

Scenario Exploration on Business Development of 2W EV Ride Hailing Service in Indonesia with System Dynamics Approach

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ABSTRACT:

The transition to electric vehicles (EVs) adopted by two-wheeled (2W) ride-hailing services represents a significant effort by ride-hailing providers to promote green investment and demonstrate their commitment to Environmental, Social, and Governance (ESG) principles, in alignment with government mandates to accelerate EV adoption. Understanding the market penetration and breakthroughs is essential to achieving the intended outcomes of emission reduction and behavioral change. Given that the existing market is relatively new and complex, it is crucial to maintain an equilibrium within a holistic system that includes the government, ride-hailing providers, drivers, and passengers to comprehend the diffusion of the market across the entire value chain. This study aims to develop a conceptual model to investigate the complex dynamic relationships among factors and linkages of government policies that influence ride-hailing providers in constructing business models and adopting 2W EV ride-hailing services in Indonesia. The conceptual model is developed using causal loop diagrams to capture the adoption process of 2W EV ride-hailing services, while a system diagram is created to comprehensively illustrate the challenges in 2W EV ride-hailing services. The results of this study can serve as a basis for developing strategies and scenarios to enhance the adoption of 2W EV ride-hailing services in Indonesia.

Keywords: Conceptual model, System Dynamics, 2W EV Ride Hailing Service.

INTRODUCTION

Carbon emissions have become a crucial issue in the global context due to their increasingly alarming contribution to climate change (Cai et al., 2023). Indonesia, as one of the countries with high biodiversity, faces a major challenge in managing carbon emissions. High carbon emissions result in adverse impacts on the environment, including increased global temperatures, changes in rainfall patterns, and significant environmental damage (Alatawneh & Torok, 2024; Kim et al., 2024; Y. Shi & Yang, 2024).

The Indonesian government has prioritized decarbonization initiatives as part of its climate change mitigation efforts. Through various policies and programs, such as increasing the use of renewable energy, forest conservation, and energy efficiency, the government seeks to reduce the country's carbon emissions. This focus is also aligned with Indonesia's commitment to achieve its carbon emission reduction target under the Paris Agreement on climate change (Victor-Gallardo et al., 2024).

Looking at real data, the amount of accumulated carbon emissions in Indonesia reached 2.4 gigatons (GT) per year 2023 and is projected to reach 2.9 gigatons per year 2050 (Chen et al., 2024) under the business as usual (BAU) scenario. The IEA (2023) states that the transport sector is the second largest contributor to carbon emissions in Indonesia, and 94.81% of this is land transport. Energy consumption in the transport sector grew at a CAGR of 5.9% from 2000 to 2018 and is expected to continue growing at 5.2% annually until 2040 under the business as usual (BAU) excess, resulting in greater GHG emissions (Y. S. Liu et al., 2023; Mazur et al., 2018).

Looking at the increase in GHG emissions, it appears that the transport sector is massively driven by increased energy consumption from fossil fuels (Veza et al., 2022) of which 74% is dominated by two wheelers (2W). This has prompted a focal point on schemes to transition two-wheelers into eco-friendly ecosystems (X. Liu et al., 2015; Ni et al., 2022). This is in line with the government's commitment to the environment stated in Indonesia's Nationally Determined Contribution (NDC) as an ambitious target in reducing carbon emissions with a short-term reduction target in 2030 of 29% and a long-term scope with a reduction target of 90% (Veza et al., 2022). One of the government's focuses in the objective scope of an environmentally friendly 2-wheeler ecosystem is the implementation of battery electric vehicles.

To escalate the electric vehicle transformation, the government needs to regulate and take action to promote the adoption of EVs as a decarbonization action in the transportation sector implemented by B2B and the government as a party that provides a viable initial market (Jiang et al., 2023). This is in line with the seriousness of the government's action as stipulated in Presidential Regulation No. 55/2019, which states support for the electric vehicle industry, especially for institutions responsible and/or involved in the implementation of the internal combustion vehicle (ICE) to battery electric vehicles (BEV) market transition (Lazer et al., 2021). Presidential Regulation No. 55/2019 is applied with a three-target approach, including first, incentivizing the purchase of EVs for private vehicles, second, encouraging the electrification of public transportation, and third, encouraging the electrification of app-based transportation services. The third target approach is the focus of this research (Li et al., 2022; X. Liu et al., 2015).

As part of the government's initiative to accelerate the EV ecosystem in Indonesia and accept the mandate to play a role in accelerating the transformation of the 2W EV ecosystem, Coordinating Ministry of Maritime and Investment Affairs has stated the government's target to be able to strive for the number of 2W EVs in Indonesia to reach 15 million by 2030. Based on

the collaboration between the Ministry of Energy and Mineral Resources (MEMR), the Coordinating Ministry for Maritime Affairs and Investment (Kemenko Marves), and the Ministry of Transportation (MoT), a target was set to encourage the involvement of the private sector in accelerating the 2W EV ecosystem, mainly aimed at ride hailing players specifically. Ride hailing players are targeted to reach 3.5 million in the 2W EV ecosystem by 2030.

Ride hailing players execute this direction and target by procuring 2W EV Ride Hailing Service that has been available from 2023 with regular improvements to the business model so that it can be competitive for public acceptance, both in terms of supply (drivers) and demand (passengers), as well as both in terms of price and service availability (Mazur et al., 2018).

The current state of implementation of 2W EV Ride Hailing Service in Indonesia in terms of ride hailing players shows that it is fully committed to becoming a carbon-neutral platform and targets a 100% EV implementation transition by 2040. Then, the business model is carried out by offering daily 2W EV rental at competitive rates and providing incentives on certain scope requirements and achievements. Ride hailing players are also committed to utilizing ~40% TKDN in their 2W EVs. In addition, in line with the government's commitment to encourage the utilization and escalation of 2W EVs, tax holidays and subsidies provided by the government and received by ride hailing players are allocated to provide incentives to drivers and passengers (Olayode et al., 2023).

The current state of 2W EV Ride Hailing Service implementation in Indonesia from the perspective of EV ride hailing drivers shows that 90% of drivers who rent 2W EVs focus on financial benefits and independent time limits (Nicholas et al., 2020; Qin & Sun, 2022; Sanguinetti & Kurani, 2021a, 2021b; J. Shi et al., 2020). Furthermore, by implementing 2W EV rental adoption, it is stated that drivers can save ~40% of monthly operation and maintenance (O&M) costs (Lazer et al., 2021). In addition, drivers were also able to find SPKBLUs within a ~3 km radius between their stations.

The current condition of 2W EV Ride Hailing Service implementation in Indonesia in terms of EV ride hailing passengers shows that 90% of passengers are willing to use 2W EV Ride Hailing services if the service fare is equal to and/or a maximum of Rp 1,000.00 higher than conventional services.

Leaning on the regulations that have been established for the acceleration and stimulation of the 2W EV ecosystem, it is classified between fiscal and non-fiscal based regulations. Fiscal-based regulations are contained in MoI Regulation No. 6 / 2022 which states technical requirements and LCSR guideline, Presidential Instruction No. 6 / 2022 which states EV adoption for government official vehicles, MEMR Regulation No. 13 / 2022 which states standardization of charging plugs and electricity tariff policy (J. Shi et al., 2020; Waluyo et al., 2022). 13 / 2022 which states the standardization of charging plugs and electricity tariff policy for SPKLU and SPKBLU, MoT Regulation No. 4 / 2020 which states the EV testing and certification process, MoT

Regulation No. 45 / 2020 which states special vehicles with electrical motors including safety requirements, riding behavior, and vehicle lane, and Ministry of Transportation Regulation No. 65 / 2020 which states the legitimation of the 2W conversion into E2W (Datsii et al., 2021).

74/2021 stating that battery electric vehicles (BEVs) are exempt from sales tax on luxury goods (PPnBM), Minister of Home Affairs Regulation No. 1/2021 stating that the annual tax (PKB) and motor vehicle registration transfer fee (BBNKB) of BEVs is a maximum of only 10% of the calculation of their imposition cost, and Minister of Finance Regulation No. 138/PMK.02. .2021 which states that the vehicle type test for E2W is ~ IDR 4,500,000.00 cheaper than ICEV and the type test certification fee for E2W is 25 times cheaper than ICEV (Cai et al., 2023; Moniot et al., 2022; Patil et al., 2022; Qorbani et al., 2018; J. Shi et al., 2020; Veza et al., 2022).

With the relevant regulations outlined to support the escalation and stimulation of E2W targets in ride hailing service implementation, it can be concluded that there are no specific regulations that specifically address further EV implementation in EV 2W ride hailing services. This illustrates that legal certainty is needed to ensure that the implementation of this business model policy can remain competitive from a B2B perspective in terms of finance and sustainability and accelerate the adoption of green transportation.

This research explores implementing 2W electric vehicle (EV) ride-hailing services in Indonesia to support decarbonization efforts. It aims to develop effective policy models promoting the shift from internal combustion engine (ICE) to battery electric vehicles (BEVs) in ride-hailing, reducing greenhouse gas emissions, fossil fuel dependency, and operational costs. The study assesses regulatory gaps, advocating for tailored regulations to ensure competitiveness and sustainability. Findings will inform policymakers, industry, and environmental advocates on advancing green transportation to meet Indonesia's carbon reduction goals and enhance environmental sustainability.

RESEARCH METHODS

This study employs the System Dynamics (SD) methodology to develop a conceptual framework for the business model of 2W EV Ride Hailing Services. In analyzing intricate industrial systems, such as 2W EV Ride Hailing within the public mobility sector, modeling serves as a vital tool for problem-solving and business optimization.

The modeling process incorporated qualitative data derived from existing literature, published sources, prior research on the Indonesian ride-hailing service industry, and interviews with industry experts. Figure 1 illustrates the system diagram of the 2W EV Ride Hailing Service in Indonesia, comprising several elements: system input, output, goals, strategic interventions, the problem owner, stakeholders, and the Causal Loop Diagram (CLD) as the system model. Strategy variables align with the problem owner's interventions, while external variables represent factors beyond the problem owner's control or influence. The CLD delineates the

model structure, visualizing the cause-and-effect relationships among variables within the 2W EV Ride Hailing Service. Figure 2 depicts the business-as-usual (BAU) model, elucidating the system variables and their interrelations. This CLD was adapted using narrative data reflecting the developments within the Indonesian ride-hailing service industry.

Modeling is an iterative process. For this research, we conducted interviews with several employees from Indonesian ride-hailing service corporations, representing domain experts. These interviews, based on the Causal Loop Diagram (CLD), were unstructured to foster an informal atmosphere conducive to discussing current business model development. The interviewees, averaging over 7 years of experience within the company, provided valuable insights. The outcomes confirmed that the CLD accurately reflects the real-world feedback loops and dynamics within the industry.

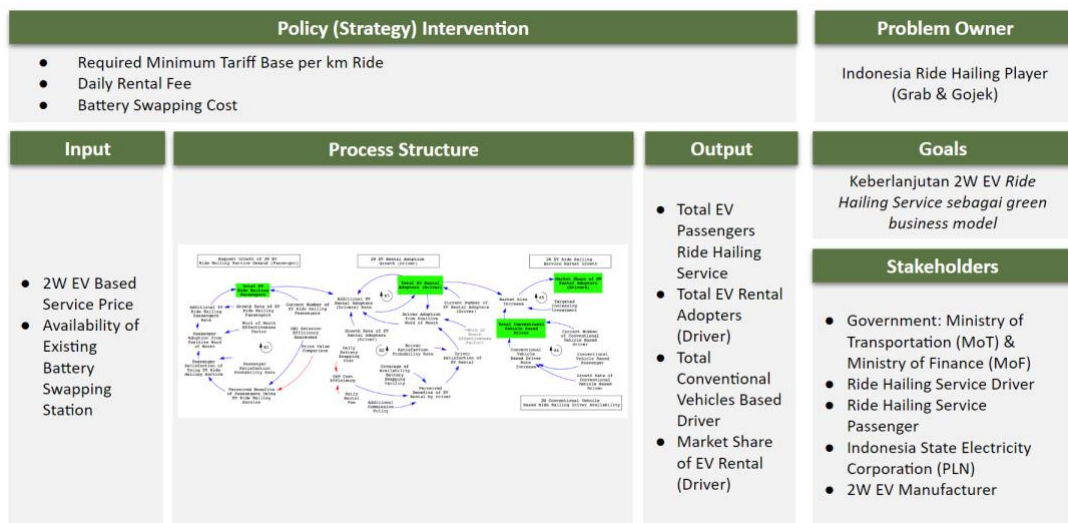


Figure 1. System Diagram of 2W EV Ride-Hailing Service in Indonesia

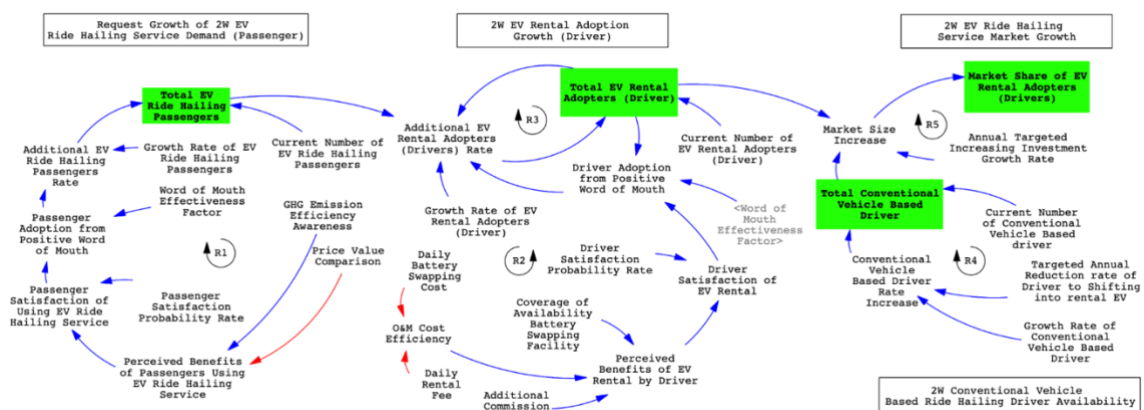


Figure 2. Causal Loop Diagram of Indonesia 2W EV Ride Hailing Service Business Model

Prior to employing the quantitative model for evaluating strategic alternatives, the developed Stock and Flow Diagram (SFD) undergoes validation through five standard tests in the system dynamics methodology: boundary adequacy test, structural assessment test, dimensional consistency test, extreme condition test, and integration error test. The model is then simulated under a business-as-usual (BAU) scenario, with the simulation period spanning from 2024 to 2028.

The boundary adequacy test was conducted to ensure that all critical variables are endogenous to the model. Concurrently, the structural assessment evaluated whether the model accurately captures both the necessary endogenous variables and the overall problem structure. This is exemplified by how the model represents the adoption dynamics of the 2W EV Ride Hailing Service. The choices of drivers to rent 2W EVs and passengers to opt for 2W EV ride-hailing services provide feedback on the attractiveness of the business model, thereby confirming the model's endogenous structure.

During the development of the Stock and Flow Diagram (SFD), the dimensional consistency test was conducted using Vensim software to ensure that the units of all interconnected variables are accurate and consistently aligned with real-world conditions.

The system dynamics model operates on a continuous time basis. The integration error test evaluates the consistency of simulation results across varying time steps, ensuring that the model's outcomes are not unduly sensitive to these variations. Figure 3 illustrates the results of the integration test, demonstrating minimal deviations between simulations with different time steps. Consequently, the model is validated as robust.

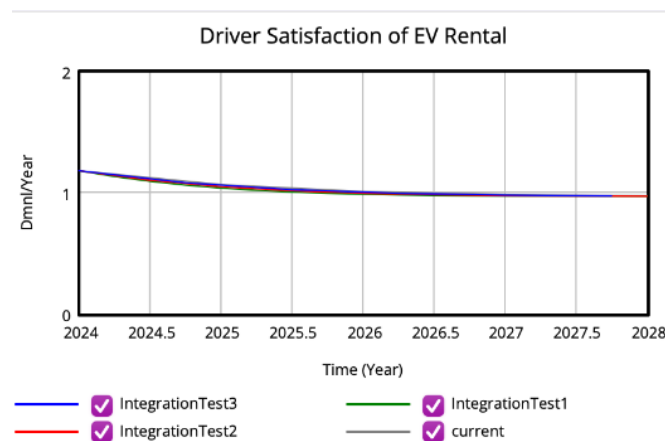


Figure 3. Integration Error Test Proof

Upon validating the baseline model, it was subsequently simulated under various scenarios. Beyond the business-as-usual (BAU) scenario, three additional scenarios were

developed to evaluate the strategic effectiveness of the 2W EV ride-hailing service business model. These scenarios are influenced by external factors impacting the system's output. This study examines the effects of EV service pricing and the availability of battery swapping stations, with strategic variables including daily rental fees, rental incentive fees, and battery swapping costs. The rationale for selecting these variables was established during the sensitivity tests. A summary of the scenario drivers is presented in Table 1, followed by detailed narratives for scenarios 1, 2, and 3.

Scenario 1: Fleet Operators Driving Electric Mobility Acceleration

In this scenario, we assume that EVs are a major contributor to decarbonization initiatives, both at the global and national levels. The initiative of green transportation acceleration is mandated to be implemented in public mobility, and giant ride-hailing players are asked to contribute. Thus, EV-based services must be equally competitive with conventional-based services.

Scenario 2: Government of Indonesia’s Support on EV Implementation

In this scenario, we assume that the EV acceptance trend in Indonesia is increasing significantly due to the high awareness of EV impact. This situation leads to a positive penetration of the 2W EV service-based demand growth trend. Thus, the green projection that illustrates this opportunity brings more investors to make financial injections so that the EV-based service price paid by passengers can be reduced.

Scenario 3: EV Trend Diminishing

In this scenario, we assume that massive development and utilization of other based fuels, e.g., hydrogen & methane, result in stagnant SPBKLU development. This situation impacts investors’ intention to shift interest to invest in EV-based services. Thus, service tariffs have to be increased as they have to bear O&M costs and asset value.

Table 1. Summary of Scenario Drivers Setting in Each Scenario

	Scenario 1	Scenario 2	Scenario 3
EV Based Service Price	IDR 2500/km	IDR 2400/km	IDR 2800/km
Availability of Existing Battery Swapping Station	1850 unit	2700 unit	2000 unit

RESULTS AND DISCUSSION

After analyzing the results for each scenario implementation, a comparative analysis between scenarios and the application of strategies for each output will be conducted. The

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strategies applied include daily rental fee, rental incentive fee, battery swapping cost, and a combination of all strategies.

The first output, Total Conventional Vehicle-Based Driver, is compared by calculating the average value of each gap between business as usual (BAU) and each scenario. The average value of Total Conventional Vehicle-Based Drivers is as follows where it can be concluded that scenario 2 is able to encourage 15.02% of conventional service-based drivers to move to EV services while scenario 3 is only able to encourage 1.67% of conventional service-based drivers to move to EV services.

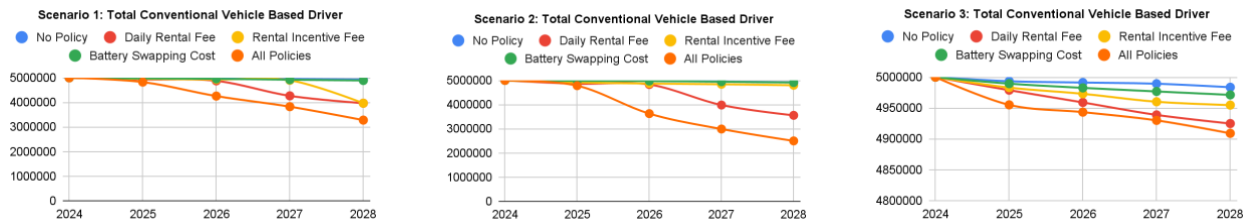


Figure 4. Total Conventional Vehicle-Based Driver

The second output, Total EV Rental Adopters, is compared by calculating the average value of each gap between business as usual (BAU) and each scenario. The average value of Total EV Rental Adopters as follows where it can be concluded that scenario 2 is able to encourage 10.88% of conventional service-based drivers to rent 2W EVs while scenario 3 is only able to encourage 0.96% of conventional service-based drivers to rent 2W EVs.

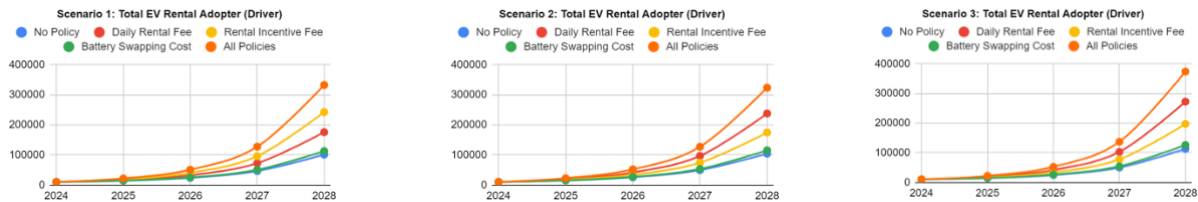


Figure 5. Total EV Rental Adopter (Driver)

The third output, Total EV Ride-Hailing Passengers, is compared by calculating the average value of each gap between business as usual (BAU) and each scenario. The average value of Total EV Ride Hailing Passengers is as follows: It can be concluded that scenario 2 is able to encourage 15.97% of passengers to switch to using 2W EV services while scenario 3 is able to encourage 9.36% of passengers to switch to using 2W EV services.

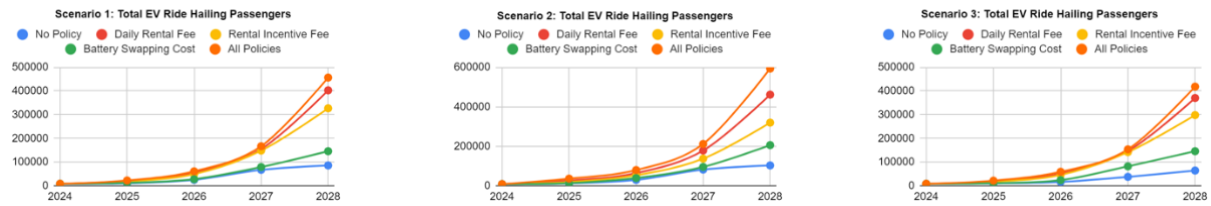


Figure 6. Total EV Ride-Hailing Passengers

The fourth output, Market Share of EV Rental Adopters (Drivers), is compared by calculating the average value of each gap between business as usual (BAU) and each scenario. The average value of Market Share of EV Rental Adopters (Drivers) is as follows: It can be concluded that scenario 2 increases the market share of 2W EV Ride Hailing Service by 0.27%, while scenario 3 increases it by 0.06%.

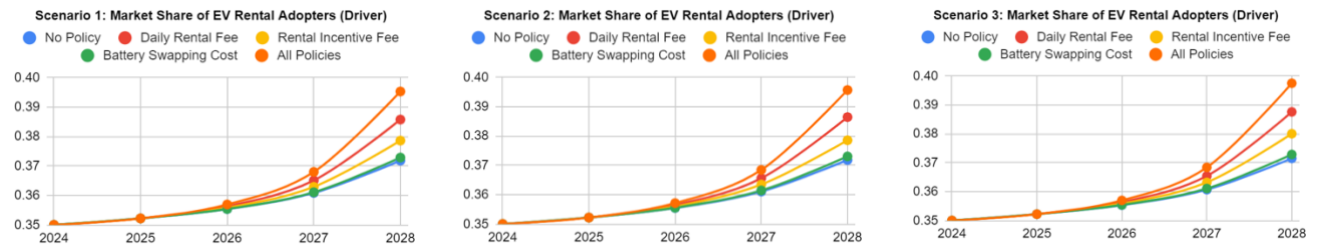


Figure 7. Market Share of EV Rental Adopters (Driver)

CONCLUSION

The research emphasizes the significant potential of the 2W EV Ride Hailing Service business model in Indonesia for fostering environmentally friendly mobility. It highlights the roles and responsibilities of key stakeholders such as ride hailing players, government bodies (MoT, MoF, PLN), 2W EV manufacturers, drivers, and passengers, stressing the need for collaboration. Internal and external factors interact dynamically within this ecosystem, influencing strategic interventions by ride hailing companies and policy adaptations. The research underscores the effectiveness of strategies like daily rental fees in enhancing system outputs. Recommendations for future studies include expanding research scope to include new business models like pay-for-ownership, integrating government incentives and tax policies, refining data accuracy, and simulating diverse industry scenarios to foster adaptive business strategies.

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