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Charging Forward

The State and Challenges of Electric Bus Adoption for Public Transport in Indonesia

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FOREWORD

Faela Sufa, Southeast Asia Director of ITDP (2019 - May 2023)

The electrification of road-based transport in Indonesia has gained significant momentum since the issuance of Presidential Regulation 55 of 2019, which focuses on accelerating the Battery Electric Vehicle (BEV) Program for Road Transportation. As part of this initiative, the government has introduced subsidy programs to stimulate the electric vehicle market, encompassing two-wheeled and four-wheeled vehicles, including buses. These efforts align with the government's broader strategy of developing the domestic electric vehicle ecosystem.

While progress has been made in promoting electric vehicles, there remains a limited emphasis on electrifying public transport. However, the electrification of public transport buses holds immense potential to drive the widespread adoption of electric vehicles, given the substantial daily mileage covered by each bus. With buses traveling up to 200 km per day, the reduction in emissions can be significant. Moreover, the implementation of electric buses is relatively easier due to the fixed routes of public transportation, which simplifies the installation of charging infrastructure. Additionally, having clear stakeholders in this industry facilitates the implementation of appropriate policies.

Beyond the environmental benefits of 58% GHG Reduction in 2030, the shift towards electrifying public transport presents economic advantages, including reduced fuel consumption, subsidy and import; as well as cost savings for transport operators, that cumulatively accounts for IDR4.2 trillion net economic benefit. Furthermore, it opens opportunities for Indonesia to leverage renewable energy sources, such as solar panels installed at depots and terminals to power electric buses where RE with solar PV could provide 20% of the power supply, on average, for electrifying Transjakarta's microbus fleets.

Leading the way in road-based public transport electrification is Jakarta with Transjakarta, the Bus Rapid Transit management company. Jakarta has committed to electrify 50% of Transjakarta's fleets by 2027 and achieve full electrification by 2030. The initial pilot project, involving the deployment of 30 buses in 2022, will provide valuable insights for smoother future implementations.

To expand the implementation of electric buses from Jakarta to other cities in Indonesia, the development of a comprehensive electrification roadmap is essential. The Institute for Transportation and Development Policy (ITDP) has conducted a study on Transjakarta's fleet electrification, offering recommendations for other cities to follow suit. The study underscores the importance of creating enabling conditions, such as establishing accountable public transport management institutions, adhering to service-level agreement, establishing robust financial and regulatory basis, establishing a strong recommendation on technology selection and charging facilities planning, and ensuring responsible operators.

To ensure the success of this transition, government support through policies and fiscal measures is crucial. This includes subsidies for electric bus procurement, the formulation of regulations to facilitate e-bus adoption, and the integration of renewable energy into the electric grid. With multiple stakeholders involved, including bus operators, power companies, charging infrastructure providers, and financial institutions, the implementation requires the development of appropriate business and finance schemes, as well as supportive regulations, to accelerate the adoption of electric buses.

In conclusion, the electrification of public transport in Indonesia plays a vital role in reducing carbon emissions, fostering economic development, and advancing the domestic electric vehicle ecosystem. The achievement of these objectives hinges on government support through well-crafted policies, fiscal measures, the development of a robust electrification roadmap, and the creation of favorable conditions for public transport electrification. The ITDP study on Transjakarta's electrification initiative serves as an invaluable reference for other Indonesian cities aiming to embrace electric buses. With the right combination of government policies, fiscal support, technological advancements, and active stakeholder involvement, Indonesia can successfully transition towards a more sustainable future for public transport.

FOREWORD

Gonggomtua Sitanggang, Interim Director ITDP Indonesia (May 2023 - Present)

In an era defined by rapid urbanization, environmental consciousness, and the pursuit of sustainable transportation solutions, the electric bus has emerged as a transformative force shaping the future of public mobility. As we stand at the crossroads of innovation and necessity, it gives me great pleasure to introduce this compendium of case studies examining the remarkable journey of electric buses across a few cities in Indonesia.

As we delve into these case studies, we are reminded that the adoption of electric buses is not merely a technological shift but a paradigmatic change that transcends boundaries. Through its pages we will understand the complexities between infrastructure development, policy advocacy, economic feasibility, and, most importantly, the community's embrace of change. It will also shed light on the opportunities and potential benefits of electric bus adoption that include tangible impact on reducing emissions and improving the quality of life for countless individuals living in cities.

The challenges encountered along the way are not concealed, for it is through these obstacles that resilience and innovation are uncovered. From overhauling charging infrastructure to addressing range limitations, the shared lessons found within these pages serve as a guide for other cities in Indonesia and worldwide embarking on their own electrification journeys.

While the focus of these case studies remains local, their implications are truly global. The shift to electric buses symbolizes a commitment to cleaner air, reduced carbon emissions, and the safeguarding of our planet for generations to come. It underscores the potency of collaboration between governments, industries, and citizens to reshape urban landscapes towards sustainability and progress.

But this book is not just about the present; it's about the exciting possibilities of the future. As electric bus adoption gains momentum, the implications for urban design, energy infrastructure, and societal progress are profound.

In closing, I extend my heartfelt gratitude to the minds behind these case studies, donors and philanthropists, the city officials, transit agencies, engineers, and citizens who have lent their dedication and insights to this collective endeavor. May this compilation serve as a testament to the transformative potential of electric buses and kindle the flames of progress in cities around the world.

CORE POINTS

Electrifying mass transportation, specifically buses, benefits the environment, economy, social, and politics.

- **Electric buses (e-buses) do not just offer a pathway to reduced GHG emissions—they also provide cleaner air by eliminating tailpipe emissions.** For instance, in the new bus rapid transit (BRT) development in Bandung Basin Metropolitan Area (BBMA), a full transition to e-buses would completely eliminate potential tailpipe pollution emissions from those future transit systems between 2023 and 2040, while with partial electrification, a notable 72% reduction can be seen in all tailpipe pollutants compared to implementing all diesel Euro IV buses in the system.
- **E-buses bring long-term economic benefits.** Lower operating costs, fuel savings, and improved public health increase productivity and access to economic opportunities. A large-scale electrification of Transjakarta would result in IDR4.2 trillion net economic and social benefit by 2030.
- **Electrifying mass transportation also promotes inclusivity for women and vulnerable groups by incorporating gender budget programs into the transition plans**. E-bus design should be improved, considering the specific needs of women and other vulnerable groups. Bus depots and stations should also be safe and comfortable spaces for these groups.
- **In politics, incorporating e-buses into public transit networks can help meet national and international climate targets,** fostering cooperation and collaboration with other nations and organizations in combating climate change.

Many cities worldwide are transitioning to electric public transportation through strong policies and innovative financing models.

- **Santiago had already introduced 784 e-buses into its fleet by the end of 2020, saving** 84.28 kt of CO_2 emissions annually**. This was accomplished by adopting an innovative business model that separated asset ownership and operations, and by collaborating with companies possessing robust financial capabilities and significant equity.** Meanwhile, government support, subsidies, and robust supply chains in Shenzhen (China) contributed to an annual reduction of 194,000 tons of CO_2 emissions by electrifying all buses owned by Shenzhen Bus Group (SZBG) in 2018.
- **In Kolkata (India), the government supported the EV adoption and charging infrastructure initiatives by providing subsidies and incentives**. In comparison, Bogotá (Colombia) has introduced 484 e-buses into its public transit system due to new business models that allow private consortiums to participate in public tendering processes. Law 1964/2019 mandates annual targets for EV adoption in mass transit systems and offers incentives for private vehicle users.
- **California (USA) required all public transit agencies to transition to a 100% zero-emission bus fleet by 2040** through the Innovative Clean Transit regulation.

Transjakarta e-bus pilot and the development of e-bus roadmap for Jakarta Bandung Basin Metropolitan Area (BBMA), and Medan Metropolitan Area (Mebidangro) offer a valuable lesson for e-bus adoption in Indonesia.

- **Lessons learned from the technical assistance programs conducted by Institute for Transportation and Development Policy (ITDP) for Transjakarta highlight the need for incentives and support,** addressing financial burdens through innovative business models and financing schemes, establishing a robust data collection and verification process, charging infrastructure optimization, and providing training for e-bus operators.
- **Meanwhile, in BBMA and Mebidangro, a partial implementation (mixed conventional and e-buses) is recommended as an initial step to reduce capital expenditure and allow for adaptation to the new e-bus technology**. Considering fiscal capacity and investment needed, the service payment with Regional Owned Enterprise (ROE) model is suggested as the most viable option for e-bus implementation in Mebidangro and BBMA area, allowing for a longer concession period and attracting private sector investment for e-bus implementation.

The feasibility of transitioning to e-buses, financing options, and innovative business models must be explored to ensure transition success.

- **ITDP analyzed several business models for e-buses, such as the concessional model, Buy The Service (BTS), fleet leasing model, fleet and depot leasing model, battery leasing model, and charging infrastructure leasing model.** In addition, a longer contract period, aligned with e-bus operational years of a minimum of 14 years, is even more preferable.
- **Implementing a carbon tax and utilizing its revenue can serve as a sustainable funding source to both drive e-bus adoption and reduce overall carbon emissions in Indonesia.** Furthermore, international loans from Multilateral Development Banks (MDBs) or Export Credit Agencies (ECAs) offer alternative financing routes. Exploring other investment instruments, such as bonds and Limited Participation Mutual Fund, can also provide financing options for e-buses. Collaboration with private sector entities like fund managers or multi-finance companies is necessary to implement these alternative financing instruments for e-bus projects.

To fully transition to e-buses, coordination among ministries is crucial for achieving net-zero emissions by 2060 and eliminating contradictory policies.

Below is the policy recommendation summary for supporting e-buses in Indonesia.

- Issue a national e-bus adoption and infrastructure development roadmap, including mandates for e-bus fleet adoption.
- Develop a strong fiscal and non-fiscal incentive package.
- Supporting policies for business model innovations, including fleet and charging infrastructure provisions.
- Establish a green procurement scheme for e-buses.
- Improving public stakeholder coordination.
- Disincentivize conventional vehicles.
- Streamline technical regulations.
- Ensure stable grid connections and integrate renewable energy sources.
- Mandate li-ion battery recycling.
- Support e-bus industry research and development.

PART ONE

POWERING THE FUTURE

Transitioning to electric buses in public transportation offers numerous benefits, including reduced GHG emissions, improved air quality, enhanced social inclusivity, and better overall transit services. To meet the growing demand for sustainable and clean transportation systems, the Government of Indonesia implements regulations and plans to support the transition to electromobility.


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Electric Buses and the Future of Public Transportation

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1.1. THE FUTURE OF SUSTAINABLE PUBLIC TRANSPORT

Developing sustainable public transport is crucial for mitigating the negative impacts of climate change, improving air quality, and ensuring equitable access to mobility in many countries around the world. Various nations have recognized the importance of transitioning to electric mobility and have set goals for electrifying their public transport fleets.

Indonesia, like many other countries, has made a national commitment to reducing GHG emissions. Indonesia's Nationally Determined Contribution (NDC) states a goal of reducing emissions by 29% by 2030, with the potential to increase it to 41% with international support. This commitment has stimulated initiatives to accelerate the adoption of electric mobility in the country, including the establishment of legislative frameworks to support the transition.

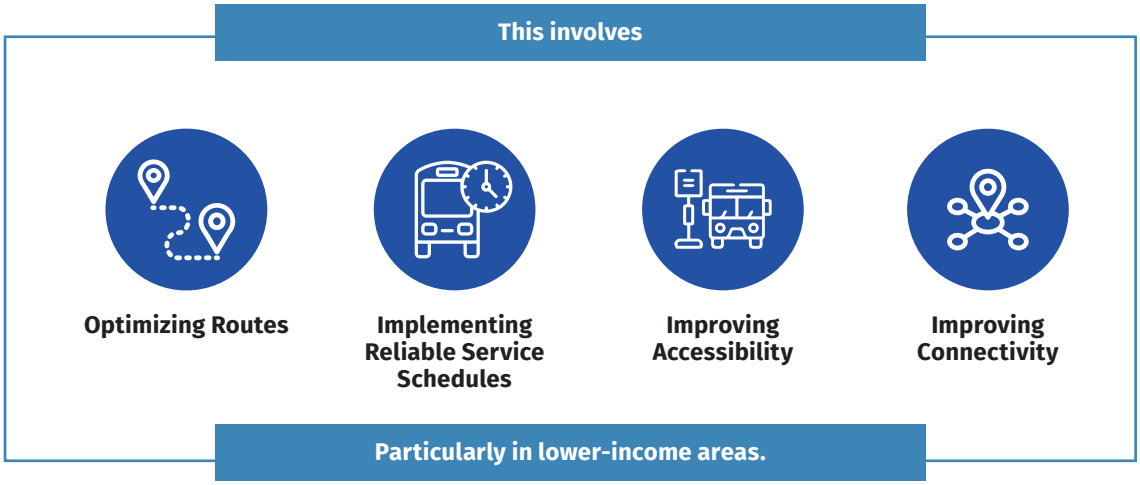
But how can electric mobility fit into the bigger picture of sustainable transportation systems? To achieve sustainable transportation systems and mitigate climate change, a joint study by Institute for Transportation and Development Policy (ITDP) and the University of California, Davis emphasizes the importance of comprehensive strategies that involve compact, mixed-use cities with walking, cycling, and efficient public transportation, along with investments in electric vehicles (EVs). Only by combining these approaches, urban passenger transport emissions can be reduced by approximately 59 gigatons (Gt) of carbon dioxide equivalent (CO_2-eq) by 2050, contributing to the objectives of the Paris Agreement and preventing the worst effects of climate change.

1.2 OPPORTUNITIES FOR ELECTRIC BUS TRANSITION

Public transport electrification is a crucial step towards promoting e-mobility. It offers advantages in terms of simpler fleet and infrastructure planning since routes and schedules are usually established. Additionally, the higher mileage of public transport vehicles maximizes the benefits of electrification compared to private vehicles.

The global market for electric buses has experienced significant growth, with cities such as Santiago de Chile, Shenzhen, Kolkata, Bogotá, and California leading the way. This positive trend can also accelerate the adoption of e-buses in Indonesia.

However, achieving sustainable and inclusive public transport electrification requires more than just replacing diesel buses with electric ones. It presents an opportunity to reform the entire public transport system, addressing issues such as irregular routes and schedules that are common in Indonesian cities' semi-formal public transport systems.



These efforts will result in efficient and dependable transportation options, enhancing mobility and inclusivity for women and vulnerable groups.

To maximize the environmental benefits of electric public transport, it is important to encourage the use of renewable energy sources like solar power, reducing dependence on fossil fuels and contributing to a greener transportation system.

By adopting a comprehensive and inclusive planning approach, bus electrification can pave the way for sustainable, efficient, and equitable public transportation systems that contribute to a greener and healthier future for all.

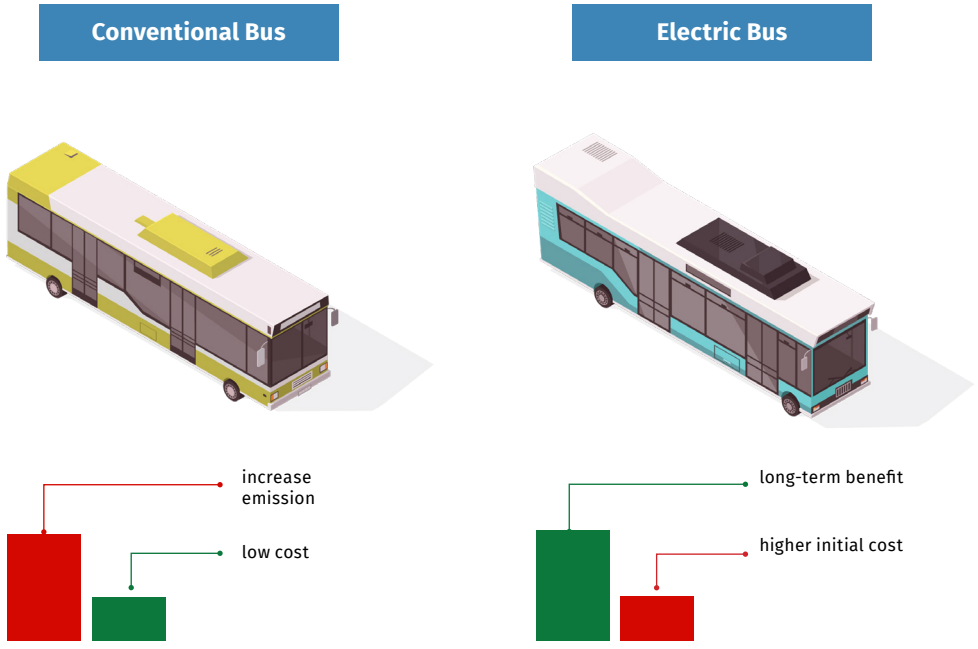
1.3 ELECTRIC BUS TECHNOLOGY AND BENEFITS

E-buses have emerged as a sustainable and efficient mode of public transportation, providing numerous environmental, social, economic, and political benefits. Battery-electric buses (BEBs) are the most common, storing energy in onboard battery packs and are charged externally.

The transition to e-buses presents several operational considerations. E-buses are typically heavier than diesel buses due to their battery systems, reducing passenger capacities. Battery types and capacities significantly impact the bus's performance, weight, and driving range, necessitating careful route and charging infrastructure planning.

Factors such as charging power, local grid capacity and distance to the grid must be considered for different charging strategies, including overnight charging and opportunity charging. Moreover, the location and size of bus depots are also essential to be considered or planned as they accommodate facilities for parking, charging, and other operations such as vehicle washing, maintenance, repair, administrative offices, and employee facilities. These factors influence operational efficiency, costs, and overall sustainability of the e-bus fleet.

Economically, despite higher initial cost, e-buses bring long-term benefits. Lower operating costs, fuel savings, and improved public health increase productivity and access to economic opportunities. One of the most significant advantages is the positive impact on the environment. E-buses contribute to better air quality and reduced GHG emissions compared to diesel buses. By reducing harmful emissions such as nitrogen oxides (NOx), particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO), e-buses help mitigate the impact of transportation on air quality, leading to a healthier environment and aiding the fight against climate change.



Another aspect is social benefits. For instance, e-bus transition initiatives can promote gender equity by incorporating gender budgeting programs to the transition plans, creating a more inclusive and accessible public transportation system, a more equitable and just society.

E-buses may also offer political benefits. Governments can demonstrate their commitment to environmental and social goals by implementing e-bus systems. Additionally, incorporating e-buses into public transit networks can help meet national and international climate targets, fostering cooperation and collaboration with other nations and organizations in combating climate change.

Electrifying BRT Buses in BBMA to Reduce Emission

The transition from diesel to e-buses in a new Bandung Basin Metropolitan Area's (BBMA) Bus Rapid Transit (BRT) system paints a promising picture of both climate change and air quality. Adopting e-buses in place of diesel buses—certified to Euro IV emission standards—offers a significant cut in harmful emissions.

Imagine the year 2025: diesel buses are still in operation, and the resulting GHG emissions amount to a hefty 17,135 tons of CO_2eq per year. However, the picture changes significantly with the introduction of e-buses. A partial shift to e-buses— which assumes a bus technology split of 143 e-buses and 55 diesel Euro IV buses — would already yield a 19.5% reduction, trimming annual GHG emissions to 13,788 tons. A full transition to e-buses – all 198 buses – could cut GHG emissions by a quarter, bringing them down to 12,720 tons per year.

This emission reduction is even more significant when considering the future of our electricity grid. While e-buses currently draw power from a fossil fuel-dependent grid, national utility company (PLN) has plans to double the renewable energy share from 8.5% in 2023 to 16% by 2030.

E-buses do not just offer a pathway to reduced GHG emissions—they also provide cleaner air by eliminating tailpipe emissions. A full transition to e-buses would eradicate the cumulative tailpipe pollution emissions between 2023 and 2040—1,764 tons of NOx, 11.2 tons of PM, 5.8 tons of HC, and 571 tons of CO — produced by the diesel Euro IV buses. Even with partial electrification, we would still see a notable 72% reduction in all tailpipe pollutants.

As we imagine this future, the benefits of transitioning to e-buses in BBMA's BRT system become clear—lower GHG emissions, cleaner air, and a significant stride towards a more sustainable future.

1.4 GLANCE AT GLOBAL MARKET TRENDS

The transition towards electrifying public transport, driven by the need to address environmental issues and climate change, has created a significant global market for e-buses. The transition towards electrifying public transport has created a major global market for e-buses. This growing global demand for EVs, including e-buses, is a direct response to addressing environmental issues and climate change. According to the International Energy Agency (IEA), in 2022, e-bus accounted for 4.5% of all bus sales worldwide.

China is currently the global market leader in e-buses with 54,000 buses being procured in 2022, representing 18% of total bus sales in China and 80% of worldwide e-bus sales. They are followed by Europe with 7%, and the United States with 2% of global e-bus sales. With China taking the lead in the market, followed by Europe, the United States, and Japan, cities across the globe are shifting towards electric mobility through robust policies, technological advancements, and innovative financing.

Santiago (Chile)
The city is determined to electrify all of its bus fleet by 2035. By employing collaboration with the private sector and implementing an innovative business model separating asset ownership and operations, Santiago had already introduced 784 e-buses into its fleet by the end of 2020. This move has saved an impressive 84.28 kt of CO_2 emissions annually.

Shenzhen (China)
The city has achieved the remarkable feat of electrifying its entire bus fleet. The achievement has relied on government support, subsidies, and robust supply chains. As part of this larger transition, Shenzhen Bus Group, a major operator within the city, has utilized a fleet leasing model. In 2018 alone, the efforts of Shenzhen Bus Group contributed to an annual reduction of 194,000 tons of CO_2 emissions.

Kolkata (India)
The focus on e-mobility is also backed by government initiatives providing subsidies and incentives for EV adoption and charging infrastructure. Operating 80 e-buses as of early 2020, the West Bengal Transport Corporation has set ambitious goals to electrify its 5,000-bus fleet by 2030.

Bogotá (Colombia)
The city has introduced 484 e-buses into its public transit system, thanks to new business models that allow private consortiums to participate in public tendering processes. Law 1964/2019 mandates annual targets for EV adoption in mass transit systems and offers incentives for private vehicle users.

California (USA)
The Innovative Clean Transit regulation requires all public transit agencies to transition to a 100% zero-emission bus fleet by 2040. Over 1,200 e-buses delivered or ordered by December 2020.

KEY TAKEAWAYS

Transitioning to e-buses for public transportation can bring substantial benefits, such as reducing GHG emissions, enhancing air quality, and promoting social inclusivity, as well as improving the overall public transit services. While there are operational and financial challenges in the short term, the long-term economic benefits far outweigh the costs. As such, continuing investment in e-buses and related infrastructure is essential for creating a more sustainable and inclusive public transportation system for everyone.

The global market for EVs, including e-buses, has grown rapidly due to various governments' commitments to climate, air quality, and industrial growth objectives. Cities worldwide are transitioning towards electric mobility through strong policies and innovative financing schemes and business models.

2 Decarbonizing Transportation Sector in Indonesia

2.1 OVERVIEW OF ELECTRIC VEHICLE TARGETS IN INDONESIA

The growing demand for sustainable and clean transportation systems, driven by the need to combat climate change and promote technological advancements in the transport and power sectors, has significantly increased the relevance of electric mobility (e-mobility) worldwide.

Presidential Decree No. 22/2017 (PR 22/2017) sets a goal of electrifying 10% of urban public transport fleets by 2025, increasing to 90% by 2030. However, as of June 2023, only 80 units have been adopted, indicating slow progress in this sector.

On the other hand, the target for light-duty vehicles, set at 2,200 units by 2025, has already been surpassed, demonstrating faster adoption. The Ministry of Industry has set ambitious objectives to produce 400,000 electric cars and 2 million electric motorcycles annually by 2025. Sales of electric and hybrid cars have seen significant growth, with 7,923 units sold from January to November 2022, compared to 687 units sold throughout 2021. The Association of Indonesian Automotive Manufacturers (Gaikindo) expects sales to reach 8,500 units in 2023.

EV Adoption Targets

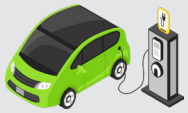
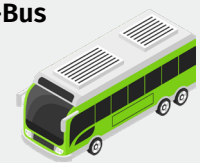
	2025 (Source: National General Energy Plan/RUEN)	**2030** (Source: National Grand Strategy for Energy/GSEN)	**Target Year for 100% electrification**	**Current uptake (June 2023)**
E-2W 	2.1 million units (1.9% of current population)	13 million units (11.5% of current population)	100% E2W in domestic market by 2040	47,710 units (0.37% from 2030 target)
E-4W 	2,200 units (0.01% of current population)	2 million units (12.8% of current population)	100% E4W I domestic market by 2050	14,993 units (0.75% from 2030 target)
E-Bus 	10% of urban bus fleets	90% of urban bus fleets (Source: MoT)	2040 (moderate target: 15,546 units)	80 units (0.51% from 2040 target)

Figure 1. EV Transition in Indonesia: Targets vs Current Uptake

Source: The Ministry of Energy and Mineral Resources, June 2023

2.2 ELECTRIFYING PUBLIC TRANSPORT IN THE COUNTRY

Electric mobility also fits as one of the solutions to Indonesia's transportation and environmental problems, among others. As a country where the transport sector is currently dominated by private vehicles, the transport sector accounted for 28% of the total emissions nationally, the second-largest contributor to carbon emissions, and also significant air pollution.

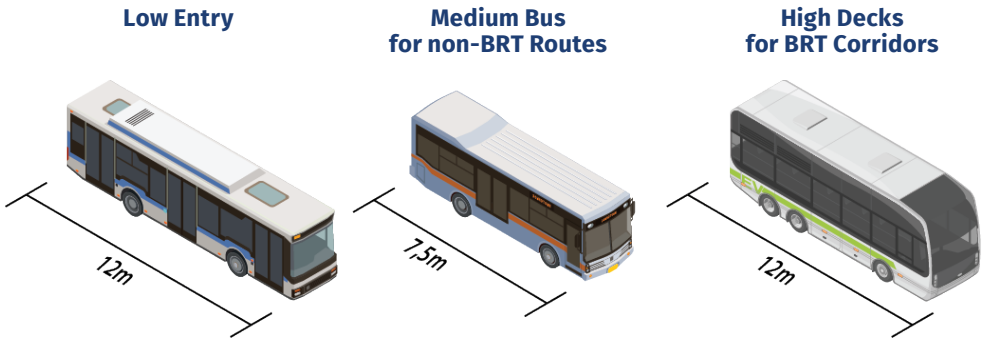
At the national level, the Ministry of Transportation has a target to electrify 90% of urban public transport buses by 2030, and achieve fully electrified public transportation across all Indonesian cities by 2045. As the first step, the new BRT system in Metropolitan Medan and Metropolitan Bandung will use e-buses in their system. In addition to that, the Ministry of Transportation has also introduced the Buy The Service program to improve public transportation services in cities. During the initial part of the program, the Ministry of Transportation implemented the e-bus system in two cities, Bandung and Surabaya, deploying approximately 30 e-buses under this initiative.

The electrification of public transport to introduce e-mobility to the public is one of the steps taken by the Government of Jakarta to address air pollution issues in Jakarta. To this end, Transjakarta, as one of the most extensive urban transportation providers in Indonesia, is expected to be the role model for deploying electric vehicles on a massive scale.

Transjakarta has set an ambitious target in its Long-term Corporate Plan 2020-2030: to deploy a fleet of more than 10,000 e-buses by 2030. This aligns with Jakarta's commitment to procure only zero-emission buses by 2025 and ensure that a major area in Jakarta is zero-emission by 2030 as per their commitment in the C40 Fossil-Fuel-Free Streets Declaration in September 2019.

Transjakarta has conducted both trial and pilot phases for e-bus implementation in Jakarta. For the trial phase, between 2019 and 2022, Transjakarta introduced three types of fleets, namely 12-m single low-entry bus and 7.5-m medium bus on non-BRT routes, as well as 12-m high-deck buses running on the BRT corridor. During the pilot phase, Transjakarta deployed 30 12-m BYD K9 low-entry e-buses, started to operate in June 2022.

Trial and pilot stages for the implementation of electric buses in Jakarta 2019-2022



2.3 POLICY AND REGULATORY FRAMEWORK REGARDING E-MOBILITY IN PUBLIC TRANSPORT

National framework

The Government of Indonesia plays a crucial role in facilitating the advancement of electromobility through regulations and programs. Key national-level stakeholders, led by the Coordinating Ministry for Maritime Affairs and Investment, are responsible for driving this progress. Each ministry within the group has specific roles, such as the Ministry of Transportation, which develops regulations for the legal status and roadworthiness of battery electric vehicles.

Indonesia has recently submitted an updated Enhanced Nationally Determined Contribution (NDC) in response to the Paris Agreement. The updated NDC sets higher emission reduction targets, both unconditionally and conditionally with international support, demonstrating Indonesia's commitment to combating climate change.

The National Long-term Development Plan (RPJPN) and National Mid-term Development Plan (RPJMN) 2020-2024, produced by the Ministry of National Development Planning (Bappenas), provide the overall direction for the transport sector. These plans highlight the need to create an effective, efficient, affordable, eco-friendly, and sustainable transportation system, aiming to save up to 30% of the current energy demand and promote electric-powered transportation as part of the country's essential industries.

Whereas, the key regulations supporting transport electrification include Presidential Regulation 22/2017 (PR 22/2017) on the National General Energy Plan (RUEN) and Presidential Regulation 55/2019 (PR 55/2019), which cover various aspects of electric vehicle implementation. PR 55/2019 focuses on the growth of battery electric vehicles (BEVs) and domestic industry development. It promotes BEV manufacturing, incentivizes research, provides fiscal incentives, assigns responsibilities for charging infrastructure, reduces charging fees, and emphasizes environmental protection.

By implementing these regulations and plans, Indonesia aims to foster the growth of the electric vehicle industry, ensure proper waste management, and encourage the development of a robust charging infrastructure to support the transition to electromobility.

Agency/Ministry	Regulation	Content
Ministry of Industry (MoI)	- Government Regulation (PP) No. 14/2015 on Master Plan of National Industry Development Year 2015-2035 - MoI Decree No. 27/2020, the Road Map of Industry Development for BEV - The MoI Decree No. 7/2022 on Completely Knocked Down and Incompletely Knocked Down BEV	- The direction of vehicle efficiency and EV technology development, in phases, from 2015 to 2035. - Series of strategies between 2020 and 2030 to address EV cost and infrastructure barriers, and technology readiness. Also includes BEV industry local content target. - The import of battery electric vehicles in the form of complete knockdowns (CKD) and semi or incomplete knockdowns (SKD or IKD).
Ministry of Energy and Mineral Resources (MEMR)	- Presidential Regulation (Perpres) 22/2017 on General Planning for National Energy (RUEN) - MEMR Decree No. 1/2023 on Provision of Electric Charging Infrastructure for Battery-Based Electric Motorized Vehicles	- The National Energy Plan, target for the number of EVs and their infrastructure in 2025 and 2050. - Various business models for selling electricity to EVs and provides technical requirements for public charging and battery swap stations, incentives on electricity tariffs.
Ministry of Transportation (MoT)	- Ministerial Regulation (PM) 87/2020 on Vehicle Physical Type Testing Battery-Based Electric Motorized Vehicle	- Regulates the physical testing of battery electric vehicles. - Tests batteries for integrity and safety.
Ministry of Finance (MoF)	- The Ministry of Finance Decree No. 38/2023 on Value Added Tax Incentives for Four Wheelers and Buses Battery Electric Vehicle - Regulation No. 150/2018 on Provision of Corporate Income Tax Reduction Facilities - The Ministry of Finance Decree No. 72/2020 on Input Cost Standard	- Tax incentive on the purchase of electric cars and buses during the tax period of April to December 2023. Battery-based four-wheel electric vehicles and buses with 40% or more domestic components qualify for a 10% government-funded value-added tax (PPN) rate, while the remaining PPN is charged at 1%. - A subsidy program for the purchase of up to 200,000 new electric two-wheelers and the conversion of up to 50,000 conventional two-wheelers to electric ones between March and December 2023. The amount of subsidy for each electric two-wheeler is IDR7 million.

Table 1. Policies and Regulations Regarding E-mobility in Indonesia

Agency/Ministry	Regulation	Content
		- Tax holiday to eligible pioneer industries, which include manufacturers of certain types of motor vehicles or components. The EV industry is categorized as a pioneer industry. - Procurement of official vehicles with BEV technology. The decree removes BEVs from previous MoF provisions on maximum vehicle acquisition prices for government fleets.
Ministry of Home Affairs (MoHA)	- MoHA Decree No. 6/2023 on Basis for the Imposition of 2023 Motor Vehicle Tax, Duty on the Transfer of Motor Vehicle Ownership, and Heavy Equipment Tax for 2023	- Provides preferential treatment for passenger and goods transport BEVs. Public transportation BEVs are set at a zero% tax base value for vehicle and transfer fees, lower than 30% for internal combustion vehicles (ICE).
Ministry of Environment and Forestry (MoEF)	- MoEF Regulation 12/2021 on Quality Standards for Lithium Battery Recycling Emissions	- Lithium battery recycling.

Regional framework

Regional policies also support these aforementioned national policies. In Jakarta, the Government of Jakarta follows a regional transportation plan and policy outlined in Presidential Regulation No. 55/2018. The Greater Jakarta Transport General Plan (RITJ) serves as a core planning policy that outlines transportation plans, including transport models and network expansion. RITJ emphasizes sustainable transport development and proposes the introduction of electric vehicles in various areas, particularly in the central business district in Jakarta, Bogor, Depok, Tangerang, Bekasi, and other surrounding cities.

To accelerate the deployment of battery electric buses under the Transjakarta service, the Government of Jakarta outlined Governor Decree 1053/2022 and set a target to electrify 50% of Transjakarta fleets in 2027 and 100% in 2030, accounting for 10,047 e-bus fleets. This Governor Decree became a robust initial and practical regulatory basis for the Transjakarta electrification. Through the decree, the governor also mandates several agencies to support the Transjakarta electrification program by various measures.

KEY TAKEAWAYS

Despite the current low adoption rate compared to the 2030 objective, EV adoption in Indonesia is on the rise, marked by increasing EV sales each year, mainly driven by government initiatives.

The regulatory framework for e-mobility in Indonesia involves multiple stakeholders and is governed by various national and city-level policies. National policies, such as PR 55/2019, promote the growth of the domestic EV industry, provide fiscal incentives, and emphasize the development of charging infrastructure.

Transjakarta is expected to be the role model for deploying electric vehicles on a massive scale for the public in Indonesia.

PART TWO

OVERCOMING BARRIERS

The transition to electric buses is not without challenges, such as the absence of a mandate at the national level for the adoption of electric buses, road map, charging infrastructure, and also financial challenges. However, reflecting on countries that have adopted electric buses, these challenges can be overcome with detailed plans.

3 Preparing the Transition

3.1 LESSONS LEARNED FROM ELECTRIC BUS IMPLEMENTATIONS AROUND THE GLOBE

Case studies of cities and countries transitioning to zero-emission mass transport provide valuable insights into the opportunities and challenges of adopting e-buses. These examples can serve as lessons for cities in Indonesia dealing with financial and operational obstacles related to e-bus transition, as well as the establishment of necessary infrastructures.

In Santiago, a private bus operator Metbus partnered with Enel X, a utility company with strong financial capabilities, to introduce e-buses and charging infrastructure for a pilot e-bus implementation. Enel X procured the e-buses and infrastructure from BYD, a bus manufacturer, and leased them to Metbus under a 10-year contract that includes maintenance services.

The financial administration agency AFC handles the monthly lease payments for the e-buses and chargers to Enel X, as well as monthly payments for bus operations to Metbus. In this partnership, the government played a role in facilitating fleet leasing contract guarantees and reducing non-payment risks associated with adopting new technology and infrastructure for mass electric public transportation.

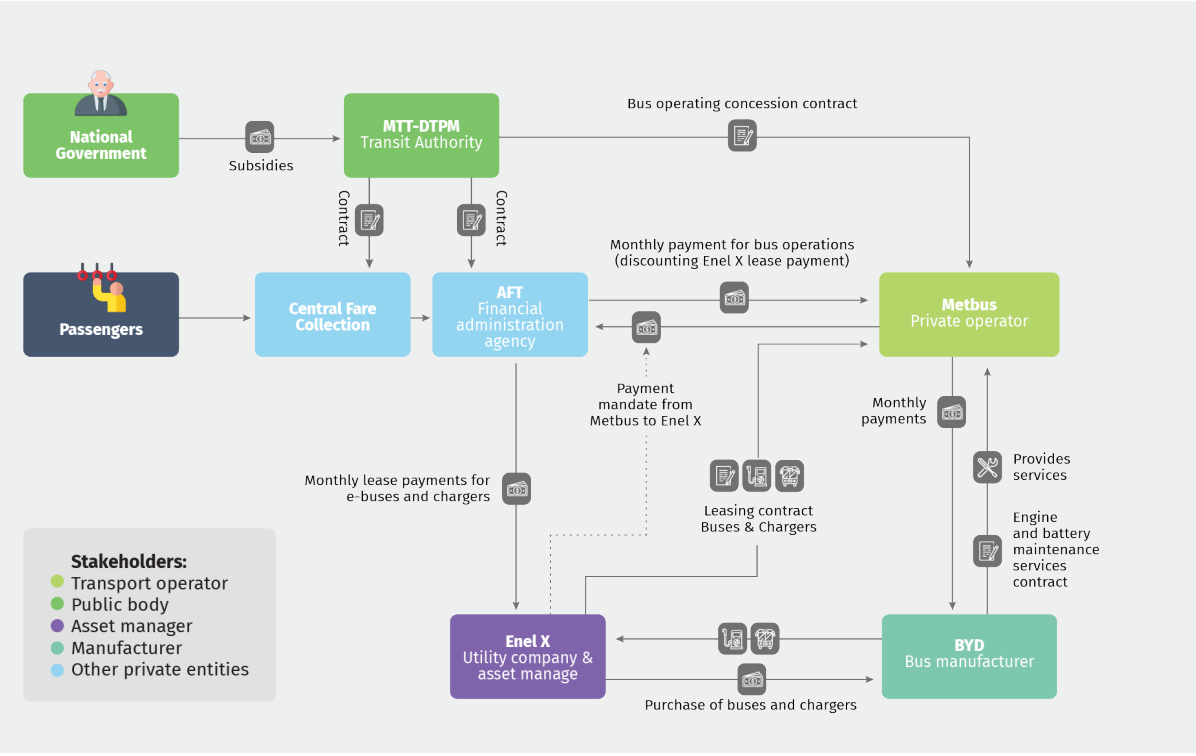


Figure 2. E-Bus Business Models in Santiago, Chile[1]

[1] Case Study: Metbus Pioneering E-Bus Deployments in Santiago. C40 Knowledge, 2020.

The pilot demonstration enabled Santiago to better understand the e-bus and charging technologies, operational performance to improve route planning in later implementation stages, and identify skill gaps and approaches to train the workforce. In addition to the invaluable technical and economic insights, the pilot successfully demonstrated the lower operating costs of e-buses, which attracted more operators to consider switching to zero-emission vehicles.

Colombia's e-bus fleet in Bogotá has seen impressive growth, increasing from 260 units in 2020 to 1,485 units in 2022 under TransMilenio. Similar to Santiago, Bogotá's innovative public transit business models have attracted electric utility companies, investors, and manufacturers.

TransMilenio, Bogotá's world-class BRT system, started operations in late 2000 and functions as an above-ground system.

Bogotá's case proved that the lessons learned in Santiago could be replicated for a successful transition. Additionally, providing longer contract terms for e-bus operators has proven effective in reducing annual financial burdens and investment risks. These achievements have prompted Colombia to mandate the phasing out of conventional bus purchases by 2035.

Another example is how Shenzhen, China, an early adopter of e-buses, enabled the electrification of its mass transit fleet. In China's case, the public sector played a more central role compared to the previous two Latin America cities. Both the local and national governments implemented policies with financial incentives to reduce the costs of e-buses, leading to widespread adoption in cities like Shenzhen. In Shenzhen, the national and local government subsidizes the Shenzhen Bus Groups (SZBG), the city's bus operator, for operating subsidies, original equipment manufacturers (OEMs) to produce and sell the fleets, and charging service providers for their services.

Furthermore, to address the challenge of limited operation mileage, the local government of Shenzhen collaborated with local bus suppliers to enhance the technical specifications of e-buses. This resulted in a significant 40% increase in bus operation mileage between 2011 and 2016. Moreover, the bus availability rate improved from 50% in 2011 to an impressive 97%.

Shenzhen, like Santiago and Bogotá, also adopted an innovative business model to reduce bus operators' financial burden. They implemented a bus leasing model with local charging solution providers. Financial leasing companies purchased e-bus fleets and batteries from OEMs and leased them to SZBG for eight years, corresponding to the regulated maximum bus life span in China. The manufacturers provided warranties for the entire contract period and received payments in three installments. After the leasing period, bus operators assume ownership of the buses, returning batteries for recycling and disposing of bus bodies. Charging and maintenance services are outsourced to charging service providers. Some providers offer battery leasing schemes, separating battery costs from the fleet. This distribution of responsibilities enables operators to share financial and operational duties.

Despite the transfer of certain responsibilities to other institutions, bus operators in Shenzhen are still required to provide their own depots, which has been challenging due to limited land availability in the densely populated urban environment. However, the local government has stepped in to support the operators by investing in lands specifically designated for depots, power supply, and charging infrastructure.

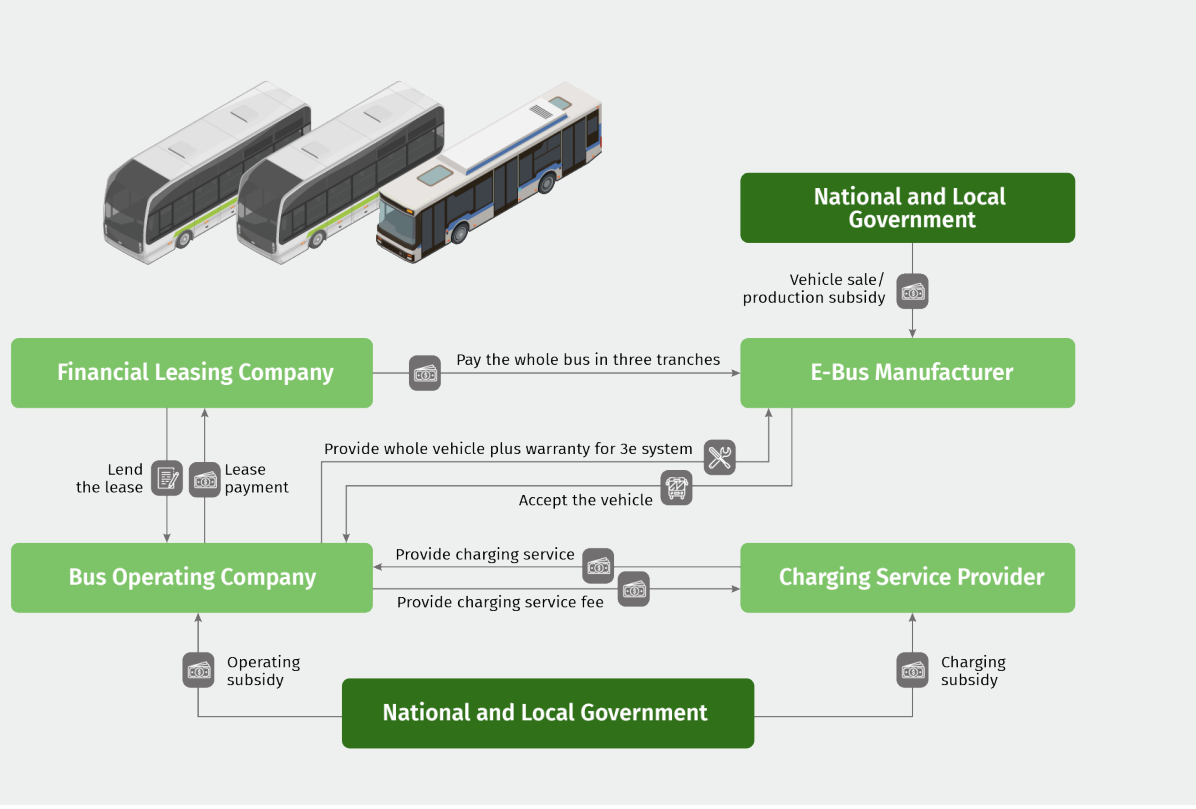


Figure 3. Battery Electric Bus Business Model in Shenzhen, China[2]

[2] Shanshan Li presentation on ITDP Webinar. June 2020.

In India, a national financial incentive program largely drives the e-bus transition process. India established a National Electric Mobility Mission Plan (NEMMP) in 2013, which includes targets of e-mobility adoption by 2020 and acted as a legal basis for the Faster Acceleration and Manufacture of Electric Vehicles (FAME) program. The program subsidized over 425 e-buses under its first phase and with additional approved tenders for up to 5,600 new e-buses nationwide by 2020.

The program also covered subsidies for charging infrastructure and non-fiscal incentives such as permit exemptions. OEMs were also included in the latest phase of FAME as part of the consortiums for the tenders, to prevent the underutilization of assets due to technical reasons and to ensure long-term maintenance support for the e-buses.

On September 23, 2017, India's first fleet of 25 e-buses was launched in Manali. These 9 m non-AC buses can run up to 230 km in a single charge that could take about 4 hours to fill up the battery.

On the other hand, California's example takes a holistic approach to encouraging transit agencies to adopt zero-emission buses. The success of their pilot programs was due to the support of state funding for the initial costs of zero-emission technologies and the long-term funded programs for transit agencies.

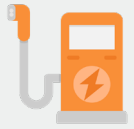
A state-wide e-bus adoption goal was issued as a regulation by the California Air Research Board in 2018, which mandated transit agencies to only purchase ZEBs (Zero-emission buses) by 2029 to successfully transition to an all zero-emission bus fleet by 2040. The demand-side mandates trickle down to manufacturers to develop their products towards EVs.

Examining the above case studies, some common opportunities and challenges are shared across regions:

In all cities, inter-institution coordinated policies with ambitious targets are key. There need to be both national-level and local-level commitments to reduce air pollution, as well as clear targets for e-bus adoption. Beginning in key urban cities, the success of transitioning to e-buses can be transmitted across regions, provinces, and cities.

Strong fiscal incentives from national, state, and local governments play a crucial role in overcoming the high initial costs associated with transitioning to e-buses. The support of local governments in India and China has been instrumental in the successful adoption of e-buses. To ensure program sustainability, government financial support should be tied to expected outcomes, ensuring the provision of high-quality transit services and adherence to technical standards.

Adaptable and innovative business models played important roles in catalyzing the transition to e-buses. The collaboration of private companies and shared responsibilities with specialized third parties in the e-bus transition initiatives allowed for the deployment of hundreds of zero-emission buses without the need for significant government funding and even proved that e-buses cost less to operate compared to diesel buses.



A common challenge encountered across the cities is providing infrastructure for charging and services. Obtaining the land needed to construct charging stations has been an issue for all cities, which the local governments can support.

Negotiating affordable energy prices and managing the operations to maintain charging frequency are also key factors to e-bus success. Thus, the lesson is that charging infrastructure planning and provision is crucial in the preparations for the e-bus transition.

3.2 A NECESSARY CHANGE IN POLICY AND REGULATORY LANDSCAPE

The Indonesian Presidential Regulation (PR) No.55/2019 was issued in August 2019, enacting the BEV National Program for Road Transport. The Government of Indonesia aims to make 20% of domestic sales of EVs by 2025. President Jokowi signed the regulation, which initiated the ambitious national agenda for the growth of a domestic industry for electric vehicle production.

Table 2 below summarizes a breakdown of an analysis of existing policies and regulations for incorporating EVs into Indonesia's mass transit system.

Governments worldwide have implemented various policy tools and strategies to tackle the barriers to e-bus implementations and stimulate the market. Comparing these policies with best practices from other countries is key to the Government of Indonesia identifying and addressing the current regulation gaps. The main policy measures taken from the international experiences can be identified as follows:

The following are some policy efforts in other countries

Regulations that boost the domestic industry of e-buses and foster high availability of models and e-bus units.

The economic incentives to support fleet procurement or operational costs and charging infrastructure development programs to maximize e-bus uptake.

Policies to enable innovation of business models.

Policy type	Current policies	International examples	Gap analysis	Responsible actor
Public fleet vehicle mandates	• PR 22/2017 on RUEN targets 10% e-bus penetration by 2025 • Ministry of Finance (MoF) Decree No. 72/2020 flexibility for higher procurement prices for electric vehicles for government fleets.	• Electrification can be pressed by implementing mandates that dictate new electric vehicle purchases or by conversion of existing fleets to electric. • Mandates for e-buses and taxis have been successfully adopted. China is the leader in e-bus adoption through its mandates. California and Colombia have established plans for public transit bus fleet electrification in the next decade.	There are no policies currently requiring cities to only implement e-buses gradually. MoT's 90% electrification goal for public transit buses by 2030 has not been imposed in any formal regulations, and furthermore may only be achieved with a mandate.	The Ministry of Transportation (MoT) would be responsible for designing and adopting a public transit electrification mandate regulation.
Direct incentives for consumers	• PR 55/2019 - Lists a number of regulatory pathways for fiscal incentives. • Ministry of Home Affairs (MoHA) - Eliminate transfer fees and vehicle taxes for BEVs, including e-buses. • The PLN and The Ministry of Energy and Mineral Resources (MEMR) - Developed regulations that include electricity rate structures that offer lower wholesale prices for the application of charging EVs.	• India, China, and California purchase subsidies for e-buses with direct incentives ranging from 30% to 60% of e-buses. • Direct subsidies are temporary with higher values given during pilot stages and for infrastructure development. • Operational costs for EVs are reduced via lower electric tariffs for EV applications (e.g., Glasgow). • Shenzhen adopts time-of-use electric tariffs to lower electricity prices during times of the day when demand is typically lower.	• There is not yet any strong direct incentive in terms of purchase price or operational subsidy for bus operators or other players in the e-bus provision, including infrastructure providers. • No further time-of-use tariff is available for e-buses.	• MoF would be responsible for designing direct incentives to support public transport acceleration. • MEMR and PLN would be responsible for developing the regulations and adopting time-of-use tariffs that favor EV use.
Indirect incentives for consumers	• PR 55/2019 - Lists a number of regulatory pathways for indirect (non-fiscal) incentives. • Ministry of Environment and Forestry (MoEF) 20/2017 sets the minimum emission standards of diesel buses at EURO IV.	Indirect incentives provide consumers with benefits such as time savings and convenience. A typical non-fiscal program that can incentivize zero or low-emission buses is restricting polluting vehicles from entering areas in the city (e.g., London) and increasing emission standards for buses.	• Lack of LEZ implementation in cities in Indonesia. • Implementation of EURO IV as bus emission standards has not pushed e-bus adoption.	• Ministry of Home Affairs (MoHA) and MoT would be responsible for developing regulations that enable local authorities to increase the presence of indirect incentives. • MoF would be responsible for increasing emission standards and providing LEZ guidelines with MoT.

Table 2. Policy Summary and Gap Analysis for Electromobility Policies in Indonesia

Policy type	Current policies	International examples	Gap analysis	Responsible actor
Adopting innovative business models	• MoF - Limits government multi-year contract at three years period • MoT - Obligates public transport operators to own a minimum number of buses	Cities in Latin America deployed hundreds of zero-emission buses in a couple of years in the absence of significant state financing. Key elements were: • A business model uses public-private partnership (PPP) between the state and private companies. Electric utility companies and other private investors became new players in this model, providing strong financial backing to this new type of technology. • Extended contract durations (14-15 years) have helped bear the financial burdens of more expensive technology. • In tendering processes in Colombia and Chile, the government provided and supported the land and management of e-bus charging facilities, which are a bottleneck when scaling up e-bus operations. • The guaranteeing of minimum daily service levels that correlate with daily utilization values (km/bus/day) of current battery e-bus technologies.	Indonesia's current business models that govern public transit bus fleet services present three key limitations: • Short contract periods, the longest in Jakarta through Transjakarta is 10 years. Direct contracts with the government are even more limited to three years. • The bundling contract of e-bus fleets, depots, and charging infrastructures needs a significantly higher capital investment than what traditional operators have today.	• MoF would be responsible for amending the multi-year contract period • MoT would be responsible for amending regulations related to bus operators • Local governments would be responsible for developing regulations that allow Transit Authorities to offer longer contract periods for e-bus operators.

Policy type	Current policies	International examples	Gap analysis	Responsible actor
Industrial policy	Ministry of Industry (MoI): • Regulations to ensure BEVs are manufactured in a country maintaining a minimum local content. • Prioritization of transit buses for the advancement of the EV agenda in the heavy-duty segment. MoF: • Policies to incentivize business investment in BEV manufacturing.	China: • The largest manufacturer of BEVs in the world because of the strong strategic plans implemented in 2009 and updated over time. • The issuance of the Auto Industry Adjustment and Revitalization Plan in March 2009. • The 2015 release of the Made in China 2025 Program established alternative energy vehicles as a key strategy which ensured that Chinese companies develop world-leading electric vehicles, batteries, and other vital parts production.	• No defined national industrial policy on e-buses manufacturing. The lack of a national manufacturing strategic plan implies that most of the e-buses would be either imported as CKD or as complete units. • Current regulations do not show how the GoI would support research and development (R&D) activities to ensure the developing of local intellectual property for e-bus local production (including vehicle, batteries, charging equipment, and other key components)	• MoI would be responsible for developing supply chain and R&D plans. • MoT would be responsible for coordinating with MoI regarding the electrification plan for public transit.
Improving stakeholder coordination	• The Coordinating Ministry of Maritime Affairs and Investment leads the national BEV task force. • MoT is leading public transport electrification and is implemented by local transit authorities at the city or provincial level.	Surveys carried out across national and subnational stakeholders showed an issue in the e-bus adoption is a lack of coordination between leaders and implementers.	No dedicated task force for e-bus adoption at the national nor regional levels	MoT – DGLT would be responsible for implementing the Public Transport Electrification Committee

Source: International Bank for Reconstruction and Development/The World Bank. (2022). E-Mobility Adoption Road Map for the Indonesian Mass Transit Program: Part I. Global Trends and Market, Policy, Regulatory and Institutional Assessment of E-mobility in Indonesia.

3.3 CHALLENGES AND RISK MAPPING

The road to accelerating e-bus adoption in Indonesia faces various challenges and requires a comprehensive approach from the government, stakeholders, and the private sector. Overcoming challenges such as high upfront costs, limited charging infrastructure, and divided support for e-buses will be crucial to achieving the ambitious targets set by the government. Several of the key challenges are identified below.

Political and regulatory challenges

- No clear long-term roadmap and mandates for large-scale e-bus deployment and charging infrastructure provision. The absence of detailed plans and action targets for electric vehicle adoption, especially for e-buses, hinders the development of a comprehensive charging infrastructure roadmap.
- Fragmented authority. Despite the establishment of a coordination team and a policy working group on battery electric vehicle acceleration, the responsibility for developing and implementing policies on electric mobility adoption remains fragmented across various government institutions. This leads to bottlenecks in policy development efforts.
- Low coordination within and outside the government causes public confusion and implementation delay. Unclear authority and vague policies create confusion among the public and private sectors, resulting in a “wait and see” approach to adopting electric vehicles.
- City-level task force on BEV, including e-bus, acceleration is missing. The lack of a city-level task force prevents local governments from effectively promoting uptake and implementing national-level programs in their respective areas.

Environmental issues

The carbon emissions intensity of Indonesia’s grid and the potential battery waste from the mass adoption of BEVs pose environmental challenges. The current power source mix for electricity generation in Indonesia reduces the overall mitigation gains from replacing conventional buses.

Demand-side challenges

The high price of e-buses, lack of added value compared to conventional buses, uncertain operational and maintenance costs, and limited secondary market for used e-buses and batteries are factors hindering private vehicle users and fleet operators from shifting to e-buses. Furthermore, limited contract periods of three years for multi-year national contracts and 10 years for bus operators in Jakarta restrict the distribution of costs over a longer period.

Supply-side challenges

High capital investment and uncertain demand are obstacles faced by industry players. Additionally, specific regulations such as gross vehicle weight limitations for buses create barriers for e-buses, as their heavier weight due to the batteries can affect the maximum passenger capacity.

Infrastructure provision issues

Infrastructure provision issues: High capital cost for certain infrastructure, long payback period, difficulty accessing land for charging infrastructure, uncertain demand, and regulatory barriers pose challenges for the large-scale provision of charging infrastructure, impacting the adoption of e-buses.

Meanwhile, there are also technical risks in implementing the e-bus electrification program, namely:

Flooding

Flooding poses a significant risk to e-bus operation, affecting fleets, batteries, and charging infrastructure. The extent of damage caused by flooding is contingent upon factors such as the height and intensity of the floodwaters, as well as the condition of the objects affected by the flooding.

Extreme heat

Extreme heat can degrade battery quality and increase electricity consumption, reducing the operating distance of e-buses.

Power outages

Power outages are a significant risk for e-buses as their operation depends on a continuous supply of electricity. Different types of power outages include blackouts (massive and prolonged), rolling blackouts (planned and localized), brownouts (voltage drops), and permanent faults (local power line issues).

Traffic congestion

Traffic congestion poses a risk to the operation of e-buses, potentially resulting in a depleted battery state of charge (SoC) and reliability concerns. To mitigate this risk, it may be necessary to provide a higher SoC buffer, ensuring that the battery does not run empty during the journey.

KEY TAKEAWAYS

While challenges will undoubtedly come, e-bus early-adopter cities worldwide provide valuable lessons for planning and implementing Indonesia's program to transition to e-buses:

- Government initiatives and incentives prove to be key factors in initiating electrification programs. Regulated mandates and policies establish the foundations for launching an e-bus market in any country. These foundations can be the key to attracting the right partnerships from the private sector, contributing to electrification programs' sustainability.

Success stories in China, India, and California highlight the important role of governments, including funding, incentives, fostering public-private collaborations, and issuing other supportive policies.

- Collaboration between governments and the private sector is crucial to address the high costs of transition programs and also the sustainability of operations following initial deployments. An unbundled business model can help disperse the financial burdens for obtaining the e-buses, infrastructure development, and depot provisions, allowing for more sustainable implementation of e-buses in mass transit systems. Therefore, it is important to address regulatory barriers that may impede the exploration of new business models.

Latin America's innovative business models can inform Indonesia about fostering a cooperative approach with the private sector for sustainable and growing electrified mass transit networks.

- Challenges to accelerating e-bus adoption in Indonesia include the absence of national-level mandates for e-bus adoption, a lack of a clear long-term roadmap for large-scale deployment, lack of infrastructure provision, and technical risks during operations.

4 Planning Electric Bus Implementation

4.1 STRATEGIES TO PREPARE AND PLAN FOR ELECTRIC BUSES

The key factors that affect e-bus planning are e-bus specifications, energy consumption, battery sizing, charging strategy, and grid capacity. Unlike conventional buses, e-buses need an integrated system that considers daily distance traveled, route topography, possible locations for charging infrastructure development, and battery technology.

Building a strategy for the transition of e-bus requires planning that considers existing resources and identifies the needs for new ones. The general methodology to plan for e-bus deployment applied in developing strategies for e-bus deployment in Jakarta, Medan, and Bandung is shown in Table 3 below.

Their energy efficiency and battery capacity determine the range of e-buses, but it can vary due to various factors. These factors include ambient temperature, auxiliary power loads, route characteristics, bus weight, and battery degradation. Estimating the range involves considering the actual usable energy from batteries, which is lower than the rated capacity due to limiting factors. These limitations include maintaining battery health by limiting the depth of discharge (DoD), ensuring safety by setting a maximum state of charge (SoC), allowing for operating flexibility with a reserve margin, and accounting for the battery's end-of-life capacity.

It is also important to set a minimum threshold of battery SoC when the bus is operating - typically around 20% - 30% - to cater to battery health and vehicle performance issues, avoid range anxiety, and ensure operational reliability. Planning can also account for battery degradation rates or reallocating buses with degraded batteries to shorter routes.

E-bus typically require more depot area than the diesel buses due to charging requirement.

STEPS		ASPECTS
Identify Key Specification for Analysis		Daily distance per route. Bus type (medium or single bus). Commonly available battery size in the market based on type.
Routes grouping allocation		Buses per route are assigned to depot locations, based on operational routes by considering distance to the depot and number of fleets. Define number of operations required. Each depot will be operated by different operations.
Identify appropriate charging strategy for each battery size option	Overnight charging Midday charging during off-peak period Fast charging at terminus	Analysis of charging strategies per route, starting from the smallest battery size option. Three options to be analyzed and optimized: 1) Overnight charging at depot. 2) Combination of overnight + midday charging at depot/ staging facility. 3) Combination of overnight at depot + fast charging terminus. Aspects to be considered: energy requirement to cover daily distance, battery size, depot proximity, space availability at terminus, operational schedule, and state of change (SoC).
Calculate total cost per route for each battery size options		CAPEX: E-bus procurement cost (including battery cost and taxes), charger procurement, installation, battery replacement cost; and salvage value of e-buses OPEX: Operational and maintenance costs
Select the most cost-effective option per route		Based on total cost per route.
Develop a road map of BRT electrification.		With regard to estimated demand, financial analysis, technology readiness, and spatial analysis (the possibility of having shared charging facility at the depot and/or terminus).

Table 3. Methodology Applied for the BRT (Bus Rapid Transit) Electrification Studies in Jakarta, Medan, and Bandung

Source: International Bank for Reconstruction and Development/The World Bank. (2022). E-Mobility Adoption Road Map for the Indonesian Mass Transit Program: Part II. Implementation Strategies to Adopt E-mobility in the Mass Transit Systems in BBMA and Mebidangro.

	Ambient temperature	Indonesia's hot climate will mean more power will be consumed for air-conditioning systems.
	Auxiliary system power loads	Auxiliary systems such as ACs mean more energy consumption. Thus, the number of stops an e-bus takes will also impact auxiliary power loads as more stops mean the doors need to open and close multiple times.
	Loads	The load a single e-bus bears will affect its energy consumption. Factors such as bus weight and the number of passengers will affect how much energy is used per route.
	Battery degradation	E-bus batteries will always degrade over time, especially with high usage. The typical battery will reach the end of its life at 80% capacity.
	Route characteristics	Road gradient, number of stops, number of traffic lights, traffic congestion, and drivers' behavior will affect the efficiency range of e-buses.

Table 4. The Environmental Factors Impacting Battery Usable Capacity

The methodology above requires several data points to be prepared, including daily distance per vehicle on each route and estimates on the number and types of buses. Unfortunately, not all public transport systems in Indonesia already have formal operational arrangements, which introduce additional challenges for fleet electrification. Prior to planning for e-buses, it has to be ensured that the principles of electrification readiness below have been addressed.

ITDP and UK PACT work with the Jakarta Government and Transjakarta to develop action plans to achieve Transjakarta's ambitious target of deploying 10,047 e-buses by 2030.

Stage	Fleet electrification challenges	Principles of electrification readiness	Gaps in the current system
Planning	Additional planning stages of fleet and charging strategy and location selection is required for e-buses. Factors like daily distance, topography, charging infrastructure installation feasibility, and operational constraints influence the technology choice. Different e-bus technologies may also necessitate specific charging infrastructure and battery options.	To plan for adequate range of e-bus fleets, key data below should be available: 1. Current/planned daily distance traveled per vehicle. 2. Route data, including topography and traffic conditions. 3. Existing or planned public transport infrastructure (bus stops, shelters, terminals, or depots) locations and potential locations of charging facilities.	1. Obtaining reliable daily distance data in microbus operations is difficult due to issues like route deviations, irregular schedules, and lack of structured operations of typical informal transit systems in Indonesian cities. 2. The absence of adequate transit infrastructure, including depot facilities, poses additional challenges for e-bus planning and charging.
Fleet procurement	The higher price of electric vehicles poses procurement challenges. Although the operational costs of e-buses are typically lower than diesel buses, the capital cost is still 2.5-3 times more expensive.	To address the barrier of high investment cost, there should be: 1. An institution with strong financial capacity or high bankability to procure e-bus fleets. 2. A sustainable business model and mechanism for the government to provide operational subsidies. Although the operators might not need to procure the fleet themselves, they still need to finance the fleet leasing and the fleet operation themselves.	1. The typical individual fleet ownership, ridership-based revenue business model barely can sustain typical informal transit operations. The current operators have insufficient financial capacity and poor bankability to secure the financing of electric vehicle procurement. 2. No clear mechanism is established yet for the government to financially support the operations of the informal transit system.
Infrastructure provision	Most cities lack the necessary infrastructure for charging e-buses, making it an additional requirement for implementing an electric fleet. Furthermore, managing and maintaining charging facilities is a new responsibility that needs to be assigned to an existing public transport operator or a new stakeholder.	To establish charging infrastructure for e-bus fleet, there should be: 1. An institution with strong financial capacity or high bankability to procure and build the charging infrastructure. 2. An institution to operate and maintain charging infrastructure. 3. Available space for the charging infrastructure. 4. A stable grid connection	1. Operators often do not have the financial capacity nor bankability to seek financing to provide the charging infrastructure themselves. 2. Without any existing depots, finding sufficient land at a strategic area near a transit route will be an additional challenge in charging infrastructure establishment. 3. Grid instability still often occurs in many Indonesian cities.

Table 5. Principles of Electrification Readiness

Stage	Fleet electrification challenges	Principles of electrification readiness	Gaps in the current system
Operations	Operational changes are necessary to incorporate charging time into the fleet schedule. Some e-bus fleets may require both overnight and opportunity charging. Adjusting the schedule with precision becomes crucial to ensure timely charging of the battery. However, the limited availability of charging stations, particularly during the early stages of e-bus adoption, leads to longer non-operational distances and increased energy consumption.	To incorporate charging times in the fleet operation, some key requirements include: 1. Predictable distance traveled during the course of the day, to predict the state-of-charge (SoC) over the operational hours. 2. Fleet operational hours. 3. Current/planned charging infrastructure locations and capacity.	The unpredictable nature of informal transit services, with irregular boarding and alighting spots, varying headways, and deviations from established routes, makes it difficult to accurately predict the progression of fleet travel distances throughout the day. Without a sufficient buffer of extra battery capacity, there is a risk of battery depletion during these irregular operations.
Maintenance	The different propulsion systems of e-buses require different maintenance, hence different knowledge and skill sets. These changes require sufficient capacities and skills which may not yet be available in most public workshops nor the existing inhouse resources.	To be able to maintain an e-bus fleet, there should be a maintenance facility for e-bus fleets and skilled maintenance workers being provided by the fleet operators or a third party (e.g., OEMs).	There is no dedicated maintenance facility for typical informal fleets, and maintenance works are done in public workshops or by the fleet owners or drivers themselves (e.g., cleaning the vehicles or doing simple repair works). The current resources might not have the capacity to do maintenance required.

Source: International Bank for Reconstruction and Development/The World Bank. (2022). E-Mobility Adoption Road Map for the Indonesian Mass Transit Program: Part II. Implementation Strategies to Adopt E-mobility in the Mass Transit Systems in BBMA and Mebidangro.

4.2 PLANNING CHARGING INFRASTRUCTURE

Charging infrastructure for e-buses will depend on the charging strategies selected for a particular e-bus fleet. The factors considered to plan the charging strategy include route characteristics, requirement of daily distance traveled, fleet capacity requirements, technology readiness, technology suitability, and land availability. The selection of a charging strategy, particularly regarding the charging speed and cycle, will affect the battery lifespan of e-buses. In general, four main charging strategies have been implemented globally:

Overnight charging at depots

E-buses are charged only once overnight at dedicated depots. The fleet usually needs bigger-capacity battery packs that can support full-day operations (used in London, Shenzhen, and Transjakarta).

Opportunity charging during layovers or shift changes

E-buses are charged on the road multiple times throughout their daily operation, in addition to the overnight charging. Charging infrastructure is needed at layover terminals or stations (e.g., used in Rotterdam and Groningen).

Battery swap systems

Battery swap remains a niche practice for e-buses due to additional costs, risks during swapping, and challenges in battery standardization (e.g., in China, Japan, and South Korea).

In-motion charging

Mainly used for trams and trolleybuses where the vehicles are connected to an overhead wire system that charges the battery as it moves.

Electricity grid assessment is one of the steps in planning charging infrastructure. This analysis is done in three steps. First, is the estimation of the electricity demands of e-buses deployment. Second, once this estimation is ready, there needs to be the identification of the potential and nearest substation to obtain power for the charging facilities. And finally, charging behavior and its impact on the local electricity infrastructure is analyzed. This will determine whether or not the existing infrastructure can cater to the expected demands, with the addition of e-buses.

Depot infrastructure planning is also important to e-bus implementation. These depots can be used for different things, such as bus parking, charging facilities, washing vehicles, maintenance areas, operations administrative offices, electrical substation buildings, and employee facilities. Charging bays for charging infrastructure can be located in the middle between two back-to-back buses to simultaneously allow shared chargers between two buses.

Some barriers that need to be taken into account for the acceleration of charging infrastructure development are as follows:

Available space to accommodate charging demands

Building charging depots on existing infrastructures will help the initial electrification and piloting stages. However, in many of the case studies on electrification in densely populated cities (such as in China), the most prominent challenge is providing the land needed to build infrastructures within the cities. This challenge will also appear when electrifying informal transit systems in Indonesia. Since they do not have depots, buses are currently parked at drivers' homes or nearby. Government support is needed to provide a dedicated space to accommodate the charging needs.

Financial barriers

The additional costs of installing, operating, and maintaining the infrastructure should also be taken into consideration. The cost of installation will also include the cost of connecting the chargers to the grid network.

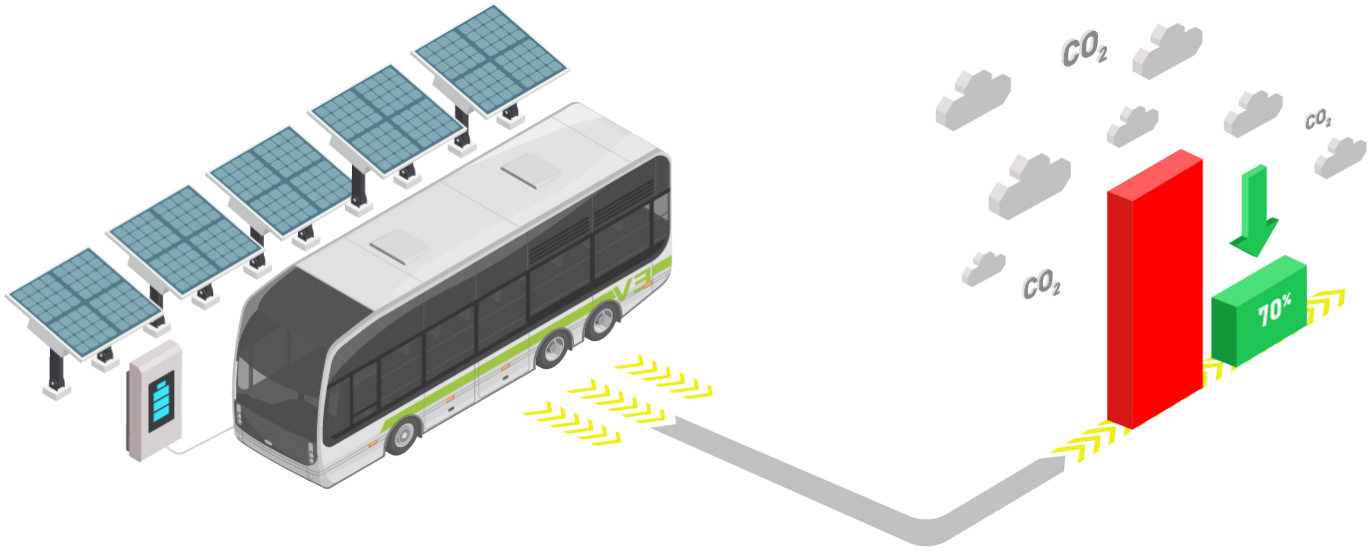
Supply chain barriers

As the EV industry is still growing in Indonesia, sufficient local supply of e-buses, batteries, and charging infrastructure are not yet in place. This would mean that e-buses, their equipment, including batteries, and charging infrastructure technology must be sourced elsewhere, especially in the early stage of adoption.

Regulatory barriers

Opportunity charging facilities, especially those located on public facilities such as sidewalks or bus stations, will need regulatory permits and arrangements for government asset utilization.

4.3 RENEWABLE ENERGY INTEGRATION IN CHARGING INFRASTRUCTURE



The introduction of e-buses contributes to a major portion of the reduction of GHG, but the introduction of solar PV integration into the charging system will add to this. Rooftop solar integration is the best for staging facility charging due to its modularity, where the charging load and solar PV production match given there are available spaces for installation. In the study of electrifying more than 3,000 Transjakarta electric microbuses, the CO_2 emission reduction from e-buses as well as the use of solar PV charging systems in Jakarta, can reach 16,579 ton CO_2eq/year, suggesting a 70% reduction of GHG.

KEY TAKEAWAYS

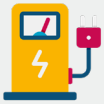
The key takeaways for the consideration of charging strategies and renewable energy are as follows:

The planning stage is the key to a successful implementation of e-buses. In addition to route planning, e-bus planning includes fleet technology and charging strategy selection, updates of operational planning to include charging occasions, and determining charging infrastructure locations while ensuring grid capacity sufficiency. Furthermore, before transitioning to e-buses, addressing the challenges inherent in informal transit systems that are prevalent in Indonesian cities is essential. These challenges go beyond financial constraints and also encompass the complexities of irregular operations, which pose additional hurdles in e-bus planning.

Pilots and demonstrations are valuable steps to take in the deployment of e-buses as they identify actual operational performance and challenges before the large-scale e-bus transition stages.

Building the right infrastructure could mean adopting more than one type of charging strategy which considers several environmental factors such as local climate, route planning, passenger mobility patterns, battery life, and the needs of e-bus operators.

Infrastructure provision and maintenance, especially if it includes land acquisitions, can prove to be one of the costly aspects of e-bus implementation. It is further encouraged to have collaborations between the public sector and multiple private sectors to share the economic burdens. Utilizing government-owned land, such as public terminals, could also become another alternative as it avoids the cost of acquiring land and offers lower dead kilometers for opportunity charging.



Different options for charging infrastructures are available in the EV market. Learning from other countries means that Indonesia has the resources to adapt different models to the existing infrastructures, and build a detailed plan to incorporate the new technologies into what already exists in the local mass transit infrastructures.

5 Working Business Model for Electric Bus Adoption

5.1 HIGH COSTS AND FINANCIAL CHALLENGES

Financing and capital costs are common challenges shared across all case studies of early adopter cities. This is particularly relevant in the case of the high up-front costs for technology procurement and infrastructure development. Global lessons around adopting electric buses (e-buses) into the public transport system show that innovative business models must be explored to ensure transition success, in addition to unlocking new financing streams.

In Jakarta, the pilot implementation of e-buses highlights the need to verify and improve the current business model for future large-scale deployment. The current model places the entire financial burden of purchasing e-buses and building charging infrastructure on the operators, which is not sustainable for expansion. To address this, transport agencies and transit service providers, like the Jakarta Transportation Agency and Transjakarta, should assist operators in developing alternative business models, such as leasing arrangements or providing guarantees for accessing financing institutions' loans.

Additionally, the existing contract between Transjakarta and operators lacks incentives and fails to consider the higher capital cost of e-buses compared to conventional buses. Re-evaluating the cost structure and adjusting payment schemes can incentivize e-bus operation. Furthermore, the local government should explore financial instruments like tax reductions and subsidies to support the adoption of e-buses and charging infrastructure.

5.2 THE BUSINESS MODEL WARS

Early adopter countries have proven the necessity of alternative business models for e-bus implementation. While traditional models rely on a single party to procure and operate buses, alternative models involve multiple parties, enabling the distribution of responsibilities and risks. These models can create a new market that attracts industries. Public-private collaboration, emphasizing specialized emerging industrial markets like renewable energy and battery technology, ensures both the sustainability of electrification and contributes to economic growth.

Cities like Santiago, Bogotá, and Shenzhen provide valuable insights by successfully implementing innovative business models that separate fleet ownership from operation, thereby reducing financial risk. Leasing schemes, along with separating fleet ownership and operations contracts, have been successfully implemented for e-bus systems.

Business model	Description	Pros	Cons
Buy The Service (Transjakarta E-Bus Pilot Business Model)	Transit Authority/Agency contracts bus operators to procure, operate, and maintain buses	· Asset-lite model for Transit Authority/Agency · Simple and familiar business model	· High capital cost from bus operators for fleet procurement and depot charging infrastructure · Not all bus operators have the financial capacity to provide the down payment for e-bus financing · Banks are hesitant to extend finance toward new technology
Concessional model	Transit Authority/Agency procures buses and operators to operate and maintain buses	· Lower capital cost for bus operators · Lower cost of funds compared to fleet procurement by bus operators · Transit Authority/Agency has full control over the assets	· Asset-heavy model for Transit Authority/Agency · Operators tend to do not take care of the assets when these are not owned by them · If using existing government funds, it is not feasible for local government with low fiscal capacity

Table 6. Business Model for E-bus

Business model	Description	Pros	Cons
Fleet leasing model	A third-party lessor procures and leases buses to bus operators	• Reduces upfront capital expenses for both Transit Authority/Agency and bus operators • Lower cost of funds compared to fleet procurement by bus operators • Spreads e-bus cost premium over bus lifecycle • Has been implemented for intermediate (informal) public transport	• Operators tend to do not take care of the assets when these are not owned by them • Adds to the operational budget
Fleet and depot leasing	Bus operators lease e-bus fleets from lessors who also provide the charging facilities and maintenance for the buses.	• Asset-lite model: Lower capital cost for Transjakarta and bus operators. • Addresses the problem of the depot and overnight charging facility availability for microbus operators.	• The Government of Jakarta indicates hesitancy to arrange/ guarantee debt financing for Transjakarta. • Operators tend to not take care of the assets when these are not owned by them.
Battery leasing model (Battery as a Service/ BaaS)	A variation of the leasing model where battery ownership is unbundled from fleet ownership	Reduces upfront capital expenses for both Transit Authority/Agency and bus operators	• Splitting ownership between the bus and battery can add contracting complexity • Adds to the operational budget
Charging infrastructure leasing model (Charging as a Service)	A third-party lessor owns and leases charging infrastructure to bus operators	• Shifts responsibility for charging investment and infrastructure away from the transit agency • Spreads e-bus cost premium over bus lifecycle • Addresses the problem of the depot and overnight charging facility availability for microbus/ informal public transport operators	• Operators tend to not take care of the assets when these are not owned by them • Adds to the operational budget

Source: Institute for Transportation and Development Policy. (2021). Business Model and Financial Analysis for Transjakarta Electric Bus Deployment: Supporting Jakarta's Transition to E-mobility.

5.3 FINANCING OPTIONS AND INVESTMENT OPPORTUNITIES

Financing options are crucial for Indonesia's transition to e-buses. Lessons from early adopters worldwide emphasize the importance of government financial investments to kickstart and sustain the transition. However, as has been mentioned in Section 5.1, there is still a lack of strong fiscal incentives at the national and local levels. Current financial incentives provided by local governments in Indonesia lack consistency, leading to a limited impact on e-bus purchases. To address this, it is essential to synchronize incentives across provinces and establish direct monetary incentives specifically for public transit. Furthermore, implementing a carbon tax and utilizing its revenue can serve as a sustainable funding source to both drive e-bus adoption and reduce overall carbon emissions in Indonesia.

The conventional funding mechanism for financing the e-bus program will result in a very limited number of buses being procured due to the operators' limited financial capacity. Several potential funding sources could be explored to accelerate the e-bus deployment.

In addition, international loans from Multilateral Development Banks or Export Credit Agencies (ECAs) offer alternative financing routes. These loans often come with favorable terms and conditions that support Indonesia's e-bus initiatives. Exploring other investment instruments, such as bonds and Limited Participation Mutual Fund, can also provide financing options for e-buses. Collaboration with private sector entities like fund managers or multi-finance companies is necessary to implement these alternative financing instruments for e-bus projects.

KEY TAKEAWAYS

The key takeaways for the consideration of alternative innovative business models are as follows:

The financial challenges of integrating e-buses into the public transportation system in any city will begin at the initial planning and procurement stage. Learning from global lessons, there needs to be a shared responsibility approach to financial strategic planning.

National governments play an important role in supporting e-bus deployment by developing fiscal strategies that incorporate the private sector to bear some of the responsibility.

The high initial costs of fleet deployment are mainly around building the foundations and right infrastructures to sustain the efficiency of e-buses.

Further financial challenges come in the maintenance and expansion stages of e-bus transitions, particularly in the access to the resources needed to ensure the lifespan of e-buses, the battery technology they use and the charging equipment they need.

A cooperative business model that brings opportunities for the private sector ensures the sustainability of e-buses in mass transit systems.

Cities worldwide face a common challenge of high costs and financing when adopting e-buses. In Indonesia, the current business model is not suitable for scaling up e-bus deployment, burdening operators financially. To overcome this challenge, new sustainable business models from Concessional Model, Fleet Leasing, or Fleet and Depot Leasing, were analyzed. Additionally, re-evaluating cost structures, adjusting payment schemes, providing incentives, and considering financial instruments such as tax reductions and subsidies can motivate operators and facilitate e-bus adoption with charging infrastructure. Embracing these innovative business models and conducting pilot projects will enable cities to transition smoothly to e-buses and establish sustainable and efficient public transportation systems.

PART THREE

ACCELERATING ADOPTION

Lessons learned from Transjakarta and Bus Rapid Transit (BRT) systems in the Bandung Basin Metropolitan Area (BBMA) and Medan Metropolitan Area (Mebidangro) offer valuable input for accelerating the transition from diesel buses to electric buses in Indonesia. Moreover, the diverse needs of vulnerable groups must also be prioritized to establish regulations and policies that align with the goals of public transport electrification.

6 Study Case: Transjakarta Electric Bus Deployment

6.1 TRANSJAKARTA ELECTRIC BUS INITIATIVES

In October 2022, The Government of Jakarta issued Governor Decree No. 1053/2022 on Guidelines for the Acceleration Program for the Use of Battery Electric Vehicle under Transjakarta Services. Through the decree, the government aims to achieve 50% and 100% Transjakarta electrification respectively in 2027 and 2030. In preparation for the large-scale implementation, Transjakarta has been conducting small-scale implementation stages to ensure the roadworthiness and the readiness of the manufacturers and operators to support the full-scale implementation of e-buses.

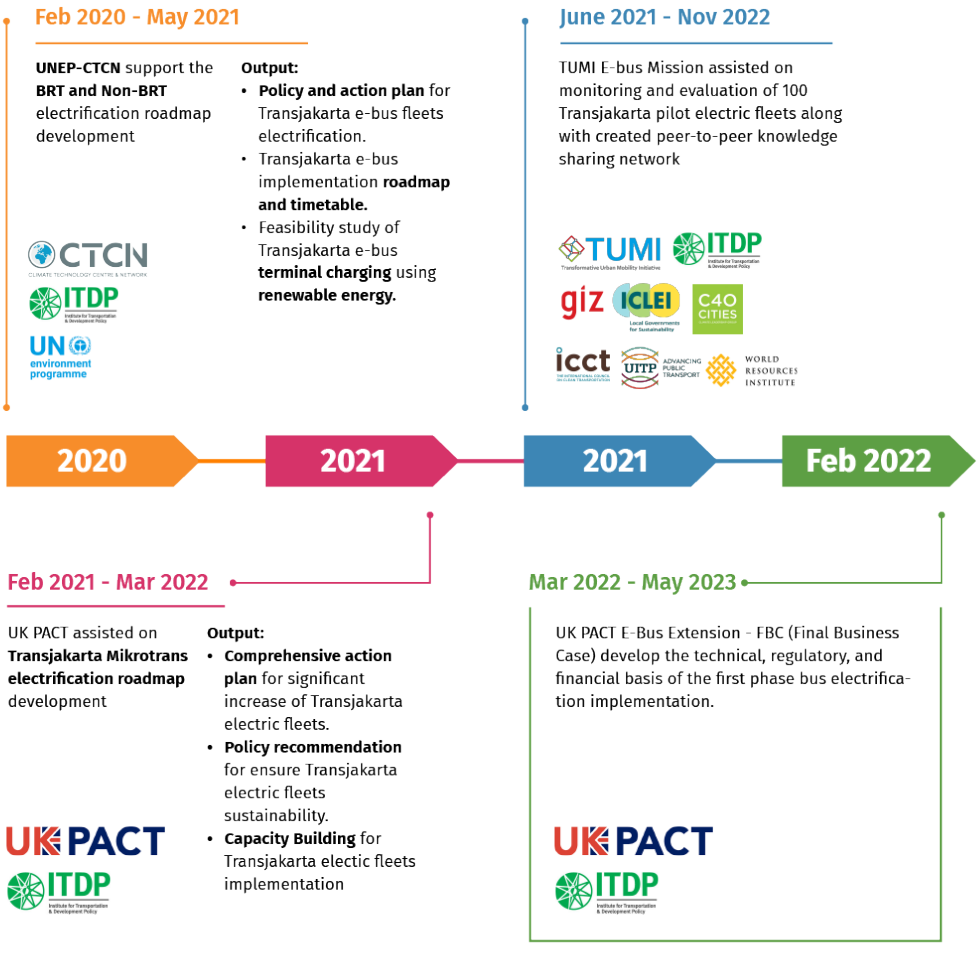
The first stage is a pre-trial, which lasts for three months between 2019 to 2020, and was intended to ensure the vehicle compliance with the regulations and law, verify the energy efficiency of the bus, as well as certify vehicle conformity to Transjakarta's requirements. A pre-trial for e-buses from September to December 2019 used two BYD buses (a 12m single bus with 324 kWh battery capacity and a 7-m bus with 135 kWh battery capacity, and one Mobil Anak Bangsa (MAB) bus (a 12 m single bus). It was then followed by a three-month pre-trial from July to October 2020 for a single bus (BYD's K9 model) and a medium bus (BYD's C6 model). Between 2021-2022, Transjakarta continued conducting pre-trials for various e-bus models from four manufacturers, including a high-deck e-bus model for the BRT service, from Mobil Anak Bangsa.

The second stage is the pilot project, which lasts two years under a Buy The Service contract to evaluate maintenance and operational costs. Due to limited policy support and a lack of domestic implementation experience, the e-bus pilot project faced significant challenges, leading to a considerable delay in its progress. An operator acquired 30 BYD K9 e-buses in August 2021 and constructed a charging station with 10 charging poles between January and June 2022. On top of insufficient charging infrastructure and vehicle availability, the pilot's commencement was also postponed. The 30 e-buses finally hit the road in June 2022.

On March 8, 2022, Transjakarta launched four e-buses that can travel 250 kilometers on a single charge.

Supporting Transjakarta's transition to electric buses

Various institutions have conducted several technical assistance to support Transjakarta's transition to e-buses. Since 2020, ITDP has conducted several studies and technical assistance to support Transjakarta's electrification target, supported by the United Nations Environment Programme (UNEP) - Climate Technology Centre and Network (CTCN), TUMI E-bus Mission, and UK Partnering for Accelerated Climate Transitions (UK PACT).



During the latest program under the support of UK PACT, ITDP developed recommendations for establishing a strong regulatory and financing foundation for large-scale electrification. This includes a long-term electrification plan considering technology readiness, investment needs, regulatory support, and Gender Equality, Disability, and Social Inclusion (GEDSI) aspects. A business case document with a detailed technical plan for the first phase of electrification has also been created to inform potential investors about the feasibility of the project, including selected routes, technology, charging locations, and the impact of partial electrification on Transjakarta's operations.

6.2 EVALUATING TRANSJAKARTA PILOT ELECTRIC BUS IMPLEMENTATION

ITDP together with Transformative Urban Mobility Initiative (TUMI) E-bus Mission conducted a technical assistance program to support the pilot e-bus monitoring and evaluation in Jakarta. The team set up an evaluation methodology consisting of four areas, namely vehicle performance, operating performance, environmental performance, and social and gender performance and received e-bus operational data from Transjakarta from March 4, 2022, to December 31, 2022, totaling ten months. Using the data provided, the team analyzed the vehicle performance on different days, months, and routes. Additionally, passenger surveys were conducted to understand their needs and ensure a satisfactory level of service.

Based on the monitoring and evaluation of the Transjakarta electrification pilot project, some key performance findings can be used to improve the overall efficiency and effectiveness of the system and optimize the planning for future deployment of the Transjakarta e-buses. The findings are as follows:

Energy efficiency

The e-buses demonstrated superior energy efficiency, averaging 0.95 kWh/km. However, the analysis identified a slight decline in km traveled along the evaluation period, indicating battery degradation. Therefore, monitoring specific vehicles and routes with lower energy efficiency is advised.

Data accuracy and availability

The study also pointed out that more detailed charging data and failure information are required for a comprehensive analysis of the system. It is recommended that Transjakarta verifies the accuracy of the received data before the control center is upgraded and e-buses are integrated.

Operational availability

The operating performance of the e-bus system was initially unstable, mainly due to issues with charging station readiness. However, the operating rate improved over time, reaching over 90%. This improvement indicates that the system is becoming more stable, and further enhancements to the charging infrastructure may improve the system's performance even more.

Dead kilometers

Another vital finding was that the distance of dead kilometers, representing kilometers traveled when trips are not scheduled for boarding and alighting of passengers, was excessively long. The study recommends the need for additional depots and terminals with charging infrastructure to minimize dead kilometers and ensure overnight charging for e-buses.

Overall level of service

Finally, passenger feedback emphasized the need to increase the number of buses and reduce headways to improve the overall level of service provided by Transjakarta.

6.3 MAPPING THE OPPORTUNITIES AND CHALLENGES

Throughout the technical assistance activities conducted for Transjakarta, both the pilot evaluation and assistance in e-bus implementation planning, several key opportunities for Transjakarta's e-bus transition were revealed as follows.

Electrifying the Transjakarta fleet is financially and economically viable, providing significant economic and social benefits.

By 2030, electrification is projected to generate IDR4.2 trillion in net economic and social benefits. It would result in a 34% economic internal rate of return (IRR) and a Benefit-Cost Ratio of 2.41.

Electrification leads to substantial cost savings and environmental benefits.

There are cumulative savings of IDR2.1 trillion in petrol fuel subsidies and IDR3 trillion in foreign exchange by 2030. Meanwhile, significant reductions in GHG emissions (58%), tailpipe PM2.5 (45%), tailpipe NOx (47%), and tailpipe SOx (47%) would be achieved compared to the current fleet. However, the emissions from electricity generation offset the reduction in tailpipe PM2.5 and SOx.

Financial analysis favors the implementation of e-buses.

Electric microbuses have a 25% lower total cost of ownership (TCO) than petrol buses. Single e-buses cost 6% less to deploy than diesel buses.

Market consultations reveal significant interest from various financiers.

Financing institutions have expressed their appetite to participate in Transjakarta's fleet electrification initiatives, particularly to finance capital expenditures (CAPEX).

Several key challenges have also been identified. To ensure successful future implementation and scaling-up of the e-bus project in Jakarta, it is crucial to address the challenges and learn from the Transjakarta pilot e-bus deployment. The challenges are outlined below:

1. Policy challenges

The absence of clear regulations on electric vehicle taxes, differing manpower costs between e-buses and ICE buses due to increased risk, and the need for proactive policies and regulations for e-buses.

2. Financial challenges and unscalable business model

The capital cost of procuring e-buses is more than double that of internal combustion engine (ICE) buses, making it financially less appealing for operators. Even in the pilot phase, operators are already burdened with the high capital cost of procuring e-buses and building the required charging infrastructure. Although the initial plan was to operate 100 e-buses in the pilot project, only 30 e-buses are currently in operation. The absence of attractive incentives has hindered the attraction of operators bidding for the e-bus pilot project and operating e-buses.

3. Operational challenges

a. **Insufficient knowledge:** Operators of the e-buses still lack knowledge in calculating the cost per kilometer traveled for e-buses, understanding different technologies, and properly maintaining e-buses in hazardous conditions such as flooding.

b. **Lack of operational standardization:** There is a need for e-bus Standard Operational Procedures (SOP) and operation manuals specifically designed for Transjakarta.

c. **Lack of operator assistance and training:** Operators require support in preparing for e-bus implementation and fully understanding and complying with SOPs. Operators also face numerous challenges in operating e-buses, due to a lack of knowledge and experience, limited access to information on emerging technologies and business models, and difficulties in coordinating with energy providers and obtaining space for charging infrastructure. In addition to implementation support, training should be conducted to transfer sufficient skills and/or knowledge to the operators.

d. **Other implementation challenges:** also include poor after-sale services due to the lack of established local resellers, insufficient charging infrastructure availability, inadequate communication with stakeholders, inadequate technician awareness of personal protective equipment, and insufficient public engagement to improve public awareness on the benefits of e-buses.

4. Monitoring and evaluation challenges

a. **Lack of data collection and sharing mechanism:** The contract does not clearly define the detailed data collection and sharing mechanism between operators and Transjakarta. Consequently, it is challenging to acquire sufficient data from the operators, hindering proper analysis of operational performance. Transjakarta itself faces difficulties in obtaining the necessary data for evaluation.

b. **Lack of data verification and analysis:** The process of data collection and sharing does not include provisions for data verification between Transjakarta and operators. As operators manually record data through forms, human errors may occur, potentially rendering the data unreliable. Establishing a verification process between Transjakarta and operators is necessary for ensuring data accuracy.

c. **Data integration challenges:** Data collection heavily relies on operators, with drivers manually recording data, resulting in inefficiencies and possible data errors. Integrating e-buses into the control center is crucial to streamlining and enhancing data collection accuracy.

6.4 ASSISTING TRANSJAKARTA ELECTRIC BUS ROADMAP PLANNING

When developing recommendations for the implementation phases of Transjakarta e-buses, including the bus types, several factors were taken into consideration. These factors include the readiness of fleet and charging technology, the feasibility of providing charging infrastructure, the electrification target set by Transjakarta, the quota of fleets in 2030 determined by The Jakarta Transport Agency, the expected completion dates of current contracts, and the projected number of fleets up to 2030. With this target, The Government of Jakarta needs to stop procuring non-battery e-buses for Transjakarta in 2024. An alternative implementation scenario was devised to expedite the deployment of e-buses that have the potential for lower a total cost of ownership per kilometer and maximize their benefits.

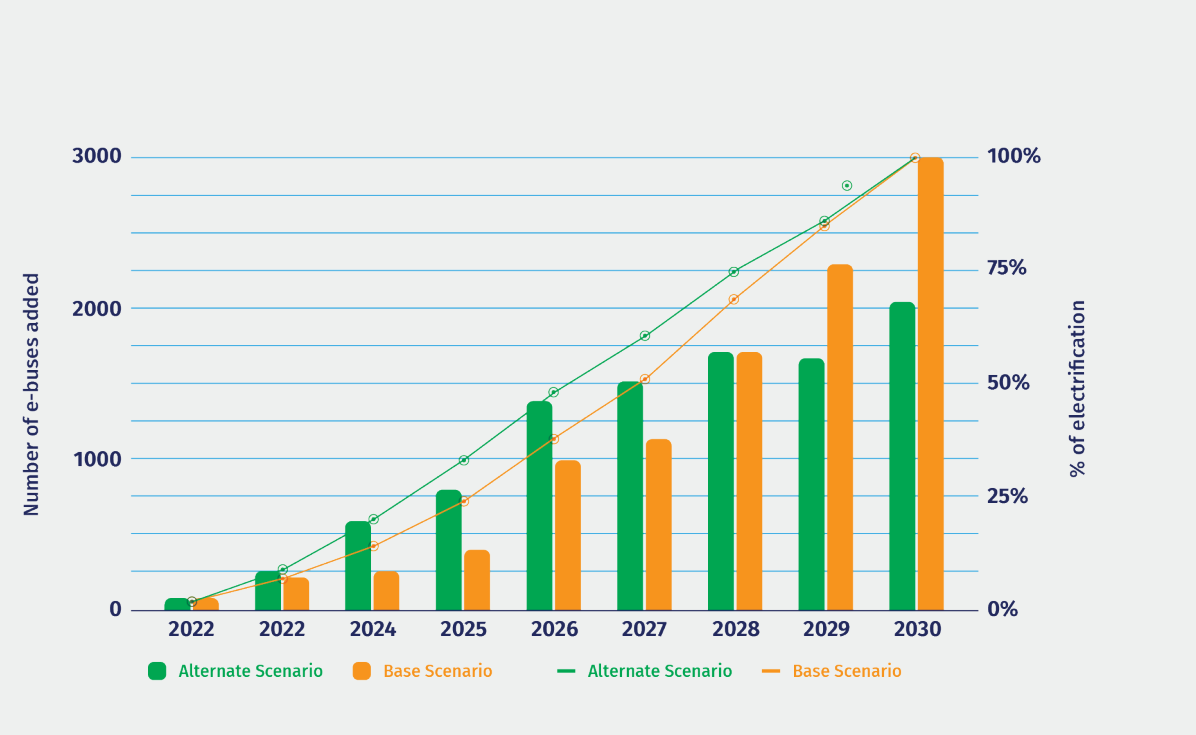


Figure 4. Recommendation for Yearly E-bus Deployment Target Recommendation for Transjakarta, First Phase of Implementation

Source: UK PACT. (2023). Business Case of Transjakarta's First Phase E-Bus Deployment: An Executive Summary.

A more thorough recommendation was made to develop a business case document for the first phase of Transjakarta's e-bus transition, which spans from 2023 to 2025. This timeframe takes into account the feasible amount of funds that can be raised through Limited Participation Mutual Funds/Reksa Dana Penyertaan Terbatas (RDPT) and consultations with various investment managers. It is estimated that these funds would be sufficient to support the acquisition of approximately 840 e-buses.

Several factors were considered when formulating recommendations for the routes to be included in the first phase of Transjakarta's implementation. These factors encompassed the route's total cost of ownership (TCO) per kilometer, the number of buses operating on the route, the visibility and usability of the fleet (taking into account potential emission-based traffic restriction areas), the charging strategy, and the potential for shared use of infrastructure. Additionally, the connection with terminal stations was also taken into account during the route selection process. As a result of the analysis, eight BRT routes, 15 non-BRT routes, and nine microbus routes are recommended to be electrified gradually between 2023 to 2025.

Several bus types, such as (1) 12-m single bus (high deck) 324 kWh; (2) 12-m low entry bus 324 kWh; (3) 18-m articulated bus 450 kWh; (4) 7-m medium bus 135 kWh; and (5) 4-m microbus 42 kWh, were recommended to be deployed for the first phase implementation, considering technology readiness as indicated by the market's wide availability of models, current fleet capacity and technical specifications, regulatory framework in particular concerning gross vehicle weight limit, and cost and efficiency of procurement, such as minimizing battery size customization to reduce costs and expedite the process.

In line with the suggested routes and fleet types, recommendations for the charging strategy and infrastructure locations were also formulated to minimize the number of dead kilometers traveled by the e-bus fleets and enhance the cost-effectiveness of their operations. Where certain electric fleets cannot rely solely on overnight charging at depots, it is advised to install opportunity charging infrastructure at various terminals. It is recommended to use plug-in chargers in the initial phase before 2025, followed by the introduction of pantograph chargers in 2025 to align with the planned introduction of electric articulated buses and the technology readiness.

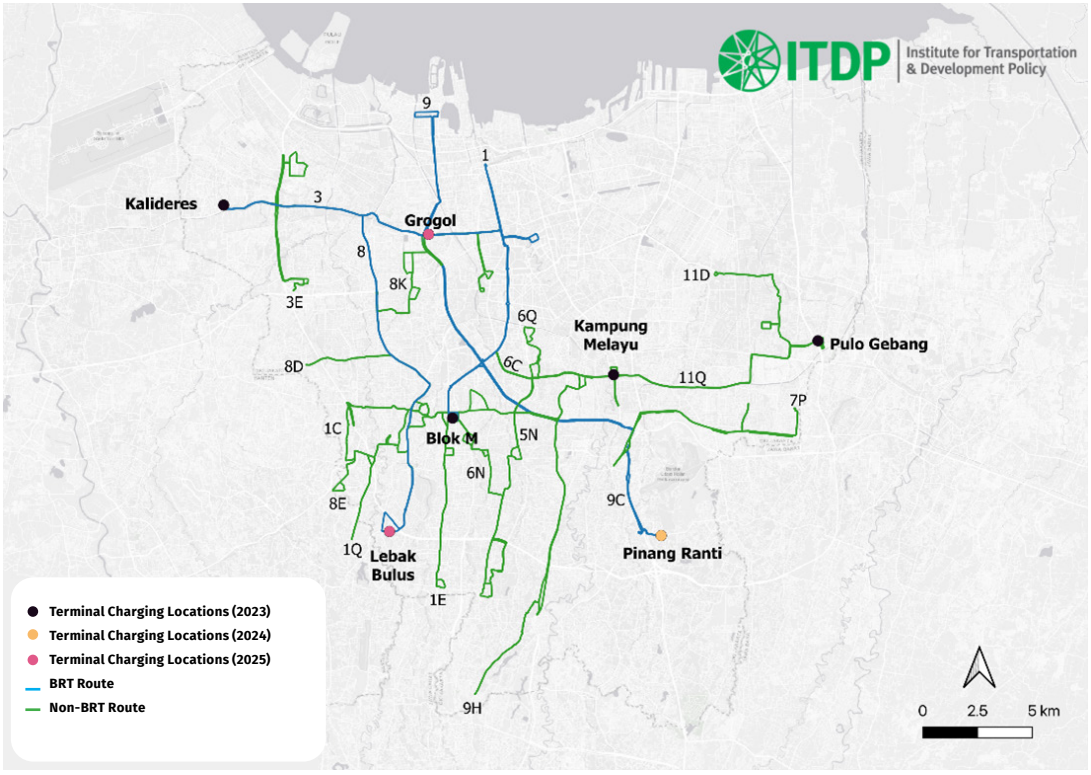


Figure 5. Recommendation for Opportunity Charging Location for Transjakarta's First Phase E-Bus Deployment

Source: UK PACT. (2023). Business Case of Transjakarta's First Phase E-Bus Deployment: An Executive Summary.

In addition to the technical recommendations, several key recommendations are proposed to support the transition process and overcome the remaining challenges.

1. Policy aspects

A strong regulatory framework is needed to provide a legal basis for Transjakarta to implement e-buses at a large scale, beyond the pilot implementation. A Governor of Jakarta Decree has been set to be an initial and practical regulatory basis for Transjakarta's large-scale electrification. Furthermore, the decree requires a strong regulatory framework in a higher hierarchy to ensure effective implementation.

2. Financing aspects

New financing solutions and partnerships are needed for fleet electrification. Asset ownership and operation should be separated and leasing arrangements with operators should be implemented to redistribute costs and risks. High upfront costs pose a barrier, and new financing models are necessary. Various financiers have shown interest, particularly in financing capital expenditures (CAPEX).

Reevaluate the total cost for operators and adjust the payment structure to reflect the higher capital cost of e-buses. Contract terms, financial calculations, and payment structures should also be reviewed to make them more attractive for operators.

Engaging stakeholders with lower financial capacity is crucial. Ensuring operators or cooperatives with lower financial or knowledge capacity are included in the electrification initiative. Collaboration with the Ministry of Finance for the lowest cost of funds and usage of a Limited Participation Mutual Fund (RDPT) as an alternative investment instrument are possibilities worth exploring. RDPT issuance can be a viable financing option, collaborating with an investment manager to raise capital for electrification, mirroring successful cases like that of the clean water investment.

Exploration of funding schemes are needed to identify the optimum cost of funds. In the study, nine schemes are explored and categorized based on sources of funds, government guarantee letter (GGL) requirements, and other investment instruments. Two-step loans from Export Credit Agencies or development financing institutions provide the lowest cost of funds but require GGL.

3. Operational planning and preparation

Charging infrastructure optimization is essential for competitive TCO. Charging facilities at terminals for opportunity charging make e-bus TCO competitive. Exploring lighter and higher-range medium bus models could also help optimize costs.

Provide more support to e-bus operators. Operators require guidance and support from Transjakarta and The Jakarta Transportation Authority to improve operational efficiency. Assistance is needed in areas such as technology knowledge transfer, coordinating with the energy sector on grid connection and electricity tariffs, and resolving charging infrastructure issues, which were found to be the major reasons for the long delays during the pilot project operation. Establishing an operational task force consisting of relevant stakeholders is also recommended to address problems and discuss vehicle performance and charging-related issues.

4. Monitoring and evaluation

Incorporate detailed data collecting and sharing mechanism. Establish a data-sharing mechanism between Transjakarta, operators, and OEMs to understand real-world e-bus performance and optimize the operational plan. Clearly define data types, frequency of collection and sharing, verification processes, data analysis, and results sharing in the contract. Transjakarta should have full access to all data collected by operators and OEMs, regularly verifying its accuracy.

Upgrade the e-bus control center and build capacity on Intelligent Transportation System (ITS). Integrate e-buses with the Transjakarta control center for automatic data collection and real-time insights. Upgrade the control center to accommodate large-scale electrification and conduct thorough data analysis. Enhance staff training on e-bus repair, maintenance, and Integrated Transportation Management System (ITMS) specification to utilize collected data effectively.

Summarize experiences and lessons learned from the pilot project. Conduct monitoring and evaluation of e-bus pilot projects to gather valuable insights. Transjakarta should further document the pilot experience to incentivize other cities and contribute to the collective outcome of decarbonization in the country.

6.5 RECOMMENDED BUSINESS MODEL AND FINANCING STRATEGIES FOR TRANSJAKARTA ELECTRIC BUS ADOPTION

While battery electric buses have a higher acquisition cost compared to diesel buses, they are cheaper to operate and maintain, resulting in a lower total cost of operations than their diesel counterparts during its lifetime. A study by ITDP under UK PACT found that the TCO of single e-buses (12-m buses) cost 6% less to deploy than diesel buses. The TCO for electric articulated buses is similar to diesel buses and can be optimized further. Interestingly, the TCO of electric microbuses is already 25% lower than comparable petrol buses. Comparing the lifespan, efficiency, environmental impacts and costs of conventional buses and e-buses, it can be seen that e-buses cost less in the long run.

	Buy The Service (BaU model)	Concessional model	Fleet leasing	Fleet and depot leasing
Business model description	Transjakarta contracts bus operators who own electric fleets to operate and maintain buses	Transjakarta as an electric fleet owner contracts bus operators to operate buses and OEMs to maintain buses	Transjakarta leases electric fleets from bus lessors and contracts bus operators to operate the buses. The bus lessor is responsible for fleet maintenance	Transjakarta contracts bus operators to operate buses. Bus operators lease electric fleets from bus lessors who also provide depot charging facilities and fleet maintenance
Applicable for	Large bus, medium bus, microbus	Large bus, medium bus	Large bus, medium bus	Microbus
Asset ownership				
E-bus fleet	Bus operator	Transjakarta	Bus lessor	Bus lessor
Overnight/ depot charging infrastructure	Bus operator	Bus operator	Bus operator	Bus lessor
Terminal charging infrastructure	Charging service provider	Charging service provider	Charging service provider	Charging service provider
Operational responsibility				
Fleet operations	Bus operator	Bus operator	Bus operator	Bus operator
Fleet maintenance	Bus operator	OEM/APM	Bus lessor	Bus lessor

Table 7. Business Model Options

Source: UK PACT. (2023). Business Case of Transjakarta's First Phase E-Bus Deployment.

ITDP recommends using different business models for large/medium buses and microbuses for Transjakarta, as the operations of the two bus types are significantly different. For instance, microbuses do not have a depot to locate the charging infrastructure and individuals under cooperatives also operate them.

Further, the study assessed the four options above to investigate the most financially attractive business and financing model for Transjakarta's first phase of bus electrification. The concessional model is still the most favorable financially, followed by a combination of business models based on bus types. To optimize the financial and implementation feasibility, combinations of business models and sources of financing as presented are recommended.

		Option 1	Option 2	Option 3	Option 4
		Buy The Service (BaU model)	Concessional model	Fleet leasing[2]	Combination of scenarios
Business model	**Fleet ownership**	Bus operator	Transjakarta	Bus lessor	**Single bus, low entry bus, medium bus: Buy The Service model Articulated bus: Concessional model Microbus: Fleet leasing**
	Fleet operations	Bus operator	Bus operator	Bus operator	
	Fleet maintenance	Bus operator	OEM/APM	Bus lessor	
Source of financing		Equity from investors and debt from local commercial banks	Equity from the Government of Jakarta and debt from PT SMI, commercial banks, financial instruments	Equity from investors and debt from financial instruments	
WACC[3]		10% p.a.	7.15% p.a.	10.54% p.a.	**Varies**
ΔNPV with BaU (ICE fleet) scenario, as % of BaU (ICE fleet) NPV		9.2%	17.9%	12.5%	16.9%
Remarks		Regulatory and institutional mechanisms already exist	Most financially attractive from NPV standpoint	Most implementable (least capital cost from operators and Transjakarta)	Optimizes financial and implementation feasibility

Table 8. Assessment of Business and Financial Model Options

Source: UK PACT. (2023). Business Case of Transjakarta's First Phase E-Bus Deployment.

Moreover, ITDP developed various alternatives of fund channeling schemes to improve financing access and address financing challenges. These schemes are designed to be replicable, scalable, flexible, and attract various private investors—and are still lower than the interest rate in the market. The assessment of fund channeling alternatives are presented on Table 9.

Source of fund / financing	Scheme	Description	Government Guarantee Letter	Special Purpose Vehicle	Other investment/ financing instruments	
Public sector	A-1	PT SMI provides regional loans to The Government of Jakarta	✗	✓	✗	
	A-2	The combination of regional loans and financing products issued by PT SMI	✗	✓	✓	
	A-3	Development Financial Institutions (DFIs) or Export Credit Agencies (ECAs) Loan to Government (2-step Loan)	✓	✓	✗	
Private Sector	B-1	Loans from local and foreign commercial banks, including Exporting Credit Agencies (ECAs)/Development Financing Institutions (DFIs)	✗	✗	✗	
	B-1A	Loan from commercial foreign banks to Private Sectors – Business as Usual (BaU)	✗	✗	✗	
	B-2	Bond as investment instrumen to raise capital	✗	✓	✓	
	B-2, Alt 1	Utilizes Limited Participation Mutual Funds (Reksa Dana Penyertaan Terbatas, "RDPT") as the investment instrument, SPV as the asset owner	✗	✓	✓	
	B-2, Alt 2	Utilizes RDPT, finance lease to operators	✗	✓	✓	
	B-2, Alt 3	Utilizes RDPT, leverage lease agreement between SPV and leasing company	✗	✓	✓	

Table 9. Fund Channeling Schemes Assessment

Source: UK PACT. (2023). Business Case of Transjakarta's First Phase E-Bus Deployment.

	WACC Simulation Result[6]	Pros	Cons
	7.21%	PT SMI has managed the GoJ's loan portfolio, so that the government has gone through the Know-Your-Customer (KYC) process by PT SMI. The tenure of municipality loans can be longer (up to 20 years) compared to market loans from the private sector.	Transjakarta must request the GoJ to issue the Regional Loan. GoJ must also have commitment for this scheme to work, e.g. issuing a regional regulation (Peraturan daerah or "Perda") which needs to be issued and approval from the Regional People's Representative Council (DPRD).
	7.39%	PT SMI has collaborated with several Development Financial Institutions (DFIs), such as Asian Development Bank (ADB) and World Bank (WB).	Compared to Scheme A-1, the structured financing is more complex because of the need for issuance of other financing instruments.
	6.86%	Tenure of sovereign loan can be longer than 10 years. An ECA has sent an Expression of Interest (EoI) Letter to Transjakarta.	ECA-UKEF requires a GGL from the Ministry of Finance. Full financial risk to the public sector.
	10.08%	The risk will be fully borne by private sectors.	Might need higher Government financial support or subsidies to increase the level of confidence of the private sector.
	10.18%	The role of the main actors will be optimized without changing the roles that have been carried out so far.	Zero mitigation on current financial barrier, high upfront cost, relatively has lower flexibility.
	11.32%	Provide an alternative to involve private sectors to raise capital without using commercial loans from banks.	Rating a company (potentially the SPV) is needed. Will be time consuming.
	9.89%	Opportunity of collaboration between Fund Managers and Transjakarta (SOE – ROE synergy) that may increase the level of confidence as well as simplicity of the process	The scheme is quite complex and involves a lot of players.
	10.03%	SPV as the asset owner has a strategic alliance agreement with leasing companies (2-step) who have financial lease agreements with bus operators.	The 2-step process that must comply with strict OJK Regulation adds to additional process and time to implement.
	10.54%	Bus operators have financial lease agreement (lease to own) to own the assets, which will be maintained/utilized properly.	

6.6 MOVING BEYOND JAKARTA: ELECTRIC BUS IMPLEMENTATION PLANS FOR BANDUNG AND MEDAN

Bandung and Medan have the highest peak-hour congestion outside the Greater Jakarta area, according to a recent big-data diagnostic by the World Bank in 38 Indonesian cities. The adoption of e-mobility for mass transit fleets in these cities can present a great potential to address this issue, as well as reduce local pollution, meet climate change goals, and create new opportunities for green financing. The German Agency for International Cooperation (GIZ) and PT SMI have conducted feasibility studies on the BRT system in Bandung Basin Metropolitan Area (BBMA) and Medan Metropolitan Area (Mebidangro), respectively. The findings from these two studies were subsequently updated by the World Bank and serve as the foundation for the analysis of the electrification of the BRT systems in these two cities that has been done by ITDP.

In general, the planning approach for BRT electrification in Mebidangro and BBMA has to consider various factors such as fiscal capacity, grid infrastructure, bus operator experience, and environmental benefits. Considering these factors, and as it is a new BRT in these metropolitan cities, the study recommends partial implementation, emphasizes the use of renewable-based electricity, and proposes the service payment with ROE as a business model to support BRT electrification in both areas. The study also finds that the current grid capacity in both cities was sufficient to accommodate the power demand from full electrification, indicating no major impediments to implementing electrification.

The partial implementation scenario is recommended to reduce capital expenditure and allow for adaptation to the new e-bus technology. This approach would also enable the operator to address any potential issues with e-buses by using diesel buses as backups in the BRT system. The fiscal capacity of the local government also plays a crucial role in determining the implementation phase. West Java had a higher fiscal capacity and could support full electrification for BBMA BRT. However, Mebidangro had limited fiscal space, making the partial electrification scenario with fiscal support like the Viability Gap Funding (VGF) a preferable option.

To support BRT electrification in Mebidangro, BBMA, and other Indonesian cities, the study also recommends the use of renewable-based electricity to power the e-bus operation, maximizing the potential environmental co-benefits. It also suggests a competitive electricity pricing scheme and a unified grid connection contract for e-bus charging to ensure affordability and efficiency.

The study proposes four business models for deploying e-buses, with the service payment with Regional Owned Enterprise (ROE) model identified as the most viable option for both cities, allowing for a longer concession period and attracting private sector investment. By using this model, the contract period of the e-BRT system can be up to 10 years, similar to Transjakarta, where they can have a contract concession with an operator for up to 10 years based on the Governor of DKI Jakarta Regulation 74/2021. The ROE also has flexibility on funding, particularly if a longer financed period from lenders/financiers is desired. In this model, the operator will be responsible for operations and maintenance (O&M) services. However, when the operator carries out the O&M services, the ROE should provide a standard to maintain both service quality and safety. The ROE will also be responsible for the asset risk, deciding whether they need to scrap or resell the bus at the end of the contract period.

KEY TAKEAWAYS

Transjakarta has been conducting a pilot project for the electrification of bus. Pre-trial for e-buses from September to December 2019 used two BYD buses (a 12m single bus with 324 kWh battery capacity and a 7-m bus with 135 kWh battery capacity, and one Mobil Anak Bangsa (MAB) bus (a 12 m single bus). It was then followed by a three-month pre-trial from July to October 2020 for a single bus (BYD's K9 model) and a medium bus (BYD's C6 model). Between 2021-2022, Transjakarta continued conducting pre-trials for various e-bus models from four manufacturers, including a high-deck e-bus model for the BRT service, from Mobil Anak Bangsa.

E-bus pilot project faced significant challenges. The capital cost of procuring e-buses is more than double that of internal combustion engine (ICE) buses, making it less appealing for operators. Strong policies and regulations for e-buses must also be present to provide a sound legal basis for Transjakarta's large-scale e-bus deployment. Moreover, operational challenges range from technical capacity gaps and charging infrastructure provision issues. And lastly, the pilot project lacks data and sharing mechanisms, data verification and analysis, and data integration.

ITDP proposed technical recommendations for Transjakarta's first phase of e-bus deployment, including eight BRT routes, 15 non-BRT routes, and nine microbus routes, which are recommended to be electrified gradually between 2023 and 2025. Several bus types, such as (1) 12-m single bus (high deck) 324 kWh; (2) 12-m low entry bus 324 kWh; (3) 18-m articulated bus 450 kWh; (4) 7-m medium bus 135 kWh; and (5) 4-m microbus 42 kWh, were recommended to be deployed for the first phase implementation.

Recommendations for the charging strategy and infrastructure locations were also formulated to minimize the number of dead kilometers traveled by the e-bus fleets and enhance the cost-effectiveness of their operations. It is advised to install opportunity charging infrastructure at various terminals. It is also recommended to use plug-in chargers in the initial phase before 2025, followed by the introduction of pantograph chargers in 2025 to align with the planned introduction of electric articulated buses and the technology readiness.

Providing a strong regulatory framework in a higher hierarchy to ensure effective implementation, new financing solutions and partnerships, as well as conducting monitoring and evaluating e-bus pilot projects to gather valuable insights are proposed to support the transition process and overcome the remaining challenges.

A partial implementation (mixed conventional and e-buses) in Mebidangro and BBMA is recommended as an initial step to reduce capital expenditure and allow for adaptation to the new e-bus technology. The fiscal capacity of the local government also plays a crucial role in determining the implementation phase. West Java had a higher fiscal capacity and could support full electrification for BBMA BRT. However, Mebidangro had limited fiscal space, making the partial electrification scenario with fiscal support like the Viability Gap Funding (VGF) a preferable option.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7 Boosting Gender, Equality, Disability and Social Inclusion on Electric Bus

7.1 TRANSPORT AND PUBLIC SERVICES REGULATIONS AND POLICIES FROM A GENDER EQUALITY, DISABILITY, AND SOCIAL INCLUSION (GEDSI) PERSPECTIVE

The public transportation system can greatly enhance equality for women and other vulnerable groups. By increasing their mobility, women and other vulnerable groups can gain more work opportunities and access health care, markets, banks, and others. In short, public transportation helps minority groups exercise independence. Based on a field survey by ITDP, the majority of public transportation users in Jakarta are women and other vulnerable groups. For the microbus, 64.88% of passengers on 49 routes were women. Five routes have as much as 80% women. They are the elderly, women holding children, women holding goods, and children.

The Government of Indonesia has committed to gender equality and social inclusion. The country has ratified international conventions, such as the UN Convention on the Elimination of All Forms of Discrimination Against Women and the UN Convention on the Rights of Persons with Disabilities. Furthermore, it acknowledges the role of gender equality and sustainable progress as a driver for national growth, as seen through Presidential Regulation No. 18/2020 on the National Mid-Term Development Plan 2020–2024, which highlights six forms of mainstreaming, including gender equality.

For people with disabilities, Indonesia has enacted laws to protect this group. The Disability Law 8/2016 defines disabled people as those with mental and/or physical deficiencies. It also includes their rights, including accessibility to public facilities and reasonable accommodation.

For women, the Government of Indonesia has enacted regulations emphasizing gender mainstreaming at the regional level, aiming to integrate gender equality into governance, development programs, and public services, such as:

Rules that emphasize gender mainstreaming

Ministry of Transportation Regulation 98/2017 requires accessible facilities and assistance for people with special needs in public transport.

Ministry of Public Works and Public Housing Regulation 14/2017 emphasizes universal design principles for inclusive infrastructure.

There are also regional-level policies in Jakarta, as follows:

Jakarta Regional Regulation 5/2014 aims to create inclusive transportation infrastructure. However, the definition of "disability-friendly" stations is limited to direct access, ramped bridges, and crossing facilities. There are no clear criteria to determine what constitutes a truly "disability-friendly" station. Transjakarta introduced Transcare in 2016 to assist persons with disabilities, but accessibility remains an issue, leading to ongoing discussions and debates.

Governor Regulation No.13 of 2019 sets service standards and promotes cashless payments and inclusive provisions on buses.

Transjakarta bus service offers free rides to various groups, as Governor Regulation No. 160 of 2016 outlines.

Transjakarta has women-only areas inside its fleets, and KRL Commuter has women-only passenger cars for its trainsets. The modes also have had Minimum Service Standards focusing on six aspects: security, safety, convenience, affordability, equality, and regularity.

Electrification of public transport can enhance transportation systems that benefit persons with disabilities, people with limited mobility, such as older people, and children.

7.2 PLANNING A JUST AND INCLUSIVE TRANSITION

Inclusive policies for e-bus operations involve considering the needs of two main groups: e-bus operators and e-bus users. It is important to address the perspectives of both the service provider and the passengers to ensure accessibility and inclusivity.

Inclusive electric bus deployment: electric bus operators' point of view

Supporting existing diesel-based bus operators and their staff in transitioning to e-buses is crucial to ensure a smooth electrification process. Excluding them from the plan could lead to manpower issues. Operators have raised concerns regarding e-bus contract payment calculations, contract designs, and safety measures, and neglecting their perspectives may have negative consequences for society.

A study conducted by ITDP, supported by TUMI, evaluated the pilot phase of Transjakarta's e-bus implementation. It highlighted the underrepresentation of female drivers and technicians, as well as the skills and knowledge gap. Based on the study, only 3 out of 67 e-bus drivers were female and zero female e-bus technicians. To bridge the knowledge gap, comprehensive training programs are needed for existing operators and staff, including drivers (especially women drivers) and technicians. Training should cover operation, maintenance, and handling of potential failures. Updated operational procedures, agreements, and standards should accompany the transition process.

By addressing these issues and considering Gender Equality, Disability, and Social Inclusion (GEDSI) perspectives, the electrification process can be more inclusive, reducing social exclusion and providing opportunities for vulnerable groups to participate.

Inclusive electric bus deployment: passengers' point of view

First and foremost: vulnerable groups have diverse needs and demands that should not be oversimplified. For instance, priority seating on e-buses benefits some groups such as the elderly but not others, such as wheelchair users. Accessibility obstacles observed in diesel buses remain in the current pilot e-buses of Transjakarta, highlighting the need for improvement.

The procurement of e-buses presents an opportunity for inclusive and accessible fleets. Features like automated ramps, additional space, and adjustable hand railings can enhance accessibility for the elderly and wheelchair users.

Inclusive public transportation should consider the entire journey, from bus stops to depots. Research on travel patterns and concentrated areas of vulnerable groups can inform planning. Unfortunately, current regulations and policies for e-bus operations focus mainly on priority seats, women-dedicated areas, and buses. Minimum Service Standards and disaggregated data on public transportation users need to be reconsidered and improved.

The lack of understanding to support vulnerable groups might stem from a core issue: the lack of disaggregated data. Disaggregated data is a key component in allowing policymakers to analyze the differences between how men versus women, for instance, use public transportation. This is important as women tend to have different travel patterns than men. For example, women travel more often to the markets than men. Having this information is crucial to allow policymakers to create practical, realistic, and just policies. Currently, the government doesn't have detailed information about the demographic of its public transportation users. Disaggregated data can categorize the use of public transportation based on gender, age, disability, and more.

Table 10. Example of GEDSI-related Data that are Needed and the Methodology

GEDSI-related Data	Methodology
Women and vulnerable groups' participation in Transjakarta internal company. GEDSI-related components at proposed e-bus fleet design from Transjakarta.	Desk Review
Disaggregated gender and vulnerable groups data of Transjakarta users. The proportion of women and men in the Transjakarta overlay locations.	Boarding-Alighting Survey
Inputs about universal fleet design and passenger information systems from four vulnerable groups of Transjakarta users: people with disabilities (PwDs), children, women, and the elderly.	Focus Group Discussions In-depth interviews

Source: UK PACT. (2021). Building Capacity and Action Plan to Scale-up Transjakarta E-bus.

ITDP, working with Transjakarta under UK PACT, integrates Gender Impact Assessment (GIA) into the planning process to ensure equal access. GIA evaluates the impact of policies on gender equality, including the needs of children, the elderly, and people with disabilities. This assessment can guide future public transportation systems and be replicated in other cities. This 'master' document can be incorporated into other Final Business Case (FBC) documents for other cities to duplicate.

In general, GIA involves several steps:

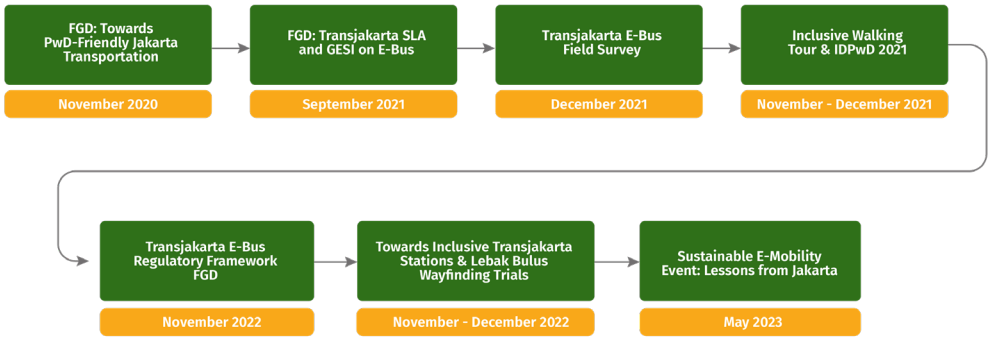
1. Portraits of the existing conditions on the facilities—in this case, all facilities related to Transjakarta electrification on the routes proposed as the first phase, such as the fleets model, the pedestrian and cycling facilities along the routes or corridors, accessibility at the terminus, etc.;
2. Analyze zero-alternative scenario;
3. Analyze the implication of the zero-alternative scenario;
4. Analyze prioritization of improvements needed;
5. Cross-sector analysis; and
6. Developing a gender action plan.

7.3 GENDER-AND DISABILITY-SENSITIVE DESIGN FOR ELECTRIC BUS FLEET AND INFRASTRUCTURE

With thousands of e-bus to be deployed in the next 5-7 years, a golden opportunity to reduce discrimination against vulnerable groups arises. ITDP has conducted an extensive FGD and interviews with passengers of various backgrounds, from people with disabilities, children, the elderly, and others. These activities were meant to gather valuable inputs based on their experiences traveling with the e-buses or any services running by Transjakarta.

Participatory Planning with Vulnerable Groups on E-Bus Deployment: Ensuring No One is Left Behind

ITDP has continuously collaborated with vulnerable groups, including women, children, the elderly, and people with disabilities to ensure their needs are accommodated since the planning process of e-bus deployment. The participatory planning process consisted of a series of focus group discussions and surveys. The participatory planning topic also covers aspects broader than e-bus, such as first-mile and last-mile audits and wayfinding trials at BRT stations, to ensure accessible transportation for all.



Fleet design

In the e-bus fleet, the entrance is a critical area that needs detailed attention. This is because it's the primary area for people in need, while at the same time, it is a high-traffic area where most people will enter or exit the bus. Thus, the space needs to consider multiple factors without undermining the safety and comfort aspects for vulnerable groups.

For instance, the front section of the e-bus should be empty of chairs to accommodate wheelchairs and baby strollers. Safety belts and handrails should be attached to the bus interior to keep the wheelchair and stroller from moving. This area should be easily accessed from the entrance with nothing obstructing the way. Ideally, each e-bus should be able to accommodate two wheelchairs. This way, the e-bus will be less likely to deny a wheelchair passenger entry if the only wheelchair area is taken. Allowing more space around the entrance for people in need will greatly add to their comfort and confidence in traveling solo.

Furthermore, all stop and emergency buttons should have Braille for blind people to read. With Braille on stop buttons, blind people with visual impairment can identify the button and finally press them when their destination approaches.

Information system

Public transportation is also dense with information from destination points, warning signs, dos and don'ts, and many others. All of this information should be provided in a way that is easy for everyone to read. If we take someone in a wheelchair as an example, that person probably won't be able to read the information above the window sills as other passengers might tower and block his/her view. Additionally, someone in a wheelchair is more likely to orient towards the side of the bus, not the front. Crucial information, such as the hotline number, should be easily read from these angles.

Everyone from any background should easily understand all information presented in an e-bus, or any other fleet for this matter. This is key to ensuring a safe space for people who are at-risk or first-timers of public transport. This is because passengers should fully understand and know their own whereabouts and where the bus is going. Otherwise, it can pose a danger to them.

Knowing how substantial this information is, it's important to convey it in a clear, concise, and easy-to-understand language, whether written, illustrated with pictures and/or icons, or audio. Passengers should understand the gist of the information quickly, especially during rush hour, when noise is at its peak and might obstruct clarity. This will increase the safety of women or vulnerable groups using public transport.

Accounting Vehicle Alerting System (AVAS)

Additionally, one pronounced difference between a diesel bus and an e-bus is that a diesel bus produces engine noise. With the typical roar of a bus, people will be more alerted of its presence. People with visual impairments are used to this audio notifier. However, the e-bus barely has any sound at all. Such silence can be dangerous for the visually-impaired community, people with earphones, or people roaming the streets because they are not aware of the abuse whereabouts. To resolve this issue, the e-bus must have additional noise installed in its infrastructure. An Accounting Vehicle Alerting System (AVAS) can generate sounds to improve the safety of road users.

Bus stops and depots

Enhancing safety and comfort in the public transportation system involves considering bus stops and depots as well. Long waiting times and nighttime travel can increase the risk of crime at bus stops. Assigning field officers to monitor safety and assist passengers, especially those with disabilities, also can improve security. Identifying busy or high-crime routes can help prioritize the deployment of field officers.

Bus stations should also provide dedicated rooms for breastfeeding mothers, equipped with comfortable seating, adequate lighting, tables, and locks. These amenities offer support to breastfeeding mothers.

Additionally, easily accessible hotlines should be available on buses, bus stops, and stations for emergency and non-emergency calls. These hotlines should be prominently marked for easy identification.

These example measures aim to prevent incidents and ensure the safety of vulnerable groups. It is crucial to analyze potential risks and their impact on each group, and e-bus operators should be prepared to promptly address and resolve such situations.

7.4 IMPLEMENTATION OF GEDSI PRINCIPLES FOR ELECTRIC BUS TRANSITION AT THE DECISION-MAKING LEVEL

GEDSI mainstreaming is an effort to include gender equality and social inclusions in all verticals and programs. However, this goal will remain astronomical if it doesn't involve related stakeholders at policy-level discussions.

During the desk research period of the study, ITDP found that all of the decision-makers at Transjakarta (director level) are men. Its staff comprises 15% female and 85% male. Transjakarta drivers are also dominated by men (97%). Adding more diversity to this mix can increase the chances for the vulnerable groups' interests to be heard. ITDP will continue to monitor and identify the stakeholders related to GEDSI mainstreaming, such as the Working Group of GEDSI Mainstreaming (to address the inclusivity aspects of public transport and electrification.

Additionally, ITDP recommends a dedicated budget for implementing the gender mainstreaming process in all stakeholders, including the Ministry of Transportation and Transjakarta. Currently, few ministries in the national government have incorporated a gender budgeting program in their budget to close the gender gap, despite the existence of a Gender Responsive Planning and Budgeting (GRPB) that was launched in 2012. This initiative was issued by four ministries: the Ministry of Finance, the Ministry of Women Empowerment and Child Protection, the Ministry of Home Affairs, and the Ministry of National Development.

Using the Gender Analysis Pathway, government agencies can analyze existing gender gaps and use allocated funds to address the gap. Krishna, a mobile app based on the Ministry of Finance, is an effort to monitor the budget implementation progress evaluated by the Ministry of Women Empowerment and Child Protection. Through these initiatives, GEDSI mainstreaming can materialize.

KEY TAKEAWAYS

Electrification of public transport can foster inclusivity by involving vulnerable groups in providing services. This includes engaging existing operators and training staff to handle e-bus operations and technical issues.

To further enhance inclusivity, e-bus design should be improved, considering the specific needs of women and other vulnerable groups.

Bus depots and stations should also be safe and comfortable spaces for these groups.

Comprehensive surveys and focus groups are necessary to understand their specific requirements.

Policymakers must prioritize the diverse needs of vulnerable groups and establish regulations and policies that align with the goals of public transport electrification.

8 Driving Transition and Enabling Electric Bus Adoption in Indonesia

The Indonesian government's interest in jumpstarting the EV industry was made public years ago. Several targets and commitments for e-bus adoption, as highlighted in Section 2.3, have been made on the national and local levels.

However, commitment is not a plan. Indonesia still has a lot of work to do, from planning to strategizing. Addressing challenges related to the planning, implementation, and financing of e-buses would require a collaborative effort among various stakeholders, including the government, the private sector, and the public. The collaboration is crucial so that Indonesia does not have policies that contradict each other, and the transition to go full electric can benefit everyone, not leaving any parties behind.

8.1 THE STAGES OF ELECTRIC BUS ADOPTION: POLICY-BASED AND IMPLEMENTATION-BASED ACTIONS

To fully transition to e-buses, effective policies need to be implemented over time. Coordination among ministries is crucial for achieving net-zero emissions by 2060 and eliminating contradictory policies. For instance, subsidies for diesel should be phased out to support e-bus deployment, and the government should develop a comprehensive strategy for electric public transportation, involving key stakeholders such as local manufacturers and bus operators. A binding commitment among different agencies can accelerate e-bus deployment and overall EV adoption.

Additional fiscal and non-fiscal incentives should be introduced, particularly to address the financial challenges faced by bus operators. Governments should also encourage the establishment of reliable and affordable e-bus implementation and charging infrastructure through partnerships with stakeholders. The private sector should be incentivized to participate in the development of the e-bus ecosystem.

Below is the policy recommendation summary for supporting e-buses in Indonesia.

1. Issue a national e-bus adoption and infrastructure development roadmap, including mandates for e-bus fleet adoption.

Stakeholders: Coordinating Ministry for Maritime Affairs and Investment (CMMAI), Ministry of Transportation (MoT), Ministry of Energy and Mineral Resources (MEMR), Ministry of Home Affairs (MoHA), and local governments.

Albeit having a 90% e-bus deployment target in urban areas by 2030, the Government of Indonesia does not yet have a roadmap to achieve it. The roadmap should include clear plans of time-bound implementation phases and supporting policy packages to both create demand and boost the domestic e-bus industry. The roadmap should also be tied to GHG reduction objectives.

The introduction of mandates stating that new purchases for public transportation fleets should include e-buses will contribute to the uptake of e-buses and ensure better planning regarding infrastructure maintenance and expansions. Even though the Ministry of Finance Decree No. 72/2020 has provided flexibility in allowing higher procurement prices for electric vehicles for government fleets, no mandate details the timeline or yearly rate of adoption of e-bus procurement. Mandates would also give a strong signal to manufacturers of the growing market for e-buses in the country, thus securing the supply for fleet deployments.

2. Develop a strong fiscal and non-fiscal incentive package.

Stakeholders: CMMAI, MoF, MoT, MoHA, local governments, PLN.

Purchase price and/or operational cost subsidy for e-buses.

To kickstart EV uptake, tax relaxations are sometimes not enough. In the case of public transit buses, the direct incentive can be implemented through the BTS program, which would cover a portion of the capital costs of e-buses in addition to the existing operating subsidies provided. Eligibility requirements for the subsidy should be established to promote equitable adoption and benefit a wide range of users, rather than only a few affluent individuals. The direct incentive can be gradually reduced and ultimately eliminated over time when the market has matured. The source of funding can be, for instance, earmarked from the upcoming carbon tax revenue streams, or from international financing and grants.

Tax reduction for both fleet and charging providers and bus industry players.

Support should also be provided for charging infrastructure providers and bus manufacturers, such as preferential loan offers, tax holidays, import duty exemptions, and land/building tax exemptions.

Other fiscal incentives to ensure the long-term involvement of the private sector and financial security in sustaining electrification.

For instance, land investment by the government to address the issue of land scarcity in urban areas and assurance of the lowest possible electricity tariff for e-bus operations, in particular during periods when demand is lower.

Non-fiscal incentives.

Such as prioritizing e-buses in public transport services tendering and enactment of low emission zones.

3. Supporting policies for business model innovations, including fleet and charging infrastructure provisions.

Stakeholders: MoF, MoT, MEMR, local governments.

For instance, allowing asset ownership-operation unbundling in public transport service provision and longer contract terms for e-buses to provide greater security for investors. Indonesia is suggested to extend public transport service provision contracts from 3 to at least 10 years to account for an even distribution of cost across the lifespan of the vehicle. A longer contract period, aligned with e-bus operational years of a minimum of 14 years, is even more preferable.

4. Establish a green procurement scheme for e-buses.

Stakeholders: MoF, Ministry of State-Owned Enterprise (MSOE), Ministry of Environment and Forestry (MoEF), the Financial Services Authority ("OJK").

Green procurements are still not common practice in Indonesia. Government-owned financial institution initiatives, such as from conventional banks and infrastructure financing institutions and insurance companies, can provide financing and offer insurance schemes for the expensive and nascent e-buses to enable procurement of e-buses.

5. Improving public stakeholder coordination.

Stakeholders: MoT, MoHA, local governments.

Set up a Public Transport Electrification Committee at national and city levels that would focus on coordinating actions at the national and subnational levels for e-bus acceleration. Their roles include designing policy recommendations that could be quickly reviewed and adopted at both national and provincial levels, developing a roadmap and overseeing e-bus uptake progression, identifying knowledge gaps amongst authorities and regulators, and suggesting capacity-building activities. City-level task forces should be established to enable local governments to implement their own actions, starting with pilot cities.

6. Disincentivize conventional vehicles.

Stakeholders: MoT, MoEF, local governments.

Diesel bus operations still benefit from the subsidized diesel fuel price, and the emission standard in Indonesia is still quite lax at EURO IV. Establishing low or zero-emission zones, which prohibit entry of polluting vehicles, can also be introduced to incentivize e-buses and other EVs in general.

7. Streamline technical regulations.

Stakeholders: CMMAI, Ministry of Public Works and Housing (MPWH), MoI, Ministry of Trade (MOTr), MoT, local governments.

Several technical regulations need updating to accommodate the adoption of new technologies. This includes increasing the gross vehicle weight limit, permitting the installation of charging infrastructure in government-owned facilities and public transit hubs, and updating building codes to allocate sufficient space for charging infrastructure, particularly in city centers. There should also be a consideration for the technical standardization of technologies to ensure the longevity of the e-buses and their facilities, as well as enable the economy of scale, including standardizing charging connectors.

8. Ensure stable grid connections and integrate renewable energy sources.

Stakeholders: MEMR, PLN.

Unstable grid issues are even more important in cities outside Java and Bali area, which often experience power cuts. Renewable energy sources should be integrated to reduce reliance on the primary grid and to optimize carbon reduction, by encouraging further usage of rooftop solar panels at charging stations, bus stops, and depots through incentive policies.

9. Mandate li-ion battery recycling.

Stakeholders: MoEF, MoT.

Policies on battery recycling, particularly for used lithium batteries, need to be issued to address environmental concerns and secure lithium sources.

10. Support e-bus industry research and development.

Stakeholders: MoI, MoF.

To increase EV model options, reduce production costs, and achieve national industry objectives, the government should implement policies targeting and supporting the research and development of the e-bus industry.

In addition to preparing the policy and regulatory framework in support of the e-bus transition, several actions below should also be pursued by the public sector:

1. **Facilitate collaboration between public and private sectors.** To encourage private sector participation, other government support in addition to financial incentives can be provided. For example, authorizing the installation of charging stations in government-owned facilities such as government buildings, commercial centers, transit hubs, or public spaces.

2. **Facilitate the implementation of innovative business models and unlock new financing schemes.** Local governments can mandate or suggest their transit authorities to unbundle contracts for procuring e-bus fleets, building depots, and charging infrastructures to distribute the high capital investments and risks. Other measures should also be taken to unlock new financing schemes. For instance, the Ministry of Finance needs to issue a Government Guarantee Letter to enable certain financing schemes or establish an SPV as an e-bus asset owner to support unbundled business models.

3. **Conduct capacity-building programs for local governments and bus operators.** Capacity-building programs for local governments and transit operators to help them learn about the benefits of e-buses, operations, and planning for the transition from conventional buses should be constant and consistent. Incentives such as reimbursement for employee or staff training can offer transit institutions to improve the capacity of their resources to plan, operate, and maintain e-bus fleets.

8.2 A HOLISTIC PLANNING APPROACH: LIFE-CYCLE ANALYSIS

To ensure the commercial viability and operational sustainability of the e-bus ecosystem, a comprehensive analysis is needed, considering factors such as operational expenses, maintenance, capital investment, and suitable battery technology. This holistic approach is crucial for a successful electric transition.

Although e-buses are currently more expensive than conventional diesel buses, it is important to recognize the potential long-term savings in operational costs. The high upfront cost, largely driven by the battery expense, has been a barrier for many bus operators to adopt e-buses on a larger scale. However, the potential cost reductions over time are often overlooked when considering the overall value and benefits of e-buses. One way to summarize the analysis is through a life-cycle cost analysis that includes direct and indirect costs over the lifetime of e-buses.

Benchmarking battery technologies

As stated previously, batteries account for a significant amount out of the total cost. This makes choosing the right battery extremely crucial. Batteries have varying chemistry, energy density, weight, and price. Each battery type will determine the bus range and energy efficiency, which governs the bus scheduling and route selection. Understanding the interplay between the right technology and operational needs is the first thing to consider before deploying e-buses in the city.

Identifying operational characteristics

Analyzing factors such as route length, timetable, number of stops, and passenger ridership can assist in determining the optimal placement of charging locations within the charging infrastructure network. This information is valuable for e-bus operators, transport authorities, or Public Transport Authorities (PTAs) when selecting the appropriate technology and battery capacity.

Operational analysis

A key question to ask is the charging system for e-bus operations. Charging can be conducted at depots during non-operational hours or en-route, during stopovers, if charging facilities are available. A depot can have a mix of slow charging, fast charging, or flash charging, and battery swapping technology. Currently, many types of charging models are available in the market, depending on the charging power, interfaces, and manufacturers. The right charging infrastructure also depends upon the bus technology and other operational requirements, like time available for charging, power supply to the charging locations, battery size and range for daily operations, etc.

Infrastructure planning

Large-scale deployment of e-buses and their charging will create an excess load on the power grid. Therefore, designing the e-bus ecosystem should take into account the available power grid in every area. A cost optimization methodology should be adopted to use the charging stations and balance the grid load effectively. Additionally, depot planning, and the location of the depots are crucial for a smooth implementation of the e-bus system.

Life cycle cost analysis

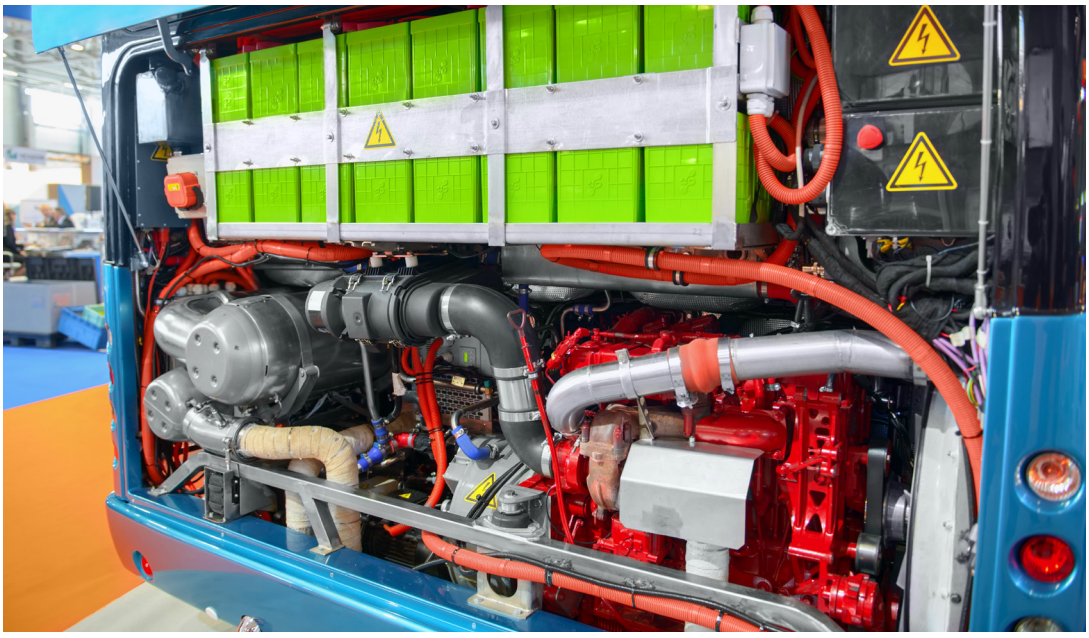
After all the above expenses are considered, the life-cycle cost can be analyzed, and further review the maintenance aspect, including the recycling stage of each battery. Steps 1-4 are all iterative and can greatly impact the financial costs. Once the financial implications are fully understood from every perspective, the procurement and contracting process can be conducted.

Monitoring and evaluation

The repair and maintenance of e-buses demand distinct skills compared to those required for conventional buses. To ensure optimal performance, maintenance practices and a monitoring and evaluation framework for e-bus performance should be established to inform any necessary adjustments to the operational plan. Measuring battery health is a complex task, but having a plan in place to track and assess it can help estimate expected degradation, detect anomalies, manage warranty claims, and plan for future service requirements.

Recycling and reuse of battery

To establish a sustainable ecosystem for EV batteries and ensure a resource-efficient transition to e-buses, it is crucial to develop a comprehensive circular economy strategy for EV batteries that prioritizes reuse, repurposing, and end-of-life recycling. This requires strong policies, regulations, and standards for battery recycling, along with effective implementation guidelines. By recovering critical raw materials through recycling and urban mining, the dependence on imports for these materials in the future can be reduced. Moreover, adopting a circular economy approach can help improve the environmental footprint of Lithium-ion batteries used in EVs.



KEY TAKEAWAYS

The e-bus deployment demands significant overhauling of the public transportation system. From charging systems to financing strategies, all stakeholders need to consider the revamping effort from all points of view, especially the technical aspects.

A deep understanding of the technology available in the market, the cost, the advantages and disadvantages, and how it suits current and future demand is required. This technological aspect should be the foundation of the stakeholders' decision-making, especially regarding financing strategies.

The government should have supporting policies (not conflicting policies) that can accelerate the development of the e-bus ecosystem.

9 Charging Forward

Transitioning to e-buses for public transportation can bring substantial benefits, such as reducing greenhouse gas emissions, enhancing air quality, and promoting social inclusivity. Seeing these great benefits, countries like Germany, Chile, China, India, and Colombia, have electrified their public vehicles, specifically e-buses.

ITDP has conducted case studies of e-bus implementation in these countries. A common challenge encountered across the cities is the high capital costs of fleet procurement and establishing infrastructure for charging and services. Initial fleet procurement, charging infrastructure development costs, and obtaining the land needed to construct charging stations has been an issue for all cities. Thus, the lesson is that innovative business models must be explored to distribute costs and risks, and infrastructure planning has to be one of the priorities in the preparations for electrification, ensuring the sustainability of e-buses.

ITDP also found that the implementation of pilot projects and demonstrations are needed to study the systems and needs as well as identify possible bottlenecks. The testing and experimentation stage is important for collecting performance data, finalizing charging systems, exploring different routes, engaging with private company stakeholders and identifying the needs for training a new workforce.

To drive the urgency toward electric implementation, the central and regional governments have to formulate regulations and mandates for e-bus adoption, and provide fiscal and non-fiscal incentives at the national and local level, such as tax reduction or subsidies for bus procurement. Further down the line, the government can use a carbon tax or other investment instruments, such as bonds or Limited Participation Mutual Fund, to fund green initiatives.

The government can also encourage and enable business models that are innovative and sustainable, as well as profitable for both parties. Involvement of other private institutions, such as utility providers and bus lessor companies in e-bus transitions also can take the burden on the operator's and government's finances away while harnessing private sector expertise. Several other business model options have been benchmarked and recommended for e-bus adoptions worldwide, including battery leasing, bus leasing, financial lease arrangement, utility ownership of charging infrastructure, energy/transportation-as-a-service, outright purchase with existing funds or grants, and outright purchase with market or concessional loans. Longer contract periods are also needed to make e-bus implementation more attractive for bus operators.

In addition, the charging infrastructure also must be considered, by identifying the optimum location, grid networks and timelines. Depending on the route and operational characteristics, a typical charging scheme for e-bus deployment is 'overnight charging only' or 'a combination between overnight and opportunity charging'. For e-buses with lower range, establishing opportunity charging at route terminus is important. A study by ITDP and UK PACT shows a potential 20% TCO/km reduction for e-bus, supported by opportunity charging at terminals rather than only overnight charging at depots.

Moreover, it is also crucial for governments to establish inclusive regulations that take into account the needs of vulnerable groups during the transition to e-buses. This entails addressing accessibility concerns, ensuring affordability, and prioritizing the provision of reliable and efficient transportation services for disadvantaged communities. By actively involving and consulting with these groups, governments can design policies that promote equity and social inclusion, making the transition to e-buses a truly sustainable and beneficial endeavor for all members of society.

The inclusive regulation in Transjakarta and other bus operators is also crucial. Women's participation as employees and drivers in Transjakarta must be increased. Adding more diversity to this mix can increase the chances for the vulnerable groups' interests to be heard. Besides that, capacity building for Transjakarta employees and officers on interacting and assisting the elderly and other vulnerable groups with special needs is a must to increase Transjakarta's services.

Not only the passenger side, the transition to e-buses should also be inclusive from the bus operator's perspective. Establishing inclusive business models and financing schemes for small bus operators with lower financial capacity can ensure that no one is left behind in this public transport decarbonization effort.

The transition to e-bus as future transportation is no longer a distant dream but a rapidly unfolding reality. With a clear roadmap, fiscal and non-fiscal incentives, innovative business models, and technological advances, the shift towards a sustainable and decarbonized energy system is becoming more feasible and urgent than ever. The energy transition is not only necessary for addressing the global climate crisis but also offers opportunities for economic growth, job creation, and improved public health. By taking action today, we can create a cleaner, more sustainable, and more equitable future for all.

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