VIETNAM

Recommendations to the National Roadmap and Action Plan for the Electric Mobility Transition

Executive Version

ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK
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Australian Aid

Viet Nam: Recommendations to the National Roadmap and Action Plan for the Electric-Mobility Transition

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RECOMMENDATIONS TO THE NATIONAL ROADMAP AND ACTION PLAN FOR THE E-MOBILITY TRANSITION

Executive Version

Bowen Wang, Chiara Rogate

FINAL REPORT

November 2024

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Abbreviations

ADS	Accelerated Decarbonization Scenario
BAU	Business-as-Usual Scenario
BEB	Battery Electric Bus
BEV	Battery electric vehicle
BESS	Battery energy storage systems
BTM	Behind the Meter
CAGR	Compound annual growth rate
COP	United Nations Framework Convention on Climate Change Conference of Parties
CNG	Compressed Natural Gas
EVs	Electric Vehicles
E-Mobility	Electric Mobility
EVN	Vietnam Electricity
GDP	Gross domestic product
GoV	Government of Viet Nam
GHG	Greenhouse gas
GVW	Gross vehicle weight
HCMC	Ho Chi Minh City
ICE	Internal combustion engine
IEA	International Energy Agency
LCOE	Levelized Costs of Electricity
MoC	Ministry of Construction
MoF	Ministry of Finance
MoNRE	Ministry of Natural Resources & Environment
MoT	Ministry of Transport
MoPI	Ministry of Planning and Investment
MoIT	Ministry of Industry and Trade
MoST	Ministry of Science and Technology
$MtCO_2eq$	Million tons of carbon dioxide equivalent
NDCs	Nationally Determined Contributions
PCs	Passenger cars
PDP8	Eighth Power Development Plan
PPP	Public Private Partnership
SPS	Stated Policy Scenario
TCO	Total costs of ownership
2Ws	Two-wheelers

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Executive Summary

In July 2022, the Prime Minister of the Viet Nam approved the 'Action Program on Green Energy Transportation – Reduction of Carbon and Methane Emissions of the Transportation Industry' through Decision 876/QD-TTg. This landmark Decision is Viet Nam's first policy specifically targeting at reducing about 7.2 percent contribution from the transportation sector to the economy wide greenhouse gas emissions. This is a key step towards achieving Viet Nam's Nationally Determined Contributions (NDCs) under the Paris Agreement and the 2050 net zero target.

This report presents a series of policy recommendations to the Government of Viet Nam to achieve the targets set under the Decision 876/QD-TTg related to transitioning the road transportation sector towards electric mobility (E-Mobility) using electric vehicles (EVs) – to have 50 percent of urban vehicles and 100 urban buses and taxi to be powered by electricity or green energy by 2030, and subsequently reach to 100 percent for all road vehicles by 2050. The recommendations are underpinned by rigorous quantitative analysis that reveals 'what it takes' to achieve the targets in terms of EV demand and supply, power sector upgrading, charging network development, and battery demands. It also provides a high-level estimate of key benefits from the E-Mobility Transition including reducing gasoline and diesel demand and importation, creating new jobs, reducing local air pollutions, and critically, contributing to Viet Nam's emission reduction targets.

This report is the Executive Version of the study targeting policy makers and senior officials. It provides key messages and the most critical snapshots of the analysis.

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Establishing a Cross-Ministerial Governing Body is Essential for Steering a Successful Transition to E-Mobility across the EV Ecosystem.

The transition to electric mobility is a complex process covering a multi-sectoral ecosystem revolved around the electric mobility development – including boosting EV supply and production, incentivizing EV demand, rolling out EV charging network, preparing the power sector for EV charging, and establishing needed skillsets for workers. The very first step that is essential for this transition is to establish a cross-governmental body to lead and coordinate efforts throughout the transition process. The Ministry of Industry and Trade, Ministry of Transport, Ministry of Planning and Investment, Ministry of Science and Technology, and the Ministry of Finance will play leading roles in their respective mandated areas in the cross-government body. The efficiency of this cross-government body will have a defining impact to optimizing the pace and costs associated with the transition.

To achieve the EV uptake targets, EV sales in Viet Nam need to increase from the current level of 500,000 units in 2022 to about 1.5 million units by 2030, and 7.3 million by 2050. Accumulatively, this represents a market demand for EVs of all kinds of more than 7 million between 2024-2030, and 71 million between 2031-2050.

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E-Mobility Transition in Viet Nam is primarily about the transition in the 2Ws segment between now and 2035.

Before 2035, two-wheelers (2Ws, including motorcycles and mopeds) are expected to remain as the dominate vehicle choice in Viet Nam's vehicle market, despite of an overall trending down demand. E-Mobility transition will be driven by the uptake of electric 2Ws (E-2Ws), as it has been since 2014. Viet Nam is already the world's second largest market for E-2Ws following China, with E-2Ws accounting for 12 percent market share in overall 2Ws sales in 2022. Viet Nam is ready for a rapid acceleration of E-2Ws uptake at a much larger scale. The supply market for E-2Ws in Viet Nam is diverse and vibrant, with many suppliers competing over quality and price. Consumers' acceptance level to E-2Ws is high particularly in cities. In several E-2W segments, the costs both in terms of purchase price and total ownership costs are already competitive against gasoline 2Ws.

To further unlock the demand for E-2Ws, key policy interventions are required to (i) enable consumers to access financing easily to overcome purchase price premium associated with high-performing E-2Ws compared with gasoline 2Ws, (ii) introducing standards and testing protocols to resolve consumer's concerns over E-2Ws safety, (iii) incentivizing E-2Ws supply with Li-ion batteries, which provide the range and power required for non-urban 2Ws users, compared with E-2Ws using Lead-acid batteries, and (iv) rolling out supportive policies to speed up the scrappage of existing gasoline 2Ws in circulation to release the market space for new E-2Ws.

Depending on the pace and scale of how relevant supporting policies are rolled out, the market size for E-2Ws would reach accumulatively 12 million between 2024-2035 to achieve the target, or 16 million if following an accelerated trajectory, which would respectively account for 42 percent and 56 percent of total 2Ws sales in Viet Nam during this period.

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Viet Nam has an enormous opportunity to decouple the passenger car motorization process from gasoline cars and leapfrog into EV era.

In the segment of passenger cars (PCs), Viet Nam has an enormous opportunity to decouple its motorization process from conventional gasoline and diesel cars and leapfrog into the era of electric PCs (E-PCs). Although the annual PC sales in Viet Nam has been growing at an annual rate of 15 percent since 2010, it will only surpass the sales of 2Ws after 2035. This means that it will take another decade before PCs replacing 2Ws and becoming the dominate choice of vehicle in Vietnamese consumer market. During this period, the price of E-PCs will becoming increasingly more competitive against conventional PCs with considerable further advancement in performance.

While car ownership remains a luxury for most Vietnamese today, E-PC is already an attractive alternative to gasoline and diesel cars to those who can afford a car in general. When VinFast, Vietnam's first local EV manufacturer, launched its first sets of E-PC models in 2021, it immediately claimed over 14 percent of overall PC market share that year. The purchase prices of some of the most popular E-PC models by VinFast are already comparable to conventional cars. These E-PC models also offer a lower total ownership cost over 10-years by up to 27 percent thanks to savings from switching fuel costs from gasoline to electricity and less maintenance needs.

Viet Nam should aim to make E-PCs more attractive for the wealthy Vietnamese who are looking to purchase cars today, and in the meanwhile, setting up the enabling environment so that E-PCs will be the preferred choice when most Vietnamese are able to afford their first car over the coming decade. The most critical policy action is systematically rolling out public charging network for E-PCs. However, it needs to be carefully planned to be cost-efficient because the overall motorization rate for PCs and E-PC ownership are both low at present. Targeted charging development strategy is essential to avoid spending much while serving a few.

Between now and 2027, the uptake of E-PCs will be concentrated to the high-income households in Viet Nam. It is recommended to plan the public charging network accordingly to optimize efficiency. Priorities should be first given to the five Special Class cities, starting with high value residential areas. Between 2027 and 2030, efforts should be concentrated in expanding the public charging network in non-urban areas. After 2030, the focus moves from expanding geographic coverage to increasing density in both urban and non-urban areas in preparation for the massive E-PC uptakes after 2035 when most Vietnamese will be able to afford PC ownership.

The accumulative market demand for E-PCs to achieve the target will be around 4 million between 2024-2035, which is about 43 percent of total PC sales during this period. The demand for E-PCs surges along with the demand for overall PCs after 2035. Between 2036-2050, the accumulative demand for E-PCs could reach 51 million, or 93 percent of overall PC sales during this period, in order to achieve 100 percent EV penetration by 2050. If the pace of public charging network development in non-urban area is accelerated, E-PC penetration could become faster, which will further increase the demand for E-PCs by over 2.8 million between 2024-2035, and 3 million between 2036-2050.

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Beyond private vehicles segments, E-Mobility transition is public transport and commercial vehicle segments are equally important, particularly from the decarbonization perspective. Although buses/coaches, and trucks together only account for 2 percent of the registered vehicle stock in Viet Nam, they contribute to more than 65 percent of GHG emissions from the road transport sector.

Promoting passenger modal shift from private vehicles to electrified public bus systems lead to the highest externality benefits.

Promoting passenger modal shift from private vehicles to electrified public bus systems will lead to the highest externality benefits in terms of reducing GHG emissions and local air pollution and improving urban transport quality in Viet Nam. Owing to the dominance of the 2Ws, public city buses have a very small share both in terms of total fleet number and modal share. In In Hanoi and HCMC where public bus service is most advanced, the mode share of public city buses is less than 10 percent. Electric public bus service is already under pilot in both cities; however, to scale it up, strong policy interventions are required to (i) reserve the declining ridership and ramping up fare box revenue from public bus operations; (ii) establishing technical specifications for E-Buses and their charging facilities, related procurement guidelines, maintenance requirements, and cost norms; and (iii) exploring financial models to improving the financial viability of E-Buses.

In order to achieve the target of having 100 percent public city buses to be electric by 2030, Viet Nam needs to phase out 9,600 existing diesel buses currently in operation and reaching the end of their lifetime. In the meanwhile, more electric buses need to be added to service in the Special Class Cities in order to achieve their respective mode share targets in Decision 876. By 2030, Hanoi and HCMC will need respectively about 6,000 and 4,500 more buses in operation using E-Buses.

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E-Mobility Transition among the inter-city commercial vehicle segments will not deliver the decarbonization impact alone.

For intercity bus/coach segments and truck segments, Viet Nam is well positioned for a potential E-Mobility Transition, sooner than the advanced economies. This is because vehicles used in these segments are dominated by small vehicle classes, such as minibuses, pick-ups, vans, and small trucks under 5 tons. These smaller vehicle classes are the first commercial vehicle segments where battery EV technology is approaching to maturity. For instance, according to IEA (2023), among 66,000 battery E-trucks sold in 2022 globally, more than 90 percent were small E-trucks under 5 tons. Viet Nam should strive to achieve a high level of EV uptake in these small class vehicle segments to reduce GHG emissions from intercity commercial passenger and truck transport.

However, E-Mobility Transition among the inter-city commercial vehicle segments will not deliver the decarbonization impact alone. Beyond small commercial vehicle classes, the remaining 30-40 percent of truck and intercity bus/coach segments consisting of large heavy-duty fleets. To bring down the overall GHG emissions from these large fleets, Viet Nam needs to actively apply other decarbonization measures. The key focus should be introducing higher fuel economy standards and promoting a shift of long-haul passenger and freight transport demand from coach buses and trucks to lower carbon modes such as railways and waterway transport.

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EV charging is not expected to impose major pressure to Viet Nam's power sector before 2030 but its impact will become very prominent afterwards.

EV charging will affect Viet Nam's power sector by adding more demand for electricity consumption and increasing the system peak load. In the Eighth Power Development Plan (PDP8) approved by the GoV in May 2023, EV charging has not been incorporated beyond the business-as-usual, where only a low-level EV uptake takes place only for 2Ws with home charging. The large-scale EV uptake beyond 2Ws segments, as targeted by the Decision 876/QD-TTg, and the associated impact to power generation and system peak load will be above-and-beyond the PDP8 current forecast.

PDP8 projects the overall grid generation to reach about 567 TWh and system peak load to reach about 90.5TW by 2030. After 2030, PDP8 includes a Base Case and a High Case outlook. The High Case outlook[1] projects the overall grid generation to reach 1,378 TWh and system peak load to reach 209TW by 2050. Assuming the generation and network capacity planned under the PDP8 High-Case outlook is implemented fully and timely, the study estimated the increment grid generation and network requirements needed to accommodate EV charging.

[1] PDP8 High Case Outlook is the operational scenario used by the power sector planning.

Before 2030, EV charging is not expected to create substantial pressure to the generation. This is because EV uptake during this period is mainly dominated by E-2Ws, which operate on small batteries and short distance in general. Overall, EV charging will require 1-2 percent of additional generation on top of PDP8 High Case Outlook by 2030, which can be addressed by increasing the planned generation surplus margins. However, Viet Nam will need about 4 percent additional transmission capacity by 2030 on top of PDP8 High Case Outlook to cope with additional load from EV charging, particularly for the medium and low-voltage network.

Beyond 2030, as EV uptake starts taking off among PCs and commercial vehicle segments such as small trucks and intercity small buses, the total charging demand surges rapidly. The additional generation required to accommodate EV charging demand increase up to 5 percent on top of the PDP8 High Case Outlook by 2035. By 2045, EV charging would require up to 16 percent more generation on top of PDP8 High Case Outlook, and subsequently raise up to 28 percent by 2050.

To put it the projected 28 percent more power demand in perspective, transport sector today accounts for 16.5 percent of Viet Nam's final energy consumption demand, with a vehicle structure that is dominated by 2Ws. By 2050, the majority of energy demand from the transportation sector will switch from petroleum to electricity if the E-Mobility targets stated in Decision 876/QD-TTg are achieved. Compare with today, the vehicle structure in Viet Nam by 2050 will be dominated by more energy-consuming large vehicles such as cars instead of 2Ws. Adding grid generation at this scale would require an annual growth rate at 5.1 percent between 2035-2050, compared with the annual growth of 3.7 percent currently planned in PDP8 High Case.

In terms of the network capacity required to cope with EV charging load beyond 2030, Viet Nam will need to add on average 3-5 percent of additional network capacity on top of PDP8 High Case Outlook to accommodate EV charging loads between 2030-2045. Subsequently, up to 15 percent of additional transmission capacity will be needed by 2050 to allow 100 percent electrification of road transport.

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Reducing efficiency loss and promoting transport modal shift are critical to size down the scale of power generation increase required for E-Mobility Transition.

To reduce the impact from E-Mobility to the power sector, it is critical for Viet Nam to deepen the efforts in improving the power network efficiency and battery efficiency, and in the meanwhile promoting passenger and freight transport modal shift in the long run. Out of 16 percent of additional generation required for EV charging on top of PDP8 High Case Outlook by 2045, 4 percent, or 53,806GWh, is to cover the efficiency loss during power distribution and transmission, and battery charging process. By 2050, efficiency loss will account for 101,541GWh, or 7 percent out of the additional 28 percent generation required for EV charging on top of PDP8 High Case. Policies and investments should focus on bringing down the assumed 10 percent efficiency loss under PDP8 during power distribution and transmission, and 20 percent battery efficiency loss during charging[2].

[2] Battery efficiency loss is assumed to be 20 percent. Iosifidou, E., Codani, P., Kempton, W. (2017), 'Measurement of power loss during electric vehicle charging and discharging', Energy, Volume 127, pp 730-742.

Since as much as 55 percent of EV charging demand after 2035 is expected to come from private E-PCs and electric small trucks for intercity freight transport, promoting transport modal shift for passenger transport demand in cities from E-PCs to public mass transit, and freight transport demand from intercity E-trucks to railways and waterway transport will substantially reduce the overall EV charging demand. A modal shift among these segments at the scale of 35 percent by 2050 will reduce the additional generation supply required by 9-11 percent.

To reduce the impact from EV charging to the system peak load, Viet Nam should aim to move EV charging to public charging facilities during daytime (off-peak hours) as much as possible. Key policies interventions include rolling out electricity tariff reforms to incentivize off-peak charging, scaling up smart charging devices, and installing rooftop solar at public charging facilities to take the EV charging load off the grid. Between 2024 and 2045, the system peak load with EV charging load incorporated is generally around the level of the PDP8 High Case. However, by 2050, about 7-15 percent additional grid capacity will be needed to cope with the EV charging load.

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The additional investment required for the power sector to cope with EV charging demand is mainly for increasing generation.

To enable the targeted EV uptake level, between now and 2030, Viet Nam will need to invest accumulatively up to US$9 billion to the power sector on top of investment needed to build-out PDP8 High Case Outlook. About US$1 billion investment will be for additional network capacity expansion. To put this in perspective, Viet Nam spent US$9 billion for importing petroleum products in 2022 alone, of which 85 percent was consumed by the transport sector.

Between 2031-2050, Viet Nam will need to invest on average US$14 billion each year for additional power generation and network expansion on top of PDP8 investment. By contrast, Viet Nam spent US$13 billion on importing petroleum products for transport consumption just in the first ten months of 2023.

The number of chargers (all levels) needed to support the targeted EV uptake is about 800,000 by 2030, 2.7 million by 2040, and 6.3 million by 2050. Most charger demand between 2024 and 2030 concentrate on level 1 chargers for E-2Ws. After 2030, the demand for level 2 and level 3 chargers for E-PC charging and depot charging for commercial vehicle segment will surge. Setting up the charging network to support EV uptake required for the target will need around US$2.2 billion by 2030, US$13.9 billion by 2040, and US$32.6 billion by 2050.

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E-Mobility plays a limited role in achieving the 2030 NDC targets but will be critical for achieving the 2050 Net-zero target.

E-Mobility plays a limited role in achieving the 2030 NDC targets but will be critical for achieving the 2050 Net-zero target. In Viet Nam's NDC, the country aims to achieve an unconditional GHG emission reduction of 64.8 MtCO2eq by 2030 from the energy-related sector including the transport sector. No specific emission reduction target is set for the transport sector only. Under the conditions of international technology and financing support, this target could increase to 227.0 MtCO2eq.

Achieving the EV penetration targets set by the Decision 876/QD-TTg will lead to a GHG emission reduction by 5.3 MtCO2eq by 2030. This amount of reduction contributes to about 8 percent of unconditional NDC emission reduction targets set for the overall energy-related sector. The impact on emission reduction from E-Mobility transition by 2030 is modest, mainly because that by 2030 the majority of electrified vehicles will be E-2Ws. The dominate segments for road transport emissions by 2030 – freight trucks, have not yet entered a rapid EV penetration stage.

However, beyond 2030 and particularly from 2035, as the E-Mobility Transition in Viet Nam shifting from 2Ws to PCs, trucks, and intercity buses, the emission reduction impact will rapidly scale up. If all stated EV uptake targets in Decision 876/QD-TTg in 2022 are achieved, the total GHG emission reduction achieved by the E-Mobility Transition would be around 226 MtCO2eq, representing a 60 percent reduction from the NDC baseline scenario in 2050.

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E-Mobility Transition does not need to wait for the decarbonization of the power sector to have an impact.

E-Mobility Transition does not need to wait for the decarbonization of the power sector to have an impact. Historically, power generation in Viet Nam has been heavily dominated by fossil fuels, which consists mainly of coal and gas. Viet Nam has set ambitious targets in current PDP8 to significantly expand its renewable energy capacity and pivoting away from coal to gas. Emission from the power sector could be further reduced as the greening of the grid mix continues. The decarbonization of the power sector is set to take place but will take time.

E-Mobility transition will generate significant GHG emission reduction impact regardless of the power grid mix because the energy efficiency of EVs is much higher than gasoline and diesel vehicles. The modelling results under this study shows that the emissions generated from generating, transmitting and distributing the electricity from the power system for EV charging can be easily offset by avoided fossil fuel combustion from gasoline and diesel cars. Even if the grid mix remains unchanged from 2022 level, E-Mobility transition alone will generate a net emission reduction of 2.2-million-ton CO2eq by 2050. If the greening of the power grid is fully achieved as per the current PDP8, the net emission reduction from the E-Mobility transition will be 5.3-million-ton CO2eq by 2050.

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E-Mobility Transition saves Viet Nam up to US$498 billion accumulatively by 2050 from petroleum importation.

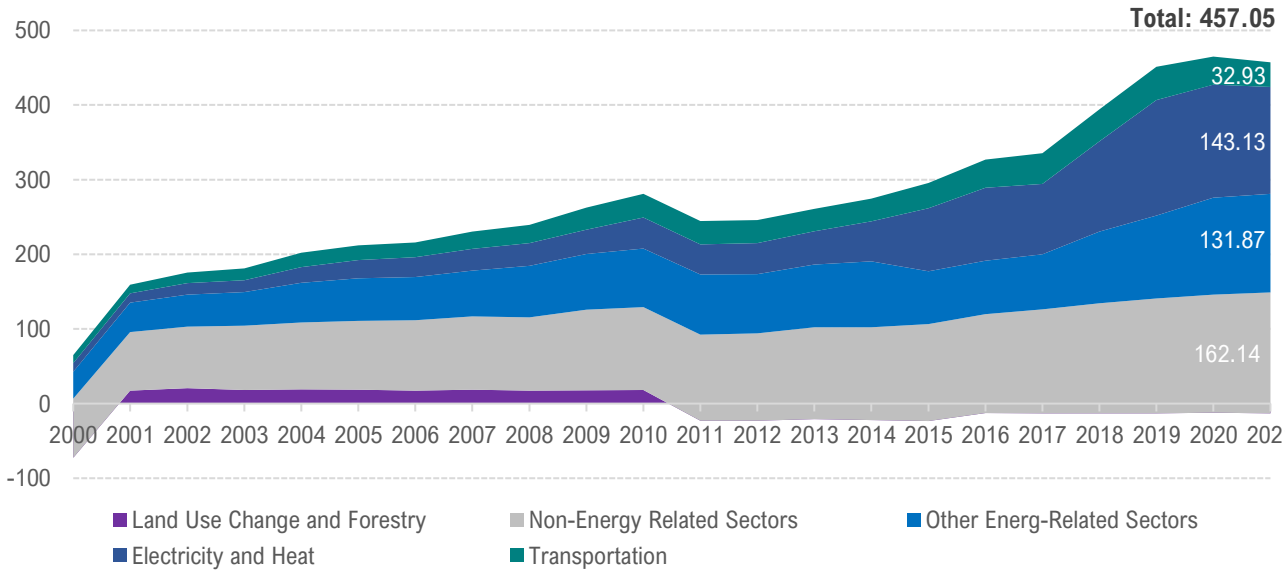
E-Mobility Transition will yield multiple economy wide benefits in addition to GHG emission reduction. It will reduce Viet Nam's dependence on oil and petroleum importation and save the economy up to US$498 billion accumulatively between 2024 and 2050. E-Mobility Transition will generate up to 6.5 million new manufacturing jobs in Viet Nam accumulatively through 2050, and substantial jobs for EV maintenance and repairing. Furthermore, E-Mobility Transition could reduce the environmental damage costs from local air pollution by US$30 million by 2030 and US$6.4 billion by 2050 for Viet Nam.

1. Context and Objectives

At the United Nation's Climate Change Conference in Glasgow in November 2021 (COP26), the Prime Minister of Viet Nam made an ambitious pledge to achieve economy-wide net zero emissions by 2050.

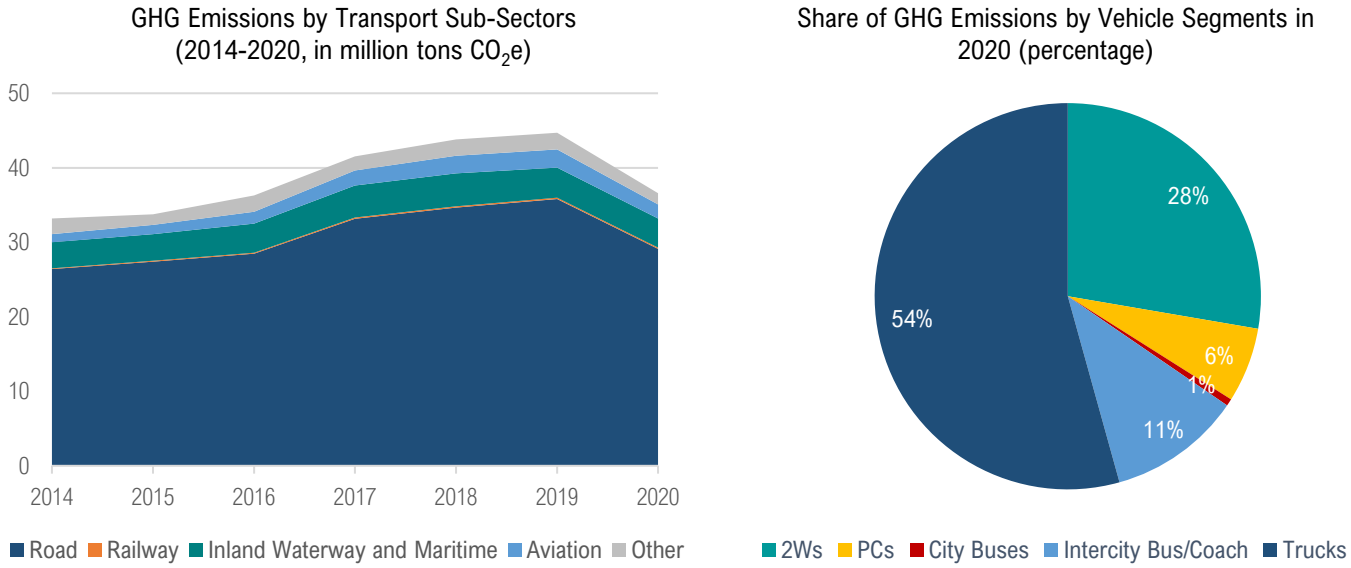
This pledge kicked off Viet Nam's urge to embark on a low carbon pathway for sustainable growth. In July 2022, Decision 876/QD-TTg was issued by the Prime Minister to approve the '*Action Program on Green Energy Transportation – Reduction of Carbon and Methane Emissions of the Transportation Industry*'. This Action Program is Viet Nam's first policy specific to decarbonizing the transportation sector, which accounted for about 32.93 million tons of carbon dioxide equivalent ($MtCO_2eq$) in 2021, representing 10.7 percent of overall energy-related greenhouse gas (GHG) emissions, or 7.2 percent of total economy-wide GHG emissions (**Figure 1**).

Figure 1: Viet Nam Historical GHG Emissions 2000-2021 (in MtCO2eq, including LUCF)



Mt CO_2e = million tons carbon dioxide equivalent
Source: Climatewatch Data. Historical GHG Emissions. Viet Nam. https://www.wri.org/data/climate-watch-cait-country-greenhouse-gas-emissions-data. (accessed April 2024)

Figure 2: Transport Sector Emission Structure in Vietnam



Source: World Bank calculation (2022) using data from Ministry of Transport, Viet Nam.

Within the transportation sector, the combustion of petrol and diesel from road transport vehicles is by far the largest contributor to GHG emissions, accounting for about 85 percent. This is remotely followed by emissions generated from inland waterways and maritime shipping at about 9 percent from the combustion of fuel oil and diesel, and from aviation transport at about 4.5 percent from the combustion of jet kerosene. Across road transport vehicles, in 2022 two-wheelers (2Ws), including mopeds and motorcycles account for 28 percent of emissions, followed by intercity buses and coaches at 11 percent, and passenger cars (PCs) are 6 percent. The most emitting road vehicle segment is freight trucks of all sizes, contributing approximately 54 percent of the road transport emissions. City buses contribute the smallest share of emissions among all road vehicle segments, about 1 percent (**Figure 2**). Decarbonization of the transportation sector in Viet Nam largely depends on the emission reduction of the road transport sector.

The electrification of the road transportation fleets across all modes is a key strategy in the Action Program to achieve the net-zero target by 2050. Targets are set to have at least 50 percent of urban vehicles will use electricity and green energy by 2030, and by 2050 to have all road motor vehicles nationwide to use electricity and green energy. Specifically, targets are set for urban buses and taxis to commence transition to EVs and green technologies starting 2025 and 2030, respectively. The Decision also sets target on charging infrastructure network development and EV production and assembly for 2030 and 2050.

Table 1: Measures and Targets for Electrifying the Road Transport Sector in Decision 876/QD-TTg

Transport Modes	Targets	Type	Timeline
Urban Transport	At least 50% of urban vehicles use electricity and green energy.	Target	By 2030
	100% of replaced and newly invested urban buses will use electricity and green energy.	Target	2025 - 2030
	100% of replaced and newly invested taxis will use electricity and green energy.	Target	2031 - 2050
	100% of urban buses and taxi will use electricity and green energy.	Target	By 2050
General Road	Promote the production, assembly, import and use of electric motorized road vehicles.	Measure	By 2030
	Develop charging infrastructure networks.	Measure	By 2030
	Limit the production, assembly and import of cars, motorbikes and mopeds using fossil fuel for domestic use.	Measure	By 2040
	100% of road motorized vehicles will use electricity and green energy.	Target	By 2050
	Complete charging infrastructure and provide green energy nationwide.	Target	By 2050

Source: Decision 876/QD-TTg, 2022.

Focusing on the electrification of road transport vehicles using battery electric vehicle (BEV) technology, this report aims to assist the Government of Viet Nam (GoV) in developing a National Roadmap for Electric Mobility (E-Mobility) Transition to achieve the stated targets. The report interprets these targets for electric vehicle (EV) adoption as the proportion of annual new EVs sales over total road vehicle sales, instead of for total active vehicle stocks in circulation[3].

Three E-Mobility Transition Pathways are modelled - namely the Business-as-Usual Scenario (BAU), the Stated Policy Scenario (SPS), and the Accelerated Decarbonization Scenario (ADS). Each transition pathway is associated with a set of implications at the economy level, including (i) market demand for EV supply, chargers, and batteries, (ii) impact from EV charging to power generation, distribution and transmission, (iii) reduction of demand for gasoline and diesel, (iv) potential for job creation across EV related industries; (v) local air pollution reduction; (vi) contribution to GHG emission reduction and Viet Nam's Nationally Determined Contributions (NDCs) by 2030 and the net-zero target by 2050, and lastly, (vii) estimated costs to the economy and investment needs across public and private sectors. Based on the modelling results and implication analysis, the report recommends an action roadmap for E-Mobility Transition between 2023-2030 and 2031-2050, which aims to help the GoV to create an enabling environment for the transition at the intended pace and scale in a cost-efficient manner.

[3] This interpretation of the stated targets for EV adoption is motivated by practical reasons. For instance, if the targets were set for total active vehicle stocks in circulation, it would mean that new sales of all gasoline/diesel urban buses and taxies should have been banned in 2018, assuming a 12-years economic lifetime of these vehicles, in order to achieve 100 percent EV adoption for all urban buses and taxis by 2030.

2. Landscape for Motorization Evolvement in Viet Nam

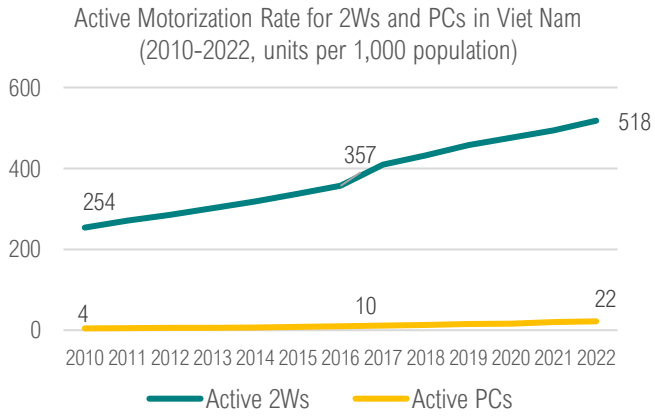
Key Message:

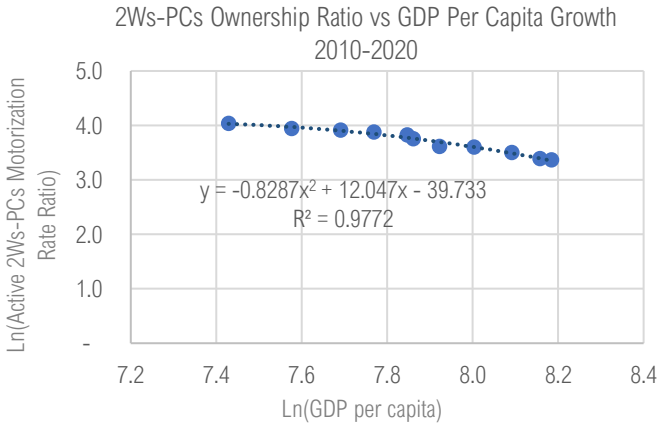
E-Mobility Transition in Viet Nam is primarily about the transition in the 2Ws segment between now and 2035 in terms of EV demand.

The E-Mobility transition is about replacing the active stock of internal combustion engine (ICE) vehicles currently in circulation with EVs. The focus of the transition for each country depends on the current vehicle stock structure and how this structure is expected to evolve overtime.

The current vehicle stock structure in Viet Nam is 2Ws, including mopeds and motorcycles of all kinds. In 2022, the registered 2Ws in Viet Nam reached 72.16 million, which accounts for 94 percent of the total registered vehicles stock. This represents a very high active motorization rate of about 518 units of 2Ws per 1,000 population[4]. Over 2018-2022, the average annual sales of new 2Ws were about 3.2 million units. In comparison, the total registered PCs in Viet Nam were about 3.1 million in 2022, with an average annual sale of 234,000 units over 2018-2022. The motorization rate of PCs is about 22 units per 1,000 population (**Figure 3**). Bus/coach and truck segments account for a small portion of the overall vehicle stock.

Figure 3: Motorcycle and Passenger Car Motorization Rate in Viet Nam in Perspectives





Source: World Bank estimates, 2023

[4] The active vehicle stock in circulation is a subset of the total registered vehicle stock. Based on the estimate by the Ministry of Transport (MoT) Viet Nam, the average vehicle survival rate (active vehicle in use) among registered 2Ws is about 70.5 percent. This report applies the same vehicle survival rate to estimate active vehicle stock in the total registered vehicle stock.

As the GDP per capita continues growing in Viet Nam, the motorization process of private vehicles will gradually shift from being driven by 2Ws to PCs. Over 2010-2022, Viet Nam's Gross domestic product (GDP) per capita (current US$) increased from US$ 1,684 in 2010 to US$4,163 in 2022, during which the ratio between active motorization rate for 2Ws and PCs has been steadily decreasing (**Figure 3**) – in simple term, PCs are being added to the active vehicle stock in circulation faster than 2Ws despite with a smaller volume. Over this period, the number of registered PCs has been growing with a compound annual growth rate (CAGR) of 15.2, twice as high as the CGAR of 2Ws at 7.2 percent.

Assuming the GDP per capita of Viet Nam continue growing at the same rate as over 2010-2022, this growth will continue driving down the ratio between 2Ws and PCs in active circulation; however, 2Ws will remain the dominant choice of vehicle in new vehicle sales in Viet Nam in the near-term due to affordability. The projected vehicle sales of PCs will reach the same level as 2Ws by 2035 at around 1.5 million units and enter an exponential growth phase afterwards, replacing 2Ws as the dominate choice of vehicle as a result of household income growth. Notably, while the consumer demand gradually shifting from 2Ws to PCs, the overall vehicle sales may decline slightly before taking off again in around 2035. This is driven by the consumer choice to keep their last 2Ws in use longer than the previous 2Ws they owned while saving to make the switch to PCs (**Figure 4**, **Table 2**).

Figure 4: Projected Vehicle Annual Sales by Segments 2023-2050 (in units of vehicles)

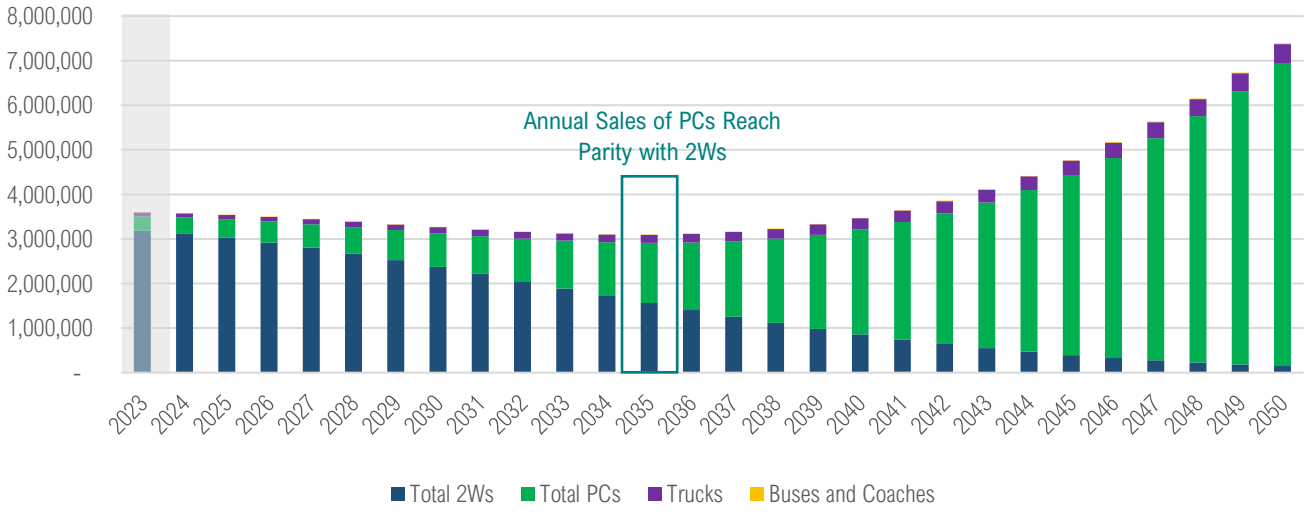
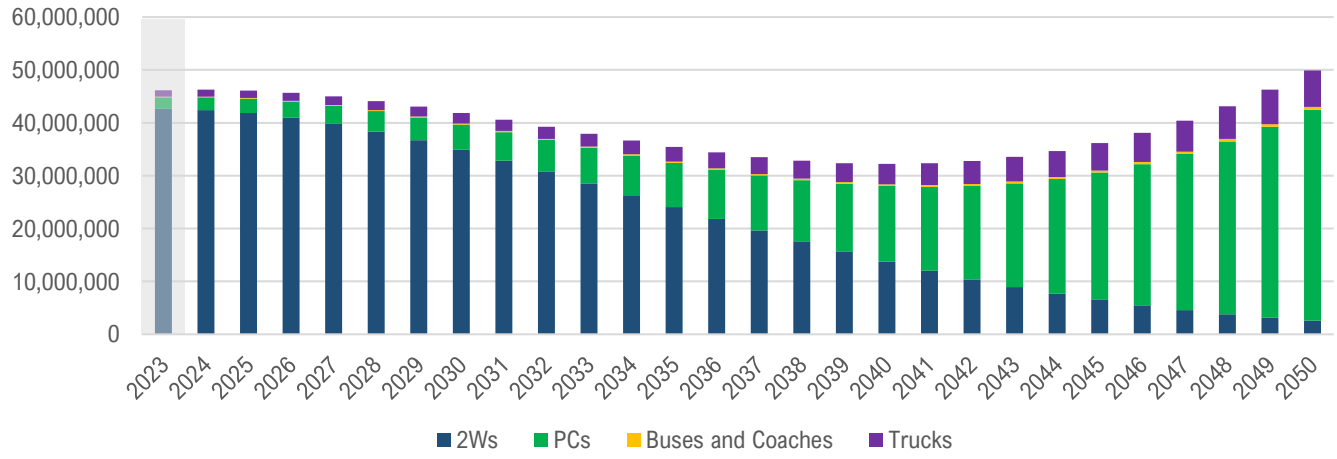


Table 2: Projected Annual Sales by Vehicles Segments in Selected Years (in '000 units)

	2022 (Historical)	2025	2030	2035	2040	2045	2050
Motorcycles	3,410	3,028	2,373	**1,562**	860	395	151
Private Cars	290	415	757	**1,350**	2,357	4,037	6,797
Trucks	67	97	133	182	244	324	424
Buses/Coaches	4	5	6	7	9	11	13
Total	**3,775**	**3,545**	**3,270**	**3,102**	**3,471**	**4,768**	**7,386**

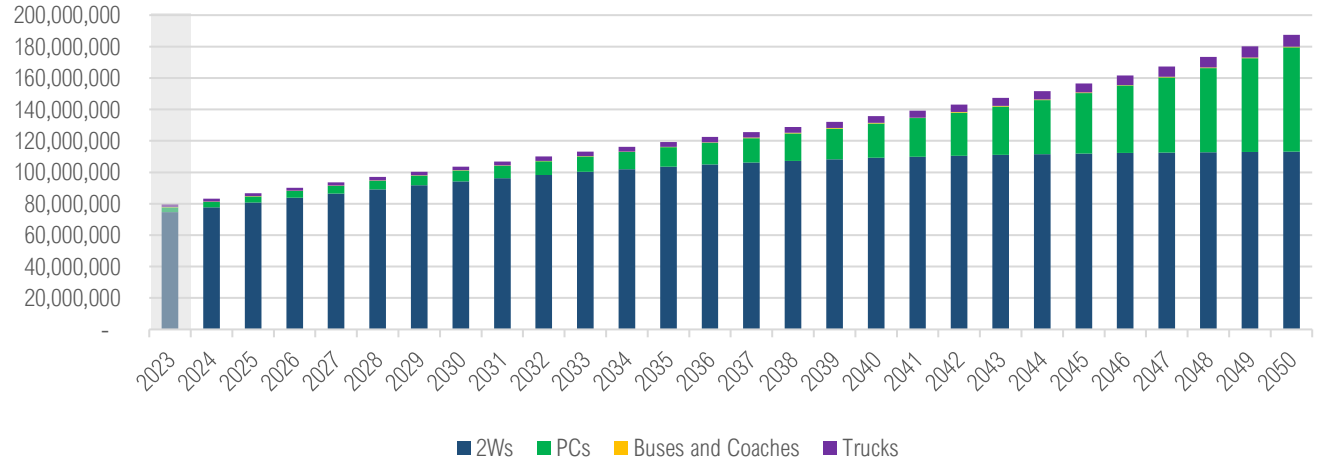
Between now and 2035, about 32 million 2Ws are expected to be sold in Viet Nam accumulatively. In comparison, only about 9.6 million PCs are projected to be sold over the same period. Between 2035-2050, the projected demand for 2Ws will reduce to about accumulatively 9.6 million over this 15-year period, while the demand for PCs will surge to nearly 54 million accumulatively. By 2050, this will lead to a total active 2Ws stock in circulation around 2.6 billion, and an active PCs stock in circulation around 40 million (**Figure 5**). Assuming the population of Viet Nam grow to about 128 million by 2050, the active motorization rate on 2Ws will be around 20 units per 1,000 population, compared with 312 units of PCs per 1,000 population.

Figure 5: Active Vehicle Stock in Circulation 2023-2050 (in units of vehicles)



The decline in 2Ws annual sales will eventually lead to a saturation of the total registered 2W stock at the level of around 110 million around 2040, while the rapid increase of PC annual sales will lead to a surge of the total registered PC stock, reaching 66.3 million by the mid-century (**Figure 6**).

Figure 6: Projected Total Registered Vehicle Stock by Segments 2023-2050 (in units of vehicles)



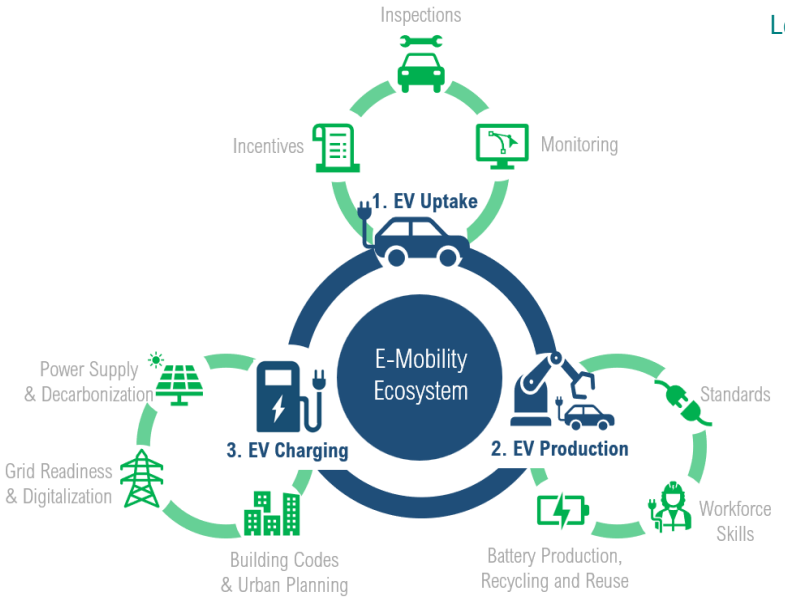
3. Multisectoral Governance for the E-Mobility Transition

Key Message:

Establishing a Cross-Ministerial Governing Body is Essential for Steering a Successful Transition to E-Mobility across the EV Ecosystem.

The transition to electric mobility is a complex process covering a multi-sectoral ecosystem revolved around the electric mobility development. Extensive benchmarking analysis of international experiences from pioneer countries for E-Mobility have clearly demonstrated that formulation and implementation of a nationwide E-Mobility transition is multi-faceted and multi-level in nature. The very first step that is essential for this transition is to establish a cross-governmental body to lead and coordinate efforts throughout the transition process across key components of the E-Mobility ecosystem (**Figure 7**), including (i) EV supply and production, (ii) EV demand and uptake, and (iii) charging infrastructure development, and corresponding supporting components such EV uptake incentives, monitoring, EV inspection protocols; power supply and decarbonization, grid readiness and digitalization, building codes and urban planning; standards for EV production and charging, battery production, recycling and reuse, and workforce skillset and training.

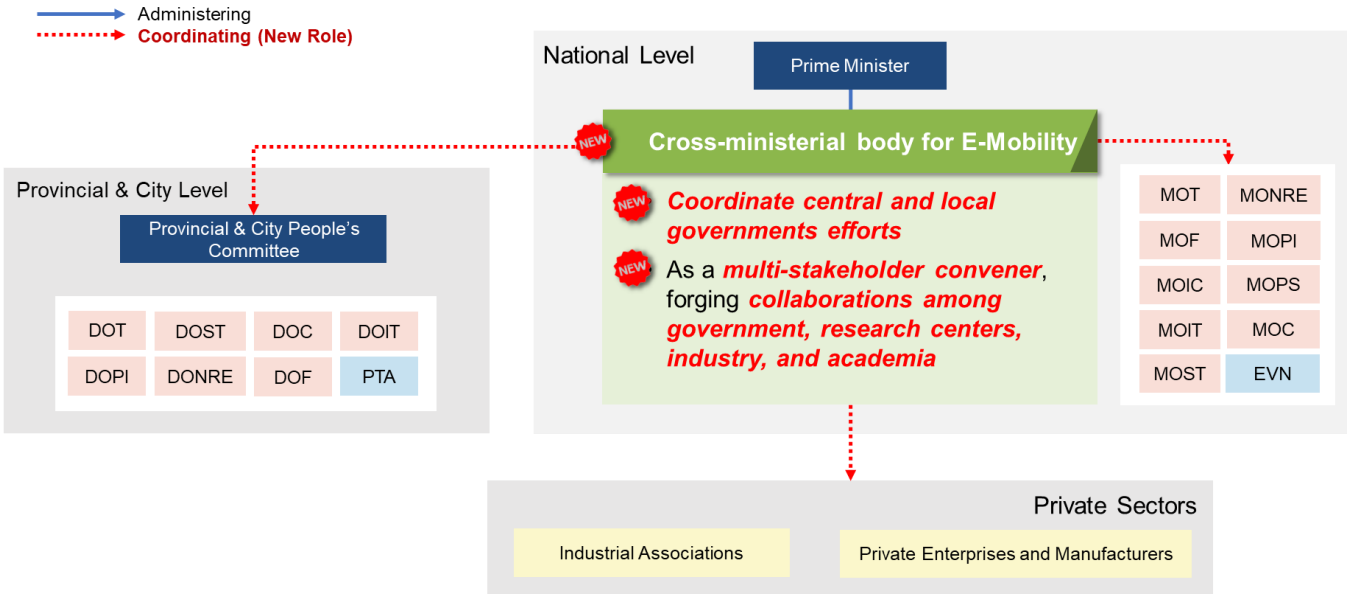
Figure 7: E-Mobility Transition Ecosystem and Key Ministries to Drive the Transition



Lead

- Ministry of Transport (MoT)
- Ministry of Industry and Trade (MoIT)
- Ministry of Finance (MoF)
- Ministry of Planning and Investment (MPI)
- Ministry of Science and Technology (MoST)
- Ministry of Natural Resources & Environment (MoNRE)
- Ministry of Education and Training (MoET)
- Ministry of Public Security (MoPS)
- Ministry of Construction (MoC)
- Centrally Managed Cities
- Municipalities of Vietnam
- EVN

Figure 8: Illustration of Coordination Mechanism of the Cross-Ministerial Governing Body for E-Mobility Transition



The Cross-Ministerial Governing Body could be established in many forms, such as a cross-ministerial Steering Committee for E-Mobility led by one or two leading ministries, or it could be established and directly led by the Office of the Prime Minister. Such cross-governmental body should include sectorial ministries at central level and key sub-national governments. The Cross-Ministerial Governing Body for E-Mobility should have a clear mandate to take ownership and leadership of the E-Mobility program by overseeing and coordinating the efforts across ministerial boundaries to streamline formulation and implementation of E-Mobility related policies, particularly in terms of the pace and sequencing of those policies. Local governments need to play an active role in the cross-governmental body as most actual deployment of E-Mobility programs will be implemented at local level and would rely on local level policies, incentives and regulations (**Figure 8**).

Based on the components across the E-Mobility ecosystem and respective mandates of central ministries and agencies, five ministries would play a critical leading role in the Cross-Ministerial Governing Body, namely the Ministry of Transport (MoT), Ministry of Industry and Trade (MoIT), Ministry of Finance (MoF), Ministry of Planning and Investment (MPI), and Ministry of Science and Technology (MoST). Other ministries such as the Ministry of Ministry of Natural Resources & Environment (MoNRE), Ministry of Education and Training (MoET), Ministry of Public Security (MoPS), and Ministry of Construction (MoC) will also play key supporting roles. Beyond the government ministries, Viet Nam Electricity (EVN) will be a critical stakeholder in designing and implementing key policies related to building power sector readiness for E-Mobility Transition and charging development.

Table 3 provides a set of proposed roles and responsibilities of key ministries and agencies for the transition.

Table 3: Proposed Roles and Responsibility of Key Stakeholder

National Level – Leading Agencies
Ministry of Transport (MoT) – Focusing on Boosting EV Uptake
• Developing targets and plans for EV uptake across all road vehicle segments. • Working with MoPS, monitoring EV uptake distribution across the country and use it to inform charging infrastructure planning and investment, and EV related industrial policies. • Developing national level policy and regulations to incentivize the uptake of EVs, particularly across the public transport system. • Updating technical regulations for motor vehicle standards and vehicle safety inspection protocols, including for EVs. • Providing guidelines for prioritizing EV use on road infrastructure, including introducing policies to disincentivize ICE vehicle usage gradually. • Working with MoIT/EVN, promoting charging network development across national road network. • Monitoring and guiding E-Mobility deployment in pilot cities.
Ministry of Industry and Trade (MoIT) supported by EVN – Focusing on Power Sector Readiness, EV Charging and Industrial Development
• Formulating strategies to develop the electric vehicle industry in Vietnam and submit to the Prime Minister for approval. • Establishing policies, targets and incentives for EV manufacturers and EV components/parts. • Leading the development of technical standards for EV production. • Promoting investment in R&D of key EV technologies. • Updating Power Development Plans to integrate projected EV charging demand and invest in building up readiness of the power sector both in terms of generation supply and grid capacity. • Co-ordinating with EVN to formulate policies related to renewable energy use for EV charging. • Setting up policies on electricity tariff for EV charging, promoting off-peak charging and smart charging. • Establishing policy and measures regarding electricity demand management and smart grid.
Ministry of Finance (MoF) – Focusing on Designing Fiscal Incentives and Supporting Trade Policies
• Working with MoT and MoIT, developing fit-for-purpose and efficient fiscal incentives for EV uptake; EV R&D and production; renewable energy and charging infrastructure; and reuse of EV batteries. • Updating trade policies and importation tariff to support Viet Nam's industrial development on EVs while integrating into global and regional EV supply chain.
Ministry of Planning and Investment (MoPI) – Focusing on Integration with the Overall Socio-Economic Plan and Foreign Investment
• Integrating E-Mobility transition and related industrial, social and economic transition into the overall master plan for Socio-economic Development of the country. • Setting policies and regulations related to foreign investment in Viet Nam's EV industry and key elements in the E-Mobility ecosystem. • Ensuring synergy, complementarity and coherence across various sectoral-specific plans and policies related to E-Mobility development.

Ministry of Science and Technology (MoST)
• Coordinating with MoT and MoIT for the establishment of the technical standard for various components of the E-Mobility ecosystem including EV battery charging and battery swapping stations.
National Level – Supporting Agencies
Vietnam Electricity (EVN)
• Strengthening the power and grid network for EV charging stations at strategic locations to serve the demand from E-Mobility. • Developing renewable energy and its integration with EV charging. • Leading or participating in EV charging business/activities. • Supporting the design and establishment of standards on charging station and smart grid. • Participating in the vehicle-to-grid working group to promote the integration.
Ministry of Natural Resources & Environment (MoNRE)
• Improving the stringency of fuel emission standards for ICE vehicles. • Developing environmental regulations related to EV battery recycling and re-use. • Managing, monitoring and supervising the disposal of lithium batteries.
Ministry of Public Security (MoPS)
• Directly managing EV registration and issues license plates for diverse types of EVs. • Establishing the guideline and capability to promptly respond to safety incidents related to EVs.
Ministry of Construction (MoC)
• Updating building codes to ensure compatibility of building power supply (including socket) with EV charging standards. • Leading the development of mandates for installation of charging infrastructure in buildings and parking areas.
Ministry of Information and Communications (MIC)
• Raising public awareness of safety of EVs as a technology and benefits of EVs for public health and the environment. • Managing/coordinating the technical standards for digital infrastructure that supports smart grid and charging. • Supporting the establishment of data exchange protocols for grid and charging infrastructure.
Ministry of Education and Training (MoET)
• Working with MoIT, leading the design and rolling out of training programs and developing a workforce for EV industry.

The Cross-Ministerial Governing Body should also be a multi-stakeholder convener, forging collaborations among government, research centers, industry associations, and academia. Important stakeholders such as Viet Nam Automobile Manufacturers' Association, Viet Nam Association of Motorbike Manufacturers, and Vietnam Association for Supporting Industries play critical roles in bridging the interests of manufacturers, government and regulatory bodies in shaping policy directions and standardization.

4. E-Mobility Transition Pathways Modelled

Key Message:

Three transition scenarios are modelled mirroring a business-as-usual scenario, a stated-policy scenario, and an accelerated decarbonization scenario.

In order to assist the GoV to chart a course for achieving the stated targets indecision 876/QD-TTg, this report presents three E-Mobility transition scenarios that Viet Nam might follow. Each scenario includes a set of EV uptake pathways for 18 specific vehicle use categories existing in Viet Nam (**Table 4**). Such level of granularity is needed because depending on the vehicle usage characteristics, the same vehicle type (such as 2Ws) often involves very different activity level (i.e. daily kilometers driven) and parking location (private residence or depots), which affect profoundly EVs' charging demand, charging modality (home-based, public charging, battery swapping), and thereby overall usage costs and dependency on public infrastructure.

The EV uptake pathway, which is defined as the share of EV sales over total vehicle shares over years, for each of the 18-usage-categories is projected based on the following key parameters, and then aggregated at vehicle segment level (2Ws, PCs, Buses/Coaches, and trucks) to derive EV uptake pathways for each vehicle segment. The EV penetration level is predicted using a sigmoid S-curve, which is typically observed in transitions to a new technology. The comparative summary across three scenarios is provided in **Table 5**.

- EV purchase costs and total costs of ownership (TCO).
- The availability of charging facilities in residential and public spaces.
- EV performance and standards, particularly in terms of safety, power, and range.
- The availability and stringency of policies that disincentivize ICE vehicle use.

Table 4: Vehicle-Use Categories Included in EV Penetration Scenario Modelling

Vehicle Segments (4)	Vehicle Types Included (11)	Vehicle Use Category Modeled (18)
Two-wheeler (2Ws)	Motorbikes and mopeds	(i) Private 2Ws Urban; (ii) Private 2Ws Non-Urban; (iii) 2Ws for Taxi/Ride Hailing; and (iv) 2Ws for Urban Cargo Delivery
Private Cars (PCs)	Sedans, SUVs, MPVs	(i) Private PCs Urban; (ii) Private PC Non-Urban; (iii) Taxies; and (iv) Commercial Ride Hailing
Buses/Coaches	Large Buses/Coaches (41-60 pax) Medium Buses/Coaches (17-30 pax) Minibuses (12-17 pax)	(i) Public City Buses (large); (ii) Public City Buses (medium); (iii) Public City Buses (mini); (iv) Commercial Intercity Coaches (large); (v) Commercial Intercity Buses (medium); and (vi) Commercial Intercity Buses (mini)
Trucks	Pick-ups, vans, trucks of all sorts	(i) Small Trucks (GVW<5t, including pick-ups and vans); (ii) Light-duty Trucks (GVW 5t-10t); (iii) Medium-duty Trucks (GVW 10t-20t); and (iv) Heavy-Duty Trucks (GVW >20t)

Table 5: Comparative View of Key Factors Affecting EV Charging Profiles under BAU, SPS, and ADS

E-Mobility Ecosystem Element and Policy Levers		BAU	SPS	ADS
EV Uptake	EV Uptake Targets and Target Coverage	No	Yes By 2030: urban vehicles, public buses and taxis. By 2050: all road vehicles.	Yes Targets with 5-year intervals starting 2025, covering 2Ws, 4Ws, buses/coaches, and trucks.
	Government Support and Incentives for EV Uptake	No	Yes, covering mainly public buses and taxies.	Yes, covering all vehicle segments.
	Policies to Limits ICE Vehicle Use	No	Yes, starting 2040.	Yes, starting 2025 for cost-competitive EV segments.
	Targeted Support for Hard-to-Transit Vehicle Segments	No	No	Yes, targeted supporting programs for intercity buses/coaches and small trucks.
EV Production & Supply	Rolling Out National Standards for EV Manufacturing and Charging	No	Yes	Yes
	Rolling Out EV Safety Test Protocol	No	Yes	Yes
	Incentives for Li-ion Battery Adoption	No	No	Yes
	Incentives for Production of Electric Mini-bus and Small-Trucks	No	No	Yes
EV Charging	Government Support Program for Public Charging Network Development	No	Yes, rapidly expanding through 2030 and fully completed by 2050.	Yes, rapidly expanding through 2030 and fully completed by 2050.
	Electricity Tariff Reform for EV Charging to Incentivize Off-Peak Charging	No	No	Yes
	Rolling Out Smart Charging Devices	No	No	Yes
	Rolling Out BTM Solar at Public Charging Facilities	No	No	Yes

Business As Usual (BAU) Scenario is a hypothetical scenario where no supportive programmes, policies, and investment are made available by the GoV for E-Mobility transition, neither for EV uptake nor public charging network development. The BAU mirrors the situation between 2014-2020 in Viet Nam, during which the uptake of EVs was purely driven by the market force as a result of capex reduction of EVs compared to ICE counterparts following the global trend. The BAU forms a baseline to evaluate the level and scale of efforts required to bring the E-Mobility Transition in Viet Nam onto the pathways to achieve the stated targets under Decision 876/QD0TTg/2022.

Stated Policy Scenario (SPS) simulates pathways through which all stated EV uptake targets under Decision 876/QD-TTg in 2022 are achieved. The targets set in the Decision covers urban vehicles, urban buses, and taxies by 2030, and all road vehicles by 2050. The Decision also sets target on charging infrastructure network development and EV production and assembly for 2030 and 2050, while limiting the production and importation of ICE vehicles starting 2040. Using the BAU scenario as a baseline, SPS provides quantified estimates to assist the GoV in understanding the scale of EV demand to be created across all vehicle segments, and subsequent policy and investment requirements to ensure EV supply, provision of charging network and electricity.

Accelerated Decarbonization Scenario (ADS) projects a more rapid EV penetration scenario across vehicle segments to maximize the decarbonization impact from the E-Mobility Transition. This presents a more ambitious scenario compared with the SPS, particularly among the 2W segments in the short-term (between now and 2035). ADS also models more aggressive EV penetration in inter-city commercial buses/coaches and small/medium trucks, which contribute to 65 percent of GHG emissions from the road transport in Viet Nam. In term of EV charging, ADS models policy interventions beyond charging infrastructure development targeted by the Decision, such as including electricity tariff reforms and smart charging to incentivize EV charging during off-peak hours, and behind-the-meter (BTM) off-grid solar for public charging facilities. These interventions reduce the impact of EV charging to the power system particularly the peak load.

Figure 9: E-Mobility Transition Pathways under BAU, SPS and ADS (In Units of Vehicles Sold Yearly)

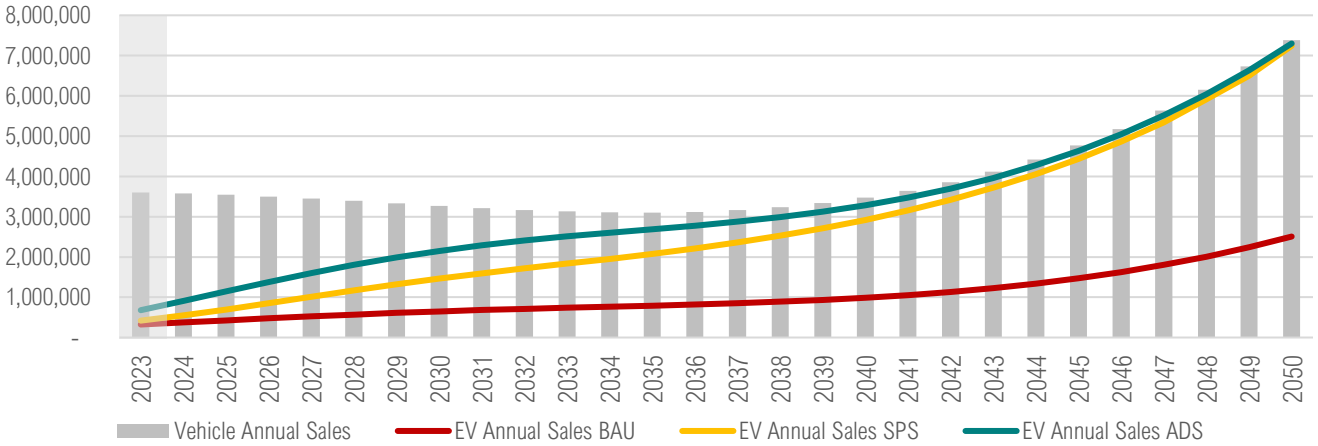


Table 6: EV Penetration in Annual Vehicle Sales under BAU, SPS, and ADS in Selected Years

EV Annual Sales	2025	2030	2035	2040	2045	2050
Business-as-Usual	425,000	648,000	791,000	988,000	1,471,000	2,506,000
% over total vehicle sales	12%	20%	25%	28%	31%	34%
Stated Policy	695,500	1,463,000	2,076,000	2,920,000	4,436,000	7,244,000
% over total vehicle sales	20%	45%	67%	84%	93%	99%
Accelerated Decarbonization	1,147,000	2,148,000	2,688,000	3,281,000	4,632,000	7,300,000
% over total vehicle sales	32%	65%	87%	95%	97%	99%

The modelled E-Mobility Transition pathways aggregated for all vehicle segments are shown in **Figure 10**, along with the corresponding EV penetration rate in annual vehicle sales in selected years, and the structural change such penetration leads to total active vehicle stock in Viet Nam. Notably, although the differences between SPS and ADS in terms of E-2Ws annual sales seems insignificant, it makes a remarkable difference to the total active vehicle stock. This indicates the impact of rapid E-2W uptake in near term. Details of the modelling methodology is available in the long version of this report published separately targeting on technical officials.

Figure 10: EV Penetration in Active Vehicle Stock under BAU, SPS, and ADS 2022-2050 (units of vehicles)

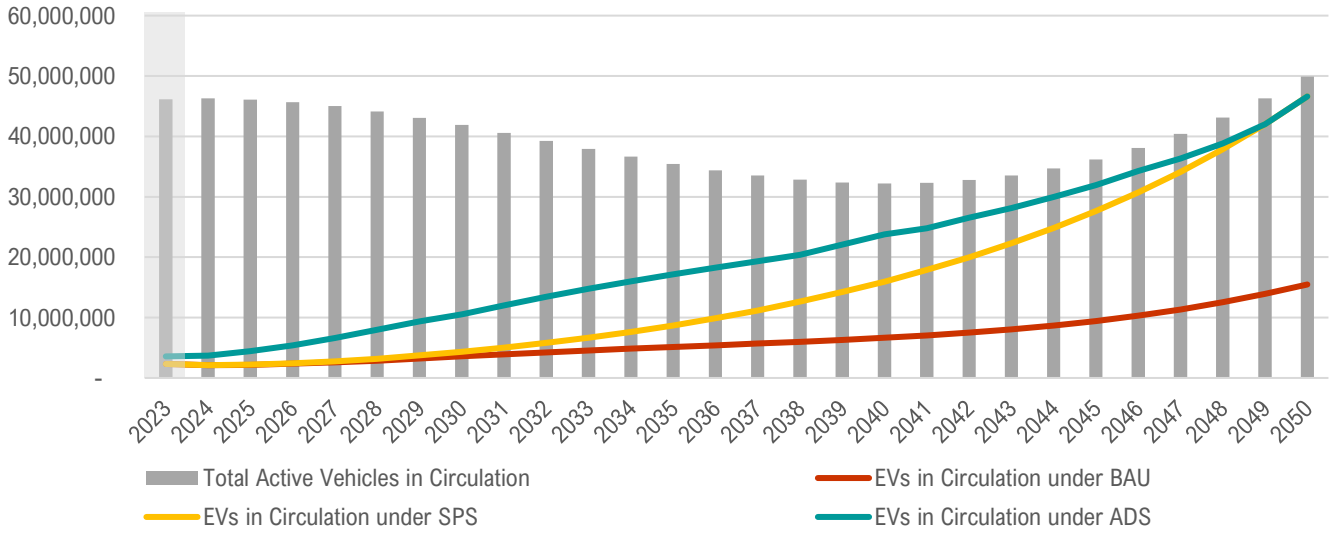


Table 7: EV Penetration in Active Vehicle Stock under BAU, SPS, and ADS in Selected Years

EV Active Stock	2025	2030	2035	2040	2045	2050
Business-as-Usual	2,400,000	3,975,000	5,698,000	7,379,000	10,476,000	17,155,000
% over total active vehicle stock	5%	9%	16%	23%	29%	34%
Stated Policy	2,435,000	4,490,000	8,138,000	15,035,000	27,608,000	43,352,000
% over total active vehicle stock	5%	11%	23%	47%	76%	87%
Accelerated Decarbonization	4,904,000	11,743,000	19,223,000	24,777,000	31,349,000	45,203,000
% over total active vehicle stock	11%	28%	54%	77%	87%	91%

5. High Level of Readiness for a Rapid E-Mobility Transition among Two-Wheelers

Key Message:

Viet Nam is ready for a rapid E-Mobility Transition in the 2Ws segment, while the main adoption obstacles include purchase price premium, speed and range limit for non-urban use, and battery safety concerns.

Within the segment of 2Ws, the transition from ICE 2Ws to E-2Ws are already taking place in Viet Nam. Since 2014, the market share of E-2Ws in annual 2W sales has been steadily on raise from about 120,000 units in 2014 to about 408,000 units in 2022, reaching 12 percent of yearly 2Ws sales. This level of E-2W penetration is the second highest worldwide, second only to China (IEA, 2023).

Viet Nam is ready for a rapid EV uptake among the 2W segment and achieve a high level of E-2W penetration by 2035. The overall transition readiness in this segment is very high for several reasons: (i) most E-2Ws models currently available in Viet Nam have a typical travel range from 70km to 120km upon one full-charge, which is already sufficient to cover a typical private 2Ws use in Vietnamese cities for up to 5-days and at least one day of typical commercial 2Ws use[5]; (ii) there is a vibrant supply market for E-2W in place in Viet Nam. As of 2022, there are about 37 suppliers of electric bicycles and 40 suppliers of electric motorcycles according to the primary market research conducted under this study. Top players such as VinFast, Pega, Dibao, Anbico, and Yadea offer a variety of models for E-moped and E-motorcycles, competing by performance and price; (iii) with a small battery size, most E-2Ws can be charged at home or destinations via wall sockets. This is currently how most of the E-2Ws are charged in Viet Nam. It allows E-2W adoption to continue increasing while the public charging network being developed overtime.

In the Decision 876/QD-TTg, there was no specific EV adoption target announced for the 2Ws segment, other than 50 percent of urban vehicles in general to be electric by 2030 and all road vehicles to be electric by 2050. However, achieving 100 percent E-2W penetration over total 2W sales by 2050 would not yield the decarbonization impact intended by the Decision, because by 2050 the projected market demand for 2Ws would have reduced to about only 5 percent of the demand in 2023 as a result of motorization shift from 2Ws to PCs (details in Section 2). Therefore, the key success factor for the E-Mobility Transition in the 2Ws segments is how rapidly could E-2Ws penetrate into 2Ws annual sale at a large scale while 2Ws remain the dominating modes of vehicles in Viet Nam.

[5] Based on Household Travel Behavior Survey conducted by Vietnamese-German Transportation Research Center in 2019, the average daily travel distance on motorcycles in Viet Nam is about 16km in urban area and 20km in rural area.

E-2Ws Uptake Obstacles

The main obstacles for rapid large-scale E-2W adoption are purchase cost premium compared with ICE 2Ws. Although cost parity has been reached between some models of E-2Ws against ICE 2Ws, those E-2Ws do not really provide a comparable vehicle performance. Taking the most popular E-2Ws models (E-moped with a lead-acid battery) and the most popular ICE 2Ws models (motorcycles with automatic transmission) as an example. The purchase cost of an E-moped with lead-acid battery is about VND27 million, which is on bar with the purchase cost of an automatic ICE motorcycle at about VND30 million. In terms of the total costs of ownership (TCO) over a 5-year usage, E-moped with lead-acid batteries actually offers a lower TCO by about 27 percent compared with an automatic ICE motorcycle.

However, this E-2Ws model provides a much lower power, speed, and longevity compared with the automatic motorcycle. It is an attractive alternative for low-speed urban commuting but will not appeal to consumers who are looking for stronger power or higher speed typically needed for non-urban settings. E-motorcycles using Li-ion batteries would provide an equivalent performance to automatic ICE motorcycles. However, their purchase prices are 2.7 times higher and the TCO is 1.7 times higher than automatic ICE motorcycles.

In addition to the cost premium, concerns over battery safety are another major obstacle preventing E-2W uptake. Both lead-acid batteries and Li-ion batteries used by E-2Ws could lead to potential risk of fire, explosion, or electrical shocks. The primary reasons for such hazard incidents include overcharging, exposure to extreme temperature, or using charging equipment not designed for the batteries. With most E-2Ws currently being charged at home overnight using wall sockets, the risk for overcharging or incompatibility between chargers and batteries are prominent. There have been cases in Viet Nam where fire hazards were caused by battery explosion of E-2Ws at residential buildings due to overcharging, involving causalities.

E-2Ws Transition Pathways

Without supportive policies, demand for E-2Ws in the 2W segments will follow the BAU Pathway and continue growing slowly but soon reach its peak at about 515,000 units in around 2030, which account for about 22 percent of total 2Ws sales that year (**Table 8**). After 2030, the demand for E-2Ws will decline along with the demand for overall 2Ws. The accumulative demand for E-2Ws under BAU Pathway is about 9 million units between 2024-2050, which is about 23 percent of the accumulative demand for 2Ws during this period, totaling 38.6 million.

E-2Ws uptake under BAU will mainly concentrate in urban areas but capped under 40 percent due to purchase cost premium against ICE 2Ws and concerns over battery safety. In the absence of public charging facilities, E-2Ws will not penetrate in non-urban areas meaningfully with the Lead-battery E-moped modals currently dominating the market, which offer limited power and range. For commercial use for taxi service and urban cargo delivery, E-2Ws are only used in urban centers where private investors provide limited battery swapping and charging facilities.

Figure 11: E-Mobility Transition Pathways for 2Ws Segments in Annual Sales 2023-2050 (in units of vehicles)

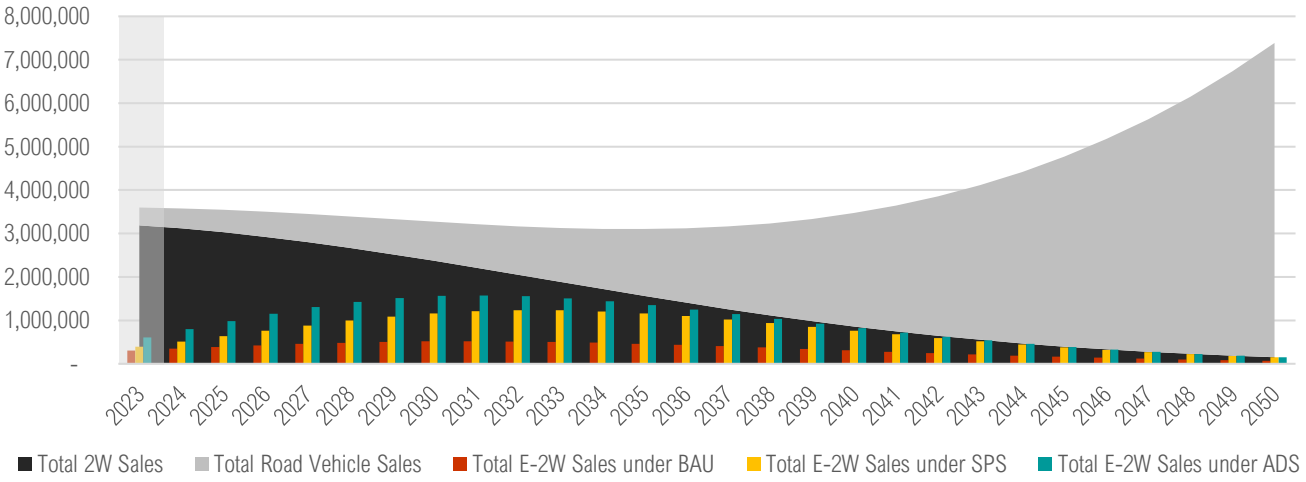


Table 8: Projected Annual Sales of E-2Ws in Selected Years under Three Transition Pathways (in vehicle units)

	2022 (Historical)	2025	2030	2035	2040	2045	2050
Total 2Ws Sales	3,003,000	3,028,000	2,373,000	1,563,000	860,000	395,000	151,000
BAU	407,550	390,000	515,000	463,000	340,000	163,000	69,000
SPS		635,000	1,163,000	1,159,000	764,000	377,000	148,000
ADS		982,000	1,560,000	1,350,000	818,000	389,000	151,000

To achieve the SPS Transition Pathway – 50 percent E-2Ws uptake in urban areas and 100 percent uptake by 2050, policy interventions are required to (i) address price and safety concerns over current E-2Ws models; and (ii) break barriers for E-2Ws penetration in non-urban areas and for commercial usages. Under the SPS Pathway, annual demand for E-2Ws will peak around 2035 at around 1.16 million units, which is about 74 percent of total 2Ws sales (**Table 8**). Achieving 100 percent E-2Ws uptake by 2050 following the SPS Pathway will lead to an accumulative demand for E-2Ws of about 20.5 million between 2024-2050, which is about 53.3 percent of the accumulative demand for 2Ws during this period. This is 30 percent higher compared with the BAU Pathway.

The most critical policy actions to switch E-2W uptake from BAU Pathway to SPS Pathway include: (i) introducing stringent standards and safety codes for E-2Ws manufacturing and batteries[6], accompanied with systematic product test protocols before they are allowed to enter the market; (ii) making the public aware of the new standards and protocol introduced by the government that

[6] In February 2024, the Ministry of Science and Technology (MoST) announced 11 Vietnamese standards (TCVN) for EV charging, including 9 standards on charging stations and 2 standards on EV battery exchange. These standards are set based on equivalent standards of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

will ensure the safety of future E-2Ws models; (iii) introducing fiscal and non-fiscal incentives to boost demand for E-2Ws, focusing on reducing the impact of purchase price premium and leveraging the cost-savings benefits of E-2Ws during operations; (iv) introducing supporting policies to incentive rapid adoption of Li-ion batteries in future E-2Ws modals to provide higher speed, power, and range for non-urban usage; and (v) systematically rolling out public charging and battery swapping facilities within and beyond cities, and in the meanwhile updating building codes and residential power standards to safeguard home-based charging for E-2Ws.

Viet Nam has a great potential to achieve the ADS Pathway for E-2Ws. The main difference between ADS Pathway and the SPS Pathway is the pace of E-2W penetration – ADS Pathway involves a much faster E-2Ws uptake at large scale. Under the ADS Pathway, annual demand for E-2Ws in 2025 is 1.5 times higher than under SPS, and peak at nearly 1.6 million in 2030 – give year earlier than SPS Pathway. The ADS Pathway fully leverages the impact of E-2Ws for road transport decarbonization by pushing for the transition while 2Ws are still the dominant choice in vehicle sales market. The accumulative demand for E-2Ws under ADS Pathway between 2024-2050 is about 25 million, 66 percent of total accumulative demand for 2Ws and a quarterly more than under SPS Pathway.

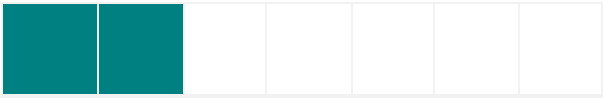
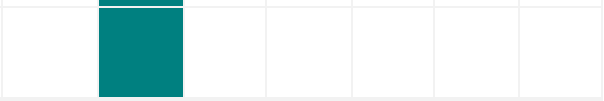
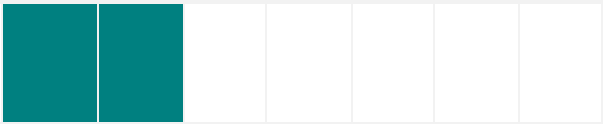
The key lever to achieve ADS Pathway is to implement policy actions required for SPS Pathway faster and more decisive, particularly in terms of rolling out demand incentives and speeding up the development of charging and battery swapping facilities at national level. In addition, policy measures to accelerate the scrappage of existing ICE 2Ws through for instance trade-in programmes will play an essential role to unleash market space for E-2Ws. Announcing more ambitious near-term E-2Ws uptake targets for 2025 and 2030 will create a powerful signal to the market to enable the rapid transition.

Recommended Roadmap for Transition to E-2Ws

Table 9 presents a set of recommendations are proposed to address the key obstacles for rapid E-2Ws uptake in Viet Nam.

Table 9: Recommended Actions to Accelerate E-2Ws Uptake in Viet Nam

	2024	2025	2026	2027	2028	2029	2030
Addressing Safety Concerns of E-2Ws Usage	**Lead: MoST and MoIT | Support: MoT, MoC, MoET**						
Setting Technical Codes and Standards for E-2W Charging and E-2W Batteries.							
Setting Product Test Protocols for E-2Ws and Batteries Production.							
Aligning E-2Ws battery charging standards with building and construction standards for home-based charging.							
Setting E-2Ws annual vehicle inspection standards.							

Launching Public Awareness Campaign and Education on Adopted E-2Ws standards and safety codes	
Creating Demand for E-2Ws	**Lead: MoT and MoF | Support: Cities**
Announcing E-2Ws Sales Targets of 40% by 2025 for urban areas and 20% for non-urban areas; and 80% by 2030 for urban areas and 50% for non-urban areas.	
Announcing mandatory E-2Ws uptake for government-owned 2Ws or public 2W taxis.	
Introducing non-fiscal incentives for E-2Ws uptake, such as reserved road rights, priority parking, registration privilege, E-2Ws-only zones, etc.	
Introducing trade-in programs to scrappage old ICE 2Ws in exchange for vouchers for E-2Ws purchase or battery swapping discounts.	
Announcing a ban of new sales for ICE mopeds by 2027 and a ban of new sales of ICE motorcycles by 2030.	
Reducing Cost Premium of E-2Ws against ICE 2Ws	**Lead: MoF and MoPI | Support: Banks**
Introducing new credit lines or re-purposing existing credit lines across major Vietnamese banks to enable consumers and 2Ws commercial operators taking loans to cover purchase cost premiums of E-2Ws compared with ICE 2Ws.	
Introducing government subsidies to Vietnamese banks to provide preferrable interest rates for loans used for E-2Ws purchase.	
Removing Barriers for E-2Ws Charging	**Lead: MoIT | Support: MoT, EVN, MoC, Cities**
Implementing rapid 6-month pilot program to test new standards for E-2Ws charging and battery swapping.	
Rolling out public AC charging network for E-2Ws at residential and commercial buildings and public locations (schools, hospitals etc.)	
Developing battery swapping stations and services for E-2Ws, particularly for commercial 2W usage and in rural areas.	
Rolling out smart chargers as a part of standard building codes to control E-2W charging hours and avoid battery overcharging.	
Increasing High Quality E-2Ws Supply and Production	**Lead: MoIT | Support: MoF, Cities**
Introducing supporting industrial policies to incentivize large scale importation, production, and adoption of Li-ion battery for E-2Ws production and assembly.	

6. Leapfrogging Opportunity for the Passenger Car Motorization with EVs

Key Message:

Viet Nam has an enormous opportunity to decouple the passenger car motorization process from ICE vehicles. While car ownership remains a luxury for most Vietnamese today, electric cars are already attractive alternatives to ICE cars to those who can afford a car.

Similar to the 2Ws segment, there was no specific EV adoption target announced for the PC segment in the Decision 876/QD-TTg other than 50 percent of urban vehicles in general to be electric by 2030 and all road vehicles to be electric by 2050. The only PC sub-segment with a stated EV adoption target is taxies, which account for about 1 percent of total PC active stock. The Decision targets to achieve 100 percent EV uptake among taxies by 2030.

As of end of 2023, Viet Nam's motorization rate in PC segments is still moderate, around 22 PCs per 1,000 population. While the annual PC sales is expected to continue growing at a rapid pace (CAGR of 15.2 percent over 2010-2022), it will only surpass the annual sales of 2Ws after 2035 due to affordability (Details in Section 2). This means that it will take another decade before PCs replacing 2Ws and becoming the dominate choice of vehicle in Vietnamese consumer market. During this period, the price of E-PCs will becoming increasingly more competitive against ICE PCs with considerable further advancement in performance, driven by the continuous improvement of the battery technology and its cost-efficiency. Therefore, Viet Nam has an enormous opportunity to fulfil its motorization process in the PC segments among the general public using EVs, leapfrogging the motorization stage dominated by ICE PCs.

The first sets of E-PCs models in Viet Nam were introduced by VinFast in 2019 and 2021. The launch of E-PCs by the Vietnamese company received a positive reaction from the market. In 2021, VinFast has reportedly sold more than 35,000 units of E-PCs, representing 14.6 percent of total PC sales of 239,000. However, in 2022, VinFast's E-PC sales were substantially lower, around 8,400 units, or 2.9 percent of overall PC sales. Compared with E-2Ws, the supply of E-PCs in Viet Nam is less diversified at present with VinFast as the only major player. Other companies involved in BEV E-PC supply in Viet Nam include KIA, BYD, and Tesla but with considerably smaller market shares.

Credit: Trở về trang chủ, Mega Story

High Potential for Leapfrogging

The existing E-PC models (SUVs) offered by VinFast are already cost competitive against some of the most popular ICE PCs. This study compared VF e34 (SUV) and Mitsubishi Xpander[7], the most popular E-PC model and ICE PCs in Viet Nam, on their purchase costs and TCOs over 10-years. The result shows that when using a battery rental scheme, meaning purchasing E-PCs without batteries, the purchase price of VF e34 is already comparable (about 6 percent higher) to the purchase price of Mitsubishi Xpander. When it comes to TCOs, VF e34 purchased with batteries is lower by 28 percent than Mitsubishi Xpander, largely due to E-PCs' much lower energy/fuel costs and maintenance costs. VinFast's 10-year battery warranty programme also plays a critical role in lowering the TCO as it enables E-PC owners to avoid any costs related to battery replacement within 10-years. In comparison, VF e34 with battery rental scheme, although with the lower purchase costs, will lead to a higher TCO comparable to that of Mitsubishi Xpander. Battery rental costs at VND30 million a month add up over 10-years and increase the TCO by 27 percent.

This indicates that for Vietnamese who can afford owning an ICE PC today, switching to E-PCs is already a viable alternative in terms of costs. In terms of vehicle performance, the existing E-PC models in Viet Nam could operate up to 390km on average with one full charge with a max power of 252hp, more than sufficient to cover typical PC usage a day in Viet Nam in urban area. The battery warranty scheme makes consumers less concerned about unexpected high cost associated with battery replacement or defects. Importantly, PC owners in Viet Nam today typically have a designated car park at their private residential building where a charging device can be installed. This allows E-PCs uptake to take place for urban commuting while the nationwide public charging infrastructure is being developed.

E-PC Uptake Obstacles

The main factor that limits E-PC demand in Viet Nam at present is affordability, which is determined by the current average household income level and is not technology-specific. In other words, it affects demand for ICE PCs as much as for E-PCs as the prices of ICE PCs and E-PCs are already comparable. Among consumers who could afford a car, the main obstacle for E-PC adoption is the lack of public charging network, which means only those who have a private or designated parking lot at their residences are able to purchase E-PCs and using private chargers to charge. VinFast has been gradually rolling out its charging network, but the coverage remains limited currently. For most wealthy consumers, E-PCs are currently used as a back-up car mainly for urban usage while another ICE PCs are used for long distance inter-city/region trips. Surveys carried out under this study shows that concerns over battery performance and safety of E-PCs remains a limiting factor for consumers to make the switch.

[7] VNExpress, 2023: Vietnam's best-selling cars in 2022.

E-PCs Transition Pathways

E-PC uptake under the BAU will limit to consumers with top 5 percent income level nationwide and primarily for urban usage only. E-PCs are charged at self-installed chargers at private parking lots. Charging network is investment by private sector only such as VinFast with limited pace and coverage. E-PC uptake among non-urban users and commercial operators is neglectable. Under BAU, E-PC sales will be less than 20 percent of total PC sales by 2030 and only reach about 35 percent of total PC sales by 2050. The accumulative demand for E-PCs between 2024-2050 under BAU is about 19 million (**Figure 12**).

The SPS Pathway models 50 percent E-PC penetration in PC sales in urban areas and 100 percent E-PC uptake among taxies by 2030, and 100 percent uptake by 2050. Charging networks are developed with government support starting 2030 and complete by 2050 nationwide. Under SPS Pathway, E-PC penetration among non-urban car owners starts taking off after 2030 from a very low level, in response to charging network development beyond urban areas. In urban areas, some targeted government support is needed for charging facility development in order to enable 50 percent E-PC uptake among taxis operators and private E-PC users. Under SPS Pathway, E-PC sales will need to reach 38 percent of total PC sales by 2030 to achieve 50 percent penetration in urban areas. The accumulative demand for E-PCs between 2024-2030 under SPS is just about 1 million. Between 2031-2050, the accumulative demand for E-PCs would reach 53 million to achieve 100 percent penetration by 2050.

Figure 12: E-Mobility Transition Pathways for PC Segments in Annual Sales 2023-2050 (in units of vehicles)

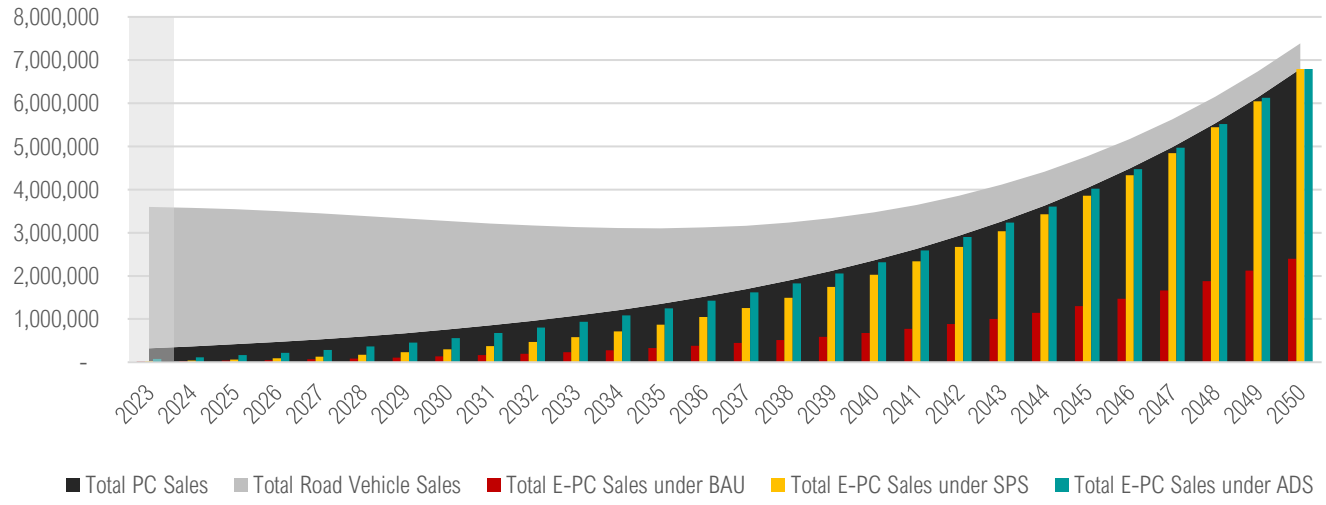


Table 10: Projected Annual Sales of E-PCs in Selected Years under Three Transition Pathways (in vehicle units)

	2022 (Historical)	2025	2030	2035	2040	2045	2050
Total PC Sales	293,000	415,000	758,000	1,351,000	2,358,000	4,038,000	6,797,000
BAU	35,000	37,000	133,000	328,000	678,000	1,298,000	2,398,000
SPS		60,000	297,000	868,000	2,029,000	3,859,000	6,797,000
ADS		163,000	559,000	1,248,000	2,312,000	4,018,000	6,797,000

The most important policy lever to lift E-PC Transition from SPS Pathway to ADS Pathway is the pace of public charging network development in non-urban areas. Under ADS, government supported development of charging network in non-urban area starts in 2025 instead of 2030, focusing on key national road corridors and expressways. This accelerates E-PC penetration in non-urban areas by 3-4 years and allow it to reach as much as 50 percent by 2030 and the overall E-PC penetration to up to 70 percent of total PC sales. As a result, the accumulative E-PC demand between 2024-2030 under ADS Pathway doubles from the SPS Pathway, reaching about 2.2 million. Between 2031-2050, the accumulative demand for E-PCs under the ADS Pathway is 5 million units more than under the SPS Pathway.

Recommended Roadmap for Transition to E-PCs

Charing network development is the determining factor for E-PC uptake in Viet Nam. However, it needs to be carefully planned to be cost-efficient because the overall motorization rate for PCs and E-PC ownership are both low at present. Targeted charging development strategy is essential to avoid spending much while serving a few.

Between now and 2027, the uptake of E-PCs will be concentrated to the high-income households in Viet Nam. It is recommended to plan the public charging network accordingly to optimize efficiency. Priorities should be first given to the five Special Class cities, starting with high value residential areas. All apartment buildings designed for high income groups and middle-class groups should include E-PC chargers at parking lots, followed by car parks at the surrounding amenities (shopping centers, supermarkets, etc.). Between 2027 and 2030, efforts should be concentrated in expanding the public charging network in non-urban areas in order to achieve 70 percent E-PC penetration by 2030 (leapfrogging effect). Between 2030-2035, the development of the charging network moves from expanding geographic coverage to increasing density in both urban and non-urban areas in preparation for the massive E-PC uptakes after 2035.

A set of recommendations are proposed to address the obstacles for Viet Nam to leapfrog into a motorization process for PCs that is driven by EVs instead of ICE cars.

Table 11: Recommended Actions to Accelerate E-PC Uptake in Viet Nam

	2024 - 2025	2025 - 2030	2030 – 2035	2035 - 2050
Addressing Concerns over Safety and Quality of E-PCs	**Lead: MoST and MoIT | Support: MoT, MoC, MoET**			
Setting Technical Codes and Standards for E-PC Charging and Batteries.	■			
Setting Product Test Protocol and Annual Inspection Standards for E-PCs and Test Protocol for E-PC Batteries Production.	■			
Launching Public Awareness Campaign and Education on Adopted E-PCs standards and safety codes	■			
Maintaining E-PCs Cost Competitiveness against ICE PCs	**Lead: MoF | Support: MoIT**			
Introducing incentives such as tax breaks for E-PC OEMs to offer long-term battery warranty for consumers.	■			
Introducing government subsidies to Vietnamese banks to provide preferrable interest rates for personal loans used for E-PC purchase.	■			
Creating Demand for E-PCs	**Lead: MoT | Support: MoF, MoNRE, Cities**			
Introducing non-fiscal incentives for E-PCs uptake, such as reserved road rights, priority parking, registration privilege, E-PCs-only zones, etc.	■			
Announcing mandatory E-PCs uptake for government-owned PCs.	■			
Rolling out collaboration with leading ride hailing companies and taxi companies on ICE PC scrappage and E-PC replacement program.	■			
Introducing more stringent fuel economy standards and emissions standards for ICE PCs.	■			
Announcing a ban of new sales for ICE PCs by 2040.	■			
Removing Barriers for E-PC Charging	**Lead: MoIT | Support: MoT, EVN, MoC, Cities**			
Mandating apartment buildings and public facilities (shopping centers, hospitals, schools etc.) in five Special Class Cities to install E-PC chargers at parking lots, and commercial depots.	■			
Expanding E-PC charging in other Vietnamese cities.		■		
Expanding basic E-PC charging network in non-urban areas including expressways and transport hubs.		■		
Increasing density of E-PC charging networks in both urban and non-urban areas.			■	■

7. Scaling-up Electrification of the Public Bus System

Key Message:

Promoting passenger modal shift from private vehicles to electrified public bus systems lead to the highest externality benefits in terms of reducing GHG emission and local air pollution and improving urban transport quality in Viet Nam.

Public city bus services in Viet Nam are managed by cities and operated by private operators under government contracts. Currently there are about 9,600 public city buses in operation, of which Hanoi and Ho Chi Minh City (HCMC) each owing about 2,000 buses. Public city buses currently operating in Viet Nam vary in sizes, from minibuses carrying 20-30 pax to medium buses for 60-80 pax and large buses for 80-90 pax. The average age of current public city buses is reaching 12.5 years and will soon require replacement.

Owing to the dominance of the 2Ws, public city buses have a very small share both in terms of total fleet number and the passenger-km carried. In Hanoi and HCMC, the mode share of public city buses is less than 10 percent while other major cities such as Da Nang, Hai Phong and Can Tho have a lower share at less than 5 percent. Public city bus services are heavily subsidized by the government. Public city buses contribute to less than 1 percent of GHG emissions from the road transport sector in Viet Nam owing to the small size of total public city bus stock.

Most of the urban public buses currently operating are diesel buses with exception of some pilot of green buses in Hanoi and HCMC using Compressed Natural Gas (CNG) buses and battery electric buses (BEBs). The BEB bus routes under pilot in two cities are operated by VinBus, the bus operating subsidiary of the VinGroup, with BEBs manufactured by VinFast. The VinBus pilot in Hanoi (since 20currently runs 202 BEBs on 17 bus routes while in HCMC the pilot operates 33 BEBs across 4 bus routes. In Hanoi, the average ridership on BEB pilot routes is about 90,000 pax per day and in HCMC about 6,100 pax per day, both are significantly higher than average ridership on public city buses. Those routes are subsidized by the GoV based on rates for CNG buses.

The current VinFast BEB model is 10-meter long and provides 70 pax capacity. It is equipped with a 281 kWh Lithium battery, which operates 220-260km upon a full charge. The overall charging time using Level 3, 150kW DCFC is about 2 hours. The maximum speed of this BEB model is 80km/h.

Credit: The City Fix

The Mutual Dependence between Modal Shift and Electrification for Public City Buses

Within cities, electrification of E-2Ws and E-PCs, even if achieved with a rapid pace, will not resolve the pressing issues of road congestions, local air pollutions, and road safety risks. BEBs running with low passenger occupancy rates will barely lead to any GHG emission reduction impacts because the per capita emissions from transport activities remain the same on private vehicles. At the same time, the conversion from old diesel buses to new BEBs for public city bus services require substantial investment, including from the government. The financial viability of this conversion depends on policies and investment to reserve the declining ridership and ramping up fare box revenue from public bus operations. Therefore, the E-Mobility Transition for the public bus segments must be pursued in parallel with shifting passenger mobility demand from private 2Ws and PCs.

Under Decision 876/QD-TTg, specific targets on passenger mode share on public transport (including metro and buses) are set for five Special Class Cities for 2030 – Hanoi (45-50 percent), HCMC (25 percent), Da Nang (25-35 percent), Can Tho (20 percent), and Hai Phong (10-15 percent). No targets are set for other cities.

E-Bus Uptake Obstacles

The main obstacles for E-Bus uptake in the public city bus segment include: (i) high upfront purchase costs of BEBs compared with diesel buses and CNG buses; (ii) lack of technical and operational frameworks among city governments related to BEBs; and (iii) high ridership risks due to infrastructure and policy gaps.

The unit price of BEBs, including the VinFast model and imported BEBs from popular brands oversees, is typically 1.4-2.8 times higher than a diesel bus, and 1.1-2.2 times higher than a CNG bus. Under the current operation model for public city bus which require bus acquisition by the operators, such high upfront purchase price of BEBs makes rapid, large-scale transition from diesel buses to BEBs prohibitive. However, during the operation, BEBs yield significant cost savings compared with diesel buses due to much lower energy costs and maintenance costs. The TCO of BEBs over 10 years is only about 6-14 percent higher than diesel buses per km. When operating for longer distances or longer years, the TCO of BEBs become more competitive against diesel buses, even if taking into account of costs for one battery replacement. Therefore, the key factor for BEB uptake is to design a financial mechanism that reduces upfront purchase costs for BEBs and converting a large portion of the upfront costs to yearly operation costs in order to leverage cost savings of BEBs compared with diesel buses.

City governments across Viet Nam in general are not familiar with the BEB technology, hence facing challenges to develop suitable technical specifications for BEBs and charging facilities, procurement guidelines, maintenance requirements, cost norms, and contractual options for the transition from diesel buses to BEBs. Ridership risk is the determining factor that affects the financial viability of the public bus services, particularly for BEB operations given the high upfront costs. The infrastructure constraints faced by Vietnamese public bus network, namely limited road space, last-mile connectivity gaps, congestions from 2Ws, poses high risk for public bus service levels and attraction for ridership, and subsequently fare revenue.

E-Bus Transition Pathways

Under the BAU Pathway, the number of BEBs in operations limit to the existing 235 VinBus pilot vehicles in Hanoi and HCMC, which will retire from service in around 2033 after 12 years of service. No new BEBs are added to operation. Diesel buses will continue being used as the main type of fleet for public city buses and the total active stock of public buses in operation increases only marginally overtime. Ridership and mode share on public city buses remain around 5-10 percent in all cities.

Figure 13: Projected Yearly Demand for E-Buses across Five Special Class Cities 2024-2030 (in vehicle units)

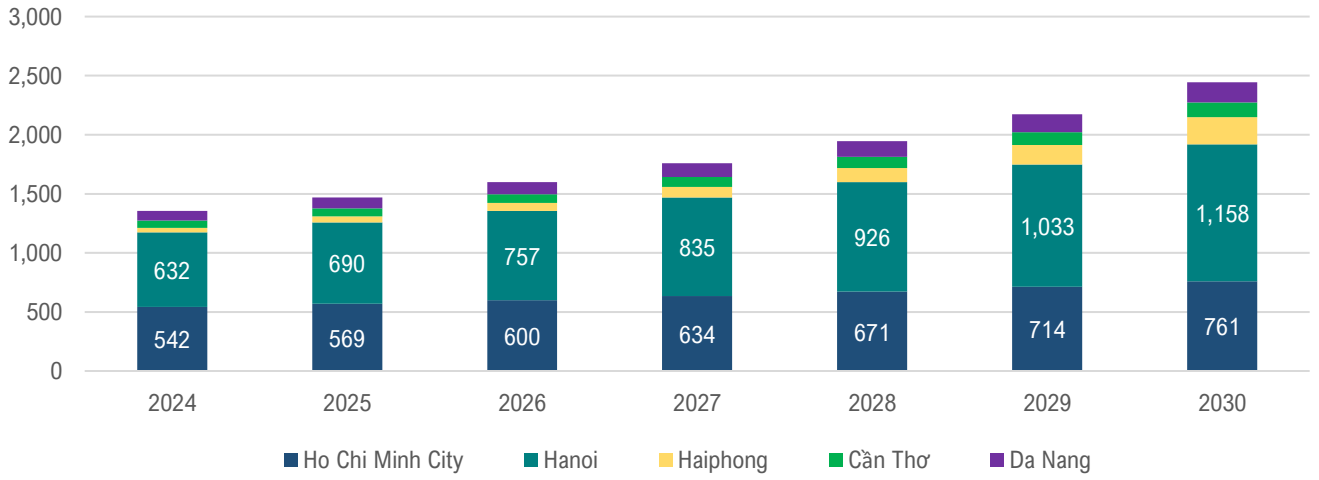


Table 12: Projected BEB Demand across Special Class Cities under Three Transition Pathways 2024-2030 (in vehicle units)

	2024	2025	2026	2027	2028	2029	2030
Total Public Buses in Service in Special Class Cities under BAU	**4,640**	**4,730**	**4,780**	**4,830**	**4,880**	**4,930**	**4,980**
Total E-Bus Order	**-**	**0**	**0**	**0**	**0**	**0**	**0**
Total Public Buses in Service in Special Class Cities under SPS	**5,330**	**6,140**	**7,080**	**8,170**	**9,450**	**10,960**	**12,750**
E-Bus Order for Converting Existing Diesel Buses	660	660	660	660	660	660	660
E-Bus Order for Service Expansion	690	810	940	1,100	1,280	1,510	1,780
Total E-Bus Order	**1350**	**1,470**	**1,600**	**1,760**	**1,940**	**2,170**	**2,440**
Total Public Buses in Service in Special Class Cities under ADS	**5,330**	**6,140**	**7,080**	**8,170**	**9,450**	**10,960**	**12,750**
Consolidated BEB Order	0	4,420	0	8,310	0	0	0
Total E-Bus Order	**0**	**4,420**	**0**	**8,310**	**0**	**0**	**0**

To achieve the SPS Pathway mirroring Decision 876/QD-TTg, the transition in the public city bus segment involves two parts: (i) converting all existing diesel buses to BEBs by 2030; and (ii) continue increasing the active public bus stock in operation to achieve the mode share targets. To achieve SPS Pathway, no new diesel buses should be added to public city bus services starting 2024. Existing 9,600 diesel buses are gradually scrapped and replaced by BEBs at a constant pace between 2024-2030. In five Special Class Cities, about 660 existing diesel buses need to be scrapped and replaced by BEBs each year, of which 290 units will be for Hanoi and 300 units will be for HCMC. The rest of the Viet Nam needs to in total replace 716 diesel buses currently in operation every year between 2024 and 2030.

In addition to converting existing diesel buses, more BEBs need to be added to service in the Special Class Cities in order to achieve their respective mode share targets in Decision 876/QD-TTg. By 2030, Hanoi and HCMC will need respectively about 6,000 and 4,500 buses in operation to achieve the mode share targets based on the projected population size. The number of buses needed by 2030 in Da Nang, Hai Phong, and Can Tho are about 850, 760, and 620, respectively. For all these buses to be BEBs by 2030, the accumulative demand for BEBs under SPS Pathway from both diesel bus conversion and service expansion is about 12,750 units between 2024-2030, of which 47 percent, or 6,030 BEBs will be for Hanoi; and 35 percent, or 4,500 BEBs will be for HCMC (**Figure 13**).

The ADS Pathway differs from the SPS Pathway mainly in terms of the pace and method used for BEB procurement, while the accumulative demand for BEBs remains the same as under SPS Pathway. Instead of spreading BEB procurement over 2024-2030 with a constant yearly rate as under SPS Pathway, ADS Pathway consolidates multi-years of BEB demand for batch procurement. This approach yields the benefits of (i) accelerating BEB uptake in public city bus segment, (ii) increasing the economy of scale for each BEB order to boost market interests among potential BEB suppliers and thereby reducing per unit price. In India and Chile, the consolidation of BEB purchase order leads to substantial cost savings per BEB unit by 30-50 percent, and (iii) allowing more time in-between BEB procurement batches to improve the road network conditions and route efficiency.

Recommended Roadmap for Transition to E-Buses

Based on the obstacle assessment and levers associated with the modeled transition pathways, a set of policy actions are recommended in **Table 13** for the transition of the public city bus segment in Viet Nam from a diesel bus system with a low mode share to an E-Bus system with a high mode share. The recommended actions aim to achieve passenger modal shift from private modes to public buses and the electrification of the public buses at the same time.

Table 13: Recommended Actions to Accelerate Public City E-Buses Uptake in Viet Nam

	2024	2025	2026	2027	2028	2029	2030
Reversing the Declining Urban Bus Ridership							**Lead: MoT | Support: Cities**
Introducing performance-based contracting for city bus operators to improve service quality.							
Optimizing bus route designs and improving last mile connectivity of bus services.							
Introducing 2Ws restrictions along bus corridors and reserve road space for bus operations where feasible.							
Mainstreaming Transit-oriented-development (ToD) in future urban land use and transport planning.							
Setting Clear Policy Directions towards E-Bus Mainstreaming							**Lead: MoT and MoST I Support: Cities**
Mainstreaming BEBs as the new norm and announcing ban of new diesel buses for public city bus services.							
Establishing Technical Specifications and Standards for BEBs and charging facilities tailored for Viet Nam's Cities.							
Developing contractual options for BEB procurement, including specific requirement on battery warranty and performance.							
Introducing operational frameworks for BEB, including operation and maintenance requirements.							
Exploring Financial Models to Enhance Viability of E-Bus Conversion							**Lead: MoT | Support: MoF, Banks**
Rolling out diesel bus scrappage programme for cities buses and using phased approach to replace old diesel buses with E-Buses.							
Consolidating E-Bus purchase orders across Vietnamese cities to reduce unit costs, starting with most profitable routes.							
Piloting and scaling up the use of a leasing mechanism to liquidize high purchase costs of BEBs to yearly operation costs as lease fees to remove BEB adoption barrier.							
Exploring guarantee options to reduce the ridership risks that prevent private sector investment in E-Bus conversion.							
Removing Barriers for BEB Charging							**Lead: Cities, EVN | Support: MoT, MoIT, MoC**
Assessing the land space of existing public bus depots across cities and evaluating the needs for extension to accommodate BEB charging facilities.							
Aligning power distribution network with depots/terminal locations including adding electricity substations and transformers.							

8. Electrification of Inter-City Commercial Vehicles

Key Message:

While promising in Viet Nam's context, E-Mobility Transition among the inter-city commercial vehicle segments will not deliver the decarbonization impact alone. Interventions to promote modal shift and higher fuel economy for ICE vehicles used in these segments are essential.

Inter-city commercial vehicle segments refer to intercity bus/coach services for passenger transport and truck services of all kinds for freight transport. Compared with light duty passenger vehicles (2Ws, PCs), trucks and intercity buses and coaches are heavier, operating for much longer distance, and using diesel only. Therefore, although truck and intercity bus/coach segments together only account for less than 3 percent of total active vehicle stock in Viet Nam, they contribute to more than 65 percent of GHG emissions from the road transport, nearly two times higher than 2Ws and PCs combined (details in Section 1). Decarbonizing intercity commercial vehicle segments will play a defining role in Viet Nam's pursuit for net-zero emission in the road transport sector.

Under the Decision 876/QD-TTg, no targets are set specifically for intercity commercial vehicle segments. The only applicable target is achieving 100 EV uptake for all road vehicles by 2050.

Potential E-Mobility Transition for Viet Nam Context

In advanced economies such as OECD where trucking services are dominated by large container trucks (>13 meters long) and intercity coach services are dominated by large coach buses (12 meters long, 50 pax), decarbonization of these vehicle segments via electrification is cost prohibitive in the short-term, with EV technology remaining evolving between the battery EV technology and fuel-cell EV technology, particularly for heavy trucks.

However, inter-city commercial vehicle segments in Viet Nam are well positioned for a potential E-Mobility Transition, sooner than the advanced economies. This is because in Viet Nam trucking sector is dominated by small trucks, pick-ups, and vans with 3.5-4.5 tons in gross vehicle weight (GVW), which account for more than 60 percent of trucks sold. Similarly, in the intercity coach/bus sector, minibuses (10-12 pax) and medium buses (12-16 pax) account for 65-70 percent of total sales. These smaller vehicle classes are the first commercial vehicle segments where battery EV technology is approaching to maturity. According to IEA (2023), among 66,000 battery E-trucks sold in 2022, more than 90 percent were small E-trucks with GVW under 5 tons. For mini/medium bus segments, cost-competitive EV alternatives to ICE models could become available around 2027-2030.

Beyond small commercial vehicle classes, E-Mobility Transition will be very limited in near-/medium terms among the remaining 30-40 percent of truck and intercity bus/coach segments consisting of large heavy-duty fleets. To bring down the overall GHG emissions from these large fleets, Viet Nam needs to actively apply other decarbonization measures. The key focus should be introducing higher fuel economy standards and promoting a shift of long-haul passenger and freight transport demand from coach buses and trucks to lower carbon modes such as railways and waterway transport.

EV Uptake Obstacles among Small Trucks and Mini/Medium Intercity Buses

The main obstacle for E-Mobility Transition among small trucks (including pickups and vans), mini/medium buses are shortage of EV supply and the lack of nationwide charging networks. EV manufacturers globally, including VinFast in Viet Nam, prioritize the production of passenger vehicle segments, owning to the large market demand compared with truck/bus segments. Traditional manufacturing giants for truck and coach production such as Volvo focus more on EV technology for container trucks and large coach buses, aiming at OECD markets where green policies are most progressive. In comparison, EV production among small trucks and mini-/medium bus segments are generally scarce. Most of EV manufacturers currently supplying EV models in these segments are from China.

For intercity commercial services to transit to EVs, a nationwide fast charging network is essential, particularly along prominent logistic corridors and highways. Developing charging network for inter-city bus/coach services are relatively easier compared with for E-trucks because buses and coaches operate on fixed routes even for long distances. Trucks, however, would need to operate on various of routes. Fright logistic demand analysis could serve as a basis for charging network planning for truck operations.

EV Transition Pathways for Trucks and Intercity Buses

Under the BAU Pathway, E-Mobility Transition in the intercity commercial vehicle segments is neglectable in Viet Nam. The only segments with a shallow EV penetration are among intercity minibuses and small trucks after 2030. This is largely driven by the estimated price parity between EVs and ICE vehicles in these vehicle classes around 2027-2030, as a result of global EV supply advancement. Private operators in Viet Nam invest in limited charging facilities along the most popular intercity passenger routes (fixed routes) and short-range logistic routes to take advantage of the operation cost savings from EVs. However, the estimated EV uptake is less than 15 percent of total minibus/small truck demand by 2050.

Under BAU Pathway, the accumulative demand for electric intercity buses/coaches is about 10,000 units over 2024-2050, or 5 percent of overall vehicle demand for this segment. The accumulative demand for electric trucks of all kinds is about 150,000 units for the same period, or 2 percent of overall demand for trucks.

The SPS Pathway models plausible EV uptake scenarios across the intercity commercial vehicle segments driven by the purchase price of EVs against ICE counterparts, and the development level of a nationwide charging network. Under the SPS, government supported charging network across Viet Nam will be built between 2030-2050. This allows E-Mobility Transition to take off firstly among inter-city minibuses operating on fixed routes, where purchase price parity of EV models against ICE counterparts takes place first around 2027. This is followed by intercity large buses on fixed routes, after EV models reaching price parity against ICE models in around 2033. In truck segments, EV uptake among small trucks (including pickups and vans) takes off gradually after 2030, following the pace of charging network expansion. EV uptake among intercity minibuses, large buses, and small trucks will reach 100 percent by 2050, while it remains low at around 10-20 percent among other large truck classes due to cost premium.

Figure 14: E-Mobility Transition Pathways Intercity Commercial Segments in Annual Sales 2023-2050 (in units of vehicles)

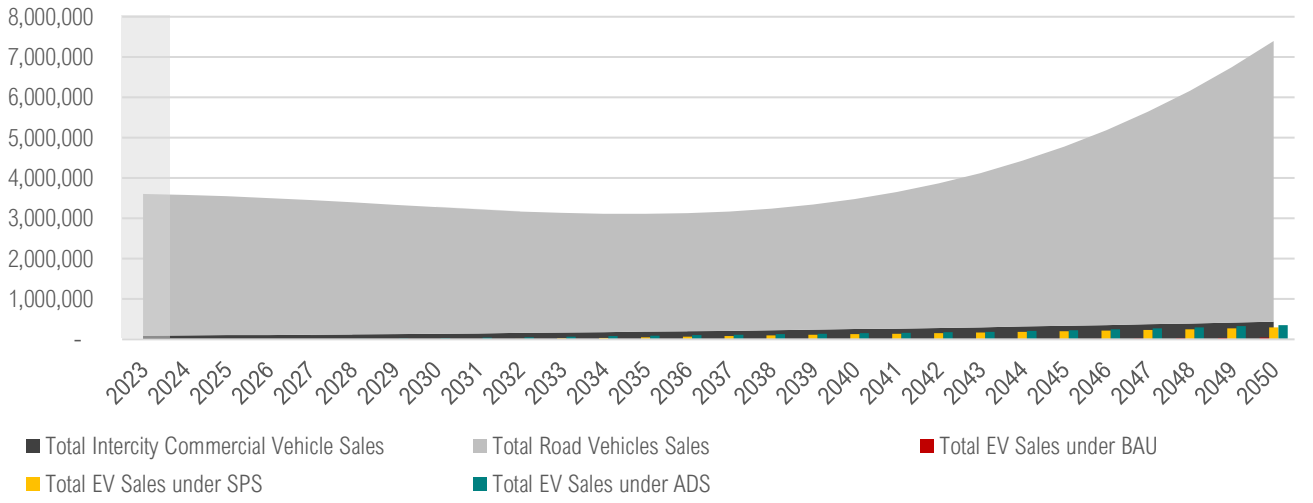


Table 14: Projected Annual Sales of EV in Intercity Commercial Vehicle Segments (in vehicle units)

	2022 (Historical)	2025	2030	2035	2040	2045	2050
BAU		**0**	**10**	**170**	**1,740**	**10,430**	**38,400**
Electric Intercity Buses		-	10	70	280	770	1,600
Electric Trucks		-	-	100	1,460	9,660	36,800
SPS		**0**	**3,550**	**48,090**	**126,040**	**198,980**	**297,070**
Electric Intercity Buses	-	-	550	3,340	6,950	9,830	12,450
Electric Trucks		-	2,500	44,750	119,090	189,150	284,620
ADS		**920**	**27,490**	**91,360**	**150,670**	**224,260**	**353,590**
Electric Intercity Buses		640	4,140	6,660	8,420	10,320	12,600
Electric Trucks		280	23,350	84,700	142,250	213,940	340,990

Achieving the SPS Pathway would create accumulative demand for about 140,000 electric intercity buses and 2.6 million electric trucks of all kinds over 2024-2050, which account for respectively about 65 percent and 43 percent of the overall vehicle demand for these segments.

The ADS Pathway for intercity commercial vehicle segments differs from the SPS Pathway mainly in two aspects: (i) the development of a nationwide charging network is accelerated, starting from 2025 instead of 2030, which allows for faster adoption of EV among the intercity commercial vehicle segments; and (ii) dedicated industrial policies are introduced to support localized production of electric trucks and intercity buses/coaches at scale, which helps to bring forward the timeline for EVs to reach price parity against ICE counterparts in these segments in Viet Nam. Achieving the ADS Pathway would create accumulative demand for about 188,000 electric intercity buses and 3.3 million electric trucks of all kinds over 2024-2050, which account for respectively about 88 percent and 55 percent of the overall vehicle demand for these segments.

Recommended Roadmap for Transition among Intercity Commercial Vehicle Segments

A set of recommendations are proposed to unlock EV uptake among Intercity Commercial Vehicle Segments, focusing on (i) incentivizing EV production and supply, including through localized production, for mini/medium buses and small trucks including pickups and vans, and (ii) accelerating the development of a nationwide charging network, starting with the most popular intercity routes for passenger transports using buses/coaches and key freight logistic corridors.

Table 15: Recommended Actions to Enable E-Mobility Transition among Intercity Commercial Vehicle Segments

	2024 - 2025	2025 - 2030	2030 – 2035	2035 - 2050
Enabling Domestic Supply and Uptake of Small E-Trucks and mini E-buses		**Lead: MoIT and MoST | Support: MoF**		
Establishing Technical Specifications and Standards for small-sized electric buses, coaches and trucks, and charging facilities.	■	■		
Providing fiscal and non-fiscal incentives to encourage local manufacturing and assembly of small battery E-trucks (<5t) and mini E-buses.	■	■		
Piloting small E-truck operations in government owned freight services.		■		
Piloting mini E-bus operations in public inter-city routes.		■		
Introducing government subsidies to Vietnamese banks to provide preferrable interest rates for commercial loans used for E-truck and min E-bus purchase.		■	■	■

Removing Barriers for Inter-city Charging	**Lead: MoT and MoIT | Support: MoC, EVN**			
Assessing the passenger and freight transport demand on intercity bus/coach services and trucking services to identify priority routes and corridors for charging network development.	■			
Rolling out charging network development systematically based on demand assessment across intercity road networks.		■	■	■

Credit: Global Passenger Network, Grab

9. Impact of EV Charging to the Power System

Key Message:

EV charging is not expected to impose major pressure to Viet Nam's power sector before 2035 but its impact will become very prominent after 2035, particularly by 2050.

The increase in EV adoption and the corresponding charging demand will impact Viet Nam's power system, which needs to be analyzed to inform the planning both in terms of electricity generation and network requirements. The GoV approved the Eighth Power Development Plan (PDP8) in May 2023. The electricity demand forecasts in PDP8 were developed based on historical demand data, which is applied with a projected growth rate corresponding to GDP growth assumptions. For 2030-2050, a Base-Case and a High-Case scenario are developed. Based on the demand forecast, PDP8 sets total power generation outlook and total national installed capacity through 2050 (**Figure 15, Table 16**).

Figure 15: Electricity Demand Forecasts in Approved PDP8

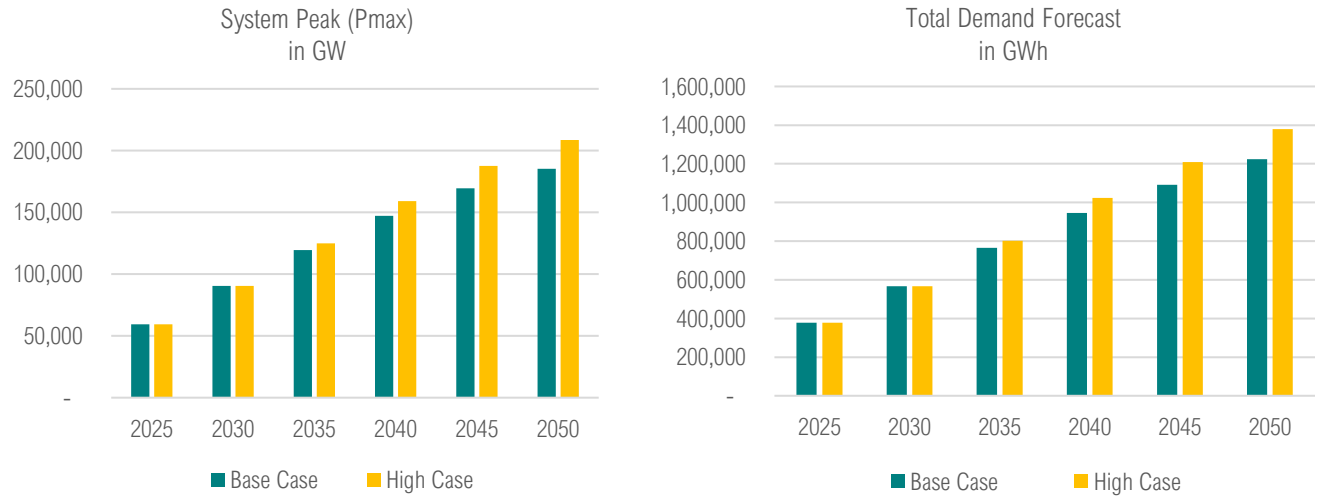


Table 16: Projected Generation Outlook and System Peak Load under Approved PDP8 in Selected Years

	2025	2030	2035	2040	2045	2050
PDP8 Base Case System Peak (GW)	59,318	90,512	119,389	147,095	169,509	185,187
PDP8 High Case System Peak (GW)	59,318	90,512	124,857	159,039	187,496	208,555
PDP8 Base Case Generation Outlook (in GWh)	378,321	566,992	765,797	945,936	1,092,158	1,224,253
PDP8 High Case Generation Outlook (in GWh)	378,320	566,990	800,870	1,022,740	1,208,050	1,378,520

Source: Approved PDP8, May 2023.

Impact to Grid Generation Requirements

The electricity demand from EV charging is determined by (i) numbers of EVs in active circulation, (ii) transport activity (vehicle-km-travelled) carried by EVs, and (iii) energy efficiency of EV batteries and the efficiency of the transmission and distribution network. These factors determine the necessary grid generation capacity to meet the aggregated EV charging demand. The validated assumptions used to for EV charging demand estimate under this study is presented in Annex 1. In terms of efficiency loss, the distribution and transmission losses are assumed at 10 percent, aligned with the underpinning PDP8 modelling. The battery charging losses are assumed at 20 percent[8].

Box 1: Brief Methodology for EV Charging Demand Analysis against PDP8

By applying assumptions on EV activity level and battery efficiency (see Annex 1) to the EV uptake level modelled under BAU, SPS and ADS Pathways, the aggregated EV charging demand at stock level is calculated for each Pathway. Since the PDP8 demand forecast is based on historical data, this report assumes that the charging demand associated with the BAU EV uptake pathway[9] is already included in the PDP8 High Case generation outlook. Therefore, the incremental charging demand associated with the SPS and ADS Pathways over the BAU Pathway is calculated as the additional grid generation required on top of PDP8 High Case outlook.

The study assumes that no spare generation margins from the underlying PDP8 capacity outlook will be used for EV charging. Under the ADS, where behind-the-meter (BTM) solar is modelled as a policy lever, impact from BTM solar installations is factored in before establishing grid-level requirements.

Overall, EV charging demand between now and 2035 is not expected to create any substantial need for additional grid generation capacity on top of the PDP8 High Case Outlook. Even if the EV uptake follows the most aggressive pathway under the ADS Pathway, total EV charging demand will require 2 percent of additional generation supply on top of PDP8 High Case Outlook by 2030 and 5 percent by 2035 (**Table 17**). This is because EV uptake during this period is mainly dominated by E-2Ws, which operate on small batteries and short distance in general. The incremental electricity demand from EV charging during this period could be relatively easily accommodated by increasing the planned generation surplus margins under the approved PDP8.

[8] For battery charging losses, sources quotes losses in the range of 10-30%. Refer to https://www.sciencedirect.com/science/article/pii/S0360544217303730, and https://www.fueleconomy.gov/feg/atv-ev.shtml

[9] The BAU Pathway mirrors the historical EV uptake trajectory over 2014-2022 during which EV uptake is concentrated among E-2W segments only.

Figure 16: Aggregated EV Charging Demand in Addition to PDP8 High Case Generation Outlook (in GWh)

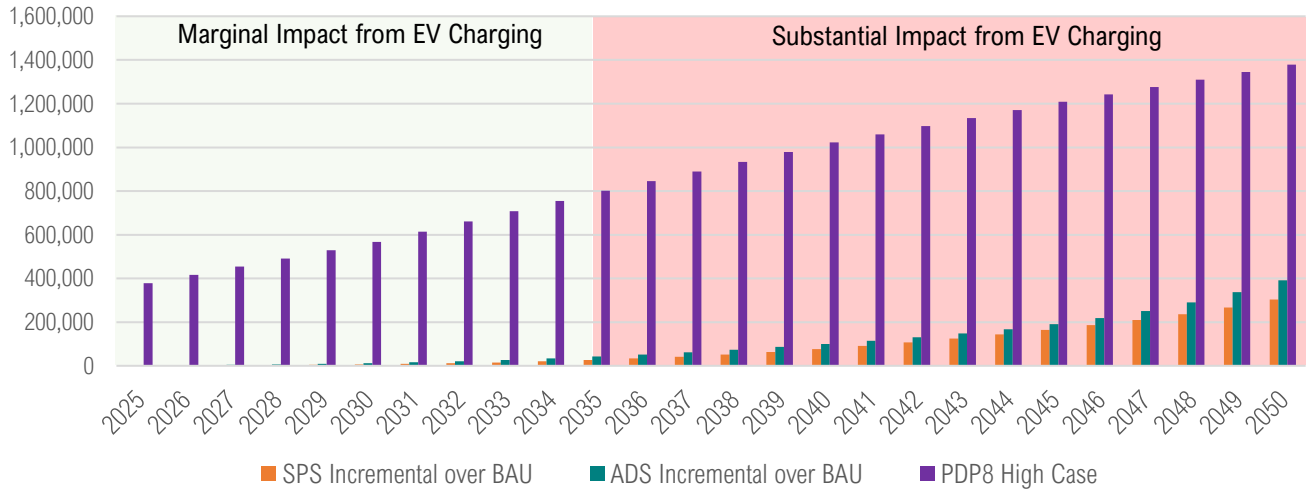


Table 17: EV Charging Demand under Different EV Uptake Scenarios in Addition to PDP8 Generation Outlook (in GWh)

	2025	2030	2035	2040	2045	2050
PDP8 High Case Generation Outlook	**378,320**	**566,990**	**800,870**	**1,022,740**	**1,208,050**	**1,378,520**
SPS EV Charing Demand incremental over BAU	670	6,040	26,140	76,270	164,240	303,090
% addition to PDP8 High Case Outlook	0.2%	1.1%	3.3%	7.5%	13.6%	22.0%
ADS EV Charging Demand incremental over BAU	1,980	12,100	42,190	99,860	190,730	391,390
% addition to PDP8 High Case Outlook	0.5%	2.1%	5.3%	9.8%	15.8%	28.4%

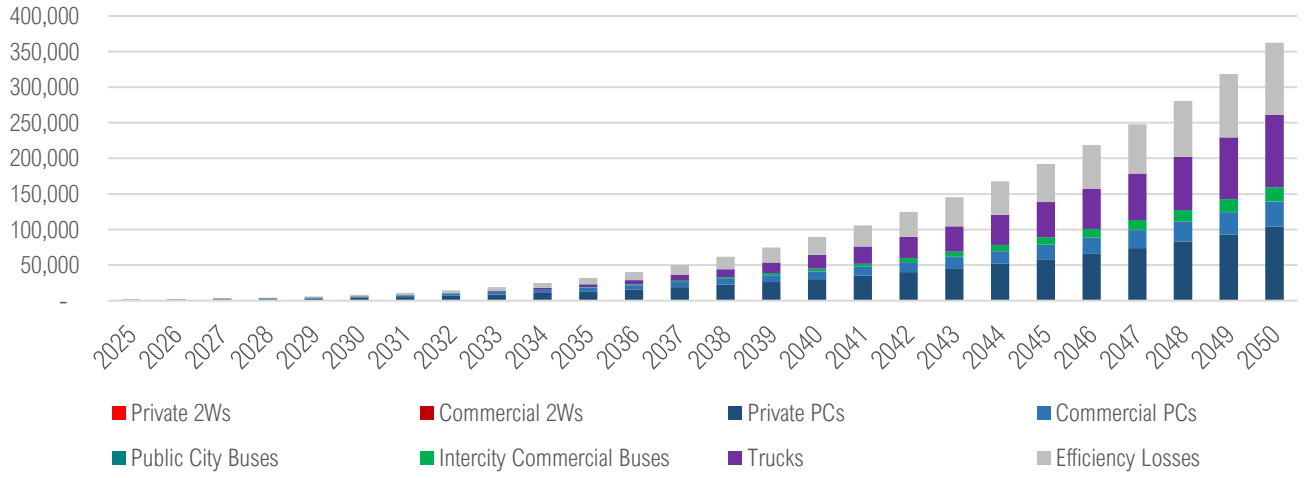
By 2035, the additional electricity demand from EV charging surges rapidly, owing to the rapid EV penetration among PCs and intercity commercial vehicle segments (intercity bus/coach, and small trucks, pickups and vans). By 2045, EV charging would require about 12-14 percent additional generation supply on top of PDP8 High Case Outlook under SPS or ADS Pathways. By 2050, about 20-25 percent more generation supply would need to be added on top of the PDP8 High Case Outlook to accommodate EV charging demand under the SPS and ADS Pathway. This would require the grid generation supply to grow at a CAGR of 4.9 percent over 2035-2050, compared with a CAGR of 3.7 percent currently planned in PDP8.

Reducing EV Charging Impact to the Power Grid Generation by Transport Modal Shift

To achieve the targeted EV uptake level following the SPS Pathway, Viet Nam will need to add 12-20 percent of grid generation supply over 2045-2050 on top of PDP8 High Case Outlook, which poses significant pressure to power generation.

To reduce the impact from E-Mobility to the power sector, it is critical for Viet Nam to deepen the efforts in improving the power network efficiency and battery efficiency, and in the meanwhile promoting passenger and freight transport modal shift in the long run. Out of 16 percent of additional generation required for EV charging on top of PDP8 High Case Outlook by 2045, 4 percent, or 53,806GWh, is to cover the efficiency loss during power distribution and transmission, and battery charging process. By 2050, efficiency loss will account for 101,541GWh, or 7 percent out of the additional 28 percent generation required for EV charging on top of PDP8 High Case. Policies and investments should focus on bringing down the assumed 10 percent efficiency loss under PDP8 during power distribution and transmission, and 20 percent battery efficiency loss during charging[10].

Figure 17: Aggregated EV Charging Demand under SPS Pathway by Vehicle Segments (in GWh)



Another main factor that contributes to the surge of EV charging demand after 2035 are the surge of EV usage among private PC and small truck segments, which respectively account for 29 percent and 24 percent of total EV charging demand over 2035-2050 (**Figure 17**). To mitigate this impact without compromising the decarbonization efforts for the transport sector, the GoV is recommended to actively pursue shifting private PC usage to electrified public transit and shifting E-truck usage to railway or waterway transport.

[10] Battery efficiency loss is assumed to be 20 percent. Iosifidou, E., Codani, P., Kempton, W. (2017), 'Measurement of power loss during electric vehicle charging and discharging', Energy, Volume 127, pp 730-742.

Sensitivity tests are carried out to illustrate the impact of transport modal shift to reducing overall EV charging demand. Three scenarios are developed for the sensitivity tests, respectively by shifting 15, 25, and 35 percent activity demand in:

- Urban passenger transport from private E-PCs to public city E-Buses by 2030 corresponding to modal shift targets, which results in a reduced annual milage and power demand of active E-PCs and an increase of passenger occupancy on E-buses.
- Intercity passenger transport from commercial E-buses/coaches to railways by 2050, which leads to a reduced annual milage and power demand from intercity commercial E-buses/coaches.
- Intercity freight transport from E-trucks to railways and waterways by 2050, which leads to a reduced annual milage and power demand from intercity commercial E-trucks.

It is assumed that modal shift at this scale will not affect the EV demand in annual vehicles sales and active EV stock in circulation. Note that this study only focuses on battery-EV technology. For vehicle segments such as heavy-duty trucks and coaches where other EV technology including hydrogen fell-cell EVs might take off, a very conservative assumption is applied on EV penetration using battery EV technology.

Table 18: Impact from Transport Modal Shift in Reducing EV Charging Demand and Pressure to Power Generation

	2025	2030	2035	2040	2045	2050
PDP8 High Case Generation Outlook (GWh)	**378,320**	**566,990**	**800,870**	**1,022,740**	**1,208,050**	**1,378,520**
SPS % addition to PDP8 High Case Outlook without Modal Shift	0.2%	1.1%	3.3%	7.5%	13.6%	22.0%
With 15% Modal Shift	N/A	-0.09%	-0.4%	-1.2%	-2.5%	-3.4%
With 25% Modal Shift	N/A	-0.12%	-0.8%	-2.2%	-4.7%	-7.1%
With 35% Modal Shift	N/A	-0.23%	-1.1%	-2.4%	-6.9%	-10.7%
ADS % addition to PDP8 High Case Outlook without Modal Shift	0.5%	2.1%	5.3%	9.8%	15.8%	28.4%
With 15% Modal Shift	N/A	-0.07%	-0.2%	-1.3%	-1.6%	-4.1%
With 25% Modal Shift	N/A	-0.11%	-0.6%	-2.5%	-4.2%	-8.3%
With 35% Modal Shift	N/A	-0.26%	-1.0%	-3.2%	-6.7%	-11.7%

Table 18 summarizes the results from the sensitivity tests on transport modal shift. Modal shift from private PC usage in urban areas to public buses by 2030 have relatively limited impact to the overall EV charging demand, reducing the additional demand on top of PDP8 High Case by around 0.25 percent under both SPS and ADS Pathway. This is largely because in 2030, private PC ownership (and E-PC stock in circulation) is still relatively small.

However, between 2035-2050, transport modal shift from E-PC usage to public transit system, and from E-truck usage to railways and waterways begin to have material impact to overall EV charging demand. Shifting 35 percent of transport demand from E-PCs and E-trucks by 2050 will reduce the additional power demand on top of PDP8 High Case by nearly 11 percent, or 14,749GWh, under the SPS Pathway, and 12 percent or 161,287GWh under the ADS Pathway, compared with no modal shift scenarios. This indicates that investing in public transit in urban areas and railways and waterway transport for intercity passenger and freight transport will contribute to decarbonize the transport sector and, in the meantime, mitigating the pressure from EV charging to the power sector.

Credit: SME Entrepreneurship Magazine

Impact to Power Network Requirements

EV charging is essentially a new source for load increase for the power network. The impact to the power network from EV charging is determined by the charging profiles of different EV segments. Charging profile refers to how the EV charging load is distributed across time (hours in a day) and space (public charging or home charging) as a result of consumers' charging behaviors, and thereby affecting the overall load curve across the power network and potentially system peak load. The assumed EV charging profile by segments is presented in Annex 2.

Under the Decision 876/QD-TTg in /2022, Viet Nam plans to roll out efforts to develop EV public charging network by 2030 and complete the network by 2050, which is modelled under the SPS Pathway. For ADS Pathway, electricity tariff reforms, smart charging devices, and BTM solar at public charging facilities are included in the modelling as measures to incentivize off-peak charging during daytime using public charging network (details see Section 4).

Box 2: Brief Methodology for EV Peak Load Analysis against PDP8

Daily EV charging demands for each EV segment are dispatched into a 24-hour power consumption profile based on assumed charging behaviors. Those 24-hour power consumption profiles are aggregated across all EV segments to derive a stock-level EV charging load curve, from which the EV charging peak load is estimated. EV charging load curves and peak loads are calculated for the BAU, SPS, and ADS Pathways based on their respective EV uptake level, total charging demand, and associated charging profiles (details in Section 4).

The study assumes that EV charging load from BAU Pathway has already been included in the PDP8 Base Case, therefore, only the incremental portion of the SPS and ADS EV charging loads over the BAU load are aggregated to the PDP8 Base Case load to derive the new coincident system peak. The new system peaks with SPS and ADS EV charging loads incorporated are then compared with the system peak planned under the PDP8 High Case to determine how much additional transmission capacity, if any, is required to accommodate the increment load increase from EV charging associated with SPS and ADS Pathways.

Credit: Down to Earth

Figure 18: Stock-Level EV Charging Peak Load (GW)

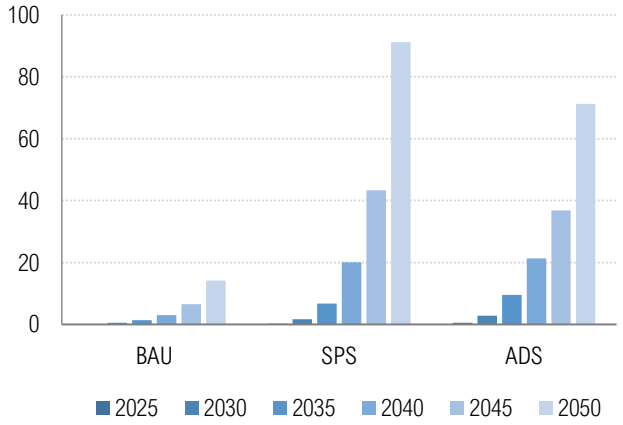


Figure 19: System Peaks Incorporating EV Peak Load (GW)

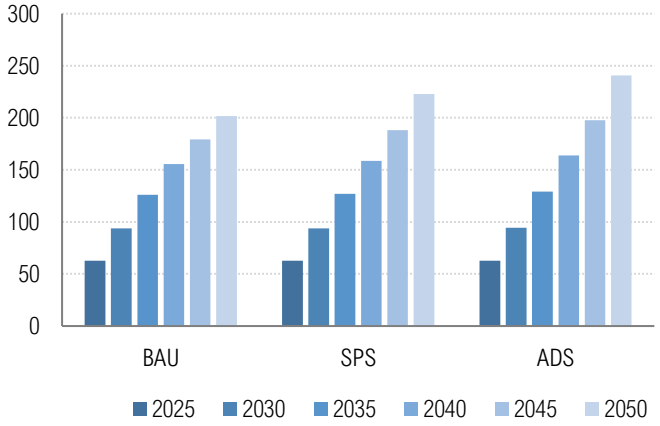


Table 19: Additional Transmission Capacity Required to Accommodate System Peak Load with EV Charging (in GW)

	2025	2030	2035	2040	2045	2050
PDP8 Base Case System Peak	59,318	90,512	119,389	147,095	169,509	185,187
PDP8 High Case System Peak	59,318	90,512	124,857	159,039	187,496	208,555
System Peak with SPS EV Charging Load	36,900	93,892	127,021	158,554	188,055	222,839
% addition to PDP8 High Case Peak Load	**N/A**	**3.7%**	**1.7%**	**N/A**	**0.3%**	**6.8%**
System Peak with ADS EV Charging Load	45,400	94,520	129,185	163,916	197,638	240,691
% addition to PDP8 High Case Peak Load	**N/A**	**4.4%**	**3.5%**	**3.1%**	**5.4%**	**15.4%**

EV charging peak load under the SPS Pathway is projected to reach about 43GW by 2045 and double to 91GW by 2050, due to the surge in charging demand from commercial vehicle segments such as small trucks. In comparison, under the ADS Pathway, the EV Charging system peak load is significantly lower – 37GW in 2045 and 71GW in 2050 – despite of having a higher EV uptake level (**Figure 19**). This shows the critical impact of introducing electricity tariff reforms and the smart charging facilities incentivizing off-peak charging and lowering the impact from EV charging to the system load peak. The application of BTM solar at public charging facilities also played a key role for lowering EV load under ADS Pathway by providing a sizable peak load reduction during daytime by up to 2GW by 2040 and 21GW by 2050.

Assuming EV charging load from the BAU EV uptake scenario is already considered in the PDP8, the incremental EV charging loads from SPS and ADS Pathways over the BAU is added to the PDP8 Base Case system peak load and then compared with the High Case system peak load. Between 2024 and 2045, the system peak load with EV charging load incorporated is generally around the level of the PDP8 High Case. However, by 2050, about 7-15 percent additional grid capacity will be needed to cope with the EV charging load (**Table 19**).

10. Investment Requirements for the Power System

Key Message:

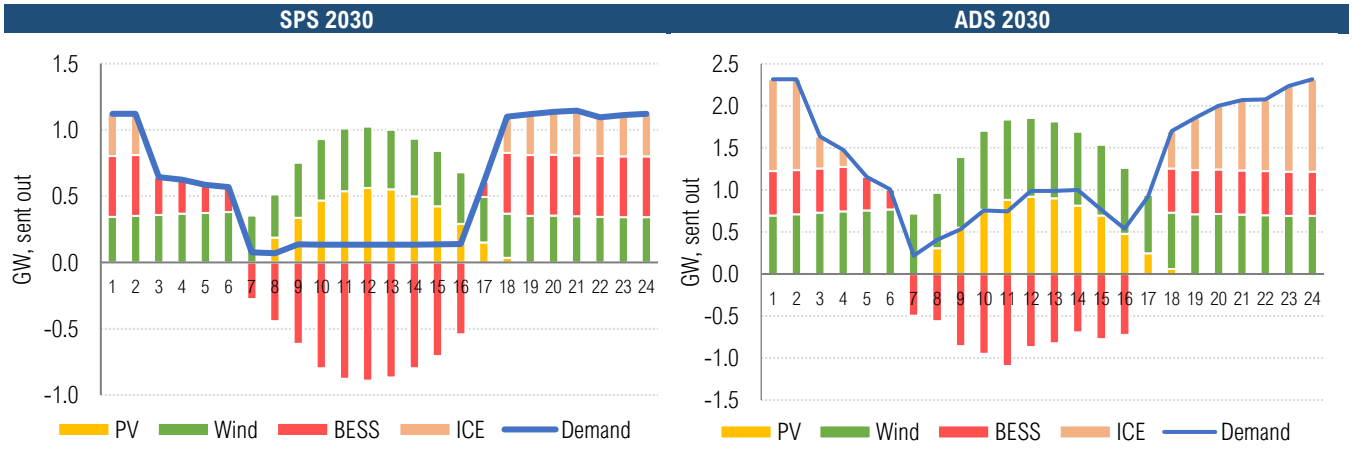
Using current PDP8 as benchmark, the additional investment required for the power sector to cope with EV charging demand is mainly for increasing generation supply. Additional investments for the grid capacity will be needed only between 2045-2050.

Investment for the Additional Generation Supply

An optimal supply mix is developed to provide additional grid generation supply required to accommodate EV charging demand associated with SPS and ADS Pathways, which are above-and-beyond the PDP8 High Case demand outlook. This supply mix only considered a new entrant portfolio consisted of grid-connected solar PV, onshore wind, battery energy storage systems (BESS), and integrated combustion engines (ICE). ICE could be swapped for more generic 'Flexible Generation' which are dispatchable and could include green hydrogen. The BTM solar generation applied under ADS Pathway is netted out from the demand profiles.

Each one of the generation types considered are associated with a particular generation role. Solar PV supplies demands during the middle of the day and onshore wind supply overnight demands but also produces energy during the middle of the day. The excess from wind and solar that is produced during the middle of the day are time-shifted to the evening peak and overnight periods via BESS, and ICE fills in the remaining gap (**Figure 20**).

Figure 20: Modelled Least-Cost Generation Supply Mix to Meet Incremental EV Demand



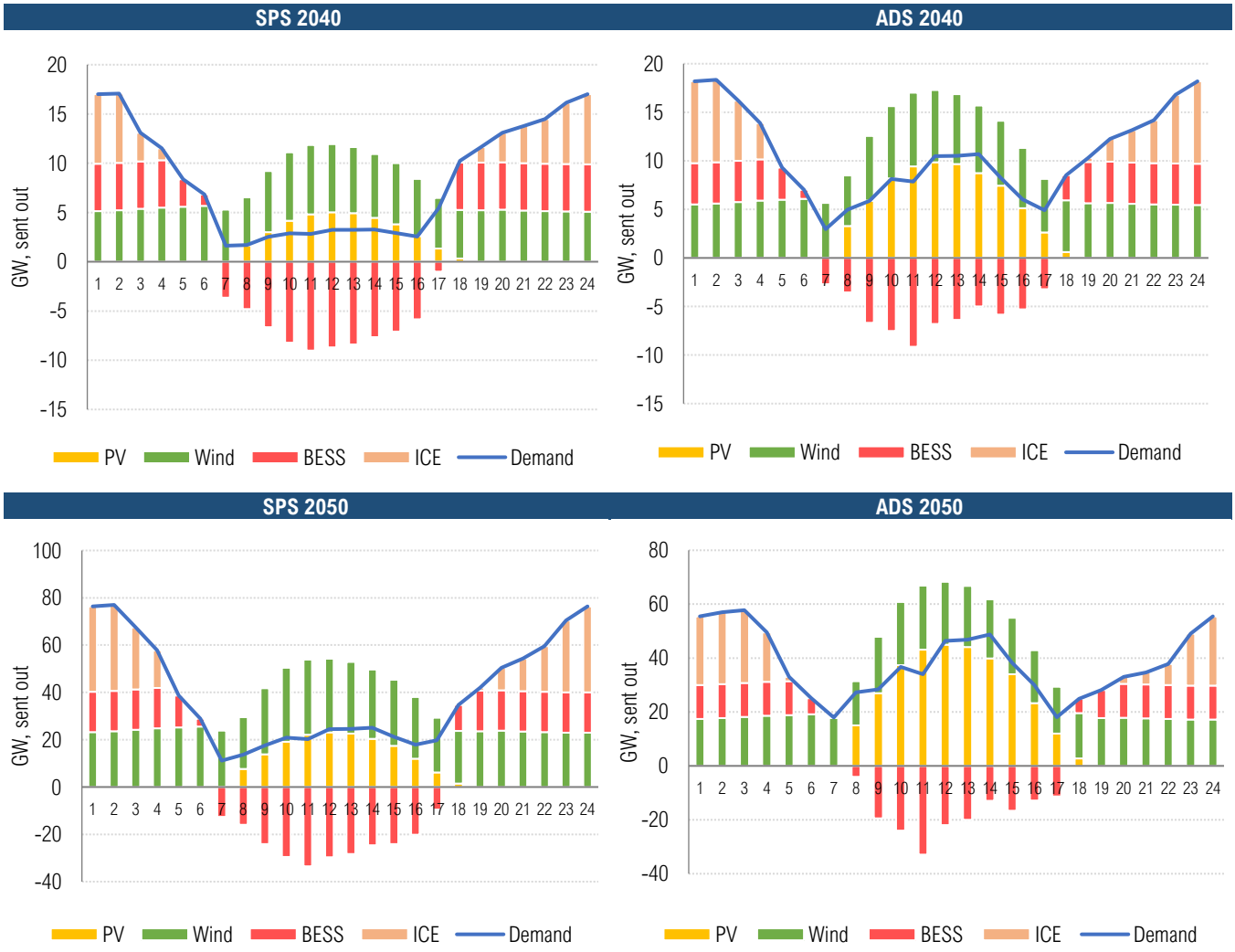


Table 20 and **Table 21** summarize the estimated supply from each of the generation types in the optimal supply mix in selected years. These results are used as the basis to calculate the investment amount required. Generation costs, including capital expenditure, fuel, and operating and maintenance costs, are calculated using the assumptions from the underlying PDP8 modelling. The capex outlook for the generation types considered are summarized in **Table 22** for selected years.

Table 20: Additional Generation Supply to Accommodate SPS Charging Demand (in MW)

Year	Rooftop PV	PV	Wind	BESS	ICE
2030	0	915	1,145	892	338
2040	566	8,166	17,069	9,016	7,127
2050	7,510	37,527	76,992	33,548	36,302

Table 21: Additional Generation Supply to Accommodate ADS Charging Demand (in MW)

Year	Rooftop PV	PV	Wind	BESS	ICE
2030	166	1,498	2,316	1,094	1,100
2040	3,150	16,043	18,345	9,138	8,485
2050	34,240	73,201	57,781	32,876	27,035

Table 22: Assumed Supply Generation Costs by Entrant Options

US$ million /MW	2025	2030	2040	2050
PV	0.84	0.70	0.60	0.51
WIND	1.47	1.36	1.25	1.14
BESS	0.25	0.21	0.18	0.16
ICE	0.63	0.61	0.60	0.58

Investment for the Additional Network Requirements

The investment needed for providing additional network requirement to accommodate system peak loads with EV charging loads from SPS and ADS Pathway is calculated, including public and commercial charging stations, battery swapping stations, private charging facilities at homes for E-PCs, and home-based charging over wall sockets for E-2Ws. The additional network requirement is assumed to be evenly distributed between the North and South regions. This distribution is then mapped to the expected location of supply to estimate the approximate transmission requirements between these regions.

In terms of costs, transmission capex estimates are derived from the PDP8 modelling. Distribution capex is assumed to mirror transmission capex. The cost of transmission is assumed to be US$0.23 million per MW, based on an older PDP8 update. Due to a lack of data, distribution costs were assumed be the same as transmission.

Total Investment Need for the Power Sector

The total cumulative investment needed for additional generation supply and transmission capacity to cope with EV charging demand is summarized in **Table 23**. The levelized cost of electricity (LCOE) incorporates generation, transmission, and distribution costs. The additional investment required for the power sector to cope with EV charging demand is mainly for increasing generation supply. Additional investments for the grid capacity will be needed only between 2045-2050. Between 2024-2030, the accumulative investment needs are between US$6-9 billion for SPS and ADS Pathways, respective.

Over 2031-2040 under the SPS Pathway, accumulatively about US$59 billion investment is needed to increase the generation supply. In the following decade between 2041-2050, another US$200 billion is needed for the same purpose. The network capacity expansion planned under the PDP8 High-Case scenario, if fully implemented, would be sufficient to handle the system peak requirements with EV charging demand under SPS Pathway.

Under ADS Pathway, Viet Nam will need to invest accumulative US$63 billion over 2031-2040 to expand the generation supply. During this period, no additional investment is needed for network expansion beyond implementing the PDP8 High Case. Over 2041-2050, another US$218 billion investment will be needed, including US$9 billion for transmission network expansion and US$209 billion for generation supply capacity expansion, incremental to on the PDP8 High-Case scenario.

Table 23: Cumulative Investment Needed for Meeting EV Charging Demand under SPS and ADS (in US$ billion)

Period	SPS				ADS			
	GEN	TX+DX	Total	LCOE $/MWh	GEN	TX+DX	Total	LCOE $/MWh
2024-2030	6	0	**6**	101	8	1	**9**	79
2031-2040	59	0	**59**	90	63	0	**63**	77
2041-2050	200	0	**200**	81	209	9	**218**	71

Recommended Roadmap for Preparing the Power System for EV Charging

Based on the modelling analysis, a set of policy actions are recommended to prepare Viet Nam's power sector for upcoming EV charging demand both in terms of generation supply and network requirements (**Table 24**).

Table 24: Recommended Policy Actions to Prepare Viet Nam's Power System for EV Demand

	2024 - 2025	2025 - 2030	2030 – 2040	2040 - 2050
Integrate EV Demand in Power System Planning				**Lead: MoIT | Support: EVN**
Integrating projected EV charging impact to the power system in the next iteration of PDP update.	■			
Rolling Out Policies to Enable Smart Charging				**Lead: MoIT | Support: EVN**
Introducing differentiated electricity tariff to incentivize charging at public charging network and off-peak charging.		■	■	
Rolling out policy incentives to encourage installation of smart chargers to enable delayed/off-peak charging.		■	■	
Introducing supportive policies to encourage the development of behind-the-meter rooftop solar at public charging stations to provide generation supply support for EV charging.		■	■	
Preparing the Power Sector for Upcoming EV Charging Impact				**Lead: MoIT | Support: EVN and MoF**
Rolling out electricity tariff reforms to fully capture the investment costs required for EV-induced power system upgrading.	■			
Increasing the investment planned for power generation supply incorporating EV charging demand.		■	■	■
Increasing the investment planned for power network capacity for transmission and distribution to accommodate additional system peak load from EV charging.				■
Continuously investing in improving the efficiency of the power network to reduce the transmission and distribution losses.	■	■	■	■
Explore Alternatives to Reduce EV Charging Demand Surge after 2035				**Lead: MoT | Support: MoPI, MoF**
Promoting transport demand modal shift (i) from PCs to public mass transit in cities and from intercity commercial buses to railways; and (ii) from trucks to railways and waterway transport for intercity freight transport.	■			

11. E-Mobility Transition and the Energy Security of Viet Nam

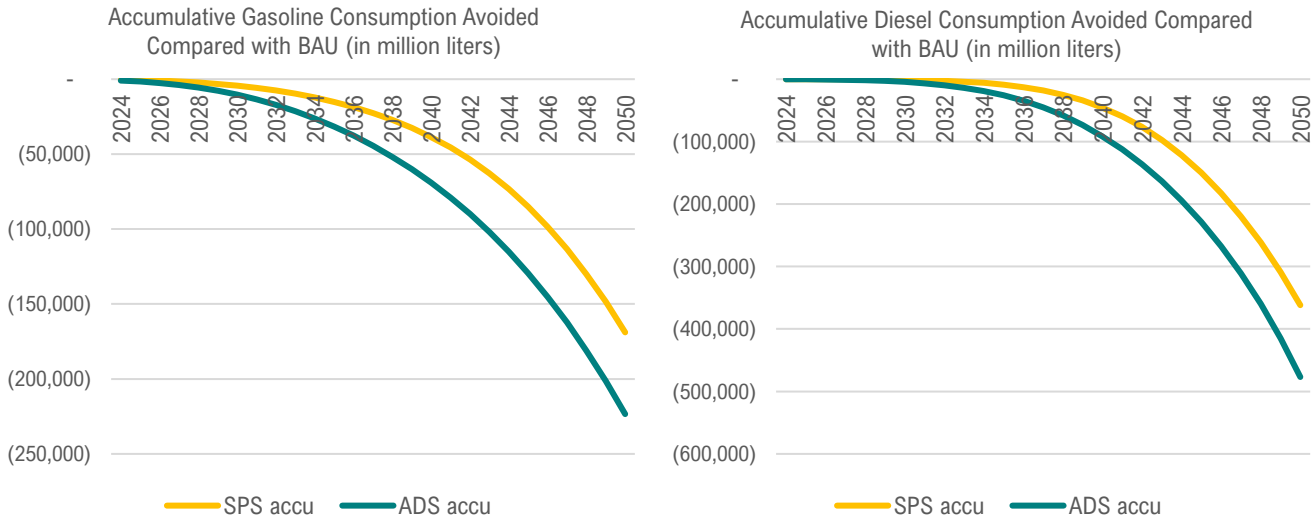
Key Message:

E-Mobility Transition will reduce Viet Nam's dependence on oil and petroleum importation and enhance the country's energy security.

One of the direct impacts from the E-Mobility Transition is the reduced gasoline and diesel consumption by ICE vehicles. It is particularly critical for Viet Nam as a net fossil fuel import country. Based on the usage characteristics of different vehicle segments in Viet Nam and their energy efficiency, it is estimated that Viet Nam is already benefiting from fuel demand reduction resulted from E-Mobility transition in the 2W segments - about 390 million liters of gasoline consumption was avoided by current E-2Ws in circulation as of 2022.

If EV uptake in Viet Nam follows the SPS Pathway, by 2050, Viet Nam would have avoided consumption of 306,401 million liters for gasoline and 409,416 liters of diesel, compared with 'No-EV scenario'. With ADS Pathway, accumulative savings for gasoline demand and diesel demand by 2050 is about 360,939 million liters and 524,471 million liters, respectively. Converting diesel and gasoline demand savings into barrels of oil equivalent, the total accumulative oil equivalent saved for Viet Nam by 2050 from E-Mobility Transition is about 4,502 million barrels of oil under SPS, and 6,224 million barrels of oil under ADS. Using the current international oil price of about US$80 per barrel, the avoided accumulative expenditure on oil importation for Viet Nam by 2050 is about US$360 billion under SPS, and US$498 billion under ADS.

Figure 21: Gasoline and Diesel Demand Avoided Accumulatively under SPS and ADS Compared with BAU



If using the BAU Pathway as the baseline scenario (**Figure 21**) instead of the hypothetical 'No-EV' scenario, Viet Nam will save accumulatively 168,907 million liters of gasoline and 361,823 million liters of diesel between 2025-2050 under the SPS Pathway. This saving will increase to 223,445 million liters of gasoline and 476,878 million liters of diesel during the same period under the ADS Pathway. The total accumulative oil equivalent saved for Viet Nam by 2050 under SPS and ADS compared with BAU is about 3,792 million and 5,006 million barrels, respectively. This translates into an avoided accumulative expenditure on oil importation by about US$303 billion and US$400 billion, respectively.

12. Demand for Chargers and Batteries

Key Message:

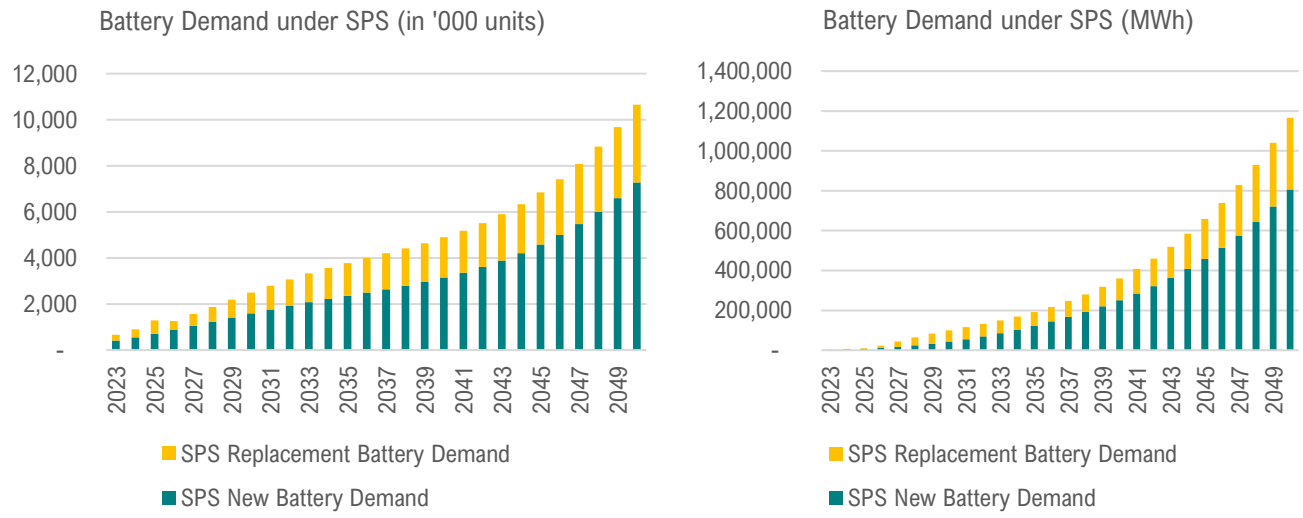
To achieve the EV penetration target, Viet Nam would need up to 0.8 million chargers and 2 million batteries by 2030, and 6 million chargers and 10 million batteries by 2050.

Depending on the size of the EVs and the types of charging, different EV segments require different types of chargers, including: (i) Level 1 (AC): 3kW; (ii) Level 2 (AC): 7kW; (iii) Level 3 (DC): 50kW; and (iv) Level 4 (DC): 150kW and 250kW. Level 1 chargers are used by private E-2Ws for home charging. Level 2 and Level 3 chargers can be used for E-PC and E-truck charging. Level 4 DC rapid charger is typically used only for E-buses. The number of chargers needed to support the targeted EV uptake under SPS Pathway is about 800,000 by 2030, 2.7 million by 2040, and 6.3 million by 2050 (**Table 25**).

Table 25: Number and Types of Chargers Required under BAU, SPS, and ADS

	Level 1	Level 2	Level 3	Level 4
BAU – 2030	128,400	72,200	3,700	50
SPS – 2030	424,600	243,600	125,200	10,500
ADS – 2030	1,050,000	815,300	189,200	11,200
BAU – 2040	421,500	385,300	24,800	6,000
SPS – 2040	511,300	1,286,300	838,400	113,700
ADS – 2040	1,109,200	1,472,500	961,100	182,200
BAU – 2050	177,100	2,219,400	268,200	88,600
SPS – 2050	169,200	4,288,800	1,555,800	328,400
ADS – 2050	231,500	4,790,300	1,649,100	471,500

Figure 22: Battery Demand for E-Mobility Transition under SPS



In terms of batteries demand, by 2040 and 2050, battery units demand will reach 4.8million and 10.7million respectively under SPS Pathway to support 100 percent EV penetration in most road vehicle segments in Viet Nam. In terms of aggregated battery capacity, the projected demand is about 100GWh by 2030, 360GWh by 2040, and 1,170GWh by 2050. Under ADS Pathway, aggressive EV uptake among the 2Ws segments is achieved in the short-term between now and 2030. As a result, battery demand under ADS Pathway by 2030 is about 4 million units, compared with 2.1 million units under SPS Pathway (**Figure 22**).

Credit: Green Car Report

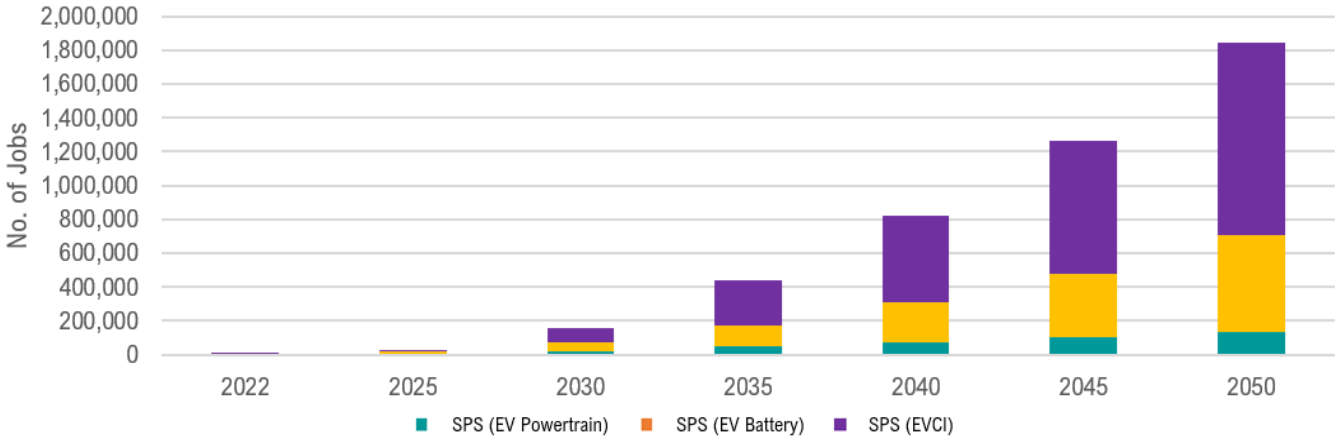
13. Job Creation from E-Mobility Transition

Key Message:

E-Mobility Transition could generate up to 6.5 million new manufacturing jobs in Viet Nam accumulatively through 2050, and substantial jobs for EV maintenance and repairing.

The EV market in Viet Nam is seen to be a huge opportunity and is expected to drive a significant growth in vehicle production and charging infrastructure. The demand for EV manufacturing, servicing, repair, maintenance, and recycling is poised to increase drastically. The EV sector will need a competent workforce to meet the rising manpower requirements realize this growth potential.

Figure 23: Jobs Created in E-Mobility Transition under SPS



Under the SPS EV penetration scenario, a total of 1.8 million jobs would be created in Viet Nam across the EV Value Chain by 2050. About 132 thousand jobs would involve manufacturing the EV Power Train directly. Due to a higher penetration of EVs and higher requirements for replacement batteries, about 574 thousand and 1.1 million jobs are anticipated to be created in the battery manufacturing and EVCI industry, respectively (**Figure 23**).

Among all jobs created by 2050, the percentage of jobs for conventional ICE powertrain manufacturing drops from 96.4 percent in 2022 to 11.9 percent in 2050. Although SPS aims for 100 percent EV penetration in new sales, the remaining jobs in ICE powertrain by 2050 is a result of component manufacturing for powertrains and production of LDV, MDV, HDV trucks where EV penetration is limited. The manufacturing of EV powertrains increases with share of 6.3 percent in 2050 compared to 1.2 percent in 2022. In 2050, the adjacent industries related to the manufacturing of EV Batteries and Chargers will be 27.4 percent and 54.2 percent, respectively.

In addition to manufacturing relate jobs, E-Mobility transition will also create substantial job opportunities in EV maintenance, repairing and operation. However, due to the lack of a creditable reference source of job coefficients for these job categories, the opportunities are not quantified under this study.

14. Towards an Efficient Transition to E-Mobility

Key Message:

A cost-efficient transition to E-Mobility would require synergized investments from public and private sectors.

E-Mobility Transition requires a profound structural shift in Viet Nam's vehicle market, mobility pattern, and energy consumption. A structural shift at this scale will be costly and require a large amount of investment and financing. Public sector, private sector, financial institutions, and individual consumers all have a pivotal role to play. It is however the responsibility of the government to coordinate the process and strive to optimize the synergy across all stakeholders across the economy.

E-Mobility Transition broadly requires investment across four categories: (i) EV production and purchase; (ii) power system upgrading in anticipation of the additional demand from EV charging, (iii) setting up charging networks, and (iv) build up battery recycling capacity.

Credit: The World Vietnam Report

EV Production and Purchase

EV production and manufacturing presents a significant opportunity for industrial development and job creation in Viet Nam. The investment required will mainly come from the private sector. Government also has a critical role to play to provide supportive policies to lower the enter barriers for the private investors, such as preferable land price for EV factories, tax breaks for EV manufacturers, or setting up EV manufacturing business together with the private sector through Public-Private-Partnership (PPP). In order to scale up the EV production capacity, private investors will benefit from financing options provided by the banks, capital markets, and other financial intermediaries. The government should come up with transparent and supporting policies and regulations to help private investors to access financing easily.

EV purchase are primarily an investment borne by the individual consumers and transport service providers, depending on the vehicle segments of concern. At the early stage of E-Mobility transition, the government has a role to play in providing fiscal and non-fiscal incentives to the consumers to facilitate the EV uptake. However, providing direct purchase subsides by the government is not recommended. The recent World Bank Flagship Report 'Economics of Passenger E-Vehicles' (2023) has drawn lessons from countries around the globe where direct EV purchase subsidies are applied and found that this approach is hugely costly and regressive. Most of the developing countries will not be able to afford sustaining EV purchase subsidies for a substantial period.

Instead, mobilizing financial institutions such as commercial banks to help consumers and operators to access financing easily for EV purchase is very effective and important. Government needs to introduce supportive policies to encourage banks in rolling out credit lines for EV purchase loans for individuals and businesses. This could be done via government subsidized interest rates, or measures to de-risk the loan issuance and increase credit worthiness of transport service operators.

Power System Upgrading

Power system upgrading require investment from both public and private sector. Generally speaking, private sector shares more load for power generation supply related investment in Viet Nam. In comparison, public sector or government bares most costs for investment related to power transmission and distribution network. New investment areas such as smart grid development would become critical under the E-Mobility Transition to enable better load monitoring and vehicle-to-grid power transfer in the future.

Charging Network Development

In terms of investment for charging network development, various business models have emerged across the world but in general public and private partnership will be the main vehicle to channel investment for this aspect. Investment related to setting up charging facilities are relatively small, as compared with the investment needed for power system upgrading. The original equipment manufacturers (OEMs) for EVs are typically active in investing in charging network in order to create an enabling environment to unlock EV uptake, as seen in Viet Nam under VinFast.

Other than EV OEMs, power utility providers, petroleum distributors, and specialized charging operators could all share keen interests in investing in EV charging network. For the government, it is recommended to focus on creating a policy environment that maximizes the motivation of the private sector and the business prospects related to charging network investment. This can be done by introducing ambitious EV uptake mandates with clear timeline, setting clear technical standards for charging infrastructure, introducing fiscal and non-fiscal incentives to encourage private investment on charging, and piloting business models for PPPs on charging network development via government-based pilot projects.

It is important to highlight the critical role that GoV plays in incentivizing charging development. Studies of international experience show that government subsidies towards charging infrastructure can be up to 5-6 times more effective compared to subsidies towards vehicle purchase.

Battery Recycling

Lastly, the investment needed for establishing the battery recycling capacity should be mainly provided by the private sector, given the expected market potential in this area as EV uptake scaling up. However, given that battery recycling is a new investment field in Viet Nam, the government has a critical role to play to leveraging existing market players in the solid waste management area and providing incentives such as tax breaks, land price preference for factories, and so on to cultivate investment climate from the private sector.

15. E-Mobility Transition and the 2050 Net-zero Target

Key Message:

E-Mobility plays a limited role in achieving the 2030 NDC targets but will be critical for achieving the 2050 Net-zero target.

Viet Nam's 2022 NDC covers the timeframe up to 2030, with 2014 being the baseline year (no EV adoption). Under the NDC, the transportation sector is counted as an energy-related sector. The conditional and unconditional emission reduction targets of the NDC are set for all energy-related sectors. Viet Nam aims to achieve an unconditional GHG emission reduction of 64.8 MtCO2eq by 2030 from the energy-related sector including the transport sector. Under the conditions of international technology and financing support, this target could increase to 227.0 MtCO2eq (**Figure 24**).

Figure 24: Road Transport Emissions through 2050 under Three Transition Pathways (in Mt CO2eq)

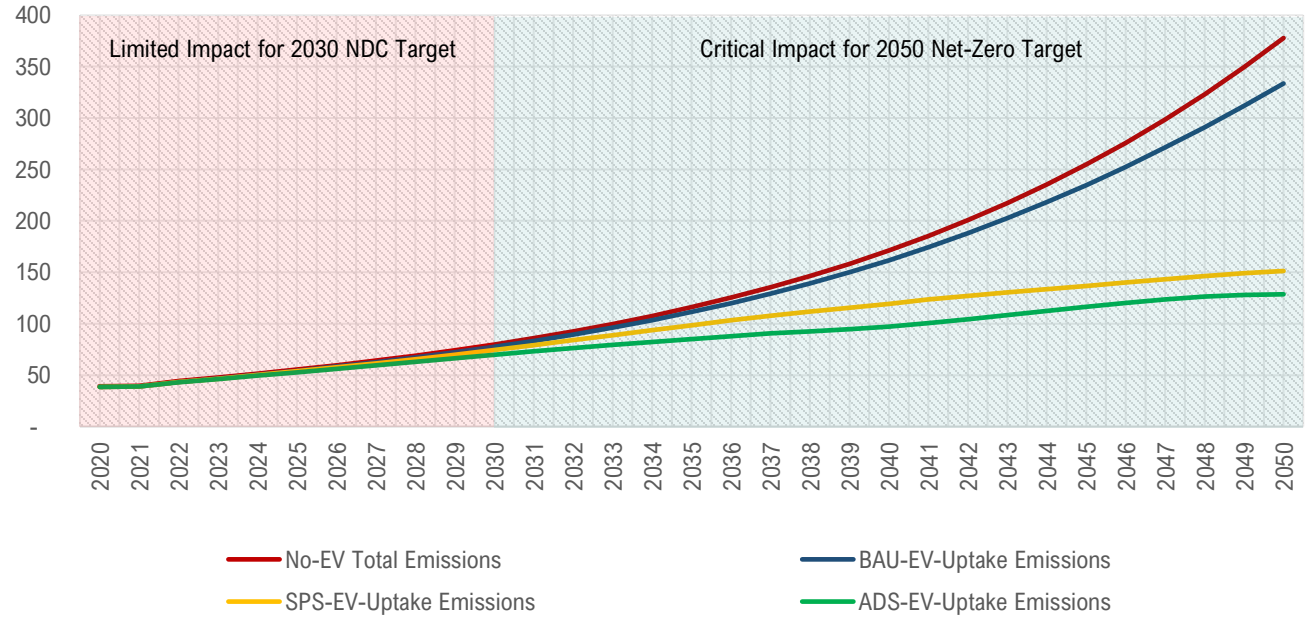


Table 26: Emission Reduction Achieved through E-Mobility Transition Compared with Baseline (in MtCO2eq)

	2030	2035	2040	2045	2050
Baseline Emission ('No-EV' Scenario)	80	116	171	255	378
Emission Reduced with BAU-EV Uptake	2.2	4.7	9.6	20.0	44.2
In percentage (%)	2.8%	4.1%	5.6%	7.8%	11.7%
Emission Reduced with SPS-EV Uptake	5.3	17.5	52.0	118.0	226.5
In percentage (%)	6.7%	15.1%	30.4%	46.3%	60.0%
Emission Reduced with ADS-EV Uptake	9.9	30.9	74.1	138.4	249.1
In percentage (%)	12.4%	26.6%	43.2%	54.3%	66.0%

Achieving the EV uptake following the SPS Pathway will lead to a GHG emission reduction by 5.3 MtCO2eq by 2030. This amount of reduction contributes to about night percent of unconditional NDC emission reduction targets set for the overall energy-related sector. If following an EV uptake pathway modelled in ADS Pathway, the total GHG emission reduction by 2030 from E-Mobility Transition would reach 9.9 MtCO2eq, contributing to about 15 percent of Viet Nam's unconditional NDC target for the energy-related sector. The impact on emission reduction from E-Mobility transition by 2030 is modest, mainly because that by 2030 the majority of electrified vehicles will be E-2Ws. The dominate segments for road transport emissions by 2030 – freight trucks, have not yet entered a rapid EV penetration stage due based on the assessed readiness level.

However, beyond 2030 particularly 2035, as the E-Mobility Transition in Viet Nam shifting from 2Ws to PCs, trucks, and intercity buses, the emission reduction impact will rapidly scale up. If all stated EV uptake targets in Decision 876/QD-TTg in 2022 are achieved, i.e. following the SPS Pathway, the total GHG emission reduction achieved by the E-Mobility Transition would be around 226 MtCO2eq, representing a 60 percent reduction from the baseline scenario in 2050. Achieving the ADS EV uptake would lead to a total emission reduction by 249 MtCO2eq, representing a 66 percent reduction from the baseline.

With the E-Mobility Transition pathways modelled under SPS and ADS Pathways, road transport emissions in Viet Nam are still about 40 percent away from net-zero by 2050. This is because the model only considers electrification via BEV technology, with conservative assumptions applied on BEV adoption among long-haul heavy-duty vehicle segments such as intercity coaches and heavy trucks where only EV penetration is capped around 25-40 percent.

16. E-Mobility Transition and Power Sector Decarbonization

Key Message:

E-Mobility Transition does not need to wait for the decarbonization of the power sector to have an impact.

Historically, power generation in Viet Nam has been heavily dominated by fossil fuels, which consists mainly of coal and gas. In 2022, coal, oil and gas collectively account for 43 percent of Viet Nam's installed power capacity and 64 percent of electricity production. Under the PDP8, Viet Nam would significantly expand its renewable energy capacity comprising wind, solar, hydropower and biomass while pivoting away from coal to gas. It aims to increase renewable energy capacity from the previously planned 17GW to a new target of 50GW and reduce coal power peak capacity to a new target of 30GW by 2030. By 2050, the country targets to raise the renewable energy to 65 percent of the total power mix.

Table 27: Power System Emission Intensity Factors

t-CO2/MWh, sent out	2022	2025	2030	2035	2040	2045	2050
BAU	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SPS	0.44	0.47	0.52	0.41	0.32	0.18	0.07
ADS	0.44	0.47	0.40	0.28	0.17	0.06	0.01

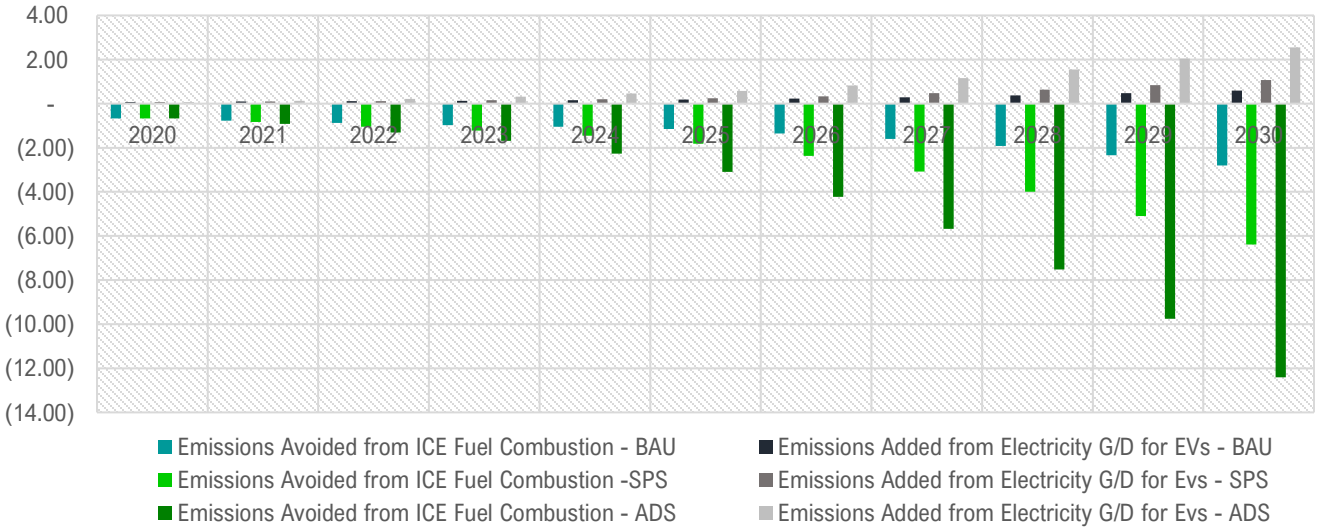
Note:

- BAU assumes the power system emission intensity would remain unchanged from the 2022 level. IES estimates the actual 2020 and 2021 emission intensity factor is 0.45.
- SPS assumes that the grid mix will involve as per the PDP8, and the emission intensity factor uses PDP8 base case.
- ADS uses the same grid mix and emission intensity factor used in Accelerated Decarbonization Scenario for the World Bank Country Climate and Development Report, 2022.

This study estimated the total emissions generated from generating, transmitting and distributing the electricity required for EV charging under three E-Mobility Transition Pathways. Different power system emission intensities are applied. Overall, it is evident that emissions added by generating and distributing electricity for EV charging is easily offset by the emission reduction achieved from avoided fossil fuel combustion if the vehicles remain as ICE vehicles. For instance, even if under the most aggressive ADS Pathway, the total emissions added for EV charging is about 2.53 MtCO2eq by 2030, compared with 12.32 MtCO2eq emission avoided from changing ICE vehicles to EVs to fulfil the same transport demand.

Certainly, decarbonizing the power grid is critical to maximize the emission reduction impact from the E-Mobility transition, but it is clear that switching ICE vehicles to EVs in itself will generate massive emission reduction impact simply due to EVs' much higher energy efficiency compared with combustion of fossil fuels by ICE vehicles. E-Mobility Transition should be actively pursued as a decarbonization strategy, while the decarbonization of the power grid taking the needed process to come online.

Figure 25: Emissions in E-Mobility Transition through 2030 under BAU, SPS, and ADS (in million-ton CO2eq)



Credit: PV Tech

17. E-Mobility Transition and Local Air Pollution Reduction

Key Message:

E-Mobility Transition could reduce the environmental damage costs from local air pollution by US$30 million by 2030 and US$6.4 billion by 2050 for Viet Nam.

The combustion process of gasoline and diesel by ICE vehicles result in significant emissions of air pollutants such as nitrogen oxides (NO_x), sulfur oxides (SO_x) and particulate matter with a diameter of 10 micrometers or less (PM_{10}). These emissions contribute to local air pollution, severe environmental damages, and threats to population health. A key benefit from the E-Mobility Transition is to avoid the emissions of air pollutants from the ICE vehicle operations by replacing ICE road vehicles with EVs.

Viet Nam is one of the countries facing rapid increase of air pollution risks. Transportation is a key contributor to this risk. According to a World Bank study "Clean Air for Hanoi: What Will It Take?" (2022), transportation sources contributed to about 25 percent of $PM_{2.5}$ pollution in Hanoi.

By achieving the EV uptake scenario under SPS Pathway, by 2030, Viet Nam could achieve avoided emissions of SO_x by 302 tons, NOx by 1,857 tons, and PMs by 181 tons. By 2050, as the E-Mobility Transition scales up to PCs, trucks, and long-haul coaches, this impact will be increased by 162 times for SO_x with 48,842 tons of SO_x avoided, by 66 times for NO_x with 122,079 tons of NO_x avoided, and by 48 times for PM_{10} with 8,607 tons of PM_{10} avoided. This level of air pollution reduction accumulatively saves Viet Nam about US$30 million environmental damage costs by 2030, which surges to US$6.4 billion by 2050 (**Figure 26**).

Figure 26: Avoided Pollution from SPS EV Uptake (tons)

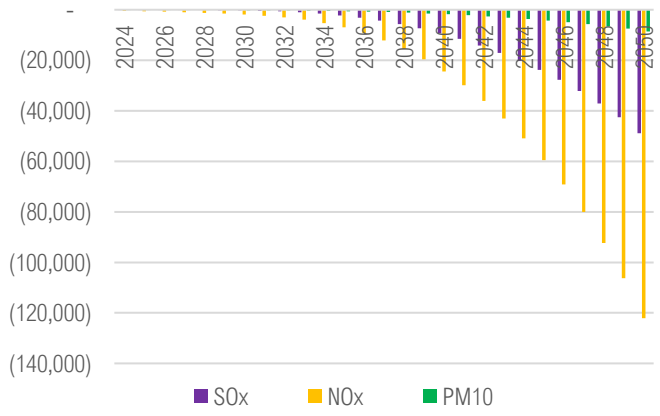
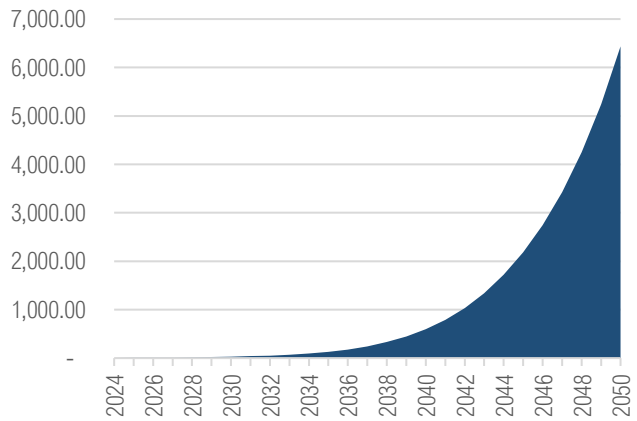


Figure 27: Accumulative Environmental Damage Costs Avoided under SPS (in US$mn)



18. Limitation of the Scope and Next Phase Engagement

This study is the first phase of the World Bank's engagement in Viet Nam on E-Mobility Transition. It aims to inform the GoV's on-going efforts to develop an overarching roadmap and action plan to steer this complex transition. The report focuses on assessments and recommendations at the national level, covering all relevant vehicle segments currently used in Viet Nam that will be subjects for the E-Mobility Transition. Particularly, the study aims to estimate the scale and level of efforts required to achieve Viet Nam's announced targets on EV uptake, and the subsequent implications to the power sector, manufacturing sector, job creation, and emission and pollution reduction.

Given the focus of the report, the study provides limited analysis on several aspects related to the E-Mobility Transition. These limitations are important to highlight to guide other complementary works.

This study uses an EV Transition projection model that is based on vehicle sales and active vehicle stocks. Although transport passenger and freight demand are used as inputs to project vehicle sales, the modal does not support in-depth analysis related to transport demand modal shift between road vehicle segments (i.e. from PCs to public buses) and between modes of transport (i.e. from road transport to railways and metro). A sensitivity analysis on transport modal shift is developed to illustrate the potential impact for reducing overall EV charging demand by reducing electrified PC and truck usage to mass transit and railway/waterways, the analysis assumes the modal shift only takes in the form of reduced vehicle-km-drives, instead of a reduced vehicles sales and stock.

The study provides a set of high-level estimates on demands and investment needs for EVs of all kinds, electricity and grid capacity for charging, batteries for EV production, and chargers at both private and public charging facilities. However, it does not provide further in-depth analysis and recommendations on business models and financing mechanism to implement, for instance, for power sector upgrading or scaling up E-Bus penetration among public buses. This subsequent analysis will be covered under the next phase of the World Bank's support to Viet Nam on E-Mobility Transition, which is currently ongoing.

The study offers limited analysis at sub-national level. This is mainly due to the lack of sub-national data on EV sales and registration records. Estimating sub-national, or local level EV penetration is critical for planning interventions for charging network, such as estimating the additional substations and transformers for the distribution network, and numbers of chargers needed for local EV usage. The World Bank is working with several cities as the second phase of this engagement to fulfill key data gaps and carry out local level studies to guide E-Mobility Transition on the ground.

Annex 1: Key Assumptions Used to Estimate EV Charging Demand

Baseline Year 2022

Vehicle Segment	Avg. Daily Distance (km)		EV Battery Efficiency (kWh/km)	
	Baseline	Annual Learning Rate (%)	Baseline	Annual Learning Rate (%)
2W Segments				
Private 2Ws (Urban)	16	1.00	0.017	1.00
Private 2Ws (Non-urban)	19	2.50		
Commercial 2Ws (Taxi, cargo delivery)	102	1.50		
PC Segments				
Private PCs (Urban)	29	1.00	0.202	1.00
Private PCs (Non-urban)	35	2.50		
PCs for Taxi	250	1.50		
PCs for Ride Hailing	82	1.50		
Bus and Coach Segments				
City Bus	245	1.00	1.252	1.00
Intercity Bus/Coach (Short haul)	277	1.50	1.402	1.00
Intercity Bus/Coach (Long haul)	431		1.037	1.00
Truck Segments				
Trucking (Short haul)	263	1.50	0.275	1.00
Trucking (Long haul)	525	1.50	1.343	1.00

Note:

- Vehicle daily activity levels are based on primary surveys conducted in Viet Nam under this study.
- EV battery efficiency for 2Ws, 4Ws, and city bus is based on the average of actual figures from the most popular EV models available in Viet Nam, mainly from VinFast. For coach and truck segments, battery efficiency number is from the global average of 60 existing popular models.

Annex 2: Assumed EV Charging Profiles by EV Segments

Baseline Year 2022

EV Segments	Default Profile (BAU)		SPS Profile		ADS Profile	
	Charged at	Hours	Charged at	Hours	Charged at	Hours
Private 2Ws	Home Charging 100%	7pm-7am	Home Charging 70%	7pm-7am	Home Charging 20%	12am-5am (off-peak)
	Public Charging 0%	-	Public Charging 30%	9am-5pm	Public Charging 80%	9am-5pm (off-peak)
Commercial 2Ws	Depot Charging 100%	9pm-7am	Depot Charging 80%	9pm-7am	Depot Charging 50%	12am-5am (off-peak)
	Battery Swapping 0%	-	Battery Swapping 20%	24 hours	Battery Swapping 50%	24 hours
Private PCs	Home Charging 100%	7pm-7am	Home Charging 70%	7pm-7am	Home Charging 30%	12am-5am (off-peak)
	Public Charging 0%	-	Public Charging 30%	9am-5pm	Public Charging 70%	9am-5pm
PCs for Taxi	Depot Charging 100%	9pm-7am	Depot Charging 80%	9pm-7am	Depot Charging 50%	12am-5am (off-peak)
	Opportunity Charging 0%	-	Opportunity Charging 20%	9am-5pm	Opportunity Charging 50%	9am-5pm
City Bus	Depot Charging 100%	9pm-7am	Depot Charging 80%	9pm-7am	Depot Charging 50%	12am-5am (off-peak)
	Opportunity Charging 0%	-	Opportunity Charging 20%	9am-5pm	Opportunity Charging 50%	9am-5pm
Intercity Bus/Coach	Depot Charging 100%	9pm-7am	Depot Charging 80%	9pm-7am	Depot Charging 50%	12am-5am (off-peak)
	Opportunity Charging 0%	-	Opportunity Charging 20%	9am-5pm	Opportunity Charging 50%	9am-5pm
Trucking	Depot Charging 100%	9pm-7am	Depot Charging 80%	9pm-7am	Depot Charging 50%	12am-5am (off-peak)
	Opportunity Charging 0%	-	Opportunity Charging 20%	9am-5pm	Opportunity Charging 50%	9am-5pm

Note:

- Under the BAU, no public charging network is developed under government program. Private EVs are charged at home and commercial EVs are charged at depots in urban centers financed by the private sector. No charging infrastructure is available in non-urban areas.
- Under SPS, public charging network is developed with government support starting in 2030 and completed in 2050. No other supportive measures such as electricity tariff reforms or smart charging devices are introduced to promote the use of public charging during the day or delayed charging after peak hours in the evening.
- Under ADS, public charging network is developed with government support starting in 2030 and completed in 2050. Electricity tariff reforms and smart charging devices are introduced to promote the use of public charging during the day and delayed charging after peak hours in the evening.

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