previous analysis above shows that the emission factor of E2W fleet is estimated to be 31.92 gCO_2/km by 2035 under BAU grid improvement (based on the plan in RUPTL), meaning that a 100% E2W fleet penetration will improve the national fleet emission factor up to

49.6% compared to 2021. The same result can be achieved without any additional E2W adoption only if the ICE fleet emission factor is improved by 44.8%.

c. RUEN Target: 13 Million Units of E2W by 2030

Nevertheless, 100% E2W fleet penetration by 2035 might not be a realistic target to pursue, given the current uptake of E2W. Indonesia's 2030 E2W adoption target is 13 million units. Assuming a 5% CAGR (compound annual growth rate) of motorized 2W population, the target will be equivalent to 5% of the total fleet. With BAU grid and ICE fuel economy improvements, it will only result to 10.7% emission factor improvement compared to 2021.

d. 40% Emission Factor Improvement

A study by ICCT mentioned a target of improving Indian 2W fleet emission factor of 2W fleet by 38% in 2030. Targeting a 40% improvement of emission factor (38 gCO_2/km) in 2035 compared to 2021 BAU, almost 76.5% E2W penetration will be needed. On the other hand, if there is no improvement in E2W penetration, around 34% increase in ICE 2W fleet emission factor is required. Figure 15 below shows the trade-off between E2W penetration rate and required ICE 2W emission factor reduction to achieve 40% emission factor improvement target.

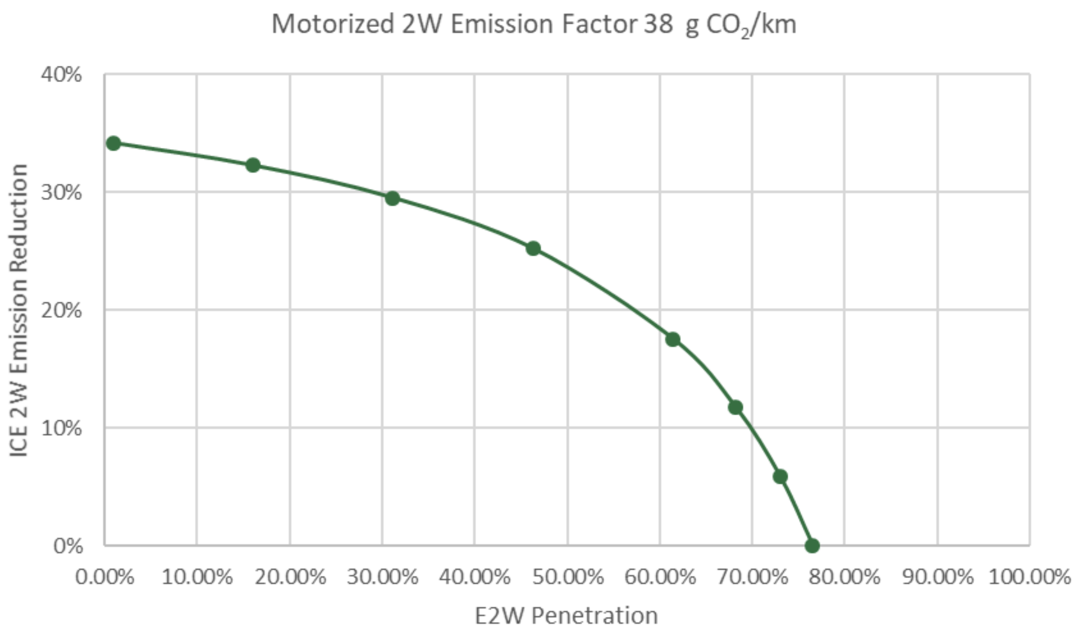

Figure 15. E2W Penetration and ICE Emission Factor Improvement Impact

4.2.2. Sensitivity Analysis on the Carbon Intensity of Electricity Generation

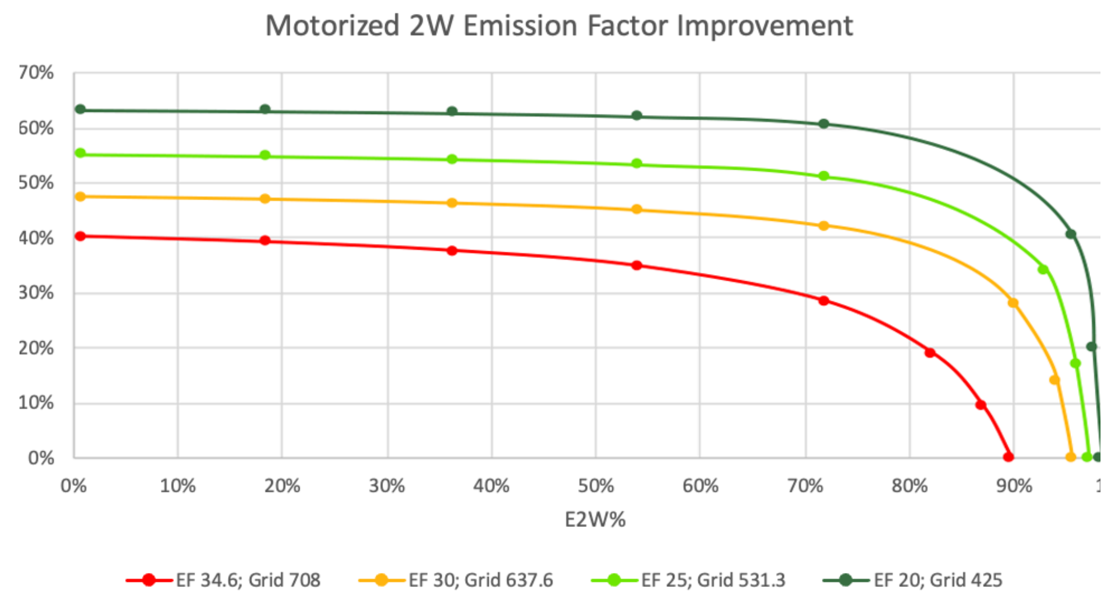

Figure 16. Sensitivity Analysis of the Carbon Intensity of Electricity Generation

Carbon intensity of electricity generation, which is the amount of CO_2 emitted per one unit of electricity at one kilowatt-hour (gCO_2/kWh), is another determining variable for lifecycle emission factor, especially for electric vehicles.

With the BAU scenario of 708 gCO_2/kWh carbon intensity in 2035, even a 100% E2W penetration would still result in a fleet emission factor of 31.92 gCO_2/kWh. Several emission factor improvement scenarios are assessed with reduction intervals of 5 gCO_2/km, up to 20 gCO_2/km (more than 65% improvement than the estimated overall emission factor) to understand how the grid carbon intensity should be improved to reach the targets.

Assuming an all-electric fleet, it would need at least 10% grid carbon intensity improvement (638 gCO_2/kWh) compared to BAU grid improvement target to reduce the emission factor to 30 gCO_2/km in 2035. Carbon intensity of 531 gCO_2/kWh (25% improvement) is needed to reach 25 gCO_2/km emission factor and last, to reach 20 gCO_2/km emission factor, a 40% grid intensity improvement (425 gCO_2/kWh) will be needed.

The calculation above is based on 100% electric motorized 2W adoption with rounded carbon intensity improvement. If the electrification is less than 100%, Figure 16 shows the need for ICE improvement with the desired electrification level.

Table 7. ICE Combustion Technology Improvement and E2W Penetration

ICE Combustion Technology Improvement and E2W Penetration

In 2021, ICCT published a study regarding the cost-effectiveness of ICE combustion improvement and E2W penetration increase to reach certain emission reduction[17]. The study examined large motorized 2W, small motorized 2W, and scooters as the cost-effectiveness would differ between each type. However, in this section, only scooter type-2W would be discussed as it represents over 60% (small scooter) of the motorized 2W market.

ICCT exercises the compliance cost of E2W adoption and ICE technology improvement. The CO_2 compliance cost was analyzed using two approaches the first being ICE technology exhaustion and the second being cost-beneficial penetration of E2W. Using the first approach, the maximum level of CO_2 reduction by implementing ICE technology improvement was assessed before the transition to E2W is being considered. While the second approach evaluates the possible CO_2 reduction from increasing E2W market penetration. It is assumed that no E2W vehicles would be sold until the cost parity with the ICE technology improvement is achieved.

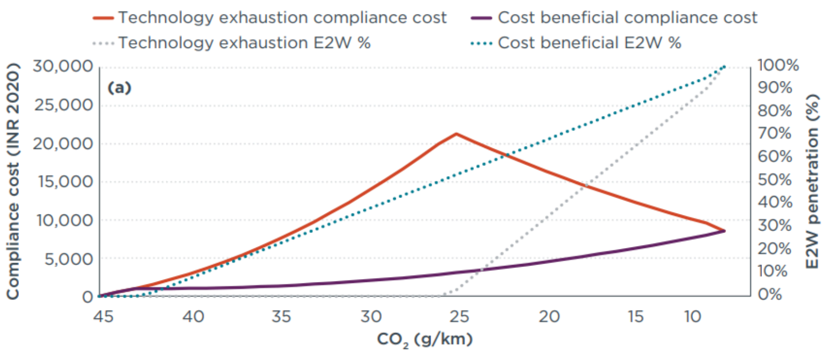

Figure 17. Compliance cost in 2030 for a scooter, ICE, and E2W packages[18]

Figure 17 shows the compliance cost explained before for the scooter model in 2030. ICE technology improvement would allow CO_2 reduction to above 25 gCO2/km but with a high cost of more than 20,000 INR. On the other hand, to reach the same level of CO_2 emission, electric motorized 2W adoption would only require less than 4,000 INR. After the introduction of electric scooters, the overall compliance cost would rapidly decrease.

Based on the second approach, the cost-benefit analysis, the penetration of e-scooter would be started beyond the emission of 44 gCO_2/km. It is evident that the escalation of electric scooter adoption would be more cost-effective, especially for lower CO_2 emission rates.

[17] Anup, S., Deo, A., and Bandivadekar, A. (2021). *Fuel Consumption Reduction Technologies For The Two-Wheeler Fleet In India*. Washington: International Council on Clean Transportation.
[18] Ibid.

5. Conclusions

A number of key takeaways from the assessment are as follows:

1. **In 2021, the 2W baseline fuel economy in Indonesia is 1.94 l/100 km.** It is worse compared to Vietnam's 2020 2W fuel economy of 1.76 l/100km[19] and India's 2018 2W fuel economy of 1.74 l/100km[20]. Nevertheless, when compared to the light-duty vehicle (LDV) fuel economy in Indonesia at 8.1 l/100km in 2019, the 2W fuel economy still fares better.

2. **The adoption of E2W has a significant impact on improving fuel economy.** Even with a very low adoption rate (less than 1.5% market share in 2021), E2W improves fuel consumption by 0.01 l/100km. This is due to the fact that the fuel economy of the most popular E2W model in Indonesia is currently 0.32 l/100km, far better compared to 1.78 l/100km for a typical small scooter.

3. **Small scooters and small underbones, or motorized 2W with smaller engine displacement in general, have better fuel economy than other ICE 2W models**. The market decline of these models in recent years and the rise of 2Ws with larger engine displacement (>150 cc) are increasing the national fuel economy of 2W fleets. Limiting the allowed engine displacement, or providing disincentives such as additional taxes for 2W with 150 cc engine capacity or more, could help achieve lower fuel economy in the near term.

4. **The national emission factor for the 2W fleet in 2021 is 63.34 gCO_2/km.** Given this value, the contribution of 2W to greenhouse gas emissions for a given area can be estimated. For example, assuming an annual vehicle kilometer traveled (VKT) by 2W fleets in Jakarta of 1.2 billion kilometers[21], the GHG emissions from 2W in Jakarta can be estimated at approximately 76 million tons of CO_2.

5. **According to the life cycle emissions analysis based on 2021 data, E2W currently has the lowest emissions at 40.79 gCO_2/km**, while the large ICE 2W (>150cc) has the worst emissions level at 82.44 gCO_2/km. For E2W, electricity production accounts for 63% of total emissions, and fuel production accounts for 73-75% of life cycle emissions for ICE 2W. Under the BAU grid carbon intensity and ICE 2W fuel economy improvement scenario, the life cycle emission factor of the 2W fleet will be reduced to 58.90 gCO_2/km by 2035. To further reduce the emission factor, increased E2W penetration should be combined with better ICE combustion. For example, to achieve a 40% improvement to 35.4 gCO_2/km, ICE 2W fuel economy would need to be improved by 40% if there is no increase of E2W market

[19] Tran, D. S., Le, H., & Yang, Z. (2022). Two-wheelers in Vietnam: A baseline analysis of fleet characteristics and fuel consumption in 2019 and 2020. Working Paper, (2022-08).

[20] Global Fuel Economy Initiative. (n.d.). Vehicle types. Global Fuel Economy Initiative; www.globalfueleconomy.org. Retrieved September 2, 2022, from https://www.globalfueleconomy.org/toolkit/vehicle-types

[21] Assuming an annual km travelled per vehicle of 10,620 km and the total national population of motorized 2W of 113 million

share. Otherwise, E2W adoption up to 87.3% is needed if there is no fuel economy improvement of ICE motorized 2W.

6. **Even 100% E2W penetration will not achieve a 20 gCO2/km (65% improvement) emission factor by 2035 without a more aggressive grid carbon intensity improvements.** To achieve a 2W emission factor of 20 gCO2/km, the carbon intensity of the electricity network would have to be increased by 40% compared to the 2035 BAU scenario.

Part B:
Overview of 2&3 Wheelers and Renewable Energy Policies in Indonesia

1. Current Policies and Standards for 2&3W

As the most popular mode in Indonesia, there are numerous policies to regulate and manage 2&3W, especially the motorized 2W. This chapter aims to provide an overview of the main policies and regulatory standards for 2&3W in Indonesia, organized into the following groups:

- Vehicle operations
- Vehicle specifications and standards
- Demand-side fiscal regulations
- Supply-side fiscal regulations

In Indonesia, vehicles are classified into two general categories: motorized vehicles and non-motorized vehicles. Based on the vehicle type, motorized vehicles are further classified into motorized 2&3Ws, passenger cars, buses, logistic cars, and special vehicles. With the introduction of electric vehicles, a new category has been introduced to accommodate electric personal mobility devices such as e-bikes, e-kick scooters, hoverboards, and e-unicycles.

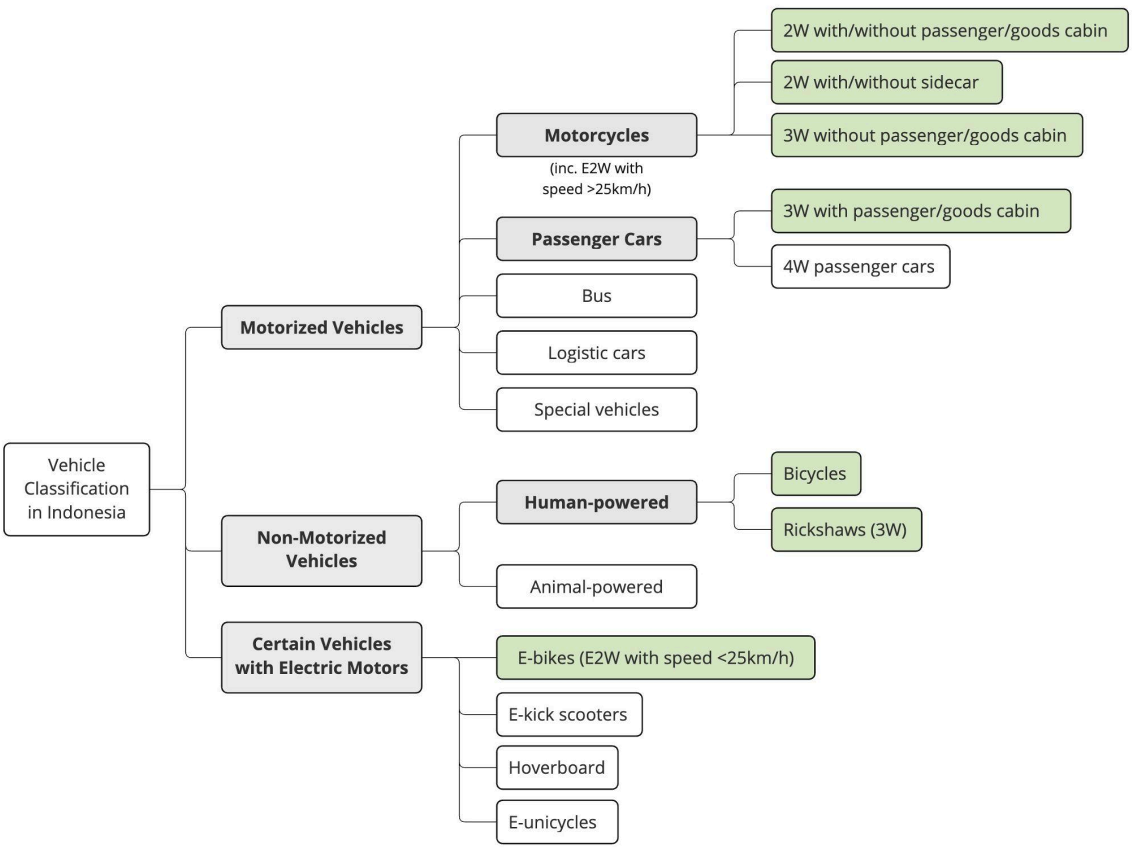

Figure 18. Vehicle classification in Indonesia

The “motorized 2W” vehicle group is further divided into L1, L2, L3, L4, and L5, based on the number of wheels, wheel configuration, maximum design speed, and cylinder capacity for ICE vehicles

.

Table 8. Motorized 2&3W classification in Indonesia

Classification	E-bikes	Motorized 2Ws				
		L1	L2	L3	L4	L5
Regulation	MOT Regulation No. 45/2020 on Certain Vehicles with Electric Motors	Government Regulation No. 55/2012 on Vehicles MOT Regulation No. 86/2020 and No. 44/2020 on Electric Vehicle Type Test MOT Regulation No. 30/2020 and No. 33/2018 on Motorized Vehicle Type Test				
Defining characteristics						
Type	2W	2W	3W	2W	3W with asymmetrical wheel configuration	3W with symmetrical wheel configuration
Power source	Electric	ICE, electric, or combination (hybrid)				
Max. design speed	≤ 25 km/h	≤ 50 km/h	≤ 50 km/h	> 50 km/h	> 50 km/h	> 50 km/h
Cylinder capacity for ICE	-	≤ 50 cc	≤ 50 cc	> 50 cc	> 50 cc	> 50 cc

1.1. Vehicle Operations

Related regulations: Law No. 22/2009 on Road Traffic, Government Regulation No. 55/2012 on Vehicles

The operations of 2&3Ws are regulated as follows:

Table 9. 2&3W Operational Regulations

Operational regulations	Bicycles	E-bikes	Motorized 2Ws (L1-L5)
Allowed Operational Areas	• Cycle lanes • Outermost lane (left) on motorized vehicle lanes	• Cycle lanes • Designated lanes for e-bikes and other vehicles in the Certain Vehicles with Electric Motors category • Certain areas: residential	Motorized vehicle lanes

Operational regulations	Bicycles	E-bikes	Motorized 2Ws (L1-L5)
		area, tourism area, office area, area around transit points where the vehicle class is integrated as a first-last mile mode system, and off-roads • Sidewalk with sufficient capacity for pedestrians (only when cycle lanes or designated lanes are not available) • Vehicular lanes (only at car-free day events)	
Maximum Speed	Not specified	25 km/h	80 km/h on intercity roads 50 km/h on urban roads 30 km/h on residential roads
Minimum Age	No minimum age	12 years old	17 years old
Driving license	Not needed	Not needed	• Mandatory • Motorized 2W driving license is different with car driving license
Vehicle Registration (License Plate)	Not needed	Not needed	• Every motorized 2W must be registered to the vehicle database managed by the National Police Department • Every motorized 2W that is operated on public roads must have a vehicle number certificate (STNK) and a license plate
Helmet Obligation	No	Yes	Yes
Pillion Passenger	Allowed with pillion passenger seat	Allowed with pillion passenger seat	Allowed

Regarding the requirement for driving license for motorized 2W, the license is further classified into three categories[22]:

a. Driving license (SIM) C: Required to drive motorized 2W with <250 cc engine
b. Driving license (SIM) C1: Required to drive motorized 2W with 250-500 cc engine
c. Driving license (SIM) C2: Required to drive motorized 2W with >500 cc engine

[22] Police Department Regulation No. 5/2021 on Driving License

In order to apply for a C1 driving license, a driver must have obtained a C driving license for at least a year. Likewise, to be able to apply for a C2 driving license, a driver must have obtained a C1 driving license for at least a year.

1.2. Vehicle Specifications and Standards

Related regulations: Government Regulation No. 55/2012 on Vehicles, MOT Regulation No. 45/2020 on Certain Vehicles with Electric Motors, MOT Regulation No. 86/2020 and No. 44/2020 on Electric Vehicle Type Test, MOT Regulation No. 30/2020 and No. 33/2018 on Motorized Vehicle Type Test

There are several specification and standards for 2&3Ws as follows:

Table 10. Specifications and Standards for 2&3W

Specifications and standards	Bicycles	E-bikes	Motorized 2Ws (L1-L5)
Maximum Dimension	Maximum WidthxLength: 550x2100 mm	Not specified	• Maximum width: 1,300 mm • Maximum height for goods: 90 cm above the seat • Maximum width for goods: Not exceeding the width of handlebar
Maximum Vehicle Weight	Not specified	Not specified	Not specified
Vehicle Type Test	Not specified	Not specified	Mandatory, with testing parameters as follows: 1. Electric accumulator 2. Charging equipment, including waterproofing protection 3. Electrical safety (touch protection), for vehicles that: a. Have a voltage >60V and ≤ 1500 V DC or b. Have a voltage >30V and ≤ 1000 V DC or 4. Functional safety 5. Hydrogen emission 6. All vehicle type test parameters applicable for ICE E2&3W are specified in MOT Regulation No. 30/2020 and No. 33/2018 on Motorized Vehicle Type Test Further details on the testing parameters can refer to MOT Regulation No. 86/2020 and MOT Regulation No. 44/2020 on Electric Vehicle Type Test
Acoustic Vehicle Alerting System (AVAS)	Not specified	Not specified	Not specified
Other remarks	None	Any modification to	None

Specifications and standards	Bicycles	E-bikes	Motorized 2Ws (L1-L5)
		increase motor power is prohibited	

1.3. Demand-side Fiscal Regulations

Related regulations: Law No. 1/2022 on Financial Relationship between the National Government and Local Governments, Government Regulation No. 74/2021 on Luxury Tax Rate for Motorized Vehicles, MOF Regulation No. 26/PMK.010/2022 on Goods Classification and Import Tax

There are several taxes or fees applicable to owning 2&3W, which are elaborated in the Table 11 below.

Table 11. Taxes and Fees for 2&3W in Indonesia

Tax or fee	Description	Bicycles	E-bikes	Motorized 2&3Ws (L1-L5)
Value added tax (VAT)	Tax for every goods or services transaction	11%	11%	11%
Motorized vehicle tax	Annual and five-yearly tax for motorized vehicle ownership, the value is determined by local governments	Not applicable	Not applicable	• Up to 2% for first vehicle ownership, and progressive tax up to 10% for the next • E2&3W is exempted from the tax
Title transfer fee (BBNKB)	Tax imposed upon the transfer of vehicle ownership	Not applicable	Not applicable	• Up to 20% • E2&3W is exempted from the tax
Luxury goods tax (PPNBM)	Tax for luxury goods sales	Not applicable	Not applicable	60% for 2&3W with engine capacity 250-500 cc, 95% for >500 cc
Import tax	Tax for imported goods	25%	40%	10-40%

1.4. Supply-side Fiscal regulations

Related regulations: BKPM Regulation No. 7/2020 on Pioneer Industries and Tax Allowance, MOF Regulation No. 130/PMK.010/2020

A. Tax Allowance

For the capital investment, according to the Government Regulation No. 78/2019, tax allowances are given for the motorized 2&3W industry.

Income tax reduction

Income tax reduction of as much as 30% from the capital investment in form of fixed assets for the main business, would be given throughout six years with 5% for each year. Income tax for dividend payments to international taxpayers is as much as 10% or lower according to the tax treaty.

Accelerated depreciation and Amortization

Accelerated depreciation for tangible fixed assets and amortization for intangible assets are given with varied utilization periods.

Loss Compensation

In addition to tax allowance facilities, the government also provides preventive facilities for motorized 2&3W industries in the form of loss compensation. Compensation for losses applies longer than five years but not more than ten years.

B. Tax Holiday

Through the regulation of BKPM 7/2020 and No. 130/PMK.010/2020, eligible Pioneer Industries, which include the motorized vehicle and its components, are granted with tax holiday or corporate income tax deduction.

According to No. 130/PMK.010/2020, The provision of corporate income tax reduction facilities is given to pioneer industries, which include motorized 2&3W industries and their components, that meet the following criteria:

- Fulfill the industrial gaps, which means the number of competitors in Indonesia is still small.
- Mainly use domestic produce for their raw materials.
- Production results are used domestically (import substitution).
- The number of similar companies in the same area/region is small.
- Employ a large number of workers.
- Investment locations are prioritized for those located outside of Java.

- Using environmentally friendly technology.
- Using new technology on production equipment.
- Support national strategic projects.
- Production results contribute greatly to the global supply chain.
- Build infrastructure facilities independently.

1.5. Other Policies and Regulations

A. Subsidized Fuel

Indonesia is one of the countries which still subsidizes fuel. Pertalite, a RON-90 fuel distributed by Pertamina, a state-owned enterprise in the oil and gas business, is sold at 55% below its market price while Pertamax, a RON-92 fuel, is sold at 30% below market price in July 2022[23]. Due to its affordability, most motorized 2Ws are using Pertalite.

There is indeed a plan from the national government to reduce subsidized fuel consumption by limiting the consumption of Pertalite only for cars below 1,500 cc and motorized 2Ws under 250 cc. Nevertheless, even if the plan has been implemented, the limitation will only affect the minority of motorized 2W users since more than 95% of the market share is contributed by vehicles under 250 cc.

B. Transportation Demand Management (TDM) "Push" Policies

In general, there is a lack of transportation demand management (TDM) policies, especially from the "push" strategies implemented to disincentivize the use of motorized 2&3W. For example, current parking fares for motorized 2W are typically[24] less than half the parking fares for cars, which is by itself still relatively low compared to other countries. In Jakarta, for instance, the hourly parking fare for motorized 2W is set between IDR 2,000-6,000 or around USD 0.14-0.42, and most parking facilities apply the minimum fare. Most other cities have lower parking rates than Jakarta.

1.6. Enforcement of the Policies and Regulations

Traffic policies and regulations

Traffic violations by motorized 2W happen frequently and are causing safety and accessibility issues for other road users. Enforcement is often a problem due to the huge volume of

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[23] Oswaldo, I., 2022. Di Bawah Harga Pasar, Ini Daftar Harga Pertalite dan Pertamax di Seluruh SPBU. [online] detikfinance. [Accessed 2 September 2022]. Available from: https://finance.detik.com/energi/d-6178390/di-bawah-harga-pasar-ini-daftar-harga-pertalite-dan-pertamax-di-seluruh-spbu

[24] In Indonesia, parking fares are loosely regulated by the local governments which typically set a maximum minimum range for parking fares in their administrative areas.

motorized 2W and the shortage of enforcement officers. Furthermore, some violations are often regarded as commonplace and thus regulators are turning a blind eye toward them.

The most typical violations include:

- **Sidewalk encroachment:** Motorized 2Ws are frequently driven on the sidewalks to bypass traffic jams or one-way traffic. They are often parked on sidewalks.
- **Disobey the traffic lights:** Many motorized 2W drivers violate traffic lights or stop at pedestrian crossings at intersections.
- **Illegal parking:** As mentioned above, illegal parking of motorized 2W is a common issue in many Indonesian cities. Not only on sidewalks but also there are many illegal on- and off-street parking facilities organized by informal organizations or individuals.
- **Young riders:** Although there is a minimum age threshold of 17 years old for riders, motorized 2Ws are often used by children, even starting from elementary school. This case more often happens in secondary cities in Indonesia.
- **Driving license:** Driving licenses can be quite easily obtained without following the regulated procedures.

The use of motorized 2&3W as shared transportation

Legally, the use of motorized 2Ws as commercial passenger vehicles is not allowed. Hence, the massive population of motorized 2W ride-hailing fleets is currently a huge political dilemma. Since the number of drivers has reached millions, decision-makers are aversed to ban or even impose stricter regulations, e.g. higher base fares, to avoid public backlash.

2. Current Policies for Renewable Energy

Indonesia today, like many countries around the globe, is on a path of decreasing its carbon footprint. The shift to electric vehicles can be one of the paths to decarbonize the transportation section, but this is not without caveats. As assessed in the Part A of this study, given the carbon intensity in Indonesia, the electricity production itself accounts for 63% of the total lifecycle emissions of an E2W. Hence, improving the renewable energy mix in Indonesia's electricity grid becomes a crucial factor in optimizing the environmental benefits of transport mode electrification in the country.

In Indonesia, the national government has an important role in formulating regulations and programs to ensure the growth of renewable energy in the future. Policies regarding energy and renewable energy in Indonesia refer to the Law of Republic Indonesia No. 30/2007. The law stated that the government set the goal of energy management as obtaining energy independence, ensuring the availability of domestic and non-domestic sources of energy, ensuring optimal, integrated, sustainable energy resources management, energy efficiency use, guaranteeing the access of individuals to energy, and improving the capacity of domestic energies.

The energy system in Indonesia can be broken down into three areas: primary sources, consumption, and intermediary energy form. Primary energy sources are basically the supply which consists of petroleum, natural gas, coal, and renewables. On the opposite, consumption lists the sectors that demand energy to be utilized. This includes transportation, industrial, residential, and commercial. Finally, the intermediary energy form is electricity that is converted from the primary energy sources to power the end-use sectors such as listed above.

2.1. General Policies

This section covers the overarching policies that govern the energy system in Indonesia, especially the ones related to renewable energy demand creation and supply of renewable energy technologies.

A. Law No. 30/2007 on Energy

This regulation establishes the legal basis for the National Energy Policy (KEN) and the National Energy General Plan (RUEN), which are the foundation of energy system development in the country. More importantly, it also provides the basis for the provision of facilities and incentives to support renewable energy policy objectives provided in KEN and RUEN.

B. National Energy Policy (KEN)

Government Regulation No. 79/2014 on National Energy Policy (KEN) is an energy management policy based on the principles of justice, sustainability, and environmental insights in order to create energy independence and national energy security. Hence, renewable energy is part of the strategy discussed in the document. It contains the target of the Indonesian government in 2025 to achieve a 23% renewable energy mix and at least 31% by 2050. This gives the basic demand for renewable energy to be fulfilled. Meanwhile, the rest of the portion will be filled with petroleum, coal, and natural gas resources.

The subsidies for fuel oil and electricity will be reduced gradually until the people's purchasing power is achieved and diverted to subsidies for renewable energy. Renewable energy price subsidies are given if the price of renewable energy is more expensive than the price of energy from unsubsidized fuel oil. Meanwhile, the utilization of renewable energy resources is prioritized for electricity, transportation, and industrial needs, with the following uses:

- **Electricity:** Energy flows and waterfalls, geothermal energy, energy movement and temperature differences in the ocean layers, and wind energy, energy from sunlight, renewable energy from biomass and waste types.
- **Transportation and industry:** Renewable energy sources from biofuels, biomass and waste, natural gas energy, and liquefied coal.

C. National Energy General Plan (RUEN)

Following up on the dissemination of the National Energy Policy, the government stipulated Presidential Regulation No. 22/2017 on the National Energy General Plan (RUEN). This regulation set up the detailed national-level energy management plan that refers to the KEN targets. With this regulation, the government settles a strategy to achieve future energy policy goals, by utilizing energy resources as capital for national development in a sustainable manner, for the purpose of providing accessible and reliable energy, increasing energy utilization efficiency, guaranteeing energy security, and developing technological, industrial and domestic energy service capabilities, as well as to improving job creation.

RUEN is developed based on energy supply-demand modeling projections from 2015 to 2050. According to this plan, Indonesia should provide 92.2 MTOE (Million Tonnes of Oil Equivalent) of renewables by 2025 (45.2 GW of electricity as indirect use and 23 MTOE as direct use) and 315.7 MTOE of fossil fuels (167.7 GW of electricity as indirect use and 79.4 MTOE as direct use). With regards to direct use for transport or industrial purposes, the strategy focuses mainly on utilizing biogas, followed by biofuel, Coal Bed Methane, and biomass.

Meanwhile, in order to achieve the renewable target in the power sector, the strategy initially relies heavily on the utilization of hydropower, amounting to 17.9 GW, which accounts for 40% of the total projected capacity of renewable electricity by 2025. However, by 2050, solar power is predicted to be the main renewable electricity source, amounting to 45 GW, contributing to 27% of the total planned capacity. According to IESR, achieving 45 GW of solar capacity only tapped between 0.2-2% (depending on land-use exclusions scenario) of total theoretical solar capacity in Indonesia[25]. Other renewable energy sources included in the plan are wind, geothermal, bioenergy, micro and mini hydro, etc.

2.2. Demand-side Policies

Demand-side energy policy refers to government policies for managing energy consumption in order to meet environmental and energy security objectives. This could encompass energy transformation, energy efficiency, demand response, and storage. Therefore, renewable energy demand is naturally a central part of this section. There are several national regulations that cover the entire renewable energy development.

This section specifically dives into the regulations that control the power sector. As the single buyer of electricity in Indonesia, PLN (*Perusahaan Listrik Negara*/State Utility Company) controls the transmission and distribution network. Moreover, the firm also owns more than 75% of the generation capacity in the country[26]. It can be said that under such a market design, Indonesia still holds an artificial monopoly over the electricity sector. Therefore, the demand for renewable energy generators is governed by the plan of the government and PLN for the future. Several documents that affect the demand for renewable energy generators are discussed as follows.

[25] IESR. 2021. Beyond 207 Gigawatts: Unleashing Indonesia's Solar Potential. Institute for Essential Services Reform. [Accessed 20 September 2022]. Available from: https://iesr.or.id/en/pustaka/beyond-207-gigawatts-unleashing-indonesias-solar-potential

[26] Maulidia, M., Dargusch, P., Ashworth, P., & Ardiansyah, F. (2019). Rethinking renewable energy targets and electricity sector reform in Indonesia: A private sector perspective. *Renewable and Sustainable Energy Reviews*, 101, 231-247.

1. National Electricity Business Plan (RUPTL) 2021-2030

The newly released RUPTL by PLN outlines the plan to increase renewables capacity up to 20.9 GW, more than half of the total additional capacity planned over a 10-year period. This RUPTL is claimed as Green RUPTL, which incorporates strategies that will help the government achieve the target of a 23% share of renewables by 2025.

According to the plan, PLN aims to increase the mix of biomass and waste in co-firing operations. Regarding this, PLN has selected several CFPPs with a total capacity of 19 GW, that have the potential to be operated with biomass and waste as a substitution for coal. PLN also intends to add 4.2 GW of pumped Hydro Energy Storage. The planned capacity for solar power plants increases significantly amounting to 4.7 GW, a fivefold increase compared to RUPTL 2019-2028 with merely 0.9 GW of planned solar power capacity. More on the demand side, this RUPTL indicates a prospective solar market for the private sector with 63% of the planned capacity allocated for IPPs. Hence, this creates more renewable energy demand for the private sector to fulfill.

However, regardless of the improved priority on renewables, coal is still the main electricity source for Indonesia, at least until 2030. Share of coal generation in the power grid is expected to reach between 59% and 64%, depending on the scenario used to replace coal with biomass or waste.

2. Development of Rooftop Solar PV

Replacing MEMR Regulation No. 49/2018, MEMR Regulation No. 26/2021 stipulates general requirements and procedures for rooftop solar PV installation. Under this regulation, several bottlenecks on the preceding regulation are addressed and amended. For instance, the net metering scheme was updated to 1:1 (previously 1:0.65), which means rooftop solar PV users can now receive 100% credit for their excess electricity. The net metering scheme is also eligible for rooftop solar PV systems coupled with battery energy storage systems. In addition to it, the credit accumulation period is extended from three months to six months. These positive changes are expected to yield significant reductions in users' electricity bills, thereby creating a more attractive rooftop solar PV investment with a shorter payback period time.

MEMR Regulation No. 26/2021 also eases the application process by introducing an integrated digital application, services, and reporting system. Besides, potential customers are able to receive approval for installation in five days, much shorter than the previous approval period which was 15 days. With this regulation, customers can also sell their excess electricity to other Power Supply For The Public Interest Business License[27] holders outside of PLN, known as private power utilities (PPUs). This regulation is therefore not only putting concern off from the

[27] IUPTLU (*Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Umum*)

customer's side, but also for private sectors that are interested to increase their renewables portfolio through rooftop solar power purchases.

3. Infrastructure Building for Utilizing Renewable Energy and Energy Conservation

Based on the MEMR Regulation No. 12/2018 and No. 4/2020, PLN is required to buy electricity from renewable energy power plants. The purchase price of electricity from renewable energy power plants is a maximum of 85% of the operating costs of generating local electricity systems. In addition, the Ministry of Energy and Mineral Resources encourages regional and provincial governments to improve renewable energy demand in the form of construction, procurement, and/or installation of electricity supply installations, installations for the supply of non-electrical bioenergy fuels, energy efficiency equipment, revitalization/rehabilitation of energy utilization installations, and other activities using renewable energy. The national government also assigned PLN to accelerate the construction of renewable energy power plants in Presidential Regulation No. 194/2014. The government provides full support for the acceleration of the licensing process related to environmental documents, land acquisition, and compensation for transmission lines.

2.3. Supply-side Policies

In contrast with demand-side policies, supply-side renewable energy policy focuses on supporting the deployment of renewable energy technologies, such as financial incentives and local content requirements and/or restricting the rollout of fossil fuel technologies, for instance through moratoriums, output caps, and other constraints. There are several national regulations that cover the entire renewable energy development.

Several regulations that affect the supply of renewable energy technologies are discussed as follows.

1. Purchase Scheme and Tariff for Indonesian Renewables IPPs

MEMR Regulation No. 04/2020 is the second amendment of MEMR Reg No. 50/2017 that regulates the utilization of renewable energy for electricity production, including renewable electricity tariff and purchase scheme under the Power Purchase Agreement (PPA) between renewables Independent Power Producer (IPP) and State Owned Electricity Enterprise (PLN). One of the main points of the amendment is the removal of the Built Own Operate Transfer (BOOT) policy. This requirement adds complexity to the procurement scheme and induces transfer costs, leading to financial disadvantages for the IPP. This regulation amendment then enables the Built Own Operate (BOO) scheme and thus, eliminates the transfer cost.

Through this regulation, PLN now is allowed to carry out direct appointments for its tendering scheme. This scheme was once provided by MEMR Regulation No. 14/2012 which regulates electricity supply business activities but was removed with the issuance of MEMR Regulation

No. 50/2017. The government then put back the scheme to overcome the heavy criticism by the IPPs concerning several situations, such as where the locations are resource-specific. Thereby, the direct appointment is permitted but limited to the situation such as if only one candidate is available for the relevant area and the local electricity system suffers a crisis or emergency situation.

However, this regulation has not addressed modifications to renewable tariffs. The purchase price paid by PLN to renewables IPPs still relies on PLN power generation cost (BPP) and is capped at 85% of local BPP in a condition in which local BPP exceeds national BPP (except for hydro, geothermal, and waste-to-energy which can be priced up to 100% BPP). When national BPP is higher than local BPP, the price will be based on the B2B agreement between PLN and IPPs.

2. Tax Incentives

Several tax incentives are available to support renewable energy industries, including suppliers, manufacturers, and developers in Indonesia.

- **Import Duty Exemption**

  Import Duty Exemption Incentives are regulated in PMK No. 66/2015 and BKPM Regulation No. 4/2021. Exemption of import duties on machinery and equipment, goods, and raw materials for production. Incentives are in the form of two years of exemption from import duty on raw materials, then an additional two years of exemption from import duty for raw materials if the company uses at least 30% of local production machines and equipment.

- **Value-added tax (VAT) exemption**

  Based on Minister of Finance Regulation (PMK) No. 21/2010, there is an exemption from VAT for imported strategic taxable goods of machinery and equipment, excluding spare parts, used by entrepreneurs in renewables projects.

- **Income tax reduction**

  One of the fiscal incentives for new and renewable energy developers is the tax allowance for capital investment. This is regulated in Government Regulation No. 78/2019, BKPM Regulation No. 4/2021, and Minister of Energy and Mineral Resources Regulation No. 16 of 2015. The government provides a six-year net Income Tax (PPh) reduction for capital investment of 5% annually or 30% of the investment value.

Table 14. Income Tax Reduction for New and Renewable Energy

Business Sector	Product Coverage	Eligibility Criteria
Petroleum and Natural Gas and Geothermal Mining (Geothermal Energy Enterprises)	1. Exploration 2. Drilling 3. Converting Geothermal Energy to Electric Power	Investment Value of at least 100 Billion Rupiah
Procurement of Electricity, Gas, Steam/Hot Water, and Cold Air (Power Generation)	Converting new energy (hydrogen, CBM, liquefied coal, or gaseous coal) and renewable energy (hydropower and waterfalls; solar, wind or ocean currents, biomass, biogas, waste) into electric power	1. Investment value of at least IDR 30 billion; or 2. Workforce of at least 100 people.

- **Tax Holiday**

  Through the regulation of BKPM Regulation No. 7/2020 and No. 130/PMK.010/2020, eligible Pioneer Industries, which include manufacturers and infrastructure for renewable energy power generations, are granted with tax holiday or corporate income tax deduction. Corporate Income Tax deduction is given as follows:

  a. 100% of the total amount of Corporate Income Tax for new investment with a minimum value of IDR 500 million. Given the following period and after the expiration of the period can be given a reduction of 50% for the next 2 years:

     - For 5 years for New Investment of at least IDR 500 billion and less than IDR 1 Trillion
     - For 7 years for New Investment at least IDR 1 Trillion and less than IDR 5 Trillion
     - For 10 years for New Investment at least IDR 5 Trillion and less than IDR 15 Trillion
     - For 15 years for New Investment at least IDR 15 Trillion and less than IDR 30 Trillion
     - For 20 years for New Investment at least IDR 30 Trillion

  b. 50% of the total amount of Corporate Income Tax for new investment with a value of at least IDR 100 million and a maximum of less than IDR 500 million, is given for 5 tax years and can be extended for the next 2 years in the amount of 25% of the payable Corporate Income Tax.

- **Loss Compensation**

  Based on PMK No. 21 of 2010 concerning the Provision of Tax and Customs Facilities for the Utilization of Renewable Energy Sources, one of the facilities provided as part of the income tax incentive is compensation for losses that are longer than 5 years but not more than 10 years. This compensation is provided with the following conditions:

a. New investment is carried out in certain fields in industrial estates.
b. Employs 500 Indonesians within 5 years
c. New investment in the economic and social infrastructure of approximately IDR 10 billion
d. There are research and development expenses of at least 5% of the total investment within a period of 5 years
e. Utilization of domestic raw materials or components at least 70% since the 4th year.

3. Acceleration of Electricity Infrastructure Development

In order to increase the fulfillment of electricity needs and meet the national energy policy target to achieve an energy mix of 25% renewable energy of the total energy used, a policy in the form of Presidential Regulation No. 4/2016 concerning the acceleration of electricity infrastructure development was issued. To succeed in accelerating the improvement of electricity infrastructure, the central and regional governments provide support in the form of fiscal incentives, ease of licensing and non-licensing, determining the purchase price of electricity from each type of renewable energy source, establishing a government-owned business entity in the context of providing electricity to be sold to PLN, and providing subsidies.

3. Conclusions

Based on the policy and regulation overview of the 2&3W landscape and renewable energy in Indonesia, key takeaways and the ways forward are summarized in this section.

3.1. 2&3W Policy Framework and Anchors for E2&3W Adoption

1. **The popularity of motorized ICE 2W as an affordable and convenient door-to-door transport mode is attributable to the current policy framework.**

    a. ***Affordable by design***
    A number of policies, such as the tax incentives for motorized 2W industries and low end-user taxes especially for domestically produced motorized 2W, the lack of luxury tax applied for most motorized 2W, and the widely available financing programs from banks and other financial institutions result in the affordability of motorized 2W.

    b. ***Convenient by design***
    Motorized 2W is usually exempted from currently applied TDM measures such as the odd-even policy in Jakarta, so practically no restriction on motorcycle usage or supply. Furthermore, such an exemption is causing the increase of motorized 2W due to shifts from cars to motorized 2W[28].

    In addition There are no dimensions, engine capacity, or speed limitations for motorized 2W. Therefore, many people use motorized 2W as it is more affordable, convenient, and reliable especially in urban traffic compared to cars or public transportation.

2. **The electric 2W is not currently growing as rapidly as the ICE 2W. The current policy framework might hinder E2W adoption.**

    a. ***Domestic content level***
    Indonesia has set minimum domestic content levels for electric vehicle production and restricted CBU imports. Drafting these regulations in the early stages of EV market development could hinder EV adoption, including by leading to higher costs. However, allowing large imports of CBUs in the long term could also hamper the domestic electric vehicle industry. Therefore, it is important to develop a comprehensive policy that balances domestic content levels and import regulations to protect the growth of local manufacturing while meeting local demand. Temporarily relaxing domestic content levels and reducing access to CBUs, IKDs, or CKDs may be necessary to ensure

[28] Maulana, A. 2019. Selain Mobil, Muncul Wacana Motor Kena Ganjil Genap. [online]. Kompas.com. [Accessed 2022]. Available from: Kompas.com

that EV market growth at this early stage is not solely dependent on the domestic industry.

b. ***Limited direct incentives***

2&3Ws have enormous potential to be catalysts for vehicle electrification. However, there are no other preferential fiscal policies for E2&3W other than the annual vehicle tax and title transfer fee exemption. Although the price gap between E2&3Ws and their ICE counterparts is less than the gap in the 4W segment, the price differences are still hindering potential users to procure E2&3Ws. Aside from limited incentives, financial institutions have yet to implement a low down payment program, unlike ICE 2Ws. Many financial institutions are reluctant to implement such policies since electric vehicles still are considered a nascent technology..

c. ***Lack of disincentives for ICE 2&3Ws***

To further accelerate the adoption of E2&3W, fiscal and non-fiscal disincentives for ICE 2&3Ws are needed. In fiscal form, an emissions-based tax could be an option in addition to increasing emissions standards for ICE 2&3W. Emission taxes are not directly included in the annual vehicle tax but are applied to luxury tax calculations, which most 2&3Ws are exempted from. Raising 2&3W emission standards for both domestic production and import, while giving more taxes to older 2&3W, could also further discourage the use of ICE 2&3W. Additionally, given the current high ownership of ICE 2&3W, a scrappage program can accelerate the adoption of E2&3Ws.

Vehicle disincentives at the local level, such as in Jakarta, often already exempt 2&3Ws from traffic restrictions and other push policies, so there is a limited opportunity to provide preferential incentives for E2&3W compared to ICE 2&3Ws without any reform in the current push policy framework. Measures such as an odd-even policy, congestion charging, or a low-emission zone, could be applied to limit the ICE 2&3W while also improving the air quality and reducing GHG emissions.

3. There is a need for a comprehensive urban traffic guideline to effectively and equitably govern E2&3W and 2&3W in general.

The introduction of E2&3W which has different characteristics compared to ICE 2&3W and the wide variety of E2&3W models have led to various traffic issues. E-bikes and e-mopeds are currently in a gray regulatory area, somewhere between conventional bicycles and motorized ICE 2W, since they are faster than a conventional bike but not as fast as a typical motorized 2W. The existing urban traffic policies for e-bikes are not sufficiently comprehensive thus resulting in the overall banning of e-bikes in some cities.

In addition to clear regulations on E2&3Ws operating areas, policies on vehicle registration and required safety equipment should be made as clear as possible. Most of the current regulations only apply to medium and high-powered motorized vehicles without clear policies for the lower-powered motorized vehicles, which should include most e-bikes.

3.2. Renewable Energy Policy Framework and Anchors for Integration to EV Charging Infrastructure

To optimize the emission reduction benefit of the shift to electric vehicles, including E2&3W, improvement of renewable energy mix in national grid as well as integration of renewable energy sources in local grids are needed.

1. Several challenges still persist to improve renewable energy mix in Indonesia

In the electricity sector, there are still several challenges related to renewable power development that need to be overcome:

a. ***Coal-fired power plants plug the penetration hole of renewable power***
With the oversupply of electricity in Indonesia, renewable energy supply cannot be increased significantly without shaving off coal plants' capacities. However, current regulations still open opportunities for CFPP to dominate the power system.

b. ***Improved regulations are needed to encourage renewable energy investment***
Several regulations that exist today actually hinder the investment stream for renewable power. A prime example is the determination of renewables tariffs that are based on the power generation cost (BPP) of PLN and the high local content requirements (LCRs), especially for solar PVs. Tariff setting has been an issue for the IPPs. The renewable tariff is not attractive to investors due to the small amount of BPP. Furthermore, the tariff is changing annually following the change in BPP. For the latter, while the government imposes high LCRs for solar PV developers, the local industry has not scaled significantly, thus creating high costs and subpar quality products. Also, BPP does not reflect a true cost of generation and thus, is not a reliable benchmark for renewable prices. This issue has been hindering the bankability of renewable projects and lessening their commercial attractiveness.

On the other hand, various incentives may not work effectively in practice. For example, where tax incentives are offered, companies can benefit from a 100% reduction in corporate income tax for a period of 5 to 20 years. Nevertheless, in the first five years, a typical company has still not made a profit on the project to build the renewable energy power plant, so even without the tax exemption, the company is not required to pay corporate income tax.

In order to tackle the issue, the government has developed the Presidential Regulation No. 112/2022 which includes the notion of renewable tariffs to replace the MEMR Regulation No.

04/2020 that determines renewable tariffs to be based on local BPP. However, instead of implementing Feed-in-Tariffs (FiT) which has long been awaited by industry players, the government imposes a ceiling tariff that varies based on the types of renewable energy power plants and its locations. Under the ceiling tariff scheme, the tariff offered and negotiated between an IPP and PLN must not be higher than the ceiling tariff for that particular type of renewable energy power plant. Even though the tariff is now no longer benchmarked against the generating BPP for non-renewable energy, the tariff is still lower than what is expected from the Feed-in-Tariffs (FiT) mechanism. Along with several incentives provided in the presidential regulation as well, more incentives or better renewable tariffs are still needed to increase the profitability and bankability of renewable energy projects, thus boosting the development of solar PV and other renewable power.

2. Fossil fuels still dominate power system planning in the "Green" RUPTL

Even though there is a renewable energy mix target from the Central Government for renewable energy mix in 2025 and 2050, it is still not addressed and derived properly to the technical documents in the electricity sector. While the 2021-2030 RUPTL is claimed to be the greenest RUPTL, PLN only targets to raise the current share of renewables to 23% by 2025 from the current status of 15%. However, to achieve a 23% share of renewables in the primary energy mix, the country would need around 34% share of renewable power capacity in the power sector. Furthermore, the renewables share will only increase to 24.8% in 2030, noting a tiny progress during 2025-2030. On the other hand, coal-fired power plants are still considered crucial and will play a major role in the power sector. The coal generation will have around 59% to 64% of the share by 2030 depending on the scenario, therefore holding back the penetration of renewable power and putting the electricity sector at risk of stranded coal-fired power plant assets.

3. More supporting policies are needed to boost solar PV adoption for renewable energy integration in charging infrastructure

A study estimated that installation of solar PV at a typical 12 slots battery swap station in Greater Jakarta area can provide around 3.35% charging demand on an annual basis[29]. The financial viability of solar integration increases as the electricity tariffs charged by PLNs increase. The highest assessed electricity price is IDR 1,447.9 with an estimated return on investment of 8.4% and a payback period of 8 years. In addition, since typical local grid installation for a battery swap station only cater electricity load under 197 kVA, it is still classified as a low voltage connection which does not require an additional infrastructure to be built[30].

[29] ITDP Indonesia. (2021). *Road Map and Timetable of Two-Wheeler Electrification in Greater Jakarta*. Study conducted under UK PACT GRCF.

[30] Ibid.

Previously, the net metering scheme for solar PV was put at a ratio of 1:0.65, but it has been updated to 1:1 in the MEMR Regulation No. 26/2021. This update can shorten the payback period of solar PV installation by around one year. However, it is still considered unattractive to the majority of small-scale (batery swap provider or residential) consumers who expect to have less than 7 years of payback period. Moreover, another barrier still persists, which is the lack of attractive financing options to lower the high upfront cost. The government can offer low-interest rates and long-term soft loans and/or tax incentives for homes that utilize rooftop solar PV.