



Electric Mobility of Indonesia: a strategy for achieving net zero emission by 2050

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ABSTRACT

Electric mobility mode could be a great opportunity to reduce emissions from the transportation sector. The future mobility calculator and electric car power demand, developed by Coalition for Urban Transitions and International Energy Agency, respectively, were used to analyze Indonesia's shifting strategy toward electric mobility. It was shown that going to electric mobility will reduce 90% of Indonesia's emissions from the transportation sector by the year 2050. Nevertheless, the charging infrastructure must be improved quickly to provide a proper ecosystem for electric mobility. Additionally, the electric vehicle waste management system is urgently needed soon. The success of shifting toward electric mobility not only benefits Indonesia's environment but also strengthens its international credibility for sustainable development.

ABSTRAK

Mobilitas secara elektrik merupakan kesempatan besar untuk menurunkan emisi yang ditimbulkan oleh sektor transportasi. *Future mobility calculator* dan *car power demand* yang dikembangkan oleh koalisi untuk masyarakat urban dunia dan agensi energy internasional digunakan untuk menganalisa strategi Indonesia untuk beralih ke mode transportasi elektrik. Hasil model ini menunjukkan bahwa Indonesia akan menurunkan 90% emisinya dari sektor transportasi pada tahun 2050. Namun demikian, infrastruktur pengisian kendaraan listrik harus di tingkatkan segera untuk menyediakan ekosistem yang di perlukan untuk transportasi mode elektrik. Selain itu, diperlukan segera pembangunan pengolahan sampah kendaraan elektrik. Keberhasilan merubah mode transportasi menjadi elektrik bukan hanya menguntungkan Indonesia dari sisi lingkungan tetapi juga memperkuat kredibilitasnya secara internasional dalam hal pengembangan yang berkelanjutan.

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1. Introduction

Electric vehicle (EV) technology has significantly developed in recent years, leading to more affordable costs. Many countries have developed policies to accelerate the transformation from petroleum-based to electric mobility. Broad support from international collaboration projects working together, such as International Energy Agency (IEA), United Nations (UN), National Renewable Energy Laboratory (NREL), and many others, to help countries around the world adopt electric mode mobility. Indonesia responds positively to this issue; more than 80% of urban citizens, like people in Jakarta, prefer electric mobility in the future [1], and the world's new passengers in the future also expect similar trends [2], [3]. In 2022, more than 15 thousand electric cars and 30 thousand electric motor vehicles were sold in Indonesia [4], [5].

One of the main parts of electric vehicles is the battery. It is the source of energy that empowers an EV to move. There are four primary batteries for EV commercial use today: Lithium-Ion, Nickel-Metal Hydride, Lead-Acid, and Ultracapacitors [6]. Lithium-Ion batteries by far dominated EV power sources. For instance, an electric car that uses NMS 532 battery. This kind of battery needs many metals from mining (about 77 kg overall), such as Nickel,



Lithium, Manganese, and Cobalt [2]. The mass of the battery represents its power capacity, therefore a trade-off between the size of the electric vehicle and its power capacity [7].

Preparation of the charging infrastructure is necessary to fulfill the power demand of electric vehicle operation—many works are devoted to optimizing the charging infrastructure: their location, power source, and charging schedule—the excellent management of charging infrastructure, the so-called “smart” EV charging strategy [8]. Electric vehicle users need various types of charging mechanisms if the goal is to shift from an internal combustion engine mode of transportation to the electrical one [9]. Integrating payment and control of electric vehicle charging also provides more convenience for the user, although security issues need to consider carefully [10].

Whatever battery uses for an electric vehicle, its performance depends on the battery’s operating temperature. The high operating temperature of the battery will induce film formation on the surface of the electrode. Simultaneously, it increases the materials’ degradation rate inside the battery [11]. Other extreme conditions include low-temperature operation, yield performance, and battery material degradation [12]. So, battery operation temperature is a crucial part of the performance and lifetime of the electric vehicle. Therefore, the battery management system is paramount to the environment of their operating condition.

This paper analyzes the charging infrastructure strategy of the electric vehicle and battery performance under Indonesia’s environment temperature. The result will contribute to Indonesia’s technology and policy development toward shifting to electric mobility mode. Moreover, this work displays the future benefit of diminishing emissions. It also indicates the following consequence of massive electric vehicles in the future: disposal of their waste, especially its battery that must be addressed to complete a sustainable development program.

2. Method

This work uses two sources to analyze Indonesia’s transition toward electric mobility. The first is a tool developed by Coalition for Urban Transitions [13] to provide a framework for achieving zero-carbon cities. The second one is a tool from the International Energy Agency (IEA) that analyzed power demand for electric cars.

2.1. Future Mobility Calculator

Zero-carbon cities provide quick and broad exposure to how a city could implement a transition toward a greener economy pathway. They developed a tool called the “future mobility calculator,” which is a tool that can visualize how a city could attain a zero-carbon target in 2050. Four modes of electric vehicles are considered here: private cars, private two-wheeler, shared fleets, and public buses [14]. In this analysis, city population density, income per capita, and all related parameters used Jakarta as a city profile example in Indonesia. Mobility data remained in default from the database except for the electric vehicles number set according to the reported data in 2022. This year was determined as a baseline for projections for 2035 and 2050.

2.2. Electric Car Power Demand

The method implemented here to predict electric car power demand was a model developed by IEA [15]; this tool was established under support from GEF 7 global program. This paper shows 1000 electric Light Duty Vehicles (LDV) with an average battery capacity of 46 kWh. The scenario applying four sets of ambient temperature (20 °C, 25 °C, 30 °C, and 35 °C) correspond to Indonesia’s annual climatology temperature report: the mean is 25.95 °C, the minimum is 20 °C, and the maximum is 31 °C [16]. The charging strategy was 90% at home because of a small number of existing EV charging stations: 346 stations spread across 295 locations in 2022 [17]. So, in this work, the charging power only considers level 1 (less than 3.7 kW). On the other hand, levels 2 and 3, 3.7 kW – 22 kW and 50 kW – 400 kW, respectively, are out of consideration.

3. Result

3.1. Indonesia Electric Vehicle Mobility

The transition toward electric mobility has already been agreed upon as one of the best ways to reduce pollution from transportation. This sector is the highest producer of world emissions. In 2021, it accounted for 37% of CO₂ emitted from the transportation sector [18]. The baseline for the calculation here was taken from the data of electric vehicles entering Indonesia in 2022. With the growth factor from the default of the software, shifting mobility from the internal combustion engine to the electric mode need broad expansion from 2022 to 2050 (table 1). This scenario will benefit Indonesia environmentally due to reduced emissions (table 2). The four indications of cleaner air quality are the weakened pollutants (CO₂, PM₁₀, PM_{2.5}, and NO_x) released into the atmosphere from the transport sector. The pollutants will mainly diminish to about 90% by 2050.

Table 1. Number of Potential Electric Vehicles

Type of Electric Vehicle	2022 (Baseline)	2035	2050
Private Cars	15,000	4,834,373	5,247,839
Private two-wheelers	30,000	322,292	526,724
Bus	30	3,339	5,675
Shared Fleet	7500	258,984	361,182

Table 2. Projected Emission Reduction

Emission Reduction	2035	2050
CO ₂	65.30 %	90.77 %
PM10	31.01 %	78.93 %
PM2.5	77.07 %	93.18 %
NO _x	68.68 %	93.10 %

Charging infrastructure is crucial for substituting Internal Combustion Engine (ICE), which already has well-established infrastructure for driving long-distance destinations, toward electrical mobility [19]. Additionally, it has consequences for unbalancing the grid load and causing high energy bills for EV users [8]. Figure 1 shows the planning diversified charging strategy from baseline 2022 and then projected to 2035 and 2050. Indonesia. Home charging (90%) currently dominates the primary EV charging strategy. EV users need to add a set of apparatus from the Indonesia State Electricity Corporation, known as PLN, to get the system ready to charge an electric vehicle [20]. In 2035, the public and work charging strategy should be able to provide 37.5% of the EV power demand. Finally, by 2050, the home charging strategy will supply only 55% of the EV power demand. This calculation also suggested that extending the battery range (300 km to 500 km) and battery capacity (60 kWh to 150 kWh) in 2050 is necessary.

Furthermore, maintenance for battery charging facilities is essential to keep optimum performance and attain desired life span of the infrastructure. Charging infrastructure levels 1, 2, and three have life spans of 25, 15, and 10 years, respectively [14]. On the other hand, slow and faster-charging infrastructure for the depot could endure ten years of service.

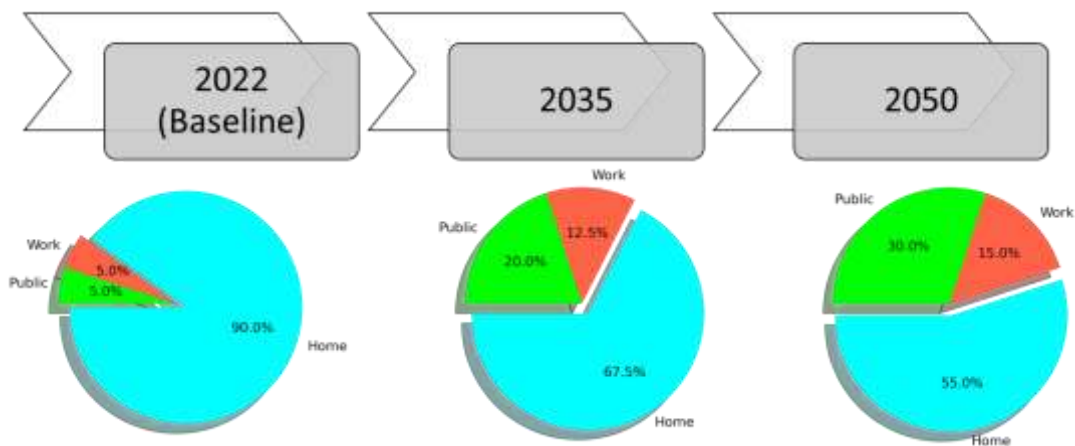


Figure 1. Projected Charging Strategy of Electric Vehicle Indonesia

3.2. Indonesia Electric Car Power Demand

Electric car development gets special attention in this article since it is by far the most significant quantity compared to other electric vehicles. It accounts for more than 85% of electric vehicles projected until 2050. Indonesia imported EVs from several countries, such as China and South Korea, and recent development shows the potential of Europe to support improvement in the Indonesia EV ecosystem [21]. The central issue of an electric car is the battery management system, for not only is it the most expensive part, but also many technical problems around its battery. In particular, it strongly affects the battery performance. In the figure below, different temperature settings determined the power demand for electric vehicles (Figure 2).

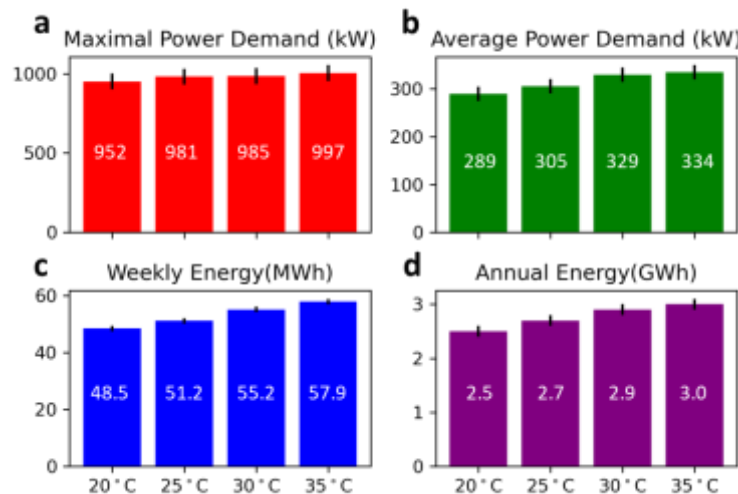


Figure 2. – Indonesia Electric Car Power Demand (a) Maximal Power Demand; (b) Average Power Demand; (c) Weekly Energy; and (d) Annual Energy.

Figure 2a shows the maximal power demand for every 1000 electric cars operating indifferent. Each temperature condition uses comparable power, about 1000 kWh for every 1000 electric cars. However, the extreme temperature of 30°C and 35°C has increased the average power needed for electric cars (Figure 2b). Therefore, higher ambient temperature requires more power for electric car transportation modes (Figures 2c and 2d). Extreme climate conditions (20°C to 35°C) consume distinctive energy. As expected, a higher ambient temperature needs more power to run the electric car.

4. Conclusion

The electric vehicle is the future of world transportation mode. It provides cleaner technology that is convenient for sustainable development orientation. As part of Net Zero emissions by 2050, all countries compete to accelerate the shift toward an electric mode of mobility. Indonesia makes a proper approach to incline with the agreement. The latest development quickly adapts new policies and necessary technology to flourish in electrical mobility mode. Some benefits are already projected in this work. Shifting toward electric mobility cut down emissions from the transportation sector in Indonesia. It is predicted 90% reduction in releasing CO₂, PM₁₀, PM_{2.5}, and NO_x by the year 2050. Cleaner air quality yielded from smaller emissions also will increase Indonesia's credibility internationally to develop potential green investments in the future.

However, this work recommends several vital points that need to be addressed. The first one is charging infrastructure. It requires special attention since Indonesia mostly leans on home charging schemes. It is necessary to accelerate the EV charging station infrastructure and facilitate a broader charging strategy, such as roadside and en route, to strengthen Indonesia's electric mobility framework. Second, it is necessary to have some improvements, especially the Battery Management System (BMS) that is able to maintain the optimum battery temperature in Indonesia's climate environment. This more optimum BMS will reduce EV battery power demand's energy consumption and prolong the battery life's span. Lastly, the recycling technology and infrastructure need to prepare accordingly. A massive number of EV waste, especially batteries, could create another environmental damage.

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