CONSOLIDATED POLICY PAPER:

# ASSESSING THE IMPACT AND OPPORTUNITIES OF ELECTRIC VEHICLES IN ADVANCING INDONESIA'S GREEN ECONOMY INDEX

CORE INDONESIA
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PAGE PARTNERSHIP FOR ACTION ON GREEN ECONOMY

# ABBREVIATIONS

| | | |
|---|---|---|
| ABTC | : | American Battery Technology Company |
| AESC | : | Automotive Energy Supply Corporation |
| AFIR | : | Alternative Fuels Infrastructure Regulation |
| AISI | : | Association of Indonesia Motorcycle Industries |
| Bappenas | : | Ministry of National Development Planning |
| BaU | : | Business as Usual |
| BC | : | Business Condition |
| BEV | : | Battery Electric Vehicle |
| BKPM | : | Ministry of Investment and Downstream Industry |
| BOE | : | Barrel of Oil Equivalent |
| BPS | : | Central Bureau of Statistics (Badan Pusat Statistik) |
| BYD | : | Build Your Dreams (Company name) |
| CALB | : | China Aviation Lithium Battery Co. |
| CATL | : | Contemporary Amperex Technology Co. Limited |
| CBU | : | Completely Built-Up |
| CED | : | Cumulative Energy Demand |
| CKD | : | Completely Knocked-Down |
| CO2 | : | Carbon Dioxide |
| E2W | : | Electric Two-Wheeler |
| E4W | : | Electric Four-Wheeler |
| EoL | : | End of Life |
| ESG | : | Environmental, Social, and Governance |
| ESS | : | Energy Storage System |
| EV | : | Electric Vehicle |
| EVSE | : | Electric Vehicle Supply Equipment |
| FOLU | : | Forestry and Other Land Use |
| GAIKINDO | : | Association of Indonesia Automotive Industries |
| GDP | : | Gross Domestic Product |
| GEI | : | Green Economy Index |
| GHG | : | Greenhouse Gas |
| GNI | : | Gross National Income |
| GoI | : | Government of Indonesia |
| ICE | : | Internal Combustion Engine |
| ICEV | : | Internal Combustion Engine Vehicle |
| IGEF | : | Indonesia Green Economy Framework |
| IGEI | : | Indonesia Green Economy Index |
| IGEM | : | Indonesia Green Economy Model |
| Kemenaker | : | Ministry of Manpower |
| Kemendag | : | Ministry of Trade |
| Kemendikbudristek | : | Ministry of Higher Education, Research and Technology |
| Kemenhub | : | Ministry of Transportation |
| Kemenkeu | : | Ministry of Finance |
| Kemenkop-UKM | : | Ministry of MSMEs |

| | | |
|---|---|---|
| Kemenperin | : | Ministry of Industry |
| KBUMN | : | Ministry of SOEs |
| KESDM | : | Ministry of Energy and Mineral Resources |
| KLH | : | Ministry of Environment |
| KPUPR | : | Ministry of Public Works and Home Affairs |
| ILO | : | International Labour Organization |
| LCA | : | Life Cycle Assessment |
| LCDI | : | Low Carbon Development Initiative |
| LFP | : | Lithium Iron Phosphate |
| LIB | : | Lithium-ion Battery |
| MHP | : | Mixed Hydroxide Precipitate |
| MSMEs | : | Micro, Small, and Medium Enterprises |
| NMC | : | Nickel Manganese Cobalt |
| NZE | : | Net Zero Emission |
| OEM | : | Original Equipment Manufacturer |
| OJK | : | Financial Service Authority |
| Pemda | : | Local Government |
| PHEV | : | Plug-in Hybrid Electric Vehicle |
| PLN | : | State Electricity Company (Perusahaan Listrik Negara) |
| PPnBM | : | Luxury Goods Sales Tax (Pajak Penjualan atas Barang Mewah) |
| R&D | : | Research and Development |
| RE | : | Renewable Energy |
| RIPIN | : | National Industrial Development Master Plan |
| RPJMN | : | National Medium-Term Development Plan |
| RPJPN | : | National Long-Term Development Plan |
| RUEN | : | National Energy General Plan |
| SIB | : | Sodium-ion Battery |
| SKKNI | : | Indonesian National Work Competence Standards |
| SME | : | Small and Medium Enterprise |
| SOE | : | State-Owned Enterprise |
| SPBKLU | : | Battery Swap Station for Electric Vehicles |
| SPKLU | : | Electric Vehicle Charging Station |
| SSB | : | Solid-State Battery |
| TKDN | : | Domestic Content Level (Tingkat Komponen Dalam Negeri) |
| ULEZ | : | Ultra Low Emission Zone |
| UNEP | : | United Nations Economic Commission for Europe |
| UNECE | : | United Nations Environment Programme |
| UNFCCC | : | United Nations Framework Convention on Climate Change |
| UNIDO | : | United Nations Industrial Development Organization |
| VAT | : | Value Added Tax |
| ZEV | : | Zero Emission Vehicle |

# EXECUTIVE SUMMARY

The Government of Indonesia has embarked on an ambitious initiative to advance its green economy through electric vehicle (EV) development, as outlined in the 2025-2045 long-term national development plan. This strategic focus aims to address critical challenges in the transportation sector, which currently accounts for 36.7% of total energy consumption and 9.5% of national greenhouse gas emissions. The government has set ambitious targets for EV adoption, aiming for 1.97 million four-wheeled vehicles (E4W) and 12.9 million two-wheeled vehicles (E2W) to comprise 44% of the national vehicle market share by 2030.

As of September 2024, Indonesia's EV market shows promising but modest growth, with 43,509 four-wheeler EVs and 152,280 two-wheeler EVs on the road. The infrastructure supporting this transition includes 1,810 public charging stations and 1,882 battery swapping stations, though these are heavily concentrated in Java, particularly the DKI Jakarta region. Sales are primarily concentrated in the middle-price segment, with 55% of purchases falling in the 250-500 million Rupiah range.

The economic impact analysis reveals significant potential benefits under the EV Impact scenario, which emphasizes domestic manufacturing. GDP growth is projected to increase from 0.01% in 2030 to 2.03% by 2060, driven by domestic value chain development. Indonesia's strategic advantage in battery production is supported by its control of 42.3% of global nickel reserves, attracting significant investments from global manufacturers including Toyota ($1.8 billion), BYD ($1.3 billion), and LG Energy Solution ($9.8 billion).

From a social perspective, the transition to EVs presents substantial employment opportunities under the domestic manufacturing scenario, with projections indicating 500,000 new jobs by 2030, expanding to 1.7 million by 2045. However, this transition requires significant workforce transformation, with new skills needed in electrical systems, battery technology, and digital manufacturing. The existing automotive workforce will require substantial upskilling, with particular emphasis on technical and analytical capabilities.

Environmental impact assessments demonstrate positive outcomes from EV adoption, showing a 14.8% reduction in overall GHG emissions compared to conventional vehicles. These benefits are expected to increase as Indonesia transitions to renewable energy sources, with the environmental pillar score in the Green Economy Index projected to reach 86.76 by 2060 under the LCDI NZE scenario. However, significant challenges remain, including the current high reliance on coal-based electricity (62.7% of production), environmental impacts from nickel mining, and limited battery recycling infrastructure.

Key challenges facing Indonesia's EV development include manufacturing and supply chain limitations, particularly in meeting domestic content requirements (TKDN) and reducing reliance on imports for critical components. Infrastructure challenges persist in the form of insufficient charging network coverage and geographic concentration of facilities. Market development faces obstacles including high upfront costs limiting adoption and consumer concerns about battery life and maintenance.

To address these challenges, comprehensive policy recommendations have been developed across economic, social, and environmental dimensions. Economic recommendations focus on maintaining and expanding purchase subsidies and tax rebates through 2030, implementing progressive taxation on conventional vehicles, and supporting flexible financing options for EV purchases. Social policy recommendations emphasize workforce development through comprehensive training programs, establishing a sectoral skills council for curriculum alignment, and developing standardized certification frameworks. Environmental policies prioritize clean energy integration in manufacturing and charging, smart grid infrastructure development, and implementation of sustainable mining standards.

The analysis concludes that Indonesia's EV development shows significant potential for advancing the country's green economy objectives, with projected improvements across economic, social, and environmental dimensions. Success requires comprehensive policy implementation, strong institutional coordination, and balanced consideration of economic development with environmental protection and social equity. The findings suggest that prioritizing domestic manufacturing capabilities while maintaining environmental standards represents the optimal path forward for Indonesia's green economy transition. []

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CHAPTER I

# INTRODUCTION

## 1.1 Background

The Government of Indonesia (GoI) has recently established the country's long-term national development plan (RPJPN) stipulated under Law 59 of 2024 for 2025-2045. The development plan envisions economic transformation by placing green economy as a key strategy for sustainable development. As part of this vision, electrifying the mobility sector and transitioning to renewable energy sources are considered pivotal steps, particularly since the transportation sector accounts for 36.7% of total energy consumption in 2023 and 9.5% of national greenhouse gas emissions in 2021 (MEMR, 2024; Climate Watch Data, 2023).

The GoI has set ambitious targets for the development and adoption of electric vehicles (EVs). These efforts are supported by Presidential Regulation No. 55 of 2019, amended by Presidential Regulation No. 79 of 2023, which outlines the framework for accelerating the Battery Electric Vehicle (BEV) Program and provides comprehensive guidance for EV development and adoption. Furthermore, the National Industrial Development Master Plan (RIPIN) 2015–2035 identifies the EV transition as a priority sector within the nation's industrial development strategy.

The government has set a target that by 2030, approximately 1.97 million four-wheeled vehicles (E4W) and 12.9 million two-wheeled vehicles (E2W) will account for 44% of the national vehicle market share, respectively. The acceleration of EVs development in Indonesia is expected to deliver multiple benefits, including reducing reliance on oil imports and fuel subsidies, increasing employment through green job opportunities, reducing greenhouse gas emissions, and also contributing to increased economic growth through the automotive industry, which currently contributes 1.8% to GDP in 2023 (BPS, 2024).

The GoI also has implemented various fiscal and non-fiscal incentives to accelerate EVs adoption, including purchase subsidies, tax reductions and exemptions, infrastructure development support, and policies mandating EV usage for government vehicles. However, current EV adoption levels remain below targets. As of 2023, E4W sales reached only 0.02 million units (2% of passenger car sales) and E2W sales reached 0.07 million units (0.01% of total motorcycle sales) (AISI, 2024; GAIKINDO, 2024).

## 1.2 Objectives of Study

Given this context, this study aims to serve a comprehensive resource for policymakers and stakeholders, contributing to the development of effective strategies and initiatives to promote the sustainable integration of EVs and to advance Indonesia's green economy development agenda. This research aims to:

1. Examine the potential economic, social, and environmental impacts of EV adoption in Indonesia;
2. Evaluate the existing policy gaps, regulatory barriers, and institutional challenges hindering the rapid expansion of EV adoption in Indonesia; and
3. Formulate the practical and actionable policy recommendations including stakeholder roles and their responsibilities to meet national EV targets that enhance Indonesia’s Green Economy Index (IGEI).

## 1.3 Scope and Limitation

This research investigates how the development of electric vehicles (EVs) influences and creates opportunities for advancing Indonesia's Green Economy Index through three critical dimensions: economic, social, and environmental impacts. The analysis focuses primarily on downstream sectors, particularly EV utilization, and midstream sectors, with specific attention to the battery industry and its technological implications. While upstream activities such as mining, metal processing, refining, and battery component manufacturing fall outside the primary scope. However, the study includes supplementary discussion of mining-related considerations in dedicated sections.

The research methodology employs a hierarchical approach, beginning with macro-level analysis before examining micro-level implications across employment, industrial development, and technological advancement. This framework necessarily encounters certain limitations within the Indonesia Green Economy Index (IGEI) model, which, being primarily macro-oriented, cannot fully capture granular impacts at detailed levels. Furthermore, while the employment impact analysis offers valuable projections through modeling and stakeholder engagement, it may not completely encompass all aspects of workforce transformation within the rapidly evolving electric vehicle sector. Despite these constraints, the methodology provides a robust foundation for understanding the multifaceted implications of EV development in Indonesia's transition toward a green economy.

## 1.4 Methodology

This study employs an integrative literature review methodology to comprehensively examine the development of electric vehicles (EVs) in Indonesia. The integrative approach has been selected to synthesize diverse sources, including empirical and theoretical literature, academic papers, policy documents, industry reports, and various research types addressing EV technologies and market trends (Toronto, 2020). This methodology is particularly valuable for consolidating and analyzing the comprehensive studies previously conducted by UNEP, ILO, and UNIDO, which serve as the primary sources for this research.

Through this integrative approach, we aim to develop a comprehensive understanding of EVs' impact across economic, social, and environmental dimensions, while assessing their potential in advancing Indonesia's Green Economy Index. Following Cohen's framework, our review process consists of five systematic stages: (1) problem formulation, (2) literature search, (3) data evaluation, (4) data analysis, and (5) interpretation and presentation of results (Russel, 2005). This structured approach enables us to evaluate the quality of existing evidence, identify knowledge gaps, and propose directions for future research and practice.

The three primary sources for this consolidated policy paper offer complementary methodological perspectives that enrich our analysis. UNEP employs a comprehensive mixed-methods design, combining quantitative and qualitative analyses through literature reviews, secondary data analysis, and focus group discussions, while utilizing system dynamics modeling to evaluate the EV sector's impact on Indonesia's Green Economy Index. ILO's approach focuses on qualitative insights through extensive stakeholder engagement, conducting in-depth interviews with key industry representatives across the battery, automotive manufacturing, and EV infrastructure sectors to understand workforce implications and industry perspectives. UNIDO implements a sophisticated technical analysis framework, incorporating Life Cycle Assessment (LCA) using Simapro software, Resources Efficiency and Cleaner Production (RECP) methodology, and Technological Readiness Level (TRL) assessment to evaluate environmental impacts, optimize resource usage, and assess technological maturity in the EV ecosystem.

Table 1 Methodology of Primary Previous Studies

| UNEP | ILO | UNIDO |
|---|---|---|
| • Data collection methods: literature reviews, secondary data analysis, and Forum Group Discussion (FGD).<br>• Analysis method: descriptive and system dynamic model. | • Literature study<br>• In-depth interviews with seven informants (representatives from business associations, companies, and industry experts representing the battery industry, automotive manufacturing (four and two-wheelers), and EV ecosystem-including EV infrastructure). | • Life Cycle Assessment (LCA) using Simapro software.<br>• Resources Efficiency and Cleaner Production (RECP).<br>• Technological Readiness Level (TRL). |

## 1.5 Overview of Indonesia's Green Economy Index

### 1.5.1 Concept

Indonesia's Green Economy Index (IGEI) is an evaluation tool to measure green economic progress in the country by assessing economic, environmental, and social nexus. Although the concept of green economy has yet to build a consensus internationally, some organizations and governments generally shared the same core idea for the green economy. In the context of Indonesia, Bappenas defines green economy as referring to UNEP's definition of an economic development model to support sustainable development with a focus on investment, capital, infrastructure, employment, and skill to achieve social welfare and environmental sustainability (UNEP (2012) in Bappenas (2022)).

As part of Indonesia's economic transformation strategy, the green economy aims to achieve high and inclusive economic growth while achieving social well-being and maintaining environmental quality. Therefore, the practices of the green economy in Indonesia are focused on the core instruments or "backbone" of the green economy itself, namely carbon development and climate resilience policies. These policies are incorporated within the national medium-term development plan (RPJMN 2020-2024), which also adheres to the mandate of the United Nations Framework Convention on Climate Change (UNFCCC) Article 3.4 to incorporate climate action into the development plan.

The Indonesia Green Economy Index (IGEI) is being developed as a tool for tracking the advancement of the green economy as part of economic reform. IGEI also offers an important step forward for Indonesia's transition to a low-carbon, green economy by offering a comprehensive and objective analysis of the economic, environmental, and social nexus. As a result, it would give evaluation and strategic development services to the government in order to assist it in designing future planning documents and policies.

There are several types of GEI developed for example by UNEP, OECD, and Green Growth and Dual Citizen. The distinction among these indices lies in the types and number of indicators utilised to construct the respective indices. For example, UNEP Green Economy Index consists of 40 indicators under environmental, policy interventions, and well-being and equity categorizations (UNEP (2012) in Bappenas (2022). PAGE utilised 13 indicators that are classified into three groups: economy, social, and environment conditions (PAGE (2017) in Bappenas (2022)). In OECD, 26 green growth indicators are incorporated and specified into productivity, natural asset base, quality of life, and policies (OECD (2017) in Bappenas (2022)). Whereas Green Economy Index developed by Green Growth and Dual Citizen utilised 18 quantitative and qualitative indicators under four key dimensions: climate change and social security are incorporated. Although some Green Economy Index has existed, Indonesia built Green Economy Index (GEI) as a framework that is able to represent green economy conditions in the context of Indonesia economy.

Besides using references from existing global indexes and studies, Indonesia Green Economy Index chooses indicators based on two criteria. First, the availability and accessibility of technical data, including the historical data and its ability for projection. Second, the indicators are Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) characteristics for its target. The interrelationships of selected indicators for the IGEI have been drawn by Bappenas using a system dynamic model.

### 1.5.2 Components

The GEI has 15 indicators that can be divided into three sustainability pillars, namely environmental, economic, and social pillars (see Table 1). The environmental pillar consists of five indicators, including the percentage of forest cover, the share of renewable energy, GHG emission reduction, managed waste and degraded peatland. The economic pillar has six indicators, namely emission intensity, final energy intensity, gross national income per capita, agricultural productivity, industrial sector labour productivity, and service sector labour productivity. Then, the social pillar has four indicators, including mean years of schooling, life expectancy, poverty rate, and unemployment rate. Each indicator in the GEI has different maximum and minimum thresholds based on the target goals from documents such as the 2060 Net Zero Emission, the Executive Summary of Indonesia's Vision 2045, the World Bank, and others.

Table 2 GEI's Pillars and Indicators

| No. | Indicators | Description | Minimum Thresholds | Maximum Thresholds |
|---|---|---|---|---|
| | | **Environmental Pillar** | | |
| 1 | Forest cover (%) | Comparison between forest cover with Indonesia's total land area (excluding water). | 30% | 54% |
| 2 | Share of renewable energy (%) | The share of energy from renewable sources against the total national primary energy mix. | 0% | 42% |
| 3 | Managed waste (%) | Level of household waste generation managed by the government compared to the total waste generated. | 0% | 82% |
| 4 | GHG emission reduction (%) | Level of cumulative emissions reduced from all sectors, started from 2010 as the base year compared to baseline of cumulative emission within the same period. | 0% | 70% |
| 5 | Degraded peatland (%) | Comparison between forest cover on peatland area out of the total peatland area in Indonesia. | 30% | 0% |
| | | **Economy Pillar** | | |
| 6 | Emission intensity ($TCO_2eq$/BnRp) | Ratio of GHG emissions per unit of economic activity, represented at the national level by GDP. | 270 $TCO_2eq$/BnRp | 26 $TCO_2eq$/BnRp |
| 7 | Final energy intensity (BOE/BnRp) | Amount of energy consumed per level of economic activity, represented at the national level by GDP. | 125 BOE/BnRp | 63 BOE/BnRp |
| 8 | Gross National Income (GNI) per capita (USD/capita) | Sum of value added by all resident producers plus any product taxes not included in the valuation of output plus net receipts of primary income, measured in IDR and converted to USD. | 500 USD | 12,695 USD |
| 9 | Agricultural productivity (ton/ha/year) | Level of agriculture production output, specific on food crops (paddy), plantations (palm oil), and fisheries (aquaculture) per total area used in a year. | 5 ton paddy/ha/year<br>2 ton CPO/ha/year<br>3 ton aquaculture/ha/year | 12 ton paddy/ha/year<br>5 ton CPO/ha/year<br>19 ton aquaculture/ha/year |

| No. | Indicators | Description | Minimum Thresholds | Maximum Thresholds |
|---|---|---|---|---|
| 10 | Industrial sector labour productivity (MnRp/person) | Value that shows the ability of labour to produce production goods in the industrial sector is measured by dividing the added value of production by the amount of paid labour. | 20 MnRp/person | 200 MnRp/person |
| 11 | Service sector labour productivity (MnRp/person) | Value that demonstrates the labour's ability to generate goods in service sector, calculated by dividing the added value of production by the amount of paid labour. | 20 MnRp/person | 200 MnRp/person |
| | | **Social Pillar** | | |
| 12 | Mean year of schooling (years) | Total years of education for adult age (25 and above) divided by total adult population age (25 and above). | 2 years | 12 years |
| 13 | Life expectancy (years) | The average period of people may expect to live. | 55 years | 75.5 years |
| 14 | Poverty rate (%) | Percentage of total population with total expenditure below the national poverty line. | 13% | 0% |
| 15 | Unemployment rate (%) | Percentage of unemployed people in the labour force. | 15% | 3% |

Source: Bappenas (2022)

To calculate the GEI, the first thing to do is to calculate the scores for each indicator. The score for each indicator is the result of comparing the existing year's score (denoted as yi) with their respective maximum thresholds (ymax) and minimum thresholds (ymin) (see Equation 1).

$$Indicator\ score\ (i) = \frac{(yi - ymin)}{(ymax - ymin)} x\ 100 \quad (1)$$

After obtaining the scores for each indicator, the second step is to calculate the scores for each GEI pillar. The score for each pillar is the arithmetic average from the sum of the respective indicators within it. The formula for the score of each pillar can be seen in the following equation.

$$Environment\ score\ (i) = \frac{\sum \quad Indicator\ score\ (i)}{5} \quad (2)$$

$$Economy\ score\ (i) = \frac{\sum \quad Indicator\ score\ (i)}{6} \quad (3)$$

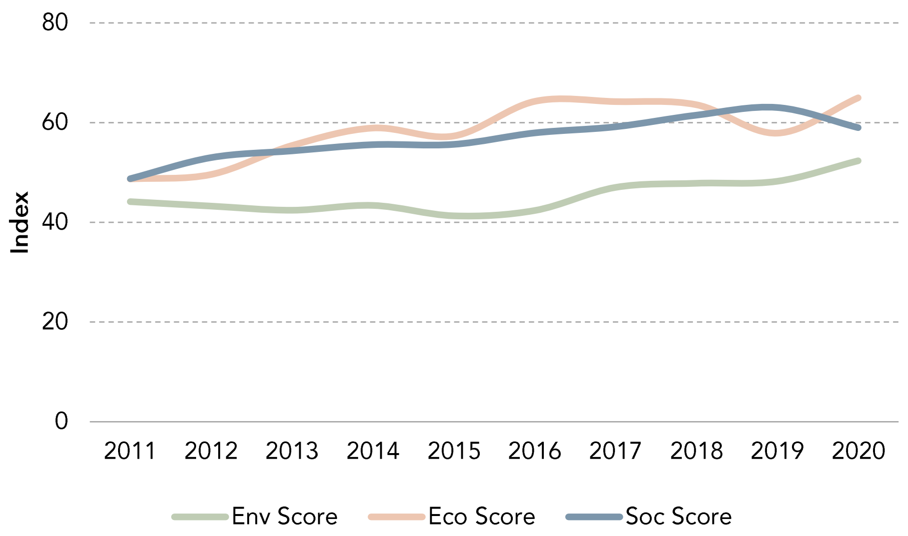
$$Social\ score\ (i) = \frac{\sum \quad Indicator\ score\ (i)}{4} \quad (4)$$

Furthermore, the scores of each pillar are aggregated with weights based on the number of their respective indicators. Therefore, the GEI can be obtained through Equation 5 below.

$$GE\ Index\ (i) = \frac{(Env.score\ (i)x5) + (Eco.score\ (i)x6) + (Soc.score\ (i)x4)}{15} \quad (5)$$

Based on the results of the Green Economy Index (GEI) over the period 2011-2020, the green economy conditions in Indonesia showed an increasing trend compared to previous years (see Figure 1) (Bappenas, 2022). However, the environmental pillar consistently had the lowest scores compared to the economic and social pillars. Therefore, various government efforts are essential to support the implementation of the green economy, particularly in the environmental pillar.

Figure 1 GEI's Annual Score




Source: Bappenas (2022)

Furthermore, when examined closely, the indicators within the environmental pillar with the lowest share are the renewable energy indicator and the emission reduction indicator (Bappenas, 2022). The renewable energy indicator has shown significant improvement after the formulation of Presidential Regulation No. 22/2017 on the National Energy General Plan (RUEN), which has promoted the use of renewable energy sources such as hydro, geothermal, and biomass. In addition, the emission reduction indicator also contributes minimally to the GEI due to high emissions from the energy sector, particularly from power generation, and the Forestry and Other Land Use (FOLU) sector due to forest and land fires.

# CHAPTER II

# ECONOMY AND INDUSTRY ASPECTS OF EV DEVELOPMENT IN INDONESIA

## 2.1 Global EV Market Overview

### 2.1.1 Global Market Size and Growth

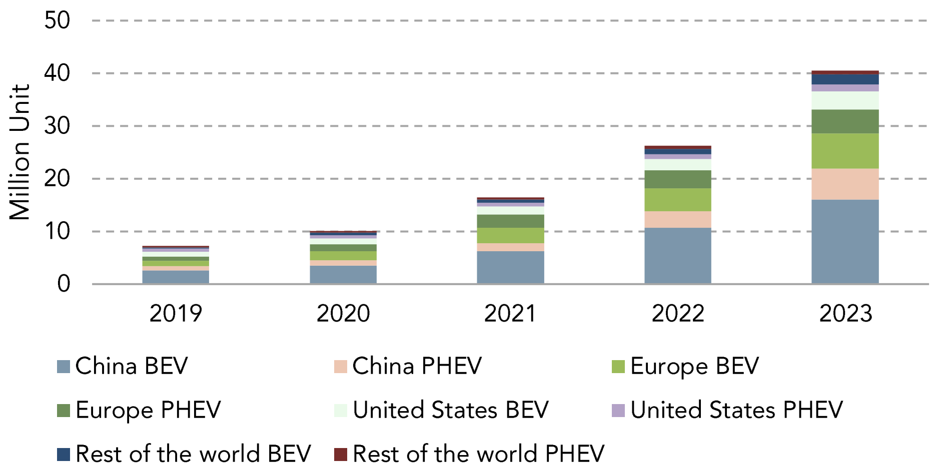
The global electric vehicle market, according to IEA (2024), demonstrated remarkable momentum in 2023, with nearly 14 million new electric cars registered worldwide, marking a 35% increase from 2022. This growth brought the total global EV fleet to approximately 40 million vehicles. The market's expansion has been dramatic over the past five years, with current sales volumes exceeding six times those of 2018. Electric cars now represent around 18% of all car sales globally, a significant jump from 14% in 2022 and just 2% in 2018.

Looking ahead to 2024, projections suggest continued robust growth, with global EV sales expected to reach approximately 17 million units, potentially capturing more than one-fifth of total car sales. This sustained growth indicates the market's increasing maturity and mainstream adoption of electric vehicles worldwide.

The global EV market remains highly concentrated in three major regions: China, Europe, and the United States, which collectively account for 95% of global electric car sales. China leads the market with approximately 60% of new electric car registrations, followed by Europe with 25%, and the United States with 10%. In terms of market penetration, China achieved more than one in three new car registrations being electric in 2023, while Europe reached one in five, and the United States one in ten.

Battery electric vehicles (BEVs) dominate the global electric car stock, representing 70% of the total in 2023, with plug-in hybrid electric vehicles (PHEVs) making up the remainder. Emerging markets, particularly in Southeast Asia and Brazil, are showing increasing adoption rates, albeit from a lower base, with countries like Thailand reaching a 10% market share and Vietnam achieving 15%.

**Figure 2** EV Stock in the World, 2019-2023




Source: IEA (2024)

### 2.1.2 Global EV Ecosystem and Enablers

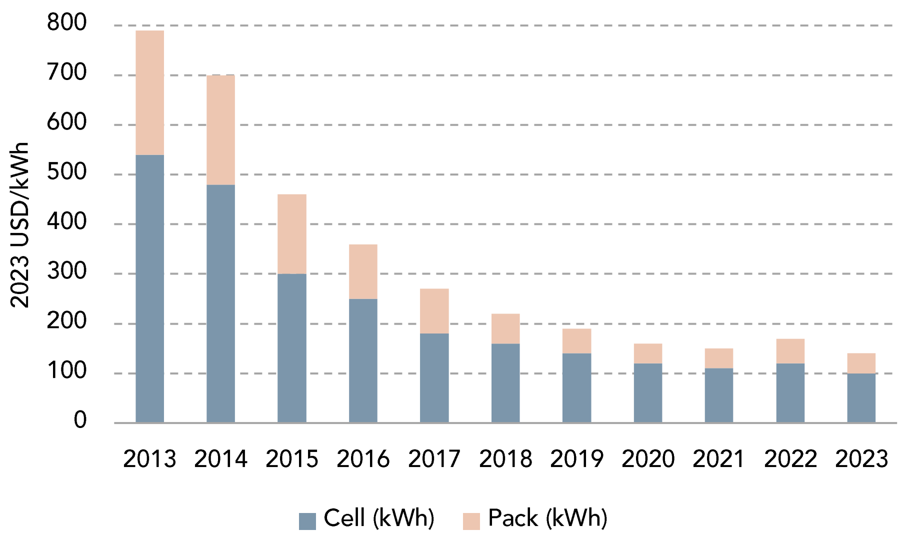
The growth of the global EV market is supported by several key enablers and a developing ecosystem, including technological advancement especially in EV batteries, charging infrastructure networking, government policies and incentives to support EV adoption, R&D investment, and development of supporting ecosystem such as secondary market for EVs, service and maintenance networks, and workforce development.

#### 1) EV Battery Manufacturing

Battery technology and supply chains have seen significant advancement. Lithium-ion battery packs and battery cells' prices have dropped to only a fifth of what they were a decade ago. This drastic cost reduction has been driven by economies of scale, alongside innovations in new battery chemistries, and improvements in energy density (see Figure 3). Battery prices have fallen in 2023, dropping by almost 14% compared to 2022, making EVs more affordable. However, at the same time, a shortage in the supply of critical materials, similar to what was already experienced in 2022 with cobalt and lithium, would result in their component cost increases (EIA, 2023; IRENA, 2023).

Moreover, the development of sodium-ion batteries by several battery producers in the United States, Europe, and China, with some producers having reached mass production, such as CATL, BYD, and Northvolt, is projected to reduce EV battery costs by up to 20 percent compared to current EV battery technology (EIA, 2023).

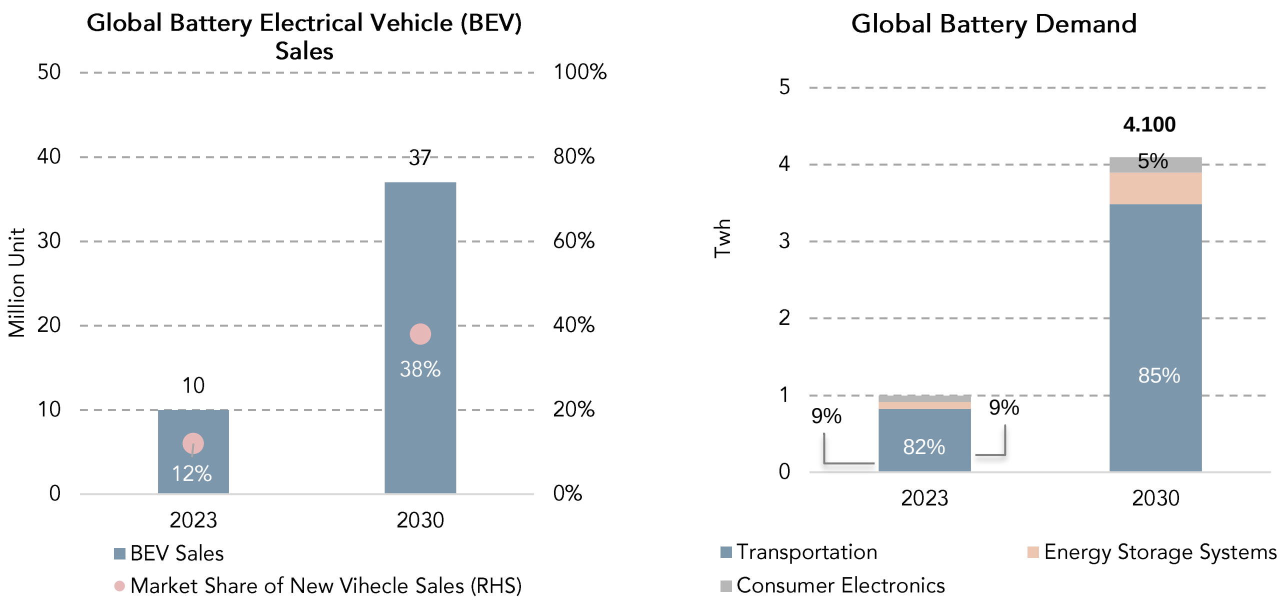
Figure 3 Volume-weighted Average Price Split for Lithium-Ion Battery Packs and Cells, 2013–2023




Source: IRENA (2024)

The demand for batteries was projected by Bain & Company (2024) to reach four times in 2030 compared to 2023, following the rapid increase in the market share of BEV share market share sales from 12 percent to 38 percent in 2030.

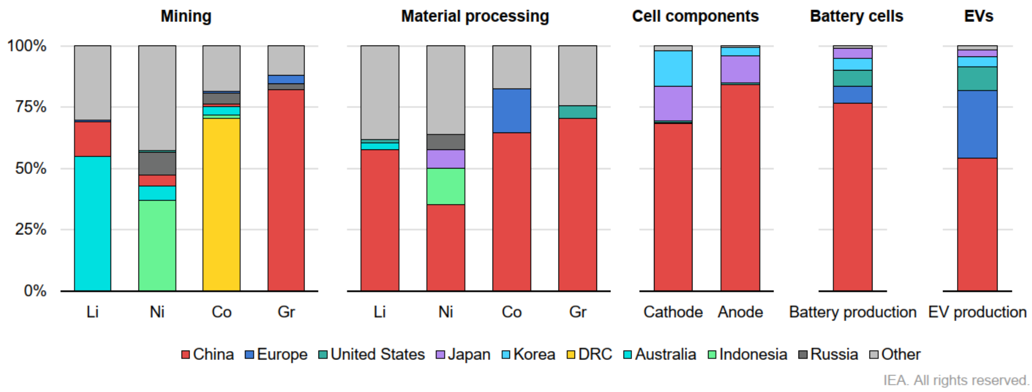
**Figure 4** Global BEV Sales and Battery Demand Projections




Source: Bain & Company (2024)

The EV battery supply chain shows distinct geographical concentrations across different stages. At the mining stage, there is a diverse distribution with Australia dominating lithium mining, Indonesia leading in nickel, DRC in cobalt, and China as a major producer of graphite production. However, moving downstream in the supply chain, China increasingly dominates-particularly in material processing, cell components, and battery cell production, with major players like CATL and BYD leading the market. South Korean companies (like LG Energy Solution and Samsung SDI) and Japanese firms (such as Panasonic and AESC) also maintain significant positions in cell components and battery cell production (see Figure 5).

Figure 5 Geographical Distribution of the Global Battery EV Supply Chain




Source: IEA (2022)

## 2) Charging Infrastructure

The development of charging infrastructure and its technology contribute to the accelerating adoption of EVs globally. At the end of 2023, fast chargers represented over 35% of public charging stock. China is shifting focus to charging infrastructure development, targeting full coverage in cities and on highways by 2030, as well as expanded rural coverage. In 2023, China leads electric vehicle supply equipment (EVSE) deployment, with more than 85% of the world's fast chargers, and around 60% of slow chargers (EIA, 2024). In late 2023, the European Union agreed on the text of the alternative fuels infrastructure regulation (AFIR), which will require public fast chargers every 60 km along the European Union's main transport corridors.

However, despite the rapid development of public charging stations, home charging still dominates, especially for users with private parking for their EVs. In Norway and the UK, 82% and 93% of EV users, respectively, use home charging, while in India, 55% of EV consumers have access to it. In densely populated cities, where most people live in multi-unit dwellings with limited private parking, users heavily rely on public charging, such as in Korea, which has the highest ratio of public charging capacity to EVs (EIA, 2024).

Renewable Energy Source for Charging. Optimizing the positive environmental impact of electric vehicles (EVs) goes beyond reducing vehicle emissions—it can also be enhanced through the use of renewable energy sources. Integrating renewable energy (RE) with EV smart charging networks is crucial to maximize EVs' potential as green transportation. However, challenges remain with RE supply, such as the high availability of solar energy during the day or wind energy at night, requiring innovative approaches to make the most of these energy sources and reduce charging costs.

One solution is to use a smart charging approach that automatically adjusts tariff rates in real-time based on peak and off-peak hours, leading to more cost-effective and efficient energy consumption. To achieve sustainable mobility, government policymakers should support this integration by providing financial aid, subsidies, research grants, job creation, and feed-in tariffs, all aimed at improving RE supply efficiency and subsequently lowering EV charging costs. Additionally, increasing consumer awareness to adopt EVs powered by RE is essential, as this rising demand will ultimately drive down production costs through economies of scale.

### 3) Government Support

Policy support continues to play a vital role, with various countries implementing purchase incentives, tax benefits, and infrastructure development programs. Based on the analysis of global EV policies and incentives, governments are implementing comprehensive strategies to accelerate EV adoption through six main categories of support measures:

1. **Purchase Subsidies & Tax Incentives** form the foundation of most countries' EV promotion strategies. These financial instruments directly address the higher upfront costs of EVs compared to conventional vehicles. They include direct purchase grants, tax exemptions or reductions (VAT, registration, annual road tax), and special provisions for company cars. The design of these incentives often varies based on vehicle type, price, and buyer category (private, commercial, or government).

2. **Manufacturing & Industry Support** measures aim to develop domestic EV and battery production capabilities. Countries are implementing various industrial policies including production incentives, R&D funding, and supply chain development support. These measures often come with local content requirements and are particularly prominent in countries with existing automotive manufacturing bases seeking to transition to EV production.
3. **Infrastructure Development** policies address one of the key barriers to EV adoption - charging availability. Governments are supporting both public and private charging infrastructure through direct funding, installation subsidies, and regulatory requirements. This includes support for various charging solutions from home and workplace charging to public fast-charging networks and, in some cases, battery swapping stations.

4. **Regulatory Measures** provide the policy framework driving the transition to EVs. These include zero-emission vehicle mandates, future ICE vehicle sales bans, emissions standards, and fleet requirements for government and commercial vehicles. Such regulations create long-term market certainty and push manufacturers to increase their EV offerings.

5. **Local/Regional Incentives** complement national policies by providing additional benefits at the city or regional level. These include access privileges (bus lanes, parking), local purchase incentives, and municipal charging programs. Cities often lead in implementing progressive EV policies, particularly through low emission zones and local infrastructure development.

6. **Professional & Public Support** measures focus on developing the ecosystem needed for widespread EV adoption. This includes workforce training programs, public awareness campaigns, dealer education, and research initiatives. These supporting measures are crucial for ensuring a smooth transition to electric mobility.

Table 3 Global Electric Vehicle Support Measures: Categories, Examples, and Implementing Countries

| Main Category | Specific Policy/ Measure | Example/Description | Countries Implementing |
|---|---|---|---|
| Purchase Subsidies & Tax Incentives | Direct cash grants for new EV purchases | Up to $7,500 tax credit for new EVs (USA), up to ¥12,600 subsidy per BEV (China), €6,000 bonus for low-income buyers (France) | Canada, China, France, Germany, UK, Sweden, Netherlands, South Korea |
| | VAT/sales tax exemptions or reductions | Complete VAT exemption on EV purchases (Norway), reduced VAT rate from 10% to 1% (Indonesia) | Norway, Thailand, Indonesia, Austria, Denmark |
| | Registration tax exemptions | Zero registration tax for EVs compared to high rates for ICE vehicles (Denmark), full exemption from first registration tax (Netherlands) | Netherlands, Denmark, Norway, Austria |
| | Income tax deductions | Up to 120% tax relief for company EV purchases (Belgium), special depreciation rates for business EVs (Austria) | Belgium, Austria, Germany, UK |
| | Reduced annual vehicle taxes | Zero annual road tax for EVs (Germany), reduced rates based on CO2 emissions (UK) | Germany, Netherlands, UK, France |
| | Scrappage bonuses | Additional €2,500 when replacing ICE vehicle over 7 years old (France), up to €4,000 for scrapping old vehicles (Italy) | France, Italy, Spain, Germany |
| Manufacturing & Industry Support | Battery production incentives | Tax credits requiring domestic battery production (USA), subsidies for battery manufacturing facilities (China) | USA, China, South Korea, Japan |
| | Domestic manufacturing subsidies | Production Linked Incentive scheme offering 4-6% of sales value (India), tax holidays for EV manufacturing (Thailand) | India, Indonesia, Thailand, China |
| | R&D funding programs | $2.4B Advanced Manufacturing Plan (UK), Battery technology development grants (Japan) | UK, Japan, South Korea, USA |
| | Supply chain development support | $6B grant program for EV supply chain (USA), battery material processing subsidies (China) | USA, China, EU countries |

| Main Category | Specific Policy/ Measure | Example/Description | Countries Implementing |
|---|---|---|---|
| | Local content requirements | Minimum 40% domestic content for subsidy eligibility (Indonesia), NEV credit system (China) | China, Indonesia, India, Thailand |
| Infrastructure Development | Public charging network funding | $7.5B national charging network (USA), subsidies covering up to 80% of charging station costs (China) | USA, China, EU, UK |
| | Home charging installation subsidies | Up to £350 for home charger installation (UK), 75% installation cost coverage (France) | UK, France, Germany, Netherlands |
| | Fast-charging corridor development | Minimum coverage requirements every 60 km on highways (EU), national charging network along highways (USA) | USA, EU, China |
| | Workplace charging incentives | Tax relief up to 200% for businesses installing chargers (Belgium), grants covering 75% of costs (UK) | UK, France, Netherlands |
| | Battery swapping station support | Subsidies for battery swapping stations (China), pilot programs for swapping infrastructure (India) | China, India |
| Regulatory Measures | Zero-emission vehicle mandates | Requirements for manufacturers to sell minimum % of ZEVs (California - 35% by 2026), NEV credits system (China) | China, California (USA), EU |
| | ICE vehicle sales ban targets | Complete ban on new ICE vehicle sales by specified dates (Norway 2025, UK 2030) | Norway (2025), UK (2030), Netherlands (2030) |
| | CO2 emission standards | Fleet average CO2 limits with penalties for non-compliance (EU - 95g/km), CAFE standards (USA) | EU, USA, China, Japan |
| | Government fleet requirements | 100% of federal fleet purchases to be ZEV by 2035 (USA), public fleet electrification targets (France) | USA, Canada, China, France |
| | Low emission zones | City areas restricting ICE vehicle access (London ULEZ), zero-emission zones (Chinese cities) | EU countries, China, UK |
| Local/Regional Incentives | City access privileges | EV access to bus lanes (Norway), unrestricted access during traffic restrictions (China) | Norway, Germany, Netherlands |

| Main Category | Specific Policy/ Measure | Example/Description | Countries Implementing |
|---|---|---|---|
| | Free/reduced parking | Free parking in city centers (Norway), reduced parking fees (Chinese cities) | Norway, China, UK, Germany |
| | Regional purchase bonuses | Additional provincial rebates up to $3,000 (Canada), state-level tax credits (US states) | Canadian provinces, US states, Chinese cities |
| | Municipal charging programs | City-led charging infrastructure deployment (Amsterdam), local charging networks (Shanghai) | European cities, Chinese cities, US cities |
| Professional & Public Support | Technical workforce training | EV maintenance certification programs (Germany), technician training initiatives (France) | Germany, France, China, UK |
| | Public awareness campaigns | National EV information portals (Norway), demonstration programs (UK) | Norway, UK, Canada |
| | Dealer education programs | Training for car dealerships (USA), sales staff certification (Norway) | USA, Norway, Netherlands |
| | Research & pilot programs | EV demonstration projects (EU), testing new technologies (China) | EU countries, China, USA |

Source: IEA (2024b), processed by the authors

### 4) Research and Development

R&D is key to developing innovation in EV production and its ecosystem. In recent years, research activities conducted by both researchers and companies have grown very rapidly. From a publications perspective, areas of EV research linked to charging infrastructure, EV adoption, thermal management systems and routing problems have been the distinct trending topics in recent years.

Meanwhile, automotive and battery companies allocate different research budgets. Chinese EV manufacturers are focusing their research and development efforts across several key areas: manufacturing innovation through smart factories and automated production systems, battery technology development, software development for vehicle operating systems (including driver-assist features, in-car entertainment, and security systems), quality management improvements, and supply chain optimization.

In terms of value of investment, among U.S.-listed Chinese EV makers, in the first quarter 2024, for instance, Nio leads with nearly 29% of revenue spent on R&D in the first quarter, while Tesla's ratio was only 5.4%. This intensive investment reflects the highly competitive nature of China's auto market, where new energy vehicles account for over 40% of sales. BYD leads in absolute R&D spending at $1.47 billion in the first quarter, surpassing Tesla's $1.15 billion, demonstrating the scale of investment Chinese companies are making to compete in the global EV market.

5) **Secondary Market**

The secondary market for EVs is emerging as a crucial enabler, with used EV sales reaching significant volumes - approximately 800,000 units in China, 400,000 in the United States, and over 450,000 in key European countries combined in 2023. This growing secondary market is making EVs more accessible to a broader range of consumers (IEA, 2023). The U.S. used EV market, for instance, although it hasn't seen a stable market following the COVID impact and rapid price cuts, will potentially provide more accessible and affordable EVs than ever before. In 2024, nearly 75% of vehicle sales are used vehicles, and low-income and rural EV drivers are more likely to buy used vehicles. The increasing availability of affordable used EVs in the market, following the decreasing prices of new EV purchases and leases, will allow more drivers to benefit from the cost and maintenance savings of EVs, getting more EVs into the pipeline and on the road.

6) **Battery Recycling**

The use of electric vehicles is expected to grow exponentially in the coming years, and so will end-of-life lithium-ion batteries (LIBs), albeit with a time lag of 10–15 years depending on the length of use in EVs and an eventual second life in applications such as energy storage. Battery manufacturers are constructing recycling facilities either directly on-site or nearby to streamline the process. Additionally, independent recyclers are making significant investments in their own lithium-ion battery recycling plants, reflecting the growing demand and opportunity in this sector. Over the past two years alone, more than 20 companies in the automotive and recycling sectors have announced plans for new partnerships.

There are at least four key battery recycling technologies that are being developed: pyrometallurgy, hydrometallurgy, direct recycling, and biotechnological methods.

1. Pyrometallurgy is a high-temperature process that recovers metals like cobalt, nickel, and copper, but not lithium. It is widely used in China but considered energy-intensive and less efficient in lithium recovery. Pyrometallurgy is expected to decline as hydrometallurgy becomes more favored due to environmental concerns.

2. Hydrometallurgy uses aqueous solutions to recover materials like lithium, cobalt, and nickel. It has been commercially implemented in China, Europe, and North America, and has high recovery rates and a lower environmental footprint compared to pyrometallurgy. Hydrometallurgy is anticipated to

dominate the industry due to higher efficiency and evolving global regulations.

3. Direct Recycling aims to reuse cathode materials directly, reducing the need for full reprocessing. It is still in the research stage but showing potential for reducing costs and environmental impacts. Direct recycling could transform the industry by offering lower costs and environmental benefits when scaled.

4. Biotechnological methods, such as bio-hydrometallurgy, which employs microorganisms to selectively extract and concentrate metals from spent lithium-ion batteries, are also being explored. While biotechnological methods show promise for recycling lithium-ion batteries, their application at an industrial scale is still in the preliminary phases, requiring further research and development to enhance performance and potential for large-scale battery recycling facilities.

## 2.2 Indonesia EV Market

### 2.2.1 Market Size and Sales Figures

The Indonesian electric vehicle (EV) market has shown remarkable growth in recent years, with distinct trajectories in both four-wheeler and two-wheeler segments. In the four-wheeler segment, the market has expanded significantly from just 120 units in 2020 to 43,509 units on the road as of September 2024, demonstrating a consistent pattern of exponential growth.

In the first nine months of 2024, four-wheeler (4W) EVs sales reached 27,547 units. Wuling still leads the market through 2024, reaching sales of 9,146 units, while BYD follows in second place with 8,536 units. 4W EV sales continue to increase amid sluggish overall domestic automotive sales, impacted by deteriorating consumer purchasing power in 2024. This makes the government's target of selling 170 thousand 4W EVs by 2024, as part of the battery-based EV roadmap, more challenging.

Analysis of the market segments reveals that majority of four-wheeler EV sales are concentrated in the middle-price segment, with 55% of sales occurring in the 250–500 million Rupiah range, while 42.7% fall in the 500 million to 1 billion Rupiah category, and only 2.25% in the premium segment above 1 billion rupiah. Notably, sales remain heavily concentrated in Java, particularly in the DKI Jakarta region.

The two-wheeler EV segment has demonstrated even more impressive growth, reaching 152,280 units on the road by September 2024. This represents a significant 144% increase from the previous year, driven largely by government support through purchase subsidies. The effectiveness of these subsidies is evident in their rapid uptake - in 2024, the government increased the subsidy quota from 50,000 to 60,857 units due to high demand. However, producers are still struggling to reach the initial government target of 1 million in 2024.

According to a recent survey, several factors have attracted Indonesian consumers to adopt EVs, including lower environmental impact, curiosity to try out the technology, better driving characteristics, suitability for daily mobility needs, ease of operation, lower operating and maintenance costs, better basic features, alignment with consumer values and lifestyle, and the convenience of charging. The survey also found that government policies and incentives are a crucial factor in the adoption of electric vehicles in Indonesia (CORE Indonesia, 2024b).

However, the adoption of EVs in Indonesia currently remains far below the government's target. Several factors are hindering this progress, including the lack of public charging infrastructure, concerns about battery durability and lifespan, uncertainty about parts availability and repair services, unsuitability for long-distance or holiday travel, concerns about battery safety and performance in extreme weather conditions, longer charging times compared to conventional refueling, range anxiety, uncertainty about the continuity of government incentives, and concerns about long-term maintenance costs (CORE Indonesia, 2024b). These discouraging factors should become top priorities for government regulations to enhance the adoption of electric vehicles and help the government achieve its EV penetration targets.

### 2.2.2 Government Adoption Scenarios

However, referring to Indonesia government's ambitious targets for EV adoption by 2030, the above EV sales in Indonesia is far below the target. According to Government Regulation Number 55 of 2019 on the Acceleration of Battery Electric Vehicle Programs for Road Transportation, Indonesia aims to reach electric car sales of 1.97 million units, holding a 44% market share of passenger car sales in 2030. For electric motorcycles, Indonesia targets sales to reach 12.9 million units by 2030, commanding a 44% market share of passenger motorcycle sales in that year.

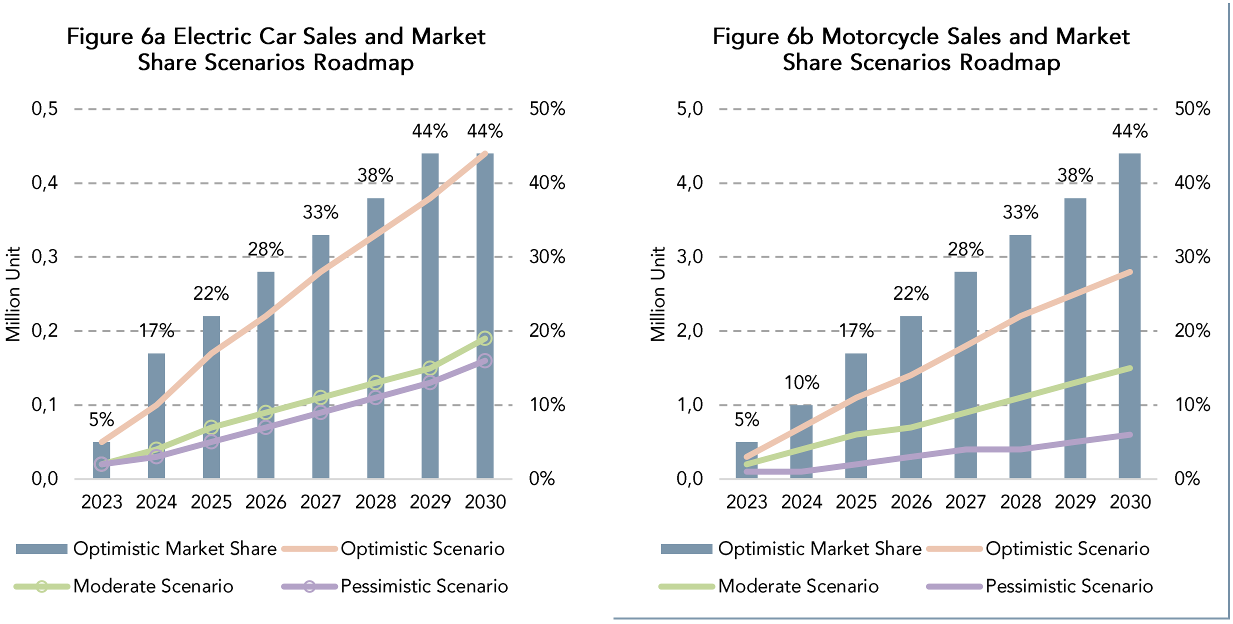
**Table 4** The Projection of EV Adoption Scenarios in Indonesia

| Vehicle Type | Scenario | Achievement by 2030 (%) | Units by 2030 (Million) | Tipping Point 5% in year |
|---|---|---|---|---|
| Four-Wheelers | Optimistic | 100 | 2.0 | 2023 |
| | Moderate | 50 | 1.0 | 2024 |
| | Pessimistic | 40 | 0.8 | 2025 |
| Two-Wheelers | Optimistic | 100 | 12.9 | 2023 |
| | Moderate | 50 | 6.4 | 2024 |
| | Pessimistic | 20 | 2.58 | 2025 |

Source: CORE Indonesia (2024a)

Notes: The optimistic scenario is based on the government's target (Coordinating Ministry of Maritim and Investment, 2023), while the moderate scenario is half of the government's target, and the pessimistic scenario follows the growth rate of 2023 sales.

Figure 6 Number of E4W and E2W Sales (2019-Oct-2024)




Source: CORE Indonesia (2024a)

### 2.2.3 Key Enablers of EV Market Growth

#### 1) Charging Infrastructure Development

The Indonesian government, through the Minister of Energy and Mineral Resources Regulation Number 13 of 2020 on the Provision of Electric Charging Infrastructure for Battery-Based Electric Motor Vehicles, has been promoting the development of infrastructure to support the adoption of electric vehicles (EVs). This includes the establishment of Electric Vehicle Charging Stations (Stasiun Pengisian Kendaraan Listrik Umum or SPKLU), which can be owned by the government, private entities, or individuals. However, as of 2030, the deployment of EV charging stations remains below the target of 31,859 units (Kemenko Marves, 2021 on CORE Indonesia, 2024a).

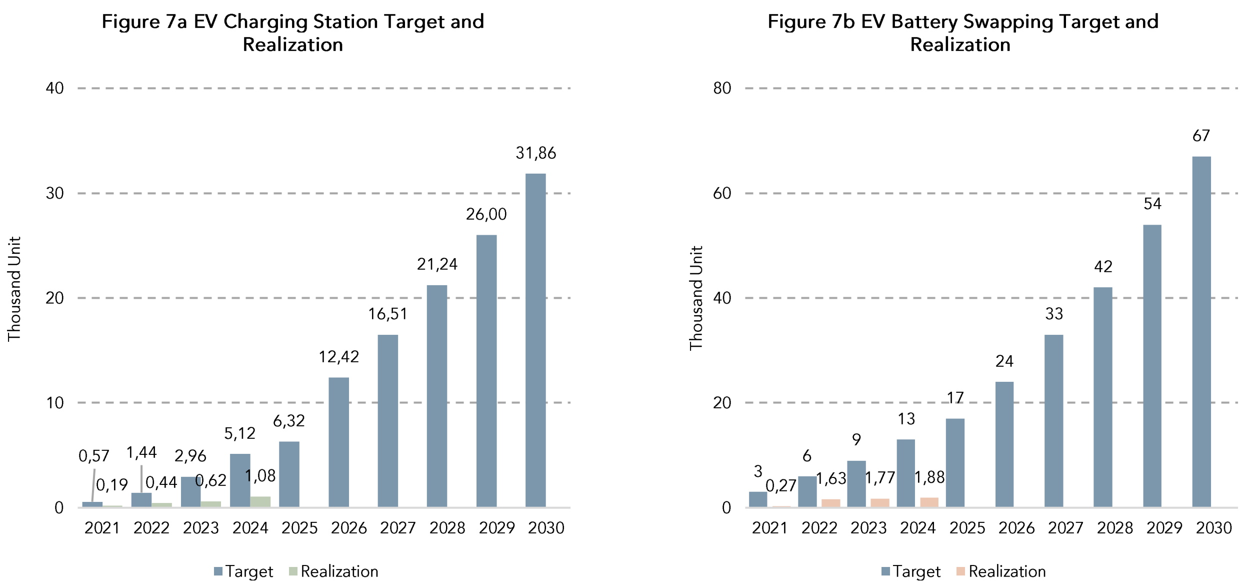
To further accelerate EV adoption, Indonesia is also encouraging the establishment of battery swapping stations (Stasiun Penukaran Baterai Kendaraan Listrik Umum or SPBKLU). The target for these stations is set at 67,000 units by 2030 (Kemenko Marves, 2021 on CORE Indonesia, 2024a).

While progress has been made in the development of EV charging infrastructure, it still requires substantial expansion to meet ambitious adoption targets. As of July 2024, the number of Electric Vehicle Charging Stations (SPKLU) has reached 1,810, while Public Electric Vehicle Battery Swap Stations (SPBKLU) number 1,882. However, these stations are predominantly located in the DKI Jakarta and West Java areas, with regions such as Kalimantan, Nusa Tenggara, Maluku, and Papua lacking such infrastructure (Dirjen Gatrik, 2023 on CORE Indonesia, 2024a).

In addition to public infrastructure, home charging solutions have gained significant traction. As of the first half of 2024, there were 14,524 home-charging customers, representing a 335% increase compared to the same period in the previous year. The total electricity consumption from these home chargers reached 4,264.8 MWh, a 344% increase from 960.1 MWh in the first half of 2023.

PLN, the state electricity company, has implemented supportive policies to encourage home charging adoption. These include significant reductions in installation costs: the cost for a 1-phase (7,700 VA) home charger has dropped from Rp 7.49 million to Rp 850,000, while a 3-phase (13,200 VA) charger now costs Rp 3.5 million, down from Rp 14.6 million. Additionally, PLN offers a 30% discount on electricity rates for home charging during off-peak hours (10:00 PM to 5:00 AM).

**Figure 7** EV Charging Infrastructure Target and Realization




Source: Dirjen EBTKE (2023) on CORE Indonesia (2024a)

## 2) Government Incentives

As in the world's leading countries for electric vehicle (EV) adoption, government incentives play a significant role in encouraging consumers to adopt EVs in Indonesia as well. The Indonesian government has implemented various policies and incentives to support the development of the EV ecosystem, both for consumers and manufacturers.

On the consumer side, the government offers subsidies for electric motorcycles (7 million IDR per unit, targeting 200,000 units) and electric cars, such as 70-80 million IDR for the Hyundai Ioniq 5 and 25-35 million IDR for the Wuling Air EV, with a target of 35,900 units. Additionally, the government has implemented a 0% luxury tax (PPnBM) for battery electric vehicles (BEVs) and reduced the VAT rate to 1% for BEVs with local content (TKDN) above 40%, or 6% for those below 40%. The government also offers tax holidays of 5-20 years for investments exceeding 1 trillion IDR and tax allowances of 25-100% for 5-15 years.

On the supply side, the government has set a target of 20% EV production by 2025 and is working to build 32,000 public charging stations (SPKLU) by 2030. To support the development of charging infrastructure, the government has provided incentives in the form of reduced electricity tariffs for SPKLU operators, with a bulk rate of 714 IDR/kWh charged to the business, which can then be sold to consumers at 2,475 IDR/kWh.

Table 5 The Indonesian Government Regulations on EV

| No. | Regulation | Key Content |
|---|---|---|
| 1 | Presidential Decree No. 55/2019 | Accelerates battery-based electric vehicle adoption in Indonesia to reduce fuel dependency and greenhouse gas emissions, focusing on EV industry development, fiscal/non-fiscal incentives, and charging infrastructure. |
| 2 | Government Regulation No. 73/2019 | Regulates vehicle tax rates based on emissions, providing tax relief for electric vehicles compared to conventional vehicles. |
| 3 | Ministry of Energy and Mineral Resources Regulation No. 13/2020 | Regulates provision of charging infrastructure for electric vehicles, including Public Electric Vehicle Charging Stations (SPKLU). |
| 4 | Ministry of Transport Regulation No. 44/2020 | Regulates physical type testing of electric motor vehicles, including safety and emission aspects. |
| 5 | Ministry of Transport Regulation No. 45/2020 | Regulates specific electric-powered vehicles like electric scooters and bicycles, including technical requirements and user safety. |
| 6 | Ministry of Home Affairs Regulation No. 1/2021 | Sets maximum 10% tax rate for Electric Vehicle Tax and Vehicle Ownership Transfer Fee. |
| 7 | Ministry of Transport Regulation No. 65/2020 | Regulates conversion of fuel motorcycles to electric motorcycles, including components and safe conversion procedures. |
| 8 | Ministry of Industry Regulation No. 6/2022 | Regulates specifications and roadmap for battery-based electric vehicles and local content requirements (TKDN). Extended 40% TKDN requirement from 2024 to 2026. |
| 9 | Ministry of Transport Regulation No. 15/2022 | Regulates conversion of non-motorcycle vehicles to electric vehicles, covering procedures and testing for road safety. |
| 10 | Presidential Instruction No. 7/2022 | Instructs development of regulations and policies to accelerate electric vehicle adoption, budget allocation, and increased use of EVs as government vehicles through purchase, lease, or conversion. |
| 11 | Ministry of Finance Regulation No. 38/2023 | Regulates government-borne VAT for four-wheeled EVs and buses for 2023. Provides 10% VAT incentive for TKDN ≥40% and 5% for TKDN 20-40%, valid **April-December 2023.** |
| 12 | President Decree No.79/2023 | revises Presidential Decree No. 55/2019, stipulating that the minimum TKDN for two-wheeled and four-wheeled electric vehicles must reach 40% by 2026 and 60% by 2030, updating the target previously set for achievement in 2024. Companies planning to build EV manufacturing |

| No. | Regulation | Key Content |
|---|---|---|
| | | facilities domestically, those that have already invested in them, or those intending to expand their facilities are permitted to import electric vehicles in a completely built-up (CBU) form and are qualified for various incentives **until 2025**, including exemptions from import duties and luxury goods sales tax (PPnBM), which are covered by the government. |
| 13 | Ministry of Finance Regulation No. 9/2024 | Provides 100% luxury goods sales tax incentive for imported CBU and CKD electric vehicles, valid **January-December 2024**. |
| 14 | Ministry of Finance Regulation No. 8/2024 | Regulates VAT incentives for EVs: 10% for vehicles with minimum 40% TKDN and 5% for electric buses with 20-40% TKDN, valid **January-December 2024**. |
| 14 | Ministry of Investment and Downstream Industry Regulation No. 1 of 2024 | Grants incentives to businesses importing or assembling four-wheeled Battery Electric Vehicles (BEVs): For Completely Built-Up (CBU) imports, incentives include 0% import duty and government-borne Luxury Goods Sales Tax (PPnBM) or government-borne PPnBM alone. For Completely Knocked Down (CKD) assembly, incentives apply to BEVs with local content (TKDN) between 20% and 40%. Eligible businesses include those building BEV manufacturing facilities, transitioning internal combustion engine (ICE) vehicle plants to BEVs, or expanding production capacities for new BEV models. These incentives are valid from the regulation's enactment until **December 31, 2025.** |

Source: Authors' analysis from various sources

### 3) Financial Mechanisms

Diverse financial mechanisms serve as critical enablers for Indonesia's EV ecosystem development. The key sources of financing for EV development are:

1. Public finance through government incentives, subsidies, and tax rebates makes EVs more affordable while direct investment from ministries supports infrastructure development.
2. Private sector investment complements government efforts through manufacturing facilities, charging stations, and workforce training programs.
3. Blended finance approaches create public-private partnerships that effectively distribute risk and increase investment scale. Special Economic Zones with tax breaks and streamlined processes attract domestic and international investors to the EV supply chain.
4. International collaborations, particularly with technology-advanced countries, bring additional capital and expertise.

As Indonesia transitions toward a comprehensive EV ecosystem, strategic alignment of financial mechanisms—across public budgets, private investment, and international partnerships—will determine the pace and scale of implementation across the EV value chain. Although both foreign and domestic direct investment to develop the ecosystem has grown, its realization value remains below what is needed to achieve the government's targets for EV adoption. Addressing this investment gap will be crucial for accelerating infrastructure development and manufacturing capabilities to support Indonesia's ambitious EV transition goals.

## 2.3 Domestic EV Manufacturing in Indonesia

### 2.3.1 Current State of Domestic EV Manufacturing

Advancing local electric vehicle (EV) manufacturing is crucial for maximizing the economic benefits associated with EVs, such as boosting the automotive sector's contribution to GDP and creating job opportunities. The Indonesian government has implemented several initiatives to support this growth, including setting ambitious targets for EV adoption and production and offering incentives to attract investors for domestic manufacturing facilities and supporting ecosystems, such as battery production plants.

The government has also developed a roadmap for local manufacturing, which includes the production of EVs, batteries, and other components. Additionally, the government has set TKDN (Domestic Content Level) targets for automotive industries that sell their products domestically (see Table 6 and Table 7).

Table 6 The Domestic Content Level (TKDN) for Electric Vehicles

| Vehicle Types | 2019-2021 | 2022-2026 | 2027-2029 | 2030 onwards |
|---|---|---|---|---|
| Two-Wheeled/Three-Wheeled Evs | - | 40% | 60% | 80% |
| Four-Wheeled or More EVs | 35% | 40% | 60% | 80% |

Table 7 Weight of TKDN Each Component for Electric Vehicles

| Component | 2020-2023 Weight (%) | 2024 onwards Weight (%) |
|---|---|---|
| **Four or More Wheels Electric Vehicle** | | |
| **A. Main Components:** | **50** | **58** |
| - Body, Cabin, and/or Chassis | 10 | 11 |
| - Battery | 30 | 35 |
| - Electric Motor Drive System | 10 | 12 |
| **B. Supporting Components:** | **10** | **10** |
| - Steering System | 2 | 2 |
| - Suspension | 1 | 1 |
| - Brake System | 2 | 2 |
| - Wheel System | 1 | 1 |
| - Electronic & Cooling System | 2 | 2 |
| - Cable System & Seats | 2 | 2 |
| **C. Development (R&D)** | **20** | **20** |
| **D. Assembly** | **20** | **12** |
| GRAND TOTAL | 100 | 100 |
| **Two or Three-Wheels Electric Vehicle** | | |
| **A. Main Components:** | **50** | **58** |

| | | |
|---|---|---|
| - Frame and/or Body | 10 | 11 |
| - Battery | 30 | 35 |
| - Electric Motor Drive System | 10 | 12 |
| **B. Supporting Components:** | **10** | **10** |
| - Steering System | 2 | 2 |
| - Brake System | 2 | 2 |
| - Wheel & Axle | 2 | 2 |
| - Electronic System | 2 | 2 |
| - Suspension | 2 | 2 |
| **C. Development (R&D)** | **20** | **20** |
| **D. Assembly** | **20** | **12** |
| GRAND TOTAL | 100 | 100 |

Source: Presidential Regulation No. 79 of 2023

Supported by high potential local demand and supporting policies from government, Indonesia's EV manufacturing landscape has attracted substantial local and foreign direct investment of automotive manufacturers. From Japanese-based companies, Toyota Motor Corporation, for instance, has plans to invest around $1.8 billion over the next five years to develop EVs in Indonesia, further strengthening the country's position as a center for EV production in the ASEAN region. As part of this effort, it will also establish an EV Center to cultivate local human resources in electrification technologies.

Chinese EV manufacturer BYD has also announced plans to invest $1.3 billion to set up a manufacturing base in the Subang Smartpolitan Industrial Estate in West Java, with a targeted production capacity of 150,000 units per year, including both battery electric vehicles (BEVs) and plug-in hybrid EVs (PHEVs).[1] Prior to these recent investments, Wuling had already invested $700 million to build a factory in the Greenland International Industrial Center in Cikarang, West Java, with a capacity of 150,000 units per year.[2]

Several manufacturers are also planning to integrate battery production facilities in Indonesia, indicating a move toward vertical integration in the supply chain. Mitsubishi has committed approximately Rp 10 trillion (around $670 million) between 2022 and 2025 to produce plug-in hybrid EVs and batteries in Indonesia. LG Energy Solution has partnered with a state-owned enterprise to invest $9.8 billion in battery production and supporting facilities for the EV industry in Indonesia. Additionally, a joint venture between Hyundai Motor Company, LG Energy Solution, and PT Indonesia Battery Corporation (IBC), known as PT HLI Green Power, has invested in a cell battery production facility that is targeted to

[1] "BYD Kebut Pembangunan Pabrik di Subang, Pastikan Rampung Akhir 2025", *Bisnis.com*. https://otomotif.bisnis.com/read/20250110/46/1830659/byd-kebut-pembangunan-pabrik-di-subang-pastikan-rampung-akhir-2025. accessed 10 February 2025:

[2] "Wuling Motors Resmikan Pembangunan Pabrik Pertama Di Indonesia." *Wuling.com* https://wuling.id/id/blog/press-release/wuling-motors-resmikan-pembangunan-pabrik-pertama-di-indonesia. Accessed 10 February 2024.

commence operations in April 2024, with a production capacity of 10 GWh per year, equivalent to the batteries for 150,000 EVs. The realization of these battery investments will depend on the growth of the EV market in Indonesia and the region, as well as the government's ability to provide a stable and supportive policy framework.

These substantial investments by leading global automotive and energy companies underscore Indonesia's growing importance as a strategic hub for electric vehicle manufacturing and battery production within the ASEAN region. However, the materialization of these commitments will require a delicate balance between market demand and government support to create a conducive environment for the success of the EV ecosystem in Indonesia.

Conversely, the two-wheeler EV segment presents a different picture, with production currently spread across 53 factories with a combined annual production capacity of 2,580 units. Interestingly, this segment is predominantly led by startups that have secured equity and venture capital funding. Meanwhile, the traditional motorcycle manufacturers.

Though the investment commitments from EV manufacturers are promising, the sales of 4W-EVs are dominated by imports, as the government allows companies to import vehicles in CBU (Completely Built-Up) form until 2025. According to the Association of Indonesia Automotive Industries, most EV imports come from China (47.8%), South Korea (47.7%), and Germany (3.25%). This high reliance on imports presents both challenges and opportunities for the development of domestic manufacturing as the market moves toward the 2030 targets. This high reliance on imports, coupled with the low rate of domestic production and the allowance for manufacturers to import CBU vehicles, poses significant challenges for achieving the government's 2030 domestic production targets.

**Table 8** Production Target of Battery-based Electric Vehicles (Units)

| Variable | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|
| Battery-Based Four-Wheeled and Above | 0 | 400,000 | 600,000 | 1,000,000 |
| Battery-Based Two and Three-Wheeled | 5,000 | 6,000,000 | 9,000,000 | 12,000,000 |

Source: Ministry of Industry (2023)

Although the government allows companies planning to build EV manufacturing facilities domestically, those already investing in them, or those intending to expand their facilities, to import electric vehicles in completely built-up (CBU) form until 2025 and receive fiscal and non-fiscal incentives, achieving the 60% TKDN target by 2026 remains a significant challenge for EV companies.

The scarcity of local suppliers for essential EV components forces manufacturers to rely heavily on imports for critical parts, particularly batteries and electric motor drive systems. Indonesia's domestic EV manufacturing currently faces significant challenges in achieving the required local content requirement (TKDN), which stands at approximately 40% with an ambitious target of 60% by 2027. Due to domestic manufacturers' unpreparedness to reach the initial TKDN target of 40% by 2024, the government has extended the deadline to 2026.

The current TKDN structure is achieved primarily through assembly processes (10%) and R&D-based development (10%). Assembly processes include basic manufacturing activities such as frame assembly, painting, component integration, and quality control, each contributing 2.5%. R&D-based development consists of market research, product planning, engineering design, and prototyping, each contributing 5%. An alternative to R&D-based development is investment-based development, which contributes 20% to TKDN when manufacturers invest IDR 250 billion in the first five years and maintain IDR 10 billion annually from the sixth year onward.

Achieving the 60% TKDN target by 2027 from the current 40% remains challenging, particularly in the main components category, which accounts for 50-58% of TKDN requirements. This category includes batteries (30-35%), frame/body systems (10-11%), and electric motor systems (10-12%), which are currently largely imported. Supporting components contribute another 10% to the TKDN requirements.

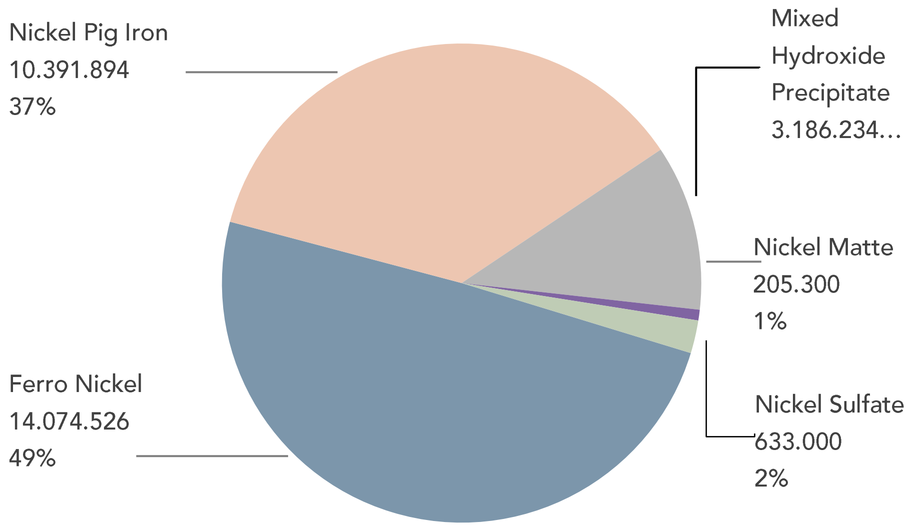
Bridging the gap between the current TKDN achievement and the 2027 target requires significant investment in local manufacturing capabilities, advanced technology acquisition, skilled workforce development, and the establishment of a robust local supply chain. Coordinated efforts between industry stakeholders and government policies will be critical to overcoming these challenges.

### 2.3.2 EV Battery and Components Supply Chain

Indonesia's EV supply chain encompasses a comprehensive ecosystem from raw materials to end-product manufacturing. The country holds a strategic advantage in raw materials, particularly nickel, which is crucial for EV battery production. Indonesia contributes 50% of global nickel production and holds 42.3% of global nickel reserves, primarily concentrated in Sulawesi and Maluku regions.

Nickel down streaming in Indonesia is being developed to enhance the value-added of nickel ore. However, as of 2024, the largest share of production capacity is still allocated to ferro nickel (49%) and nickel pig iron (37%), both predominantly used in stainless steel production. In contrast, the raw materials for EV battery components, such as Mixed Hydroxide Precipitate (MHP), account for only 11%, while nickel sulfate represents just 2%. MHP serves as a precursor for nickel sulfate, which is directly used in battery manufacturing, while nickel matte (1%) also holds potential for battery-grade applications. Despite these advancements, the small share of battery-grade nickel products highlights Indonesia's early stage of transitioning to the EV battery market. To fully capitalize on the global EV boom, Indonesia must prioritize expanding production of battery-grade materials through increased investments in refining technology, partnerships with battery manufacturers, and supportive government policies.

**Figure 8** Production Capacity Distribution of Active Smelter Plant

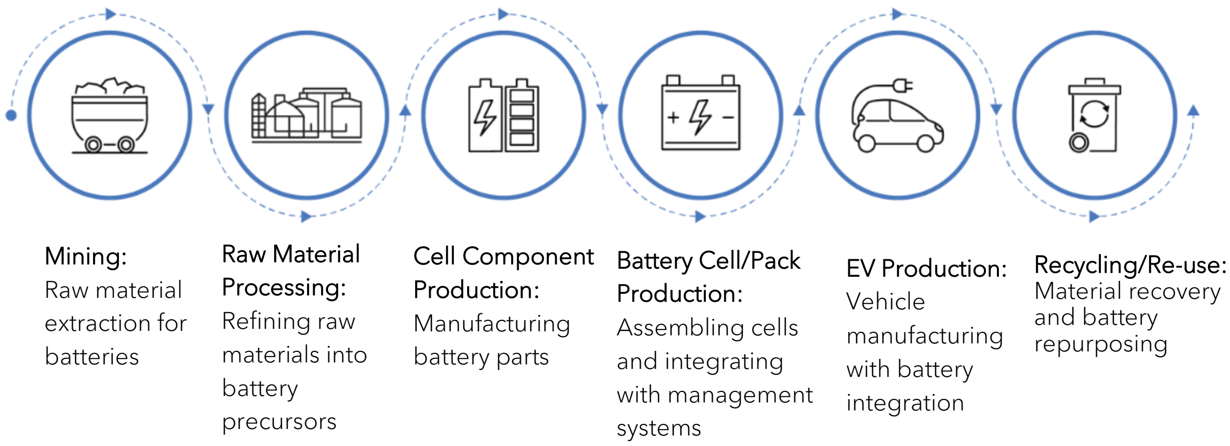



Source: China Global South Project (2024), processed

One company that has initiated investment in battery production is Indonesia Battery Corporation, in collaboration with LG Energy Solutions (LGES) and Contemporary Amperex Technology Co., Limited (CATL). This partnership aims to develop a fully integrated battery industry, spanning upstream to downstream processes. The collaboration includes the development of battery cell manufacturing plants and the utilization of mineral resources in Indonesia and Africa. The total investment required to establish this battery ecosystem is estimated at $6 billion. The investment covers mining, smelting and refining, precursor and cathode production, battery cell manufacturing, recycling, and energy storage systems. The main product from this investment is battery cells for electric vehicles, with IBC targeting a production capacity of 15 GWh per year to meet domestic demand and partially supply global markets. The project is expected to be ready for production in 2026.

IBC is an EV battery holding company consisting of four state-owned enterprises (SOEs), each holding a 25% share. PT Mining and Industry Indonesia (MIND ID) is responsible for mining and smelting raw materials, particularly nickel. PT Pertamina (Persero) focuses on battery cell production, packaging, and supporting infrastructure for EV charging. PT Perusahaan Listrik Negara (PLN) contributes to the development of EV charging stations. Meanwhile, PT Aneka Tambang Tbk specializes in nickel ore mining and smelting to produce raw materials for EV batteries. These subsidiaries work collaboratively to establish a comprehensive and integrated EV battery ecosystem in Indonesia.

Figure 9 EV Battery Supply Chain

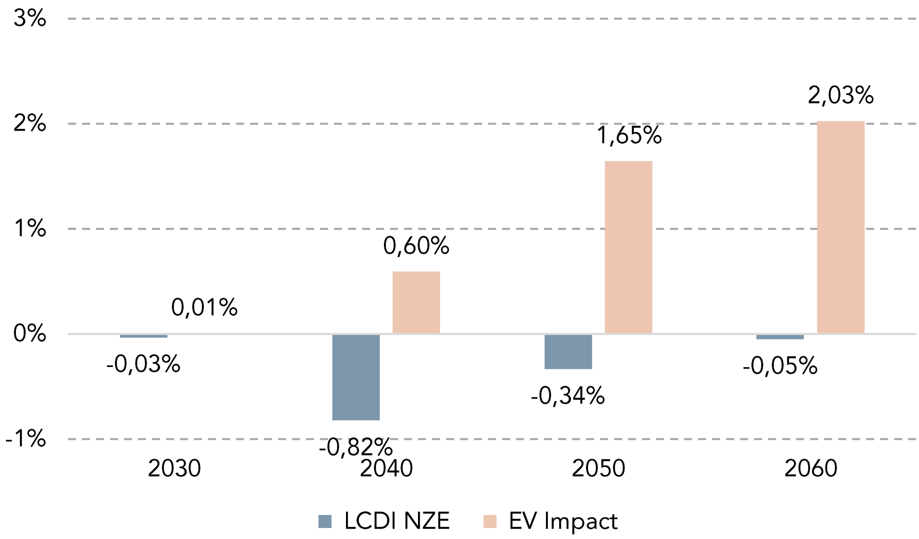



Source: IEA (2022)

## 2.4 Economic Impact Analysis

The implementation of EV development strategies shows significant potential impacts on Indonesia's macro-economic performance, particularly when domestic manufacturing is prioritized. The economic impact of EV strategies varies significantly between scenarios, with the EV Impact scenario showing positive GDP effects while the LCDI NZE scenario indicates negative impacts compared to Business as Usual (BaU). As shown in Figure 13, under the EV Impact scenario, which prioritizes domestic manufacturing, GDP growth starts modestly at 0.01% in 2030 but steadily increases to 0.60% in 2040, 1.65% in 2050, and reaches 2.03% by 2060. In contrast, the LCDI NZE scenario, which relies more heavily on imports, shows mostly negative GDP impacts, starting at -0.03% in 2030, declining to -0.82% in 2040, improving slightly to -0.34% in 2050, and ending at -0.05% in 2060. This data suggests that prioritizing domestic EV manufacturing could lead to more favorable economic outcomes compared to an import-dependent approach.

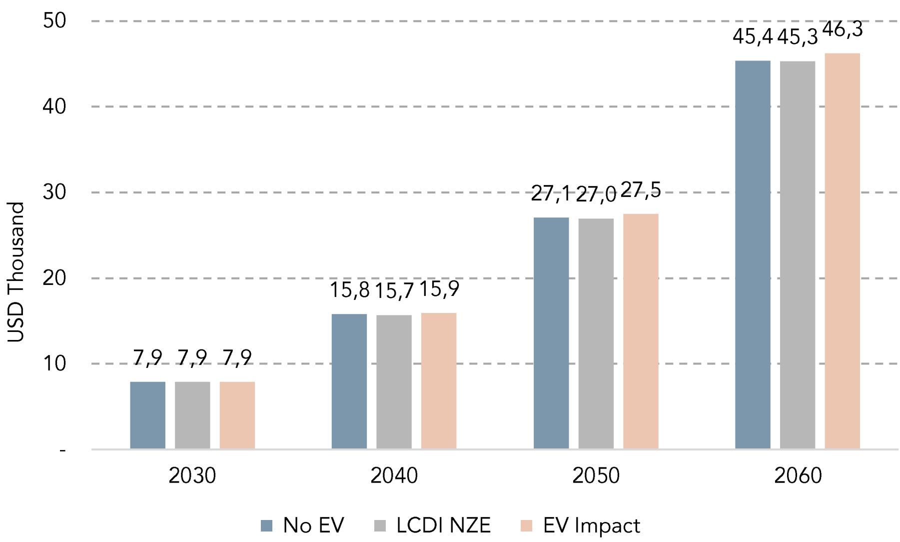
Figure 10 Projected Change in Real GDP within LCDI NZE and EV Impact Scenarios Compared to BaU




Source: CORE Indonesia (2024a)

Gross National Income (GNI) per capita shows promising growth under the EV Impact scenario, reaching $46,275 per person by 2060, representing a 1.95% increase over the Business as Usual (BaU) scenario's $45,392 (Figure 14). This substantial difference is primarily attributed to the development of domestic industries across the EV value chain, from battery cell production to vehicle assembly. While the LCDI NZE scenario shows $45,327, representing a 0.14% lower GNI per capita compared to BaU, this highlights the economic advantages of domestic manufacturing over import-dependent strategies.

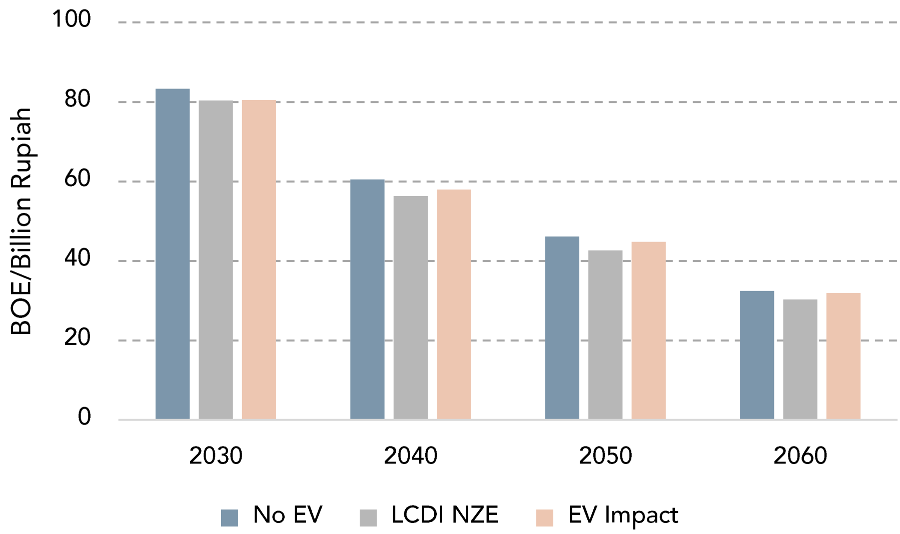
Figure 11 GNI per capita (USD/person) by No EV, LCDI NZE, and EV Impact Scenarios




Source: CORE Indonesia (2024a)

The EV Impact scenario shows promising potential in reducing final energy intensity compared to both BAU (No EV) and LCDI NZE scenarios, though with some differences due to manufacturing assumptions. As shown in the graph, both LCDI NZE and EV Impact scenarios consistently maintain lower energy intensity than the BAU scenario through 2060. The LCDI NZE scenario shows slightly lower energy intensity than EV Impact because it assumes all EVs are imported, requiring less domestic energy for manufacturing. In contrast, the EV Impact scenario factors in the energy requirements for domestic production of batteries and EVs. The graph illustrates this pattern clearly, with all scenarios starting from approximately 80-83 BOE/Milyar IDR in 2030 and showing a consistent decreasing trend to around 30-32 BOE/Milyar IDR by 2060. Throughout this period, the BAU scenario maintains the highest energy intensity, while LCDI NZE generally shows the lowest, with EV Impact falling between these two pathways due to its domestic manufacturing energy requirements.

Figure 12 Final energy intensity (BOE/ Milyar IDR)




Source: CORE Indonesia (2024a)

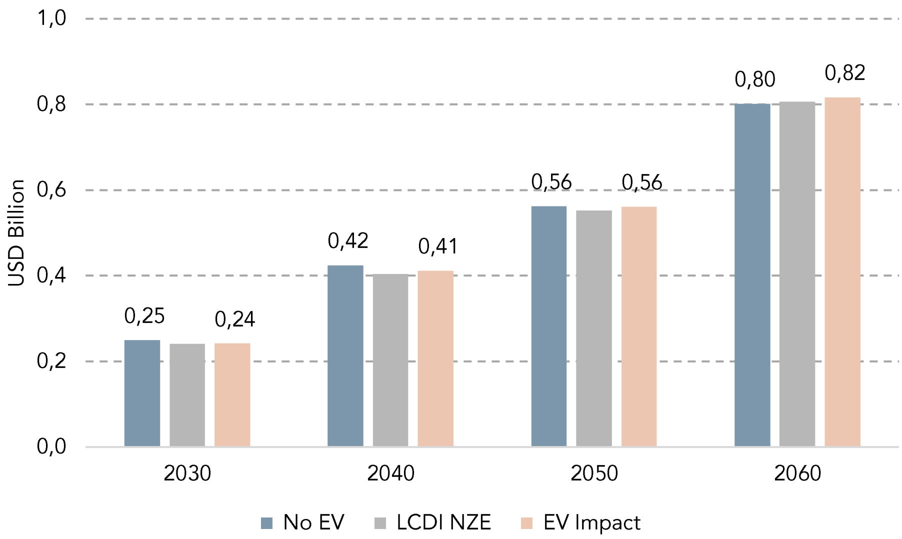
These reductions are driven by the higher energy efficiency of electric vehicles which convert up to 70% of energy to motion compared to 30% in conventional vehicles (U.S Department of Energy). These results can be more efficient if there are improvements in power generation through the shift to renewable energy sources and the integration of smart grid technology that enables better energy management and reduces transmission losses.[3]

Furthermore, the Figure 13 show that the EV Impact scenario also have slightly better impact on labor productivity. The LCDI NZE scenario, which relies on

[3] U.S Department of Energy, "All-Electric Vehicles." https://www.fueleconomy.gov/feg/evtech.shtml#data-sources, accessed February 10, 2024.

imported EVs to meet domestic demand, shows slightly lower labor productivity compared to the EV Impact scenario in the long term. By 2060, labor productivity under LCDI NZE reaches 0.81, marginally below the EV Impact scenario's 0.82. This suggests that while importing EVs can help achieve environmental goals, it may limit productivity gains since it doesn't develop domestic manufacturing capabilities and associated skills development. In contrast, the EV Impact scenario, which focuses on domestic EV production, demonstrates marginally higher labor productivity in the long run, outpacing 1,9% of BAU scenario. This scenario involves developing local manufacturing facilities, supply chains, and workforce capabilities.

Figure 13 Labor Productivity by No EV, LCDI NZE, and EV Impact Scenarios




Source: CORE Indonesia (2024a)

## 2.5 Discussions

Indonesia's electric vehicle (EV) industry currently shows modest but growing adoption rates, with 43,509 four-wheeler EVs and 152,280 two-wheeler EVs on the road as of September 2024. These sales are concentrated in the middle-price segment, with 55% in the 250-500 million Rupiah range and 42.7% in the 500 million to 1 billion Rupiah category. Despite government initiatives including Presidential Regulation No. 55 of 2019 (amended by No. 79 of 2023) and various fiscal incentives such as purchase subsidies and reduced VAT-rates, current adoption levels remain significantly below the government's ambitious targets of 1.97 million four-wheeled EVs and 12.9 million two-wheeled EVs by 2030. The sector currently contributes 1.8% to GDP and faces challenges such as limited charging infrastructure, high upfront costs, and consumer range anxiety, along with concerns about battery durability, parts availability, and repair services.

The EV industry presents substantial economic opportunities, though outcomes vary significantly across different scenarios. Under the EV Impact scenario which emphasizes domestic manufacturing, GDP growth is projected to increase from

0.01% in 2030 to 2.03% by 2060, while the LCDI NZE scenario shows mostly negative GDP impacts (-0.03% in 2030 to -0.05% in 2060 compared to BAU). This difference is primarily driven by the development of domestic industries across the EV value chain in the EV Impact scenario, from battery cell production to vehicle assembly. Similarly, GNI per capita reaches $46,275 by 2060 in the EV Impact scenario (1.95% higher than BAU), while LCDI NZE achieves $45,327 (0.14% lower than BAU). In terms of energy intensity, both scenarios show improvements over BAU, but LCDI NZE demonstrates slightly lower energy intensity because it assumes all EVs are imported, requiring less domestic energy for manufacturing compared to the EV Impact scenario's domestic production requirements. Indonesia's strategic advantage in battery production, supported by holding 42.3% of global nickel reserves, positions the country favorably in the global EV supply chain. The sector has already attracted significant foreign investment, including $1.8 billion from Toyota, $1.3 billion from BYD, and $9.8 billion from LG Energy Solution's partnership with state-owned enterprises.

However, significant gaps exist between current conditions and these opportunities. On the consumer side, the market requires more comprehensive and long-term financial incentives, with a reduction while reaching the government target, as being adopted by countries with higher adoption rates, including sustained purchase subsidies, tax rebates, and practical benefits like discounted parking and toll fees. The infrastructure ecosystem, that became one of the most significant obstacles to EV adoption, remains underdeveloped, with only 1,810 Electric Vehicle Charging Stations (SPKLU) and 1,882 Battery Swap Stations (SPBKLU) as of July 2024, mostly concentrated in Java and limited coverage in other regions. On the supply side, while domestic manufacturing for two-wheeled vehicles has grown through 53 factories with a combined annual production capacity of 2,580 units, four-wheeled vehicle production still heavily relies on imports, with China and South Korea being the primary sources. The manufacturing sector faces challenges in meeting local content requirements (TKDN), currently at 40% with an ambitious target of 60% by 2027, particularly in critical components like batteries (30-35% of TKDN), frame/body systems (10-11%), and electric motor systems (10-12%). This challenge is compounded by the scarcity of local suppliers for essential EV components, forcing manufacturers to rely heavily on imports for critical parts.

To bridge these gaps, a comprehensive policy framework is needed across three key areas. Consumer market development policies should focus on maintaining and expanding financial incentives while introducing practical benefits to make EV ownership more attractive, including progressive taxation on conventional vehicles and support for interest-free EV credit purchasing. Manufacturing sector policies should prioritize strengthening incentives for meeting TKDN requirements, especially favoring EVs that utilize local batteries using domestically produced nickel, supported by the fact that Indonesia controls 50% of global nickel production and 42.3% of global reserves. The supporting SME integration into the EV supply chain and establishing comprehensive quality standards for EV manufacturing are also important, particularly given the current fragmented state of the 2W-EV manufacturing sector across 53 factories. Infrastructure development requires creating more attractive investment packages for private charging station development, by maintaining current incentives including electricity rate discounts (such as PLN's 30% discount during off-peak hours), simplifying licensing procedures, providing land, and implementing strategic mapping for nationwide charging station placement to achieve the government's target of 31,859 charging stations by 2030.

Success in implementing these policies would position Indonesia to capitalize on the significant opportunities presented by the growing global EV market while advancing its green economy objectives, particularly as these align with the government's vision of economic transformation through green economy as outlined in the country's long-term national development plan (RPJPN) for 2025-2045.

# CHAPTER III

# SOCIAL IMPACTS OF EV DEVELOPMENT IN INDONESIA

## 3.1 Current Employment in Automotive Industry

The automative industry represents a vital component in Indonesia's economy and workforce as it contributes 4.5% of GDP in 2023 and 4.2% in 2022. With its contribution, the sector is chosen as one of prioritized industry under the Indonesia's National Industri Masterplan (RIPIN) 2015-2035. As of 2021, the sector supported approximately 1.5 million workers through both direct and indirect employment opportunities across its extensive supply chain network. This substantial workforce is distributed among 57,570 enterprises operating throughout various segments of the automotive industry.

The employment structure within the sector is notably diverse, with different segments contributing varying levels of job creation. Based on Ministry of Manpower (2021), Original Equipment Manufacturers (OEMs), though comprising only 20 companies, employ 75,000 workers, with more than 38 thousand workers for 4W and more than 31 thousand workers more for 2W manufacturers (Ministry of Industry, 2022). The auto parts manufacturing segment, consisting of both Tier 1 manufacturers (550 enterprises) and Tier 2 and 3 manufacturers (1,000 enterprises), provides employment for 220,000 and 210,000 workers respectively. This manufacturing base forms the backbone of the industry's employment structure.

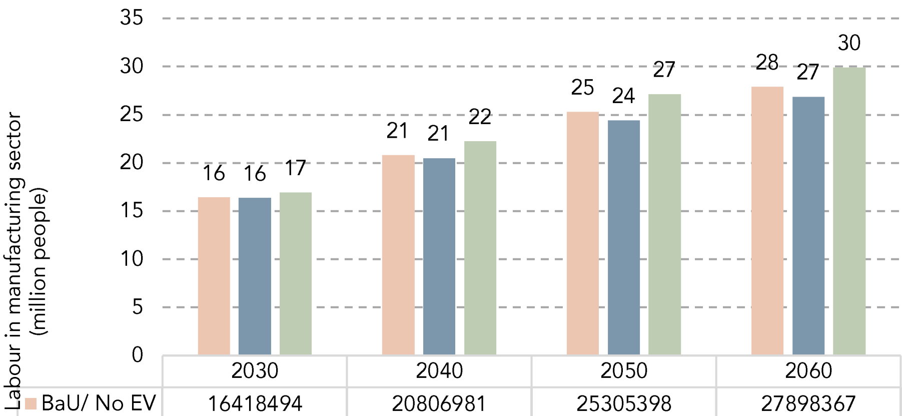
The service-oriented segments of the automotive sector actually employ the largest portion of workers. Authorized dealers, workshops, and service centers, numbering 14,000 establishments, employ 400,000 workers. Additionally, the non-authorized segment, which includes independent dealers, workshops, and service providers, encompasses 42,000 businesses and provides employment for 595,000 workers, making it the largest employment segment within the industry (Ministry of Manpower, 2021).

## 3.2 Employment Impact of EV Transition

### 3.2.1 Projected Reduction of Unemployment from EV Transition

Indonesia's EV transition is projected to give positive employment outlook based on IGEF Model by CORE Indonesia (see Figure 14). The Indonesia Green Economy Framework (IGEF) represents an enhanced iteration of the Indonesia Green Economy Model (IGEM), incorporating an Electric Vehicle (EV) industry manufacturing sub-model to evaluate the comprehensive economic implications of EV development scenarios. The foundational IGEM employs system dynamics modeling methodology to identify the primary determinants of systemic behavior and generate predictive insights regarding policy implementation outcomes within specific temporal and contextual parameters.

Figure 14 Projected Labor in Manufacturing Sector from EV Transition




| | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|
| BaU/ No EV | 16418494 | 20806981 | 25305398 | 27898367 |
| LCDI NZE | 16376809 | 20508709 | 24413684 | 26876966 |
| EV Impact | 16945971 | 22229797 | 27137388 | 29919558 |

BaU/ No EV   LCDI NZE   EV Impact

Source: CORE Indonesia (2024a)

The impact of EV to Indonesia's Green Economy Index is assessed in three different scenarios using IGEM model; (1) Business as usual (BaU)/No EV; (2) LCDI Net Zero Emission (NZE), where EV usage target is achieved by importing the EV; and (3) EV Impact, where EV usage target is achieved through domestic industry production. Under EV Impact scenario, where EV adoption targets are met through domestic production including battery manufacturing and assembly, the manufacturing sector could gain approximately 500,000 new jobs by 2030, expanding to 1.7 million jobs by 2045 compared to the business-as-usual scenario. This growth is primarily driven by increasing domestic vehicle demand and production capacity development. Thus, although EV require approximately 30% less labor than ICEs, the employment absorption is positive as job creation potentially offset losses by producing less jobs per unit of output but accompanied by more unity or by jobs in the emerging industries (ILO, 2024).

However, the net employment impact of EV transition scenario compared to business as usual could become net negative if EV adoption targets are achieved solely through imports. The LCDI NZE scenario, which relies on imported EVs, projects potential job losses of over 40,000 by 2030 (see Table 9). This highlights the crucial role of developing domestic manufacturing capabilities to ensure positive employment outcomes. Without local production capacity, the phase-down of Internal Combustion Engine Vehicles (ICEVs) could lead to significant layoffs without alternative employment opportunities.

Table 9 Projected Change in Labor Manufacturing within LCDI NZE and EV Impact Scenarios Compared to BaU

| Scenario | 2030 | 2045 | 2060 |
|---|---|---|---|
| LCDI NZE | (41,685) | (676,835) | (1,021,401) |
| EV Impact | 527,477 | 1,714,327 | 2,021,191 |

Source: CORE Indonesia (2024a)

The EV transition is expected to create varying employment impacts across different subsectors. Growth sectors include EV OEM manufacturing, battery cell and pack, battery parts (cathode, precursor), EV component manufacturing, and EV assembly. In downstream, job growth potentially happens in charging infrastructure construction and operation, EV-specific repair services, and waste management. Conversely, job losses are anticipated in ICEV-related sectors, including ICEV OEM, traditional auto parts manufacturing (particularly in Tier 1 and lower-tier suppliers), ICEV and conventional vehicle maintenance services (fuel supply, dealer and repair, and used car market) (ILO, 2023).

Global evidence presents varying perspectives on the employment impact of EV transition. European studies, including research by ILO and UNECE (2020) and the Electrical Construction Association (2019), project positive employment outcomes with potential for creating 200,000 permanent jobs by 2030, particularly in electrical equipment manufacturing, battery technology, and infrastructure development._However, contrasting analyses from automotive manufacturers, such as Ford and Volkswagen, suggest that EV production requires 30-40% less labor than traditional vehicles (Business Insider, 2023). A notable study by CLEPA indicates potential job losses of 275,000 in the EU automotive sector by 2040, though this excludes potential gains in EV ecosystem segments. More optimistically, research in Southeast Asia by Pirmana et al. (2023) suggests a 0.5% positive net employment impact, potentially creating 500,000 additional jobs. BCG's bottom-up analysis reveals that while total labor requirements between EVs and ICEVs remain similar, significant redistribution occurs from traditional OEM and Tier 1 manufacturing to battery production. These findings emphasize that adverse employment impacts can be mitigated when EV development includes domestic battery manufacturing and follows a managed, gradual transition that allows for industry adaptation and workforce reallocation.

Aside from previous evidence, IGEF model exhibits specific methodological constraints in its employment impact projections. Its scope is predominantly confined to passenger vehicles and motorcycles, omitting heavy-duty vehicles and charging infrastructure development from the analysis. The scenario-based simulation methodology inherently suggests differential investment levels, which could generate varying socioeconomic outcomes across scenarios, particularly in terms of employment generation and GDP growth. However, this investment variability is not incorporated as a model assumption. Additionally, the model does not account for the Local Content Requirement (LCR) mandated by Presidential Decree 79/2023, which could substantially influence economic outcomes through domestic value addition requirements and industrial localization effects. While this limitation potentially understates the aggregate employment effects, the model nevertheless yields significant insights into the broader economic implications of the transition.

### 3.2.2 Work Transformation and Skills Requirements

The transformation of the EV sector workforce is significantly influenced by organizational structures and ownership patterns. Large-scale 4W-EV manufacturers, operating within global value chains, implement systematic changes under international principal direction, particularly in technological advancement and production strategies. The 2W-EV segment, dominated by domestically-owned enterprises with national investment backing, exhibits greater operational flexibility despite limited research capabilities. State-Owned Enterprises represent a distinct organizational model, playing critical roles in infrastructure and battery production development, with their organizational evolution primarily directed by national policy frameworks.

Labor requirement transformations demonstrate varying patterns across the automotive sector's components. Significant changes are most evident in component manufacturing, where traditional combustion engine parts are being replaced by electrical systems and battery technologies. While research and development undergo substantial evolution in power systems and safety features, the impact on Indonesia's domestic workforce remains limited due to overseas R&D centralization. Manufacturing processes show minimal disruption, benefiting from existing automation and modular production systems. Industry stakeholders emphasize the importance of gradual transition strategies, warning that sudden restrictions on ICEV sales could disrupt workforce adaptation and create skill mismatches. Notably, substantial uncertainty exists regarding long-term employment implications for lower-tier component manufacturers, highlighting a critical area requiring further research.

An examination of Thailand's EV transition experience provides relevant lessons for Indonesia's automotive sector evolution, given the similarities between two countries. According to Osatis and Asavamirandara's (2022) analysis, the shift toward zero-emission vehicle production creates divergent employment effects across workforce categories. Their findings indicate growth in demand for advanced technical roles, particularly in engineering and skilled technical positions. However, the study also identifies potential displacement risks for lower-skilled manufacturing positions as automation and technical requirements increase. These insights, drawn from Thailand's more advanced stage of EV adoption, highlight the importance of implementing strategic workforce development initiatives through coordinated industry and educational sector efforts.

Table 10 Impact of EV Transition on Workforce Profile and Occupations

| | Skill Levels | Occupations | Major Skill Types | Major Challenging Issues | Preliminary Change in Labor Demand |
|---|---|---|---|---|---|
| Engineer | Highly skilled | • Quality assurance, quality management representative<br>• Engineer: design, storage and energy<br>• Product designer | • Hybrid engine, lightweight body, suspension, motor brake, battery management system<br>• Lean automation system integrator, artificial intelligence, mechatronic, programming and coding | Sharply increasing labor demand but shortage of labor supply | Increase from 10% to 20% |
| Technician | Skilled non-manual | • Logistics and supply chain management<br>• Warehouse<br>• Technicians<br>• Information technology (IT) | • PLC, ERP, MRP, SCM*<br>• Sensor, relay, timer, and pneumatic | Multi-skilled workforce which is compatible with new technology | Increase from 20% to 50% |
| | Skilled manual | • Supervisors<br>• Production<br>• Maintenance<br>• Parts assemblers<br>• Machine operators | • Basic IT or digital skills<br>• Multi-skills tasking<br>• Soft skills tasking | Effective upskilling of existing workforce | |
| Operator | Low skilled | • Labors in the production line<br>• Quality control | • Basic IT or digital skills<br>• Multi-tasking skills | Decreasing employment trend and issues related to workforce relocation | Reduce from 70% to 30% |

Source: Osatis and Asavamirandara (2022)

*Notes: PLC (Programmable Logiv Control), MRP (Material Requirement Planning), ERP (Enterprise Resource Planning), and SCM (Supply Chain Management)

Table 11 The Global Talent Competitiveness Index 2023

| Indicators | USA | Germany | Malaysia | South Korea | China | Indonesia | Vietnam | Thailand |
|---|---|---|---|---|---|---|---|---|
| **VOCATIONAL AND TECHNICAL SKILLS** | **1** | **6** | **38** | **27** | **47** | **65** | **71** | **81** |
| **Mid-Level Skills** | **6** | **4** | **48** | **38** | **95** | **92** | **101** | **99** |
| Work force with secondary education | 37 | 29 | 33 | 72 | n/a | 73 | 82 | 88 |
| Population with secondary education | 23 | 11 | 24 | 34 | n/a | 52 | 68 | 76 |
| Technicians and associate professionals | 12 | 4 | 48 | 10 | 64 | 107 | 112 | 89 |
| Labour productivity per employee | 3 | 21 | 48 | 30 | 77 | 84 | 90 | 76 |
| **Employability** | **6** | **21** | **34** | **24** | **1** | **25** | **30** | **60** |
| Ease of finding skilled employees | 9 | 34 | 22 | 14 | 4 | 33 | 46 | 70 |
| Relevance of educations system to the economy | 5 | 38 | 37 | 36 | 10 | 12 | 32 | 82 |
| Skills matching | 52 | 44 | n/a | 74 | n/a | 69 | 66 | 71 |
| Highly educated unemployment | 25 | 14 | n/a | 12 | 7 | 55 | 10 | 9 |
| **GLOBAL KNOWLEDGE SKILLS** | **5** | **23** | **34** | **8** | **43** | **100** | **71** | **68** |
| **High-Level Skills** | **3** | **32** | **48** | **16** | **84** | **102** | **108** | **86** |
| Workforce with tertiary education | 10 | 41 | 49 | 4 | n/a | 94 | 89 | 81 |
| Population with tertiary education | 7 | 36 | 59 | 12 | n/a | 71 | 68 | 58 |
| Professionals | 20 | 23 | 56 | 30 | 118 | 95 | 109 | 97 |
| Researchers | 19 | 14 | 60 | 1 | 46 | 74 | 57 | 39 |
| Senior officials and managers | 6 | 63 | 41 | 104 | 49 | 96 | 117 | 69 |
| Digital skills | n/a | 43 | 8 | 24 | n/a | 55 | 79 | 72 |
| **Talent Impact** | **11** | **22** | **27** | **3** | **24** | **83** | **40** | **52** |
| Innovation output | 5 | 7 | 36 | 4 | 8 | 73 | 40 | 43 |
| High-value exports | 23 | 33 | 3 | 5 | 9 | 61 | 4 | 11 |
| Software development | 5 | 16 | 63 | 27 | 91 | 72 | 62 | 81 |
| New business density | n/a | 75 | 59 | n/a | 17 | 106 | 67 | 78 |
| Scientific journal articles | 24 | 25 | 41 | 22 | 50 | 80 | 84 | 66 |

Source: INSEAD (2023)

The transition to electric vehicles necessitates a comprehensive skills development framework across multiple proficiency levels. Core competencies have expanded beyond mechanical expertise to include analytical thinking and continuous learning capabilities. Workers must develop diverse skills ranging from interpersonal coordination to specialized technical knowledge in electrical and chemical systems. Managerial roles increasingly require advanced capabilities in systems analysis and resource optimization, particularly in emerging sectors like battery production and charging infrastructure. Educational requirements focus on specialized engineering disciplines, especially electrical, chemical, and industrial fields, supported by strong foundations in mathematics and sciences.

However, Indonesia's labor market is confronting significant structural challenge. The rank of workers with high level skills is below other peer countries such as

Vietnam and Thailand. While the EV industry demands expertise in hybrid technology, battery management systems, and advanced programming, Indonesia's labor market remains predominantly characterized by middle to lower-skilled workers. This disparity underscores the critical necessity for comprehensive workforce development initiatives focused on high-level technical competencies to fully capitalize on the growth potential of Indonesia's emerging EV industry. Thus, a strategic skills transformation framework is particularly crucial within a managed transition framework, where adequate time for workforce development can minimize supply chain disruptions.

Based on ILO (2024), using the the O*NET Framework that was adopted to develop the Indonesia's Occupational Tasks and Skills (BAPPENAS and World Bank, 2020), the following working requirements that are emerging and/or needed by the industry to support the EV transition are:

1) **Skills:**

   **Basic skills**: Emphasize is put on the acquisition of basic skills that support learning process and adjustment to the EV transition in the workplace for occupation at all levels. This aspect includes content basic skills, specifically on active listening and speaking, mathematic, and science, as well as the process basic skills that includes critical thinking and active learning.

2) **Cross-functional Skills:**

   **Social skills**: with the EV transition in Indonesia involves various form of partnerships and the new business process on the plants focuses on integration, skills on coordination are important for operational and support functions, and service orientation is identified as important for workers in the EV ecosystem.

   **Complex problem-solving**: this skill is important especially for high skilled position, in the operation (engineer, RnD, manager) and supporting functions (such as business development, ICT, and commercial). This is the skills required to identify complex problems and review related information to develop and evaluate options and implement solutions.

   **Technical**: This is especially for workers in the operation, such as technician and operators, which includes equipment maintenance and selection, installation, operation and control, operation monitoring, operation analysis, repairing, technology design, troubleshooting with content that includes electrical, chemical, and mechanical knowledge.

   **System skills**: Systems skills are increasingly needed for highly skilled positions, especially in the initial phase of transition which includes judgement and decision making, system analysis, and system evaluation.

   **Resources management skills**: Resource management skills especially for managerial and business development, that includes financial resources, material resources, personnel resources, time management. This is especially needed in the emerging process and business, such as the battery manufacturing, EV infrastructure, and EV ecosystem.

3) Knowledge:

**Operational functions:** there is an increased demand on technical skills in engineering and technology, especially electrical, chemical, and mechanical, meaning that workers with an educational on electrical, chemical, industrial, and mechanical (including mechatronic), and automotive engineering and science (chemistry and physics). Talents that have working experience in the manufacturing industry, especially automotive industry and utilities industry that in related process are preferred.

**Research and Development:** knowledge in engineering and technology, mathematical and science, and manufacturing and production, especially to work on the area for process design, product design, and safety and performance that includes complex data analysis and system thinking. Workers with knowledge in design, electrical engineering, chemical engineering, industrial engineering, computer science, and data analysis.

**Business support:** the area of work with emerging demand for business support functions are information and system, project management, business development (including financial management), and commercial/marketing as critical to accelerate the transition process. Talent from similar industries, such as telecommunications, technology, and financial sectors are prioritized by enterprises to address skill shortages.

**Education:** For the highly skilled positions, such as managers and engineers, the enterprise requires a tertiary degree attainment, while for skilled (manual and non-manual) and low skilled (plant operator) the enterprise often require vocational educations in the tertiary or secondary level. In addition, for certain position such as line manager, machine operator, electrical technician, software/system development, the company will require or prioritize talents with certification.

**Recruitment process and skills gaps:** Given the identified changes in the workers requirement, the industry representatives expressed the conviction that talent acquisition for the above listed skills will not be challenging, given the already existing and relative extended array of workers possessing a similar profile in the manufacturing industry, especially the ICEV automotive industry; as well as the electricity utility industry for EV infrastructure. Moreover, with the uncertainty and rapid technological changes, the industry also emphasizes the importance of transferrable basic skills such as agility, adaptability, and analytical and critical thinking when acquiring talents. To ensure the workers' readiness, enterprises often implement company's internal skilling strategy/process, with the exceptions for position with a high and specialized skills, such as in business development and research and development.

### 3.2.3 Training and Skills Development

1) **Heavy Reliance on In-House Training by Companies**

   Contemporary automotive industries have developed sophisticated approaches to address evolving workforce needs during the EV transition period. Rather than pursuing extensive recruitment drives, organizations prioritize the enhancement of existing workforce capabilities, recognizing the inherent value of employees who understand established systems and corporate practices. Companies demonstrate a pronounced reliance on in-house training programs, particularly evident in emerging sectors like battery production and charging infrastructure development, reflecting the specialized nature of required competencies.

2) **Limited Capacity of Formal Education System to Meet Industry Needs**

   The formal education system currently faces significant limitations in meeting industry requirements, creating a substantial skills gap. Educational institutions often struggle to maintain pace with rapid technological advancements, leading companies to invest heavily in internal training programs. This misalignment is particularly evident in technical education sectors, where curriculum development frequently lags behind industry innovations. Consequently, organizations must allocate additional resources to bridge the gap between academic preparation and practical industry requirements.

3) **Need for Improved Skill Standardization and Certification**

   Skill standardization and certification frameworks have emerged as critical factors in workforce development. While Indonesia's National Work Competence Standard exists, industry stakeholders identify significant opportunities for enhancement to better reflect contemporary technological requirements and operational practices. The need for comprehensive, industry-aligned standards becomes increasingly crucial as the sector continues its technological evolution.

4) **Importance of Strategic Partnerships for Skill Transfer**

   Strategic partnerships play a vital role in facilitating knowledge transfer and skill development within the EV sector. Organizations actively pursue collaborations with international principals, experienced partners, and technology providers to accelerate capability development. These partnerships provide essential channels for accessing advanced technological expertise and established industry practices, particularly beneficial for emerging segments of the EV value chain.

5) **Multi-stakeholder Approach Needed for Workforce Development**

   The complexity of workforce development in the EV sector necessitates a multi-stakeholder approach, involving coordination between government agencies, educational institutions, industry representatives, and training providers. This collaborative framework enables more effective alignment of training programs with industry needs, ensures relevant skill certification standards, and facilitates knowledge transfer across the sector. Such coordination becomes particularly crucial in addressing the rapid technological changes and evolving skill requirements characteristic of the EV transition.

## 3.3 Discussions

The analysis of Indonesia's EV transition reveals both significant opportunities and critical challenges for workforce development and employment. The automotive sector currently serves as a major employer, supporting approximately 1.5 million workers across its extensive value chain. This employment is notably concentrated in the service segment, where dealers, workshops, and related services employ nearly 1 million workers. The manufacturing segment shows a clear structure with 20 OEMs employing 75,000 workers and 1,550 parts manufacturers providing jobs for 430,000 workers. This existing workforce structure demonstrates a clear segmentation between large-scale 4W manufacturers operating within global value chains and domestically-owned 2W producers, each with distinct organizational approaches and workforce development needs.

The transition to EV manufacturing presents several significant challenges that must be carefully managed. Without proper planning and support, traditional ICE vehicle manufacturing and maintenance sectors could face significant job losses, particularly affecting lower-tier suppliers and service workshops. A substantial skills gap exists between current workforce capabilities and emerging EV industry requirements, especially in specialized areas such as battery technology and electrical systems. The formal education system's current limitations in meeting these new industry needs, coupled with insufficient standardization and certification frameworks for EV-related occupations, creates barriers to workforce mobility and development. Small and medium enterprises in the supply chain face particular difficulties in adapting their workforce to these new requirements.

However, the transition also presents substantial opportunities for employment growth and workforce development. Under the EV Impact scenario, which emphasizes domestic manufacturing, the sector could generate approximately 500,000 new jobs by 2030, expanding to 1.7 million by 2045. These opportunities span multiple areas, including EV OEM manufacturing, battery production, component manufacturing, charging infrastructure development, and specialized maintenance services. The existing automotive workforce possesses strong foundational skills that can be enhanced through targeted upskilling programs. Strategic partnerships with international companies offer valuable opportunities for knowledge transfer and accelerated capability development, while the establishment of new certification programs and standards can create clear career pathways in the emerging EV sector.

Based on these findings, Indonesia requires a comprehensive policy approach to maximize the positive employment impacts of the EV transition while minimizing workforce disruption. To achieve the social aspects of Indonesia's Green

Economy Index targets, several key policy areas need immediate attention. These include strategic workforce planning, targeted skills development programs, multi-stakeholder collaboration frameworks, and standardized certification systems. The following recommendations outline specific actions needed in each priority area, with implementation requiring sustained commitment from government agencies, industry players, and educational institutions:

1. **Strategic Workforce Planning & Transition**: The government should adopt a comprehensive and gradual approach to EV transition. This includes implementing phased transformation strategies while protecting existing workers, encouraging companies to prioritize retraining over layoffs, and developing clear timelines that align with ICE vehicle production phase-out. Companies should be supported through incentives to maintain employment during the transition period, with specific attention to protecting workers in vulnerable segments of the supply chain. Clear job transition pathways should be developed for workers in traditional automotive sectors, identifying transferable skills and additional training needs.
2. **Skills Development & Specific Focus Areas for Training**: Priority should be given to developing specialized training programs that address core competencies required by the EV industry. This includes basic skills like analytical thinking and active learning, technical skills in equipment operation and maintenance, systems skills for analysis and project management, and resource management skills for managerial roles. Educational institutions should be supported in developing curricula that specifically address EV manufacturing and maintenance requirements, with particular focus on emerging technologies in battery production and electrical systems.
3. **Multi-stakeholder Collaboration for Human Capital Development**: A sectoral skills council should be established comprising industry representatives, academic institutions, and government agencies to ensure alignment between training programs and industry needs. This council should facilitate regular dialogue between stakeholders, oversee the development of industry-relevant curricula, and promote industry-led skilling programs through targeted incentives. Strong partnerships between educational institutions and EV companies should be fostered to ensure training programs remain current with technological advancements.
4. **Standardization & Certification:** The government should lead the development of expanded National Work Competence Standards (SKKNI) specifically for the EV sector, ensuring these standards align with international best practices. Clear certification pathways should be established for EV-specific technologies, supported by a standardized qualification framework that enhances skill transferability across the sector. These standards should be regularly reviewed and updated to reflect technological changes and emerging industry needs.

### Box I. EV Boom Implications for Women

The electric vehicle (EV) industry's rapid growth—from 1 million cars sold in 2017 to over 13 million in 2023—has created significant employment opportunities, yet women represent only 25% of the automotive workforce (Sunberg, 2024). This gender disparity extends to Indonesia's EV sector, where women face multiple barriers to equal participation. According to research from the Institute for Transportation and Development Policy (ITDP), women in Indonesia encounter significant challenges in accessing opportunities within the emerging electric mobility ecosystem.

The representation gap is particularly evident in public transportation, with Transjakarta (Jakarta's BRT system) employing only three female electric bus drivers with no female technicians as of June 2022. At the leadership level, only one woman serves on Transjakarta's nine-person board of directors, while just three of 40 decision-making positions at electric bus manufacturers are held by women. This imbalance is further reflected in upstream sectors like nickel mining for battery production, where women submitted only 21% of 6,000+ job applications to PT Vale Indonesia (Kontan, 2023).

Financial barriers also disproportionately affect women, particularly those from lower-income groups who typically have less financial independence. The high initial cost of electric vehicles creates a more significant obstacle for women, limiting their access to the benefits of electric mobility, including lower operational costs and environmental advantages. Additionally, women's mobility patterns—characterized by shorter trips for shopping, school runs, and household activities—are often overlooked in vehicle design and infrastructure planning.

Despite these challenges, the EV transition presents substantial opportunities for women's participation across the value chain. Potential roles include battery production and technology (leveraging Indonesia's rich nickel reserves), vehicle manufacturing and assembly, infrastructure development, research and development, and vehicle operation services (Institute for Transportation Development Policy, 2024). Research shows that increasing women's involvement could also boost EV adoption, as current marketing predominantly emphasizes technology (prioritized by only 12% of women) rather than safety (valued by 65% of women) (Davis, J., 2023).

Addressing these disparities requires gender-disaggregated data collection, inclusive regulatory frameworks, transparent financing schemes, targeted recruitment initiatives, and women-centered design approaches. With appropriate interventions, electric mobility can simultaneously advance environmental sustainability and gender equality in Indonesia, creating an inclusive ecosystem that benefits the entire society.

# CHAPTER IV

# ENVIRONMENTAL IMPACTS OF EV DEVELOPMENT IN INDONESIA

## 4.1 Current Environmental Impact of the Transportation Sector

The transportation sector represents a significant source of greenhouse gas (GHG) emissions in Indonesia. This sector accounts for 23% of national GHG emissions. Within the transportation sector, road transportation is the dominant source of emissions, responsible for over 90% of all transportation-related emissions. Moreover, the transportation sector significantly contributes to the nation's high energy consumption, accounting for an average of 43% of the total final energy consumption. Thus, one of the national priorities in the Long-Term National Development Plan (RPJPN) 2025-2045 draft is environmentally friendly transportation, focusing on electric vehicles (EVs).

## 4.2 Environmental Impacts of EV Development

When examining the impact of EV development on the environmental pillar of IGEI, CORE Indonesia (2024a) shows that the highest environmental pillar score is achieved in the LCDI NZE Scenario, reaching 86.76 by 2060, higher than the EV Impact Scenario at 86.64. In the EV Impact Scenario, domestic EV production increases energy consumption and GHG emissions from manufacturers. Conversely, in the LCDI NZE Scenario, EV adoption through completely built-up (CBU) imports optimally impacts the environment since the energy savings and emissions reductions from replacing fossil fuel use in internal combustion engine vehicles (ICEVs) with clean electricity are not offset by the energy and emissions involved in domestic EV manufacturing (CORE Indonesia, 2024a).

Specifically, the comparative Life Cycle Assessment (LCA) of EV and ICEV, with the current largest sales status in Indonesia such as BYD Seal and Toyota Camry as a model, highlights significant differences in environmental impact categories. The adoption of EV impacts various stages of the supply chain, from raw material sourcing to end-of-life recycling. It increases demand for critical materials like lithium, cobalt, and nickel, driving the need for sustainable practices and innovations. EV production requires shifts in manufacturing processes, including the use of lightweight materials and energy-efficient methods. In transportation and logistics, it emphasizes optimization and the need for safe battery handling. During the usage phase, EVs reduce energy consumption and maintenance costs while integrating with smart grid systems. At the end-of-life stage, batteries can be repurposed or recycled, supporting a circular economy and minimizing environmental impact.

Table 12 Environmental Impact of EV Adoption Based on Supply Chain

| Phase | Environmental Impact of EV Adoption |
|---|---|
| Raw Material Sourcing (Upstream) | Increased demand for critical materials like lithium, cobalt, and nickel drives the need for sustainable and ethical sourcing. EV adoption also raises geopolitical risks and prompts innovation in alternative materials. |

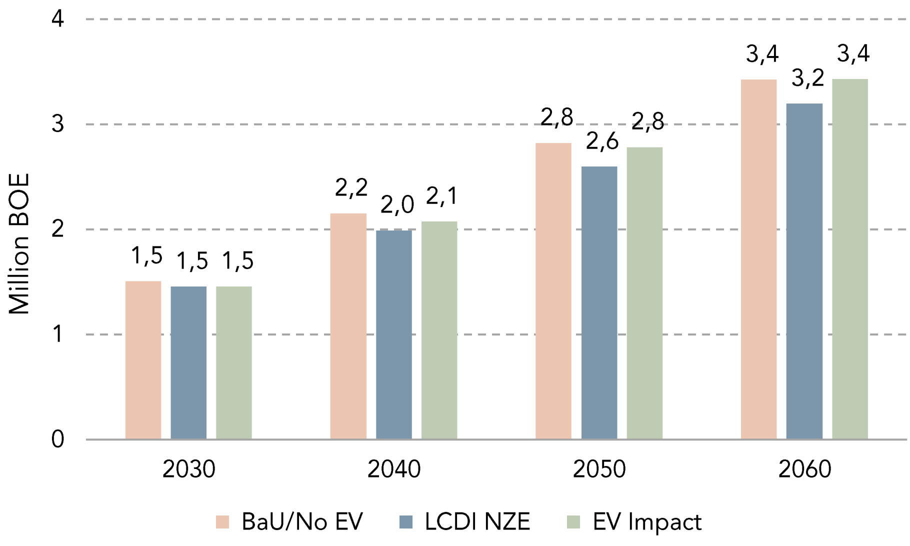
| Phase | Environmental Impact of EV Adoption |
|---|---|
| Manufacturing Processes (Midstream) | EV production necessitates changes in manufacturing, such as energy-efficient processes, the use of lightweight materials, and the establishment of battery production facilities to meet increasing demand. |
| Transportation and Logistics | EV adoption pushes the need for logistics optimization, electrification of transport fleets, reduced emissions, and the development of safe battery handling protocols due to the complexity of battery transport. |
| Usage Phase / Operation Stage | EVs offer lower energy consumption, reduced maintenance, and integration with smart grid systems. However, they require widespread charging infrastructure and advancements in battery technology to alleviate range anxiety. |
| End-of-Life and Recycling | EV batteries can be repurposed for second-life applications or recycled for valuable materials. This supports the circular economy, reduces waste, and minimizes the environmental impact of EVs at the end of their lifecycle. |

Source: Life Cycle Indonesia (2024)

### 4.2.1 Projected Reduction of Final Energy Consumptions from EV Adoption

From a macroeconomic perspective, the LCDI NZE Scenario achieves the lowest final energy consumption by 2060 at 3.20 BOE, compared to 3.43 BOE in both the EV Impact and Business as Usual (BaU) Scenarios (see Figure 15). Under the LCDI NZE Scenario, the production of EVs to meet domestic demand is assumed to rely on outsourced electricity, requiring approximately 8,048 GWh/year by 2060, thereby avoiding additional domestic energy consumption. Conversely, the EV Impact Scenario involves energy-intensive domestic production, resulting in slightly higher final energy consumption compared to the LCDI NZE Scenario.

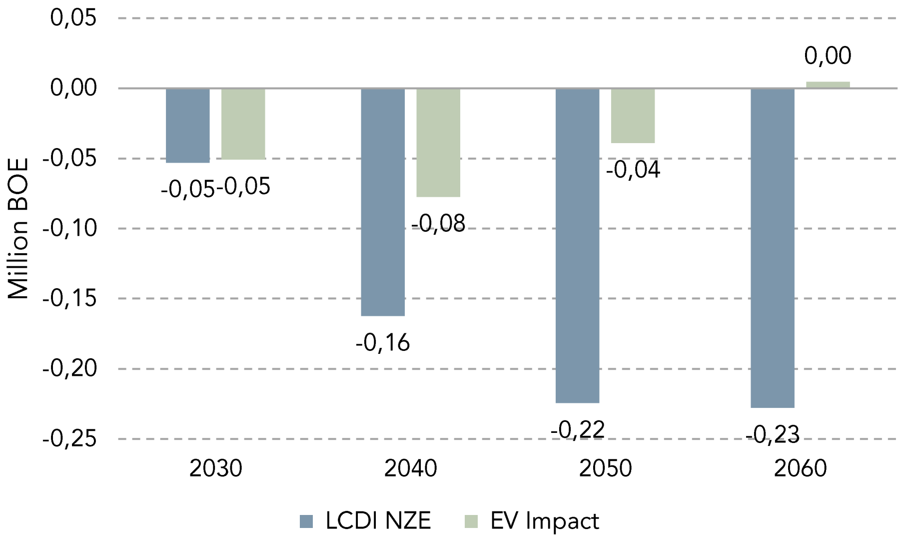
**Figure 15** Impact of EV Adoption on Final Energy Consumption




Source: CORE Indonesia (2024a)

Thus, the overall adoption of EVs results in a marginal net reduction in final energy consumption, ranging between -0.05 and 0.23 BOE compared to the BaU or No EV Scenario. If produced domestically, the net reduction in final energy consumption would be even smaller compared to the BaU or No EV Scenario, ranging from -0.05 to 0 BOE (see Figure 16).

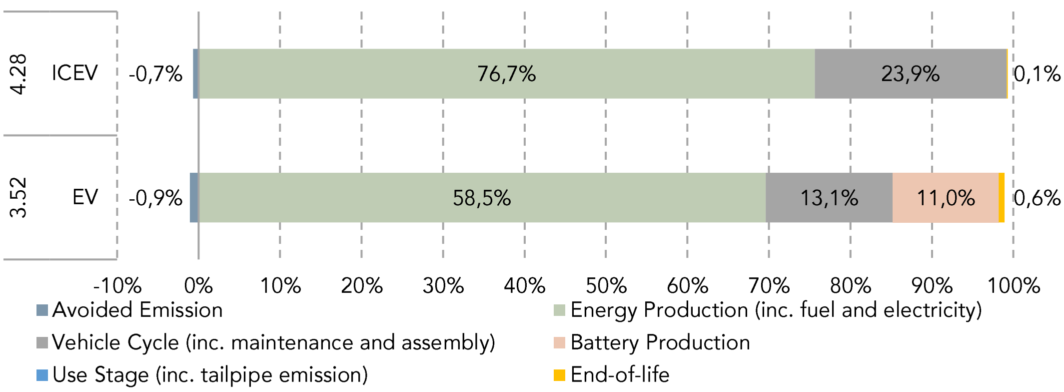
Figure 16 Projected Change in Final Energy Consumption within LCDI NZE and EV Impact Scenarios Compared to BaU




Source: CORE Indonesia (2024a)

Based on the comparative LCA results, EV performs better in reducing overall fossil energy demand and final energy consumption but faces challenges with negative impacts related to battery production, especially in terms of acidification and eutrophication potential. On the other hand, the ICEV have high impacts related to fossil fuel combustion and fossil fuel consumption, due to the substantial energy demands of fuel production and combustion process, contributing significantly to cummulative fossil energy demand. Thus, EVs demonstrate a 17.8% reduction in CED-Fossil, consuming only 3.52 MJ compared to 4.28 MJ for ICEVs (see Figure 17) (Life Cycle Indonesia, 2024).

Figure 17 Cumulative Fossil Energy Demand in EVs vs ICEVs

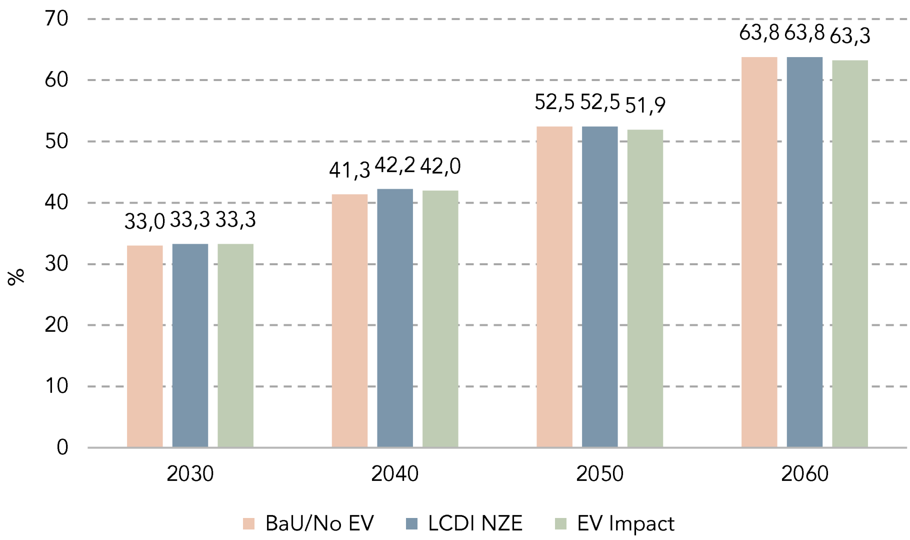



Source: Life Cycle Indonesia (2024)

### 4.2.2 Projected Reduction of GHG Emissions from EV Adoption

From a macroeconomic perspective, the LCDI NZE Scenario also achieves the highest cummulative GHG emission reduction by 2060 at 63.8%, compared to 63.3% and 62.2% in the EV Impact and Business as Usual (BaU) Scenarios respectively (see Figure 18). In the EV Impact scenario, the cumulative GHG emissions reduction is slightly lower than in the LCDI NZE scenario due to higher annual emissions resulting from production activity. Conversely, under the LCDI NZE scenario, domestic demand for EVs is met through the import of completely built-up units, thereby avoiding an increase in energy consumption and national GHG emissions.

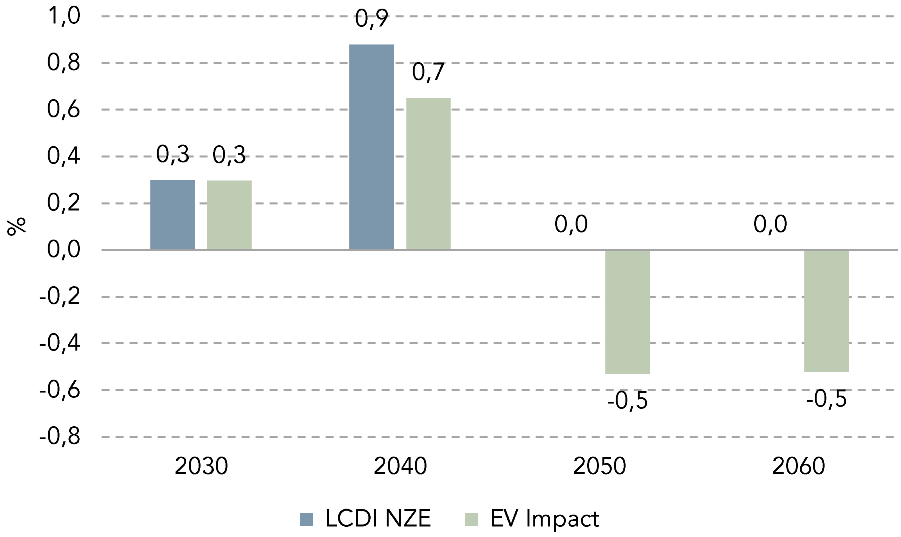
Figure 18 Impact of EV Adoption on Cummulative GHG Emission Reduction




Source: CORE Indonesia (2024a)

Thus, the overall adoption of EVs results in a marginal net increase in cummulative GHG emission reduction, ranging between 0.3% and 0.9% compared to the BaU or No EV Scenario. If produced domestically, the net reduction in GHG emission reduction would be even smaller compared to the BaU or No EV Scenario, ranging from -0.5% to 0.7% (see Figure 19).

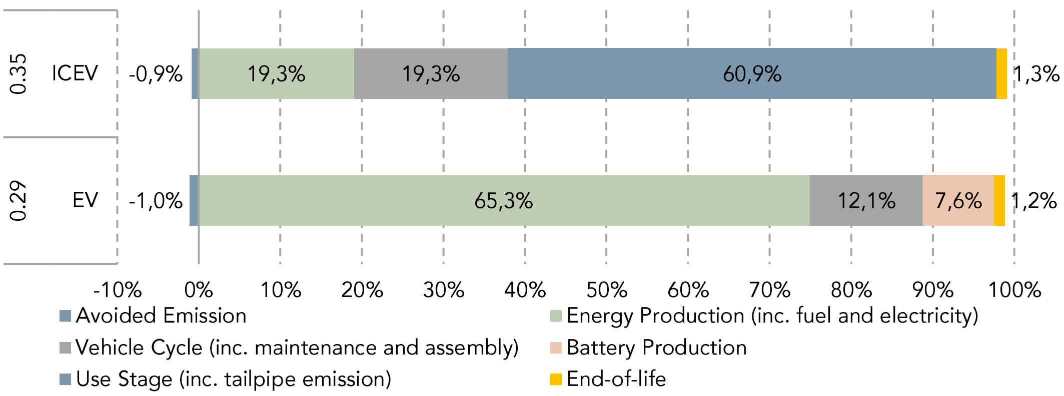
**Figure 19** Projected Change in the Cummulative GHG Emission Reduction within LCDI NZE and EV Impact Scenarios Compared to BaU




Source: CORE Indonesia (2024a)

Based on the comparative LCA results, ICEV's GHG emission is dominated by fuel production and tailpipe emissions, emphasizing the carbon impact of burning fossil fuels. For EV, GHG emission is mainly driven by electricity production, followed by vehicle manufacturing and battery production. EVs avoid tailpipe emissions, which helps reduce 14,8% overall GHG emission. EVs emitting only 0.29 kg CO2 eq compared to 0.35 kg CO2 eq for ICEVs (see Figure 20) (Life Cycle Indonesia, 2024).

**Figure 20** Cumulative GHG Emission Reduction in EVs vs ICEVs

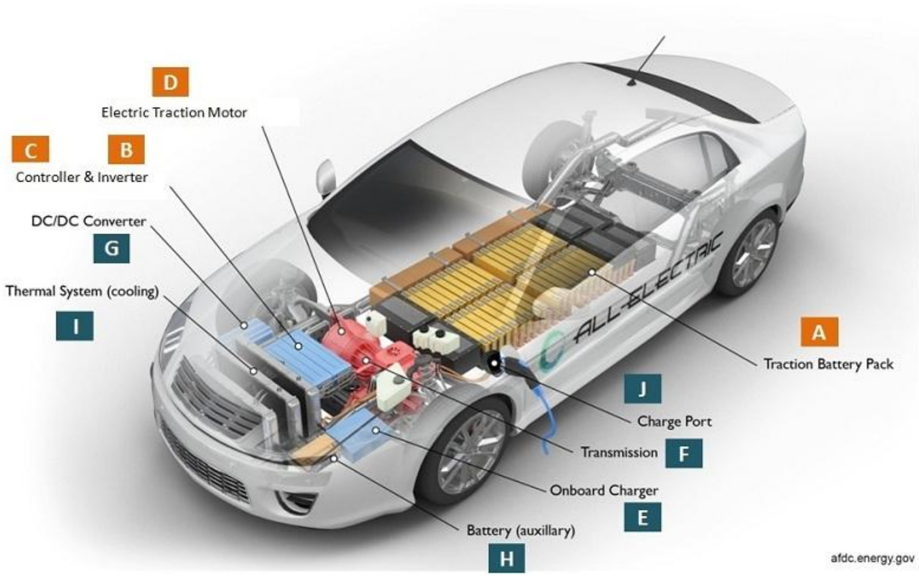



Source: Life Cycle Indonesia (2024)

### 4.2.3 GHG Emission Potential Hotspots During Vehicle Production Stages

Other than energy production during the use stage, the next significant hotspots for EV are battery production and vehicle assembly. Further analysis has identified the lithium-ion battery cathode as a major contributor to environmental impact, along with steel and aluminum. Implementing green chemistry practices, such as using eco-friendly chemicals, can reduce harmful by-products and enhance worker safety. However, the primary environmental challenge with steel and aluminum production remains their energy-intensive processes. The adoption of green steel, which utilizes hydrogen-based reduction and electric arc furnaces powered by renewable energy, presents a viable solution for reducing greenhouse gas emissions in steel manufacturing. Incorporating green steel into EV production enables automakers to reduce the carbon footprint of steel components, thus aligning with broader sustainability goals and supporting climate neutrality targets. Table 12 shows the breakdown of global warming potential hotspots during the vehicle production stage, including battery production.

Figure 21 Electric Vehicles Components




Source: U.S. Department of Energy (2024)[4]

Table 13 GHG Emission Potential Hotspots During Vehicle Production Stages

| Car Parts | Unit | Amount | Percentage | Hotspot |
|---|---|---|---|---|
| Battery Production | kg CO2 eq | 0.026 | 38.34% | Cathode |
| Body | kg CO2 eq | 0.011 | 15.55% | Steel |
| Chassis | kg CO2 eq | 0.005 | 7.75% | Steel |
| Electronic Controller | kg CO2 eq | 0.002 | 3.16% | Cast Aluminum |

[4] U.S. Department of Energy. (2024). *How Do All-Electric Cars Work?* Retrieved from https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work.

| Car Parts | Unit | Amount | Percentage | Hotspot |
|---|---|---|---|---|
| Powertrain System | kg CO2 eq | 0.001 | 1.73% | Plastic |
| Traction Motor | kg CO2 eq | 0.004 | 5.60% | Cast Aluminum |
| Transmission System | kg CO2 eq | 0.002 | 2.39% | Aluminum Sheet |
| Tire | kg CO2 eq | 0.002 | 2.43% | Rubber |
| Assembly | kg CO2 eq | 0.008 | 11.03% | Electricity |
| Maintenance | kg CO2 eq | 0.008 | 12.01% | Electricity |
| **Total for Car Production** | **kg CO2 eq** | **0.068** | **100.00%** | |

Source: Life Cycle Indonesia (2024)

### 4.2.4 Scenario Analysis: Environmental Impacts of EV Adoption using Different Types of Batteries

Based on previous discussion on different emerging battery technologies, this study also addresses the potential environmental impact of using EV with different battery technologies, particularly the conventional NMC battery, LFP battery, Sodium-ion battery and Solid-state battery. The specifications of each battery are derived from Degen et al. (2024), which can be seen in Table 14. The table below details the comparative results, setting the LFP battery as the baseline against which the impacts of the NMC111 battery are measured.

Table 14 GHG Environmental Impact of EV Usage in Indonesia with Different Battery Technologies

| Impact Category | Unit | LFP (Baseline) | NMC811 | Difference | Li-SSB | Difference | SIB | Difference |
|---|---|---|---|---|---|---|---|---|
| GHG emission potential | kg CO2 eq | 0.29 | 0.30 | **0.9%** | 0.29 | -0.4% | 0.30 | 2.3% |
| Acidification potential | kg SO2 eq | 1.54E-03 | 1.55E-03 | **0.4%** | 1.52E-03 | -1.2% | 1.48E-03 | -4.1% |
| Eutrophication potential | kg PO4 eq | 1.52E-03 | 1.52E-03 | **-0.1%** | 1.52E-03 | -0.2% | 1.52E-03 | -0.3% |
| Cummulative fossil energy demand | MJ | 2.52 | 2.77 | **9.9%** | 2.67 | 5.9% | 2.75 | 9.1% |

Source: Life Cycle Indonesia (2024)

Table above highlights the environmental trade-offs of different EV battery technologies in Indonesia. The LFP battery, as the baseline, demonstrates balanced performance across all impact categories. NMC811 and SIB show higher cumulative energy demands, reflecting more resource-intensive production processes, while SIB achieves the lowest acidification potential, making it a promising alternative for reducing GHG emissions. Li-SSB stands out for its moderate improvements in GHG emission potentials and acidification potentials, while keeping energy demand relatively low. Overall, the choice of battery technology depends on prioritizing specific environmental impacts, with SIB excelling in reducing acidification and LFP offering the most balanced performance.

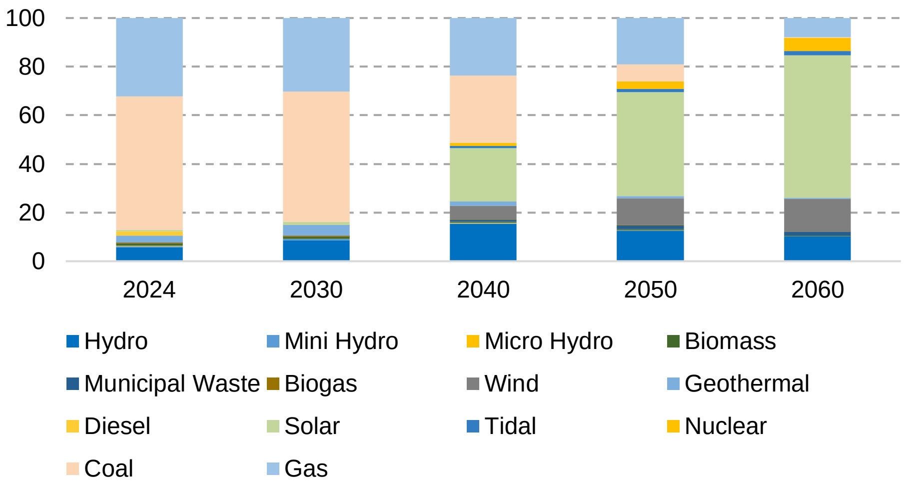
### 4.2.5 Electricity Mix and Renewable Energy Supply

The transition from ICEVs to EVs necessitates a substantial increase in electricity demand due to the electrification of the land transport sector and the energy-intensive nature of battery production. However, Indonesia's current energy supply is predominantly fossil-based, with coal contributing 62.7% to the total national electricity production (MEMR, 2024). This heavy reliance on fossil fuels presents significant challenges to enhancing the environmental pillar of the Green Economy Index (GEI), particularly in reducing greenhouse gas (GHG) emissions and advancing renewable energy adoption.

Given the reliance on an average energy mix, there is a pressing opportunity to focus efforts within the automotive industry to exceed national energy transition targets. A more ambitious strategy is essential, particularly in integrating renewable energy sources such as solar photovoltaic (PV) and wind power into automotive production facilities. These clean energy technologies are highly viable in Java, where most of Indonesia's automotive plants are located. Denmark, which have successfully incorporated renewable energy sources into their grids. Thus, by investing in solar and wind energy and leveraging its geographical strengths, Indonesia can diversify its energy mix. The adoption of smart grid technologies would further enhance energy distribution efficiency and support the increased electricity demand from EVs (Rietmann et al., 2020).

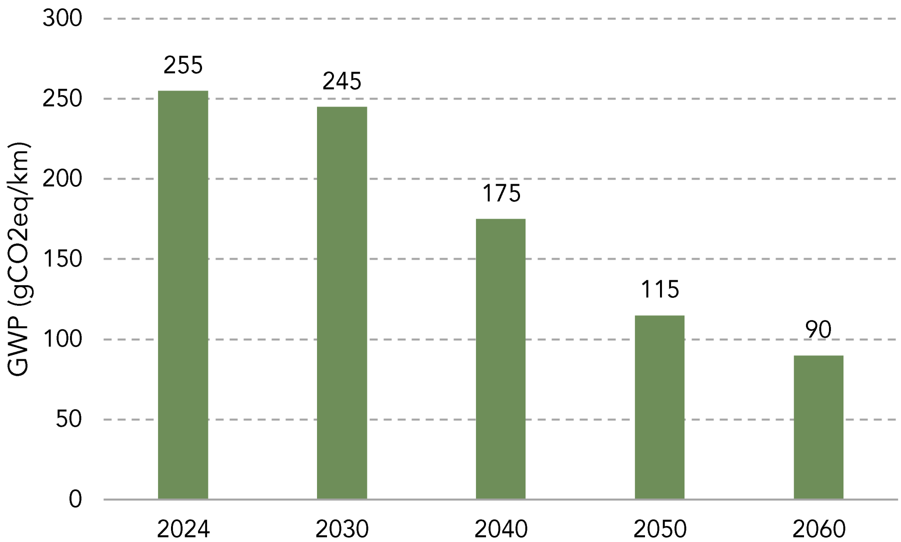
By 2060, the energy mix shifts significantly toward renewable sources such as solar, biomass, and hydropower, while reliance on coal and gas declines significantly (see Figure 22). This transition supports Indonesia's net-zero emission goal, ensuring a cleaner energy supply for the growing adoption of EVs. Between 2024 and 2060, GHG emission per kilometer traveled by EVs (GWP CO2-eq) are projected to decrease by 64.58%, supported by the decarbonization of the electricity grid (see Figure 23).

Figure 22 Electricity Mix Projection




Source: CORE Indonesia (2024a)

Figure 23 GHG Emission Potential Impact Projection of 2024-2060




Source: Life Cycle Indonesia (2024)

Conversely, the absence of a specific roadmap or regulatory framework to ensure the supply of clean energy for EV usage highlights the need for strategic intervention. Developing a comprehensive decarbonization roadmap for electricity generation is vital to fully realize the environmental potential of EV adoption.

#### 4.2.6 Resource-Efficient and Cleaner Production Technology in Battery Manufacturing

The production of conventional EV batteries, primarily lithium-based like Lithium-ion batteries (LIBs), offers high energy efficiency and longevity but encounters challenges with raw material costs and environmental concerns. The manufacturing process is highly automated and refined to ensure large-scale efficiency and reliability. It involves preparing a slurry of active materials, binders, and conductive agents, which is then coated and dried onto current collectors. Electrodes are compressed via calendaring to improve performance, cut into precise shapes, and assembled into cells through stacking or winding with separators. The final step involves carefully injecting electrolytes to ensure full saturation of the electrodes, a crucial factor for optimal performance.

Leading EV battery manufacturers play a pivotal role in fostering sustainable production through innovation, technological progress, and circular economy principles. They supply key technologies such as lithium iron phosphate (LFP) and nickel manganese cobalt (NMC) batteries to meet the growing demand for EVs while promoting efficient resource use and waste reduction. Table 14 highlights key global players in the EV battery industry, their roles in the supply chain, and their current status.

Table 15 Global EV Battery Manufacturers and Current Status

| Company | Country | Battery Type | Current Status |
|---|---|---|---|
| Contemporary Amperex Technology Co. (CATL) | China | LFP, NMC | Leading global producer; supplies major brands like Tesla and SAIC; expanding production capacity. |
| Build Your Dreams Company Ltd. (BYD) | China | LFP, NMC | Major player in EVs and battery production; innovating with sodium ion technology for cost efficiency. |
| LG Energy Solutions | South Korea | LFP, NMC, NCMA | Secured a large supply deal for LFP batteries with Renault; expanding production capabilities in Europe. |
| Panasonic Corporation | Japan | NMC | Supplier for Tesla; investing in all solid-state battery technology for enhanced performance. |
| SK On | South Korea | NMC | Focused on scaling production to meet rising demand from automotive manufacturers. |
| Samsung SDI | South Korea | NMC | Innovating in energy storage systems and expanding its footprint in the EV battery market. |
| China Aviation Lithium Battery Co. (CALB) | China | LFP | Rapid growth in lithium-ion battery production for various applications including EVs. |
| Farasis Energy | China | NMC | Focus on high energy density batteries for improved vehicle performance. |
| Sunwoda Electronic Co. | China | LFP | Advanced battery management systems and automated production lines enhancing efficiency. |
| Tesla, Inc | USA | 4680 Cells (NMC) | Produced its 100 millionth cell in September 2024; ramping up production at Gigafactory Texas despite challenges with dry coating technology. |

Source: Life Cycle Indonesia (2024)

As the push for sustainable manufacturing intensifies, innovations in battery production and digital transformation are becoming essential to enhance efficiency and minimize environmental impact. These advancements emphasize cleaner production processes, optimized energy use, effective recycling, and the integration of digital technologies to streamline manufacturing and resource management. Key innovations shaping the future of battery production and smart manufacturing are outlined below.

1. Cleaner Battery Manufacturing

- Dry Electrode Processing: Adopting this method reduces water and solvent use in battery cell production, making the process more environmentally friendly.
- Localized Sourcing: Establishing supply chains closer to manufacturing sites minimizes transportation emissions and enhances sustainability.

2. Efficient Energy Use in Cell Assembly

- Using energy-efficient machinery, such as regenerative braking and power management systems, lowers electricity consumption during production.

3. Recycling and Second-life Use

- Battery Recycling Programs: Recycling end-of-life batteries directly within production facilities recovers critical metals and minimizes waste.
- Second-life Battery Integration: Repurposing used batteries for energy storage supports cleaner energy practices within facilities or nearby applications.

4. Digital Transformation and Smart Manufacturing

- IoT and Data Analytics: Leveraging IoT and real-time data analytics enables efficient resource monitoring, predictive maintenance, and waste reduction by improving equipment efficiency and minimizing downtime.
- Digital Twin Technology: Implementing digital twins allows manufacturers to simulate and optimize production processes before implementation. This reduces resource usage and energy consumption while ensuring efficient manufacturing operations.

### 4.2.7 Circular Economy and The End-of-Life Battery Management

The End of Life (EoL) management of batteries, particularly for electric vehicles (EVs), is crucial for ensuring environmental sustainability and resource efficiency. The EoL refers to the stage when a battery can no longer perform its intended function effectively, which typically occurs when its State of Health (SoH) falls below 70-80% of its original capacity. At this point, various strategies can be employed to manage the battery's remaining utility, primarily through recycling and second-life applications.

1. **The Second-life Battery Integration:**

After an EV battery has served its purpose in a vehicle, it usually retains around 70-80% of its capacity. Instead of recycling it immediately, the battery can be repurposed for other uses, giving it a "second life".

Used EV batteries can be repurposed for stationary energy storage systems (ESS) including renewable energy storage, backup power, grid stabilization, and portable power banks. Second-life battery utilization reduces demand for new battery production, decreases costs, and minimizes environmental impact by delaying material recovery needs and reducing electronic waste. While no longer meeting high EV performance standards, these batteries remain valuable for less demanding stationary applications.

These batteries can be employed in various settings, such as:

- Energy Storage Systems (ESS): Providing backup power or storing renewable energy.
- Grid Support: Stabilizing the grid by managing peak loads and integrating renewable sources.
- Microgrid Solutions: Supporting remote areas with limited access to traditional power sources.

According to Pertamina Energy Institute (2022), EV batteries transition to second-life applications between years 5-8, typically retaining 70-80% of original capacity. These batteries can be refurbished for stationary energy storage in electrical grids, communication towers, and renewable energy installations such as wind and solar farms, with varying technological readiness levels as detailed in Table 16.

Table 16 Technological Readiness Level (TRL) of Second-life Battery for EV

| Technology/ Application | Description | Current TRL | Maturity Level | Evidence of Maturity Level |
|---|---|---|---|---|
| Small-scale Energy | Technology demonstrated in a relevant environment; pilot projects using second-life EV batteries in small-scale applications. | TRL 7-8 | Pilot project and pre-commercial demonstration has already performed. | RWE and Audi collaborated on a pilot-project repurposing Audi e-tron batteries, creating a 4.5 MWh storage system for stationary applications.<br><br>Jaguar, Land Rover, and Allye Energy developed a mobile energy storage unit using Range Rover batteries, capable of powering homes and charging vehicles. |

Source: Reuters (2023)[5]; RWE (2021)

[5] Reuters. (2023). *Jaguar develops energy-storage unit using Range Rover batteries*. Retrieved from https://www.reuters.com/business/autos-transportation/jaguar-develops-energy-storage-unit-using-range-rover-batteries-2024-04-15/?utm_source=chatgpt.com.

## 2. Battery Recycling:

The use of electric vehicles is expected to grow exponentially in the coming years, and so will EoL LIBs albeit with a time lag of 10−15 years depending on the length of use in EVs and eventual second life in, for example, energy storage applications (Rajaeifar et al, 2021). Battery manufacturers are constructing recycling facilities either directly on-site or nearby to streamline the process. Additionally, independent recyclers are making significant investments in their own lithium-ion battery recycling plants, reflecting the growing demand and opportunity in this sector. Over the past two years alone, more than 20 companies in the automotive and recycling sectors have announced plans for new partnerships (BCG, 2023). The process of battery recycling and the technological readiness level of recycling can be seen on Table 15.

Generally, LIBs can be removed from their initial application after approximately 3–10 years of service, depending on their performance degradation status. It was estimated that 47.8 GWh of LIBs reached their end-of-life worldwide in 2019, equal to 262k tons, and it was predicted that this number will grow to 314 GWh in 2030, with an annual average growth rate of 18.8%.

In the retired LIBs, valuable metals, including Li, Co, Ni, and Mn, are critical components that account for more than 50% of some $LiNixCoyMn2O2$ (NCM) batteries. In addition, retired LIBs also contain some toxic and harmful components, such as organic electrolytes (Li et al., 2020). Hence, the rational disposal of retired LIBs not only helps conserve resources but is also conducive to environmental protection (Miao et al., 2022).

Table 17 Technological Readiness Level (TRL) of Battery Recycling Technologies for EV

| Technology/ Application | Description | Existing Technology | Current TRL | Maturity Level | Evidence of Maturity Level |
|---|---|---|---|---|---|
| Pyrometallurgy | High-temperature process recovering metals like cobalt, nickel, and copper, but not lithium. | Widely used in China but considered energy-intensive and less efficient in lithium recovery. | TRL 7-8 | Established with operational plants. | Multiple operational facilities, e.g., Umicore in Belgium and Li-Cycle in North America. |
| Hydrometallurgy | Uses aqueous solutions to recover materials like lithium, cobalt, and nickel. | Commercially implemented in China, Europe, and North America; has high recovery rates and a lower environmental footprint compared to | TRL 6-8 | Pilot-scale applications ongoing. | Companies like American Battery Technology Company (ABTC) running pilot plants. |

| Technology/ Application | Description | Existing Technology | Current TRL | Maturity Level | Evidence of Maturity Level |
|---|---|---|---|---|---|
| | | pyrometallurgy. | | | |
| Direct Recycling | Aims to reuse cathode materials directly, reducing the need for full reprocessing. | Still in research but showing potential for reducing costs and environmental impacts. | TRL 4-6 | Experimental stage, promising results. | Research projects at institutions like the University of California, Berkeley, and companies like Redwood Materials. |

Source: Blackridge Research & Consulting (2024); Latini et al. (2022)

The adoption of battery recycling in Indonesia hinges on several critical enablers that address regulatory, infrastructural, and technological challenges, as well as workforce development and international collaboration are outlined below.

1. **Regulatory Framework**

A comprehensive EV-specific recycling regulatory framework is essential to support the growth of battery recycling in Indonesia. Current policies are outdated and lack the necessary guidelines for handling toxic waste effectively. The development of robust regulations will ensure proper waste management and create an enabling environment for the recycling industry to thrive.

2. **Infrastructure Development**

Decentralizing recycling facilities is vital to overcome Indonesia's unique geographic challenges. Establishing facilities across the archipelago can reduce transportation cost and improve accessibility, ensuring that battery waste is collected and processes efficiently.

3. **Research and Development (R&D)**

Advancing battery recycling technologies requires a strong focus on research and development. The planned establishment of the Morowali research center, combined with collaboration with international institutions, is a promising step. Locally appropriate

technologies for battery recycling must also be developed to align with Indonesia's specific needs. Furthermore, efforts to enhance R&D capacity in EV battery recycling will play a pivotal role in advancing the industry.

4. **Skilled Workforce**

Investment in human capital is crucial to build a skilled workforce capable of driving innovation in battery recycling technologies. Initiatives such as sending students abroad for specialized training will ensure that Indonesia has the expertise necessary to manage and advance recycling operations.

5. **Public-Private Partnerships**

Collaborations between the government, state-owned enterprises such as PLN, and private companies are key to scaling up battery recycling operations. Such partnerships can foster resource sharing, technological innovation, and efficient implementation of recycling initiatives.

**6. EV Adoption**

The growth of EV adoption in Indonesia will directly support the battery recycling industry. As the EV market expands, it will create a larger demand for recycling services, making investments in recycling technologies more economically viable and sustainable in the long term.

**7. International Collaboration**

Partnering with global players in the EV and battery recycling industries will bring much-needed expertise and technology transfer to Indonesia. These partnerships will help bridge gaps in knowledge and accelerate the development of efficient and sustainable recycling systems.

## 4.3 Discussions

The transportation sector currently represents a significant environmental challenge in Indonesia, accounting for 23% of national greenhouse gas (GHG) emissions. Road transportation is particularly problematic, responsible for over 90% of all transportation-related emissions. Additionally, the sector is a major consumer of energy, accounting for approximately 43% of total final energy consumption. This substantial environmental impact has led the government to prioritize environmentally friendly transportation, specifically electric vehicles (EVs), in its Long-Term National Development Plan (RPJPN) 2025-2045.

The development of Indonesia's EV industry presents significant environmental opportunities, as demonstrated by scenario analyses conducted by CORE Indonesia. Under the LCDI NZE Scenario, the environmental pillar score could reach 86.76 by 2060, while the EV Impact Scenario projects a score of 86.64, both surpassing the Business-as-Usual scenario. Life cycle assessment reveals that EVs can achieve a 14.8% reduction in overall GHG emissions compared to conventional vehicles, emitting only 0.29 kg CO2 eq compared to 0.35 kg CO2 eq for traditional vehicles. Furthermore, by 2060, the energy mix is projected to shift significantly toward renewable sources, which would further enhance the environmental benefits of EV adoption.

However, significant gaps exist between the current situation and these potential opportunities. The current electricity supply remains predominantly fossil-based, with coal contributing 62.7% to total national electricity production. The nickel mining industry, crucial for EV battery production, generates substantial emissions and environmental impacts, with each ton of nickel produced resulting in 4.61E+04 kg CO2 equivalent of global warming impact. Additionally, there is limited infrastructure for battery recycling and second-life applications, while sustainable mining practices are not yet widely implemented. These gaps collectively hinder the full realization of EVs' environmental benefits.

To bridge these gaps and capitalize on the environmental opportunities presented by EV development, comprehensive policy interventions are required across multiple areas. These include supporting the integration of renewable energy in upstream processes and charging infrastructure, developing smart electrical grids, promoting green industry standards, establishing specific regulations for battery recycling and reuse, and developing sustainable mining standards. Success in these policy areas would enable Indonesia to maximize the environmental benefits of its EV transition while minimizing negative impacts from manufacturing and resource extraction.

### Box II. Metal Mining and Processing Issues

Indonesia's position as the world's largest nickel producer, contributing 50% of global production and holding 42.3% of reserves, comes with significant environmental and health implications (CORE Indonesia, 2024a). The nickel industry generates substantial emissions, with each ton of nickel produced resulting in 4.61E+04 kg CO2 equivalent of global warming impact and 5.58E+03 kg 1,4-DB equivalent of freshwater aquatic ecotoxicity. These impacts primarily stem from electricity usage and CO2 emissions, particularly from coal-fired power plants that release CO2, SOx, NOx, and PM2.5. The health consequences are quantifiable, with the industry contributing to asthma cases (9.21E-04 Person years/t) and cancer cases (7.15E-06 Person years/t), primarily due to fuel oil and electricity usage (Wahyono et al., 2024).

Environmental challenges in mining regions like Sulawesi and Maluku are intensified by unsustainable practices, non-compliance, and illegal operations that generate heavy metal-laden tailings posing significant contamination risks. The situation is worsened by the industry's dependence on coal power amid insufficient green energy infrastructure and weak renewable energy regulations. Despite available technological solutions—including cyclones for particle separation, bag filters for emissions capture, and scrubbers for pollutant removal—implementation remains limited due to poor ESG principles adoption. Alternative approaches showing promise include biodiesel usage to reduce emissions and microbial enhanced recovery to mitigate heavy metals in sediments, as noted by Wahyono et al. (2024).

**The UN Secretary-General's Panel on Critical Energy Transition Minerals (2024) proposes several key actionable recommendations to guide mineral development toward equity and justice: establishing a High-Level Expert Advisory Group to accelerate benefit-sharing; creating a global traceability framework for accountability; forming a Global Mining Legacy Fund for abandoned mines; empowering artisanal miners as transformation agents; and setting targets for material efficiency and circularity. These recommendations aim to ensure mineral demands benefit producing countries while protecting human rights and the environment through multilateral cooperation and sustainable practices. Without widespread adoption of such sustainable mining practices and a transition to renewable energy sources, Indonesia's nickel industry risks undermining the environmental benefits of EV development and impeding the country's progress toward a green economy.**

CHAPTER V

# CONCLUSION AND POLICY RECOMMENDATIONS

## 5.1 Conclusion

The rapid growth of EV adoption across various countries, particularly in China, the USA, and Europe, has generated significant impacts on economic, social, and environmental aspects. In economic terms, it has stimulated growth in the automotive sector and its supply chain, from battery components to EV assembly, creating substantial added value while simultaneously eroding the ICE vehicle market share. Another consequence has been the shift in workforce demands, as the rise of EVs requires specialized skills that are partly distinct from those needed in ICE vehicle production. Environmental impacts have been significant, with reduced fuel consumption leading to lower emissions. Indonesia, with its significant automotive market share and potential for manufacturing development and ecosystem growth, has the opportunity to capitalize on these trends. Against this backdrop, this study examines the following key findings regarding Indonesia's EV development trajectory:

From the economic perspective, Indonesia's EV transition offers significant growth potential, particularly when prioritizing domestic manufacturing. Under the EV Impact scenario emphasizing local production, GDP growth could increase from 0.01% in 2030 to 2.03% by 2060, substantially outperforming import-dependent approaches. Indonesia's position as the world's largest nickel producer, contributing 50% of global production and holding 42.3% of reserves, presents a unique opportunity for domestic battery production. However, several critical challenges impede this potential: limited local supply chain capabilities, with domestic manufacturers struggling to meet the 40% TKDN requirement; insufficient coordination among government agencies; and inadequate charging infrastructure, with only 1,810 SPKLU and 1,882 SPBKLU stations heavily concentrated in Java. While the government has implemented various incentives, including purchase subsidies and tax reductions, there is a need for stronger incentives specifically targeting vehicles using domestically produced nickel-based batteries to leverage Indonesia's natural resource advantage. The sector's development is further complicated by the current dominance of imports, with China and South Korea being primary sources, highlighting the need for strengthening domestic manufacturing capabilities.

The social impact analysis reveals that despite initial concerns about job displacement, Indonesia's EV transition holds substantial employment potential. While EVs require approximately 30% less labor than traditional vehicles, domestic manufacturing development could generate approximately 500,000 new jobs by 2030, expanding to 1.7 million by 2045 compared to business-as-usual. However, this positive outcome depends heavily on developing local production capacity - the LCDI NZE scenario, relying on imported EVs, projects potential job losses exceeding 40,000 by 2030. The transition affects different segments of the automotive workforce differently, with growth expected in EV OEM manufacturing, battery production, charging infrastructure, and specialized maintenance services, while job losses are anticipated in traditional ICEV-related sectors, particularly among Tier 1 and lower-tier suppliers. The workforce transformation demands new skills across electrical systems, battery technology, and digital manufacturing processes, with particular emphasis on core competencies such as analytical thinking, continuous learning capabilities, and specialized knowledge in electrical and chemical systems. Current challenges include limited capacity of formal education systems to meet industry needs, insufficient skill standardization frameworks, heavy reliance on in-house training by companies, and significant variations in organizational approaches between large-scale 4W manufacturers operating within global value chains and domestically-owned 2W producers. The transition particularly impacts the service segment, which currently employs nearly 1 million workers in dealers, workshops, and related services, highlighting the need for comprehensive reskilling programs.

The environmental assessment presents mixed but generally positive impacts. The LCDI NZE Scenario achieves the highest environmental pillar score of 86.76 by 2060, slightly above the EV Impact Scenario's 86.64, primarily due to additional energy consumption and emissions from domestic manufacturing in the latter scenario. Life cycle assessment reveals that EVs achieve a 14.8% reduction in overall GHG emissions compared to conventional vehicles, emitting 0.29 kg CO2 eq versus 0.35 kg CO2 eq. The analysis of different battery technologies shows varying environmental trade-offs, with LFP batteries demonstrating balanced performance across impact categories, while sodium-ion batteries excel in reducing acidification despite higher energy demands. However, these benefits are partially offset by environmental impacts from battery production and mining activities, with nickel production alone generating 4.61E+04 kg CO2 equivalent per ton. Battery production represents the largest environmental hotspot during vehicle production, accounting for 38.34% of emissions, followed by body manufacturing (15.55%) and assembly processes (11.03%). The transportation sector currently accounts for 23% of national GHG emissions, with road transportation responsible for over 90% of these emissions and 43% of total final energy consumption. The analysis emphasizes the critical importance of transitioning from Indonesia's current 62.7% coal-based electricity supply to renewable energy sources, implementing sustainable mining practices, and developing comprehensive battery recycling and second-life application frameworks to maximize environmental benefits. By 2060, projections indicate a 64.58% decrease in GHG emissions per kilometer traveled by EVs, supported by the planned decarbonization of the electricity grid.

The study identifies several critical institutional and regulatory gaps that must be addressed to realize these potential benefits. Current policy implementation remains fragmented across government agencies, with insufficient coordination particularly evident in infrastructure development and workforce preparation. The regulatory framework lacks comprehensive guidelines for crucial aspects such as battery recycling, grid integration, and sustainable mining practices. While various incentive programs exist, they require better alignment with domestic manufacturing goals, particularly for leveraging Indonesia's nickel resources. Additionally, the current institutional structure shows limited coordination between educational institutions and industry needs, potentially hampering workforce development. Infrastructure development faces challenges due to insufficient coordination between central and local governments, resulting in geographically imbalanced charging network deployment.

Overall, the analysis of Indonesia's Green Economy Index (GEI) demonstrates that EV development positively impacts the country's green economic development trajectory. By 2060, the GEI score is projected to reach 95.47 in the LCDI NZE Scenario and 95.50 in the EV Impact Scenario, both surpassing the Business-as-Usual Scenario's score of 95.32. This improvement is driven by advances across all three pillars - economic, environmental, and social. The EV Impact Scenario, which emphasizes domestic manufacturing, achieves the highest overall GEI score, suggesting that developing local production capabilities while maintaining environmental standards represents the optimal path forward for Indonesia's green economy transition. However, the potential advantage of EV adoption to GEI requires comprehensive and sustained policies and regulations as well as strong institutional policy and solid coordination to balance economic development with environmental protection and social equity considerations.

Table 18 Impact of EV Adoption on Green Economy Index

| Year | GEI | | | ECO | | | ENV | | | SOC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BaU/ No EV | LCDI NZE | EV Impact | BaU/ No EV | LCDI NZE | EV Impact | BaU/ No EV | LCDI NZE | EV Impact | BaU/ No EV | LCDI NZE | EV Impact |
| 2020 | 56.067 | 56.067 | 56.067 | 58.385 | 58.385 | 58.385 | 47.988 | 47.988 | 47.988 | 60.669 | 60.669 | 60.669 |
| 2025 | 68.282 | 68.486 | 68.487 | 72.877 | 73.247 | 73.139 | 54.102 | 54.221 | 54.221 | 75.570 | 75.610 | 75.775 |
| 2030 | 77.624 | 78.058 | 78.325 | 86.642 | 87.344 | 87.336 | 60.009 | 60.345 | 60.336 | 81.713 | 81.843 | 82.797 |
| 2035 | 86.145 | 86.707 | 86.738 | 93.981 | 94.682 | 94.556 | 70.949 | 71.683 | 71.607 | 89.585 | 89.770 | 90.143 |
| 2040 | 90.071 | 90.178 | 90.267 | 96.799 | 96.895 | 96.871 | 74.406 | 74.592 | 74.535 | 95.646 | 95.689 | 96.093 |
| 2045 | 91.672 | 91.766 | 91.869 | 97.566 | 97.566 | 97.566 | 76.600 | 76.836 | 76.739 | 97.904 | 97.996 | 98.454 |
| 2050 | 92.911 | 93.032 | 93.109 | 97.926 | 97.926 | 97.926 | 79.209 | 79.489 | 79.365 | 99.091 | 99.233 | 99.629 |
| 2055 | 94.110 | 94.248 | 94.318 | 98.345 | 98.345 | 98.345 | 82.484 | 82.802 | 82.671 | 99.384 | 99.549 | 99.924 |
| 2060 | 95.324 | 95.473 | 95.506 | 98.446 | 98.448 | 98.444 | 86.413 | 86.766 | 86.645 | 99.552 | 99.720 | 99.962 |

Source: CORE Indonesia (2024a)

## 5.2 Policy Recommendations

### 5.2.1 Economic Aspects

#### A. Consumer Market Development

1. Continue and expand current purchase subsidies and tax rebates in gradually reduced schemes until 2030. This is crucial as current EV adoption remains below targets, with only 27,547 4W EV units sold in the first nine months of 2024. The success of subsidy programs, such as the

increased quota from 50,000 to 60,857 units for 2W EVs in 2024 due to high demand, demonstrates the effectiveness of financial incentives.

2. Implement progressive taxation on conventional vehicles and phase out older, high-mileage vehicles. Without strong disincentives for ICEVs, the transition to EVs may not meet the government's target of 1.97 million E4W and 12.9 million E2W by 2030. Current evidence suggests that a combination of incentives for EVs and disincentives for ICEVs is most effective in accelerating adoption.
3. Introduce discounted parking rates, toll fees, and bus lane access privileges for EV users. Consumer surveys indicate that practical benefits significantly influence adoption decisions, with convenience and cost savings being key factors in the decision to switch to EVs.
4. Support interest-free EV credit purchasing and grants for leasing/used EVs. Market analysis shows that 55% of sales are in the 250-500 million Rupiah range, indicating the need for more flexible financing options to make EVs accessible to a broader market segment.
5. Implement targeted incentives for sustainable public transport through tax breaks and subsidies for electric buses. Electrifying public transportation can significantly contribute to reducing the transportation sector's 23% share of national GHG emissions, of which road transportation accounts for over 90%.

### B. Manufacturing & Industry Development

1. Prioritize nickel-based batteries while enhancing NMC R&D and exploring LFP alternatives. Indonesia's strategic advantage in nickel (50% of global production and 42.3% of reserves) provides a strong foundation, yet current production capacity shows only 11% allocated for MHP and 2% for nickel sulfate, indicating significant room for optimization in battery-grade materials.
2. Strengthen incentives for meeting TKDN requirements through targeted support programs. The current TKDN achievement of 40% needs to reach 60% by 2027, particularly in main components including batteries (30-35%), frame/body systems (10-11%), and electric motor systems (10-12%). This requires significant support for domestic manufacturers and suppliers.
3. Support SME integration into the EV supply chain through capacity building and technical assistance programs. Currently, only 53 factories produce 2W EVs with a limited combined annual capacity of 2,580 units. A robust support system for component manufacturers would help create a more resilient and competitive domestic supply chain.

### C. Infrastructure Ecosystem

1. Create attractive investment packages for private charging station development, including tax exemptions and installation subsidies. The current infrastructure of 1,810 SPKLU and 1,882 SPBKLU stations is

insufficient for national coverage, requiring significant private sector participation to meet growing demand.

2. Develop comprehensive mapping for charging station placement based on population density and travel patterns. Current charging infrastructure is heavily concentrated in DKI Jakarta and West Java, leaving regions like Kalimantan, Nusa Tenggara, Maluku, and Papua underserved. A strategic approach to infrastructure deployment would ensure more equitable access nationwide.

### 5.2.2 Social Aspects

#### A. Strategic Workforce Planning & Transition

1. Adopt a gradual and managed transition approach, encouraging companies to prioritize retraining over layoffs. Analysis shows that while EVs require 30% less labor than ICEs, domestic production could create 500,000 new jobs by 2030 and 1.7 million by 2045, highlighting the importance of proper transition management.
2. Introduce standardized training programs and certifications that facilitate worker mobility between ICEV and EV industries. The automotive sector currently employs 1.5 million workers across 57,570 enterprises, making structured skill transfer programs essential for workforce retention.

#### B. Skills Development & Training

1. Develop specialized training programs focusing on critical EV-specific skills including electrical systems, battery technology, and digital manufacturing processes. The transition requires workers to develop diverse skills ranging from interpersonal coordination to specialized technical knowledge in electrical and chemical systems.
2. Implement training programs covering basic analytical thinking, technical operations, systems analysis, and resource management. Industry feedback indicates that alongside technical skills, transferrable basic skills such as agility, adaptability, and analytical thinking are crucial for workforce development.

#### C. Multi-stakeholder Collaboration

1. Establish a sectoral skills council comprising industry and academic representatives to align curricula with industry demands. Current educational institutions struggle to maintain pace with rapid technological advancements, creating a substantial skills gap that requires coordinated action.
2. Develop comprehensive National Work Competence Standards (SKKNI) specific to the EV industry. The current framework needs enhancement to better reflect contemporary technological requirements and operational practices in the EV sector.

### 5.2.3 Environmental Aspects

#### A. Clean Energy Integration

1. Renewable Energy Implementation: Support integration of renewable energy in upstream processes and charging infrastructure. Currently, Indonesia's electricity supply remains predominantly fossil-based, with coal contributing 62.7% to total national electricity production, necessitating a shift toward cleaner energy sources.
2. Smart Grid Development: Support the development of smart electrical grids capable of handling increased EV charging demand while integrating renewable energy sources. Projections indicate that by 2060, domestic EV production will require approximately 8,048 GWh/year of electricity, highlighting the need for robust grid infrastructure.

#### B. Sustainable Manufacturing

1. Green Industry Standards: Promote adoption of green industry standards across the EV value chain, particularly in battery manufacturing where environmental impacts are significant. Analysis shows that battery production contributes 38.34% of vehicle production emissions, making it a critical area for environmental improvement.

#### C. Circular Economy Implementation

1. Battery Recycling Framework: Establish specific regulations for EV battery reuse and recycling, supported by fiscal and non-fiscal incentives. Current recycling infrastructure is primarily focused on lead-acid batteries, with limited capacity for handling lithium-ion batteries used in modern EVs.
2. Second-Life Battery Programs: Enforce implementation of second-life applications for EV batteries in energy storage systems. Research indicates that EV batteries retain 70-80% capacity after their vehicle use, making them viable for stationary energy storage applications.
3. Sustainable Mining Practices: Develop and enforce Green Mining Standards for sustainable extraction of EV materials. Current nickel mining operations generate significant environmental impacts, with each ton of nickel produced resulting in 4.61E+04 kg $CO_2$ equivalent of global warming impact.

### 5.2.4 Institutional Aspects

#### A. Regulatory Framework and Coordination

1. Formulate a detailed roadmap with measurable targets and timelines for each phase of the EV supply chain. Current policies, while supportive, lack cohesive coordination across different government agencies, leading to implementation gaps and overlapping regulations.

2. Establish a dedicated coordination team responsible for monitoring and evaluating policy implementation across different government bodies. Currently, there is no dedicated team for monitoring policy effectiveness, particularly in evaluating various forms of incentives such as tax holidays and allowances.
3. Establish strategic international agreements to ensure access to essential EV-related technologies and expertise. Current investments from global players like Toyota ($1.8 billion), BYD ($1.3 billion), and LG Energy Solution ($9.8 billion) demonstrate the importance of international partnerships in developing Indonesia's EV ecosystem.

### B. Transition Period Management

1. Introduce phased emission standards that gradually lower permissible emissions for vehicles. Current EV adoption levels remain below targets, with E4W sales reaching only 0.02 million units (2% of passenger car sales) and E2W sales at 0.07 million units, indicating the need for a structured transition approach.
2. Mandate government agencies to transition their fleets to EVs while providing incentives for public transportation electrification. This approach can help stimulate demand and demonstrate government commitment to EV adoption.

### C. Infrastructure Development Coordination

1. Establish clear guidelines and incentives for private sector participation in charging infrastructure development. The current target of 31,859 charging stations by 2030 requires significant private sector involvement to achieve.
2. Create coordinated planning mechanisms between central and local governments for infrastructure deployment. Current charging infrastructure shows significant regional disparity, with most stations concentrated in Java, requiring better coordination for nationwide coverage.

### D. Research and Development Support

1. Establish R&D centers through partnerships between state-owned enterprises, universities, and private companies. The domestic EV industry currently faces challenges in technological development, particularly in battery technology and manufacturing processes.
2. Implement structured programs for knowledge and technology transfer from international partners. Current joint ventures and technical partnerships, such as those with global battery manufacturers, need more systematic approaches to ensure effective technology transfer to local industry.

### 5.2.5 Priority Recommendation

Based on a comprehensive analysis of the EV ecosystem in Indonesia, here are 10 priority recommendations to accelerate electric vehicle adoption in the country (see Table in the Annex for more detail recommendations). These recommendations are prioritized based on their potential impact, implementation feasibility, and strategic importance in building a robust and sustainable EV ecosystem in Indonesia.

Table 19 Top 10 Priority Recommendations for Driving EV Adoption in Indonesia

| No. | Recommendation | Period | Rationale for Prioritization |
|---|---|---|---|
| 1. | Formulate a comprehensive roadmap with key milestones, defining measurable targets and timelines for each phase of the EV supply chain. | Short-term | Prioritized as it forms the foundation for implementing all EV strategies. A comprehensive roadmap with clear milestones provides guidance for all stakeholders in developing the EV ecosystem and ensures a measured and directed transition. |
| 2. | Maintain and expand financial incentives like purchase subsidies and tax rebates in gradually reduced schemes until 2030 to make EVs more affordable for consumers. | Short-term | Price remains the main barrier to EV adoption. Short-term financial incentives are essential to drive market demand and create a critical mass of EV users while the industry is still developing. |
| 3. | Develop a mapping plan and construct EV charging stations (SPKLUs) and battery swapping stations (SPBKLUs) based on population, density, and public space availability. | Long-term | Charging infrastructure is a fundamental need that addresses "range anxiety" - consumers' primary fear regarding EV adoption. Proper planning ensures efficient and equitable infrastructure development. |
| 4. | Create more attractive investment packages beyond current incentives for private companies to build public charging stations. | Mid-term | Private sector participation is crucial to accelerate charging infrastructure development. Attractive investment packages will expedite infrastructure development without solely relying on government budgets. |
| 5. | Develop specialized and vocational training programs for EV manufacturing jobs, focusing on key technical skills. | Mid-term | Human resource development is a critical factor for the sustainability of the EV industry. Specialized EV training prepares skilled workers needed by the industry and prevents talent shortages that could hamper growth. |
| 6. | Establish a sectoral skills council comprising industry and academic representatives to foster stronger partnerships between educational institutions and EV companies. | Short to Mid-term | Multi-stakeholder collaboration ensures educational curricula relevant to industry needs and accelerates knowledge transfer. |
| 7. | Implement targeted incentives for sustainable public transport, for instance by offering tax breaks or subsidies for electric or low-emission buses. | Long-term | Electrification of public transportation has a large-scale impact on emissions reduction and can showcase EV technology to the wider community. Incentives for electric buses not only drive EV adoption in the mass transportation sector but also introduce EV technology to the general public, creating a strong demonstration effect and building an inclusive EV ecosystem. |
| 8. | Implement a comprehensive strategy to optimize Indonesia's battery industry by prioritizing nickel-based batteries, enhancing NMC R&D, and exploring LFP for diversification. | Long-term | Indonesia has a competitive advantage in mineral resources for batteries. A comprehensive battery industry development strategy maximizes the added value from natural resources and drives industrialization. |

| No. | Recommendation | Period | Rationale for Prioritization |
|---|---|---|---|
| 9. | Establish and implement specific regulations for EV battery recycling infrastructure, including its fiscal and non-fiscal incentives. | Long-term | Environmental sustainability and circular economy are crucial for the long-term success of the EV industry. Battery recycling regulations reduce environmental impact and increase the availability of critical materials. |
| 10. | Support the integration of affordable and reliable renewable energy in upstream processes, the EV supply chain, and EV charging stations through targeted incentives. | Long-term | Clean energy integration ensures that the entire EV value chain is sustainable from upstream to downstream, strengthening the environmental argument for transportation electrification. |

Table 20 Policy Recommendations for Driving EV Adoption in Indonesia

| Aspects | Target Contribution | Policy Recommendation | Period[6] | Stakeholders |
|---|---|---|---|---|
| Economy | Consumer Market Development | Maintaining and expanding financial incentives like purchase subsidies and tax rebates in gradually reduced schemes until 2030 to make EVs more affordable for consumers. | Short-term | Ministry of Finance, Ministry of Transportation |
| | | Disincentivizing the adoption of conventional vehicle (ICEV) such as increasing conventional vehicle tax, progressively ban the use of older & high mileages vehicle. | Mid-term | Ministry of Finance, Ministry of Transportation |
| | | Introducing practical benefits like discounted parking rates and toll fees & permission to use line bus to make EV ownership more attractive. | Mid-term | Local Government, Ministry of Transportation |
| | | Support flexible leasing and purchasing options like free interest for EV credit purchasing and grant for leasing or purchasing used EV to help more consumers access EVs. | Mid-term | Financial Services Authority, Ministry of Finance |
| | | Implement targeted incentives for sustainable public transport, for instance by offering tax breaks or subsidies for electric or low-emission buses. | Long-term | Ministry of Finance, Ministry of Transportation, Ministry of Energy and Mineral Resources |
| | Manufacturing & Industry Development | Implementing a comprehensive strategy to optimize Indonesia's battery industry by prioritizing nickel-based batteries, enhancing NMC R&D, and exploring and investing in LFP for diversification and risk mitigation. | Long-term | Ministry of Industry |
| | | Establish a robust and scalable battery manufacturing sector through incentives for companies adopting advanced manufacturing tech and joint ventures with global battery manufacturers. | Long-term | Ministry of Industry, Ministry of Investment and Downstream Industry, Ministry of Higher Education, Research and Technology, EV Related Companies |
| | | Strictly implementing local sourcing mandates and increasing incentives for companies who fulfill the local content regulation. | Long-term | Ministry of Industry, Ministry of Finance |
| | | Establish clear quality standards for EV manufacturing including battery and its components while supporting research and development. | Mid-term | Ministry of Industry, Ministry of Transportation |
| | | Build a resilient local supplier network including supporting SMEs in developing capabilities, adopting advanced technologies for EV | Long-term | Ministry of Industry, Ministry of MSMEs |

[6] Period definition: implementation period of policy including its preparation process.
Short-term: 1-2 years; Mid-term: 3-5 years; Long-term: >5 years.

| Aspects | Target Contribution | Policy Recommendation | Period[6] | Stakeholders |
|---|---|---|---|---|
| | | components, and creating opportunities to supply parts and services to larger EV manufacturers. | | |
| | | Create Special Economic Zones with tax breaks and streamlined processes for EV mineral processing, clustering all EV-related activities, from manufacturing to parts production, to facilitate growth in this sector. | Long-term | Ministry of Industry,<br>Ministry of Trade |
| | | Facilitate partnerships with countries to bring advanced processing technology to Indonesia through strategic collaborations with global companies, including joint ventures, technical assistance agreements, and R&D partnerships, supported by training programs, and investment incentives to enhance domestic technological capabilities in EV manufacturing. | Long-term | Ministry of Industry,<br>Ministry of Investment and Downstream Industry,<br>Ministry of Higher Education, Research and Technology,<br>Ministry of Manpower,<br>Ministry of Finance |
| | | Develop innovation hub by establishing R&D centers or in partnership with state-owned enterprises, universities, and private companies to advance EV and battery manufacturing technology. | Long-term | Ministry of Industry,<br>Ministry of Manpower,<br>Ministry of Higher Education, Research and Technology,<br>Universities,<br>EV Related Companies |
| | EV Infrastructure Ecosystem | Create more attractive investment packages beyond current incentives (e.g. electricity rate discounts) for private companies to build public charging stations by offering comprehensive fiscal incentives (including tax exemptions and installation subsidies) and non-fiscal benefits (simplified licensing procedures, land provision and planning, and priority grid access). | Mid-term | Ministry of Finance,<br>Ministry of Energy and Mineral Resources,<br>Ministry of Investment and Downstream Industry,<br>State Electricity Company,<br>Local Government |
| | | Develop a mapping plan and construct EV charging stations (SPKLUs) and battery swapping stations (SPBKLUs) based on population, density, and public space availability to establish a high-quality charging infrastructure system, ensuring comprehensive city-level coverage, linear highway coverage, and targeted rural coverage. | Long-term | Ministry of Energy and Mineral Resources,<br>Ministry of National Development and Planning,<br>State Electricity Company,<br>Local Government |
| Social | Strategic Workforce Planning & Transition | Adopt a gradual and managed transition approach by implementing phased strategies, encouraging companies to prioritize retraining existing workers over layoffs, and supporting targeted workforce | Mid-term | Ministry on Manpower,<br>Ministry of National Development and Planning, |

| Aspects | Target Contribution | Policy Recommendation | Period[6] | Stakeholders |
|---|---|---|---|---|
| | | upskilling programs to minimize job displacement while facilitating the shift to a sustainable economy. | | Ministry of Industry |
| | | Introduce practical measures like training programs, standardizations and certifications, and collaboration between ICEV and EV industries to help workers smoothly switch jobs and make the most of their existing skills. | Mid-term | Ministry on Manpower, Ministry of National Development and Planning, Ministry of Industry |
| | Skills Development & Specific Focus Areas for Training | Develop specialized and vocational training programs for EV manufacturing jobs, focusing on basic skills like analytical thinking and active learning, technical skills such as equipment operation, troubleshooting, technology design, service and maintenance, systems skills including analysis, informatics, and project management, and resource management skills for managerial roles. | Mid-term | Ministry of Manpower, Ministry of National Development and Planning, Ministry of Higher Education, Research and Technology, Ministry of Industry, EV Related Companies |
| | Multi-stakeholder Collaboration for Human Capital Development | Establish a sectoral skills council comprising industry and academic representatives, foster stronger partnerships between educational institutions and EV companies to align curricula with industry demands, and promote industry-led skilling programs through targeted incentives. | Short to Mid-term | Ministry of Manpower, Ministry of National Development and Planning, Ministry of Higher Education, Research and Technology, Ministry of Industry, Universities, EV Related Companies |
| | Standardization & Certification | Develop a comprehensive National Work Competence Standards (SKKNI) by incorporating review, revision, and public awareness initiatives to ensure alignment with the evolving skill requirements and technological advancements of the EV industry. | Short-term | Ministry of Manpower, Ministry of National Development and Planning, Ministry of Higher Education, Research and Technology, Ministry of Industry, Universities, EV Related Companies |
| | | Develop clear certification pathways for EV-specific technologies, ensure better recognition of qualifications across sectors, and create a standardized qualification framework to enhance skill transferability and workforce adaptability. | Short-term | Ministry of Manpower, Ministry of Industry, EV Related Companies |
| Environmental | Clean Energy Integration | Support the integration of affordable and reliable renewable energy in upstream processes (e.g. raw materials extraction and mining | Long-term | Ministry of Finance, Ministry of Industry, |

| Aspects | Target Contribution | Policy Recommendation | Period[6] | Stakeholders |
|---|---|---|---|---|
| | | processing), the EV supply chain, and EV charging stations through targeted incentives. | | Ministry of Energy and Mineral Resources,<br>State Electricity Company |
| | | Support the development of smart electrical grids that can integrate renewable energy and handle increased EV charging. | Long-term | Ministry of Energy and Mineral Resources,<br>Ministry of Investment and Downstream Industry,<br>State Electricity Company |
| | Sustainable Manufacturing | Promote the adoption of green industry standards (Standar Industri Hijau) including clean energy adoption across the entire value chain of the EV industry. | Long-term | Ministry of Energy and Mineral Resources,<br>Ministry of Industry,<br>Ministry of Environment,<br>EV Related Companies |
| | Circular Economy Implementation for EV Battery | Establish and implement specific regulations for EV battery recycling infrastructure, including its fiscal and non-fiscal incentives, financing scheme, certification standards, and maintain integrated monitoring and reporting systems. | Long-term | Ministry of Environment,<br>Ministry of Energy and Mineral Resources,<br>Ministry of Industry,<br>Ministry of Finance,<br>Ministry of Investment and Downstream Industry,<br>EV Related Companies |
| | | Enforce the implementation of second-life EV batteries for solar and wind energy storage, including its requirement for manufacturers to take back end-of-life batteries under Extended Producer Responsibility, and its circular business models—such as product-service systems or battery leasing. | Long-term | Ministry of Environment,<br>Ministry of Energy and Mineral Resources,<br>Ministry of Industry,<br>Ministry of Investment and Downstream Industry,<br>EV Related Companies |
| | Mineral Extraction | Develop Green Mining Standard for sustainable mining materials needed across the entire value chain of the EV industry. | Long-term | Ministry of Environment,<br>Ministry of Energy and Mineral Resources,<br>Ministry of Industry |
| Institution and Transition Period | Roadmap | Formulate a comprehensive roadmap with key milestones, defining measurable targets and timelines for each phase of the EV supply chain. | Short-term | Ministry of National Development and Planning, |

| Aspects | Target Contribution | Policy Recommendation | Period[6] | Stakeholders |
|---|---|---|---|---|
| | | | | Ministry of Investment and Downstream Industry,<br>Ministry of Trade,<br>Ministry of Industry,<br>Ministry of Manpower,<br>Ministry of Energy and Mineral Resources |
| | | Establish strategic international agreements to ensure access to essential EV-related technologies. | Short-term | Ministry of National Development and Planning,<br>Ministry of Investment and Downstream Industry,<br>Ministry of Trade,<br>Ministry of Industry |

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