Study of electric mobility development in Viet Nam

Report for NDC Transport Initiative for Asia (NDC-TIA)

August 2021

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STUDY OF ELECTRIC MOBILITY DEVELOPMENT IN VIET NAM

REPORT

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Abbreviations

AAGR	Annual average growth rate
ADB	Asian Development Bank
AQI	Air Quality Index
ASEAN	Association of Southeast Asian Nations
BAU	Business as Usual
BEV	Pure battery electric vehicle
CNG	Compressed natural gas
CPC	Central Power Corporation
CV	Conventional vehicle
DOST	Science and Technology Department
DOT	Department of Transport
DRVN	Directorate for Roads of Viet Nam
E2W	Electric two-wheeler
E4W	Electric four-wheeler
EMPI	E-mobility Potential Index
EPR	Extended Producer Responsibility
ERAV	Electricity Regulatory Authority of Viet Nam
EV	Electrical vehicle
EVN	Vietnam Electricity Group
EVSE	Electrical vehicle service and equipment
GDE	General Directorate of Energy
GENCO	Power Generation Joint Stock Corporation
GHG	Greenhouse gas
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit GIZ
GRDP	Gross regional domestic product
GSO	General Statistical Office
HCMC	Ho Chi Minh City
HEV	Hybrid electric vehicle
HW	Hazardous waste
ICE	Internal combustion engine
ICEV	Internal combustion engine vehicles
IEA	International Energy Agency
IFC	International Finance Corporation
IWT	Inland waterway transport
JICA	The Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
LCA	Life cycle assessment
LCV	Light-commercial vehicles
LDV	Light-duty vehicles
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LULUCF	Land use, land-use change, and forestry
MOF	Ministry of Finance
MOIT	Ministry of Industry and Trade

MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
NCCS	The National Climate Change Strategy
NDC	Nationally Determined Contributions
NDC-TIA	NDC Transport Initiative for Asia
NGGS	National Green Growth Strategy
NSDS	National Sustainable Development Strategy
NTSC	National Traffic System Coordinator
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid vehicle
PM	Particulate Matter
PVN	Vietnam Oil and Gas Group
QCVN	National Technical Regulation
R&D	Research & Development
SAIDI	System Average Interruption Duration Index
TDSI	Transport Development and Strategy Institute
TKV	Vietnam National Coal and Mineral Industries Group
TOR	Terms of Reference
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VAMA	Vietnam Automobile Manufacturing Association
VAMOBA	Vietnam Auto Motorcycle Bicycle Association
VCAP	Vietnam Clean Air Partnership
VKT	Vehicle kilometres travelled
VNGO&CC	Vietnamese Non-governmental Organisations and Climate Change
WB	The World Bank

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Acknowledgement

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In Viet Nam, the project's implementing organisation is GIZ and partner institutions include World Resources Institute (WRI) and International Council on Clean Transportation (ICCT). Viet Nam Ministry of Transport (MOT) is Lead executive organisation and the Department of Environment (DOE) is project owner. For more information on the project, please visit: https://www.ndctransportinitiativeforasia.org/.

The consultant team includes team leader: Prof. Dr. Le Anh Tuan and team members: Dr. Nguyen Thi Yen Lien and M.S. Do Duc Tue, together with the support of other experts including Dr. An Minh Ngoc, Dr. Tran Tuan Vu, Dr. Tran Minh Tu, M.S. Diep Anh Tuan; review, assessment, and advice from GIZ's Project Team.

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EXECUTIVE SUMMARY

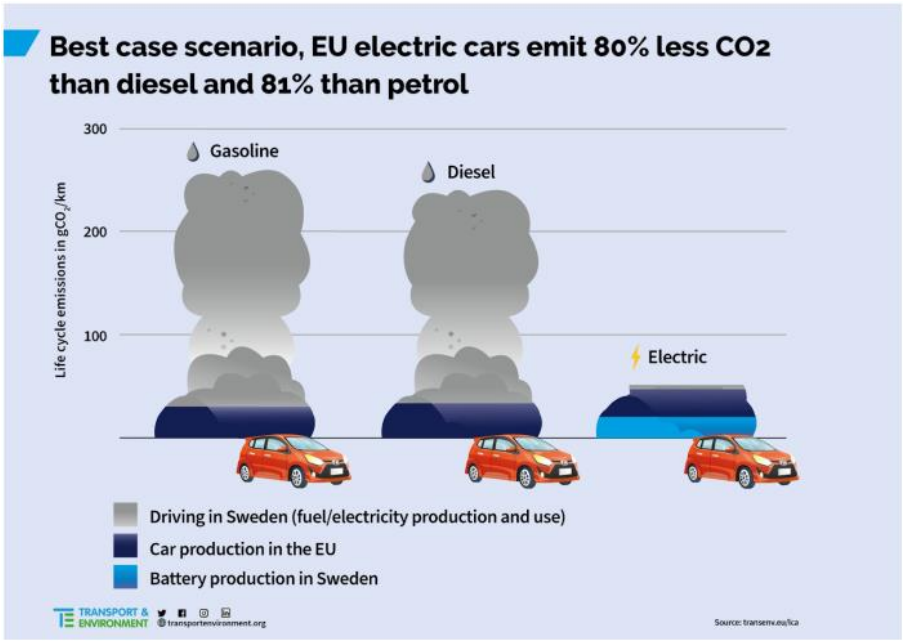
Viet Nam has achieved remarkable success in socio-economic development and poverty reduction in the last 20 years, which has enabled the country to move out of the group of low-income countries. Viet Nam's transport sector has undergone major development, making positive contributions to the economic development. The rise in incomes and economic growth has led to rapid motorisation. By the end of 2018, Viet Nam had a population of over 95 million, 3.9 million registered automobiles and 58.2 million registered motorbikes. While motorbikes continue to be the major component of the vehicle fleet (above 92%), cars have quickly been replacing motorbikes since 2016 (). The annual growth rate of the number of automobiles in circulation was 15.5% in the period 2014-2018 (). The fast increase in the number of vehicles, especially automobiles, has increased pressure on the road infrastructure system. In response, the country's road network has been rapidly expanded and improved to meet the high motorisation rate.

In addition, the increased vehicle kilometres is increasing the demand for fuel consumption and causing serious environmental pollution. According to a GIZ/WB report published in 2019, the transport sector is becoming a large and growing contributor to total greenhouse gas (GHG) emissions in Viet Nam; the transport sector in 2014 contributed about 18% of the country's total CO_2 emissions. The report stated that under Business-as-Usual (BAU) conditions, the transport sector's CO_2 emissions will increase from 33.2 million tons of CO_2 in 2014 to 89.1 million tons in 2030. Throughout this period, road transport was the largest emitter at 26.4 million tons of CO_2 in 2014, which will increase to 71.7 million tons in 2030 (Oh J.E., 2019).

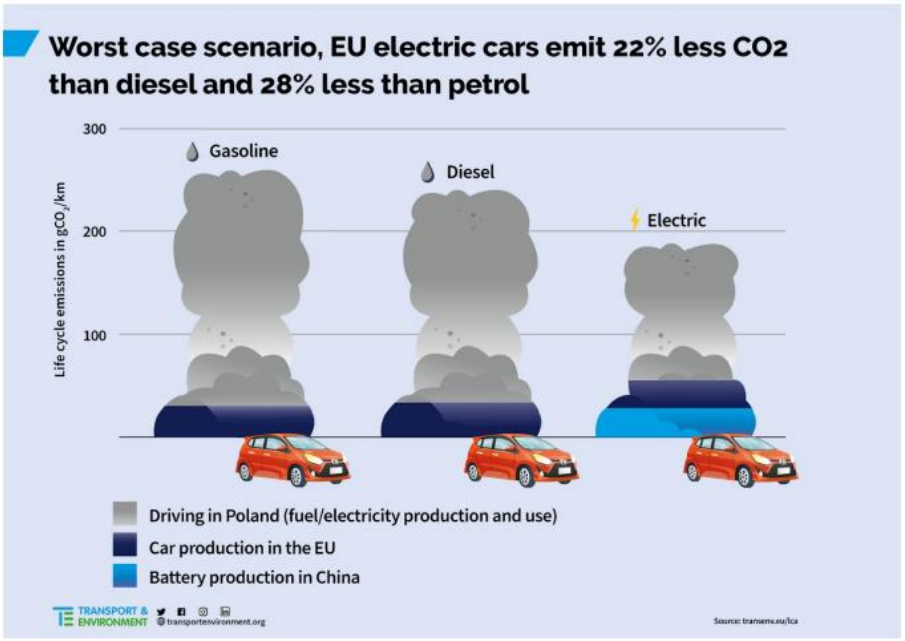
In Viet Nam, around 60,000 deaths each year are related to air pollution. According to the Ministry of Natural Resources and Environment (MONRE), most of Viet Nam's major cities are facing increasing air pollution. Particulate matter (PM) pollution is at a high level in large cities, especially in areas near major traffic routes. Recently, Hanoi and Ho Chi Minh City have risen in the rankings for PM2.5 levels for major cities in the world. With the current air pollution situation, Viet Nam has suffered economic losses estimated at between USD 10.8-13.2 billion associated with ambient air pollution each year, equivalent to about 5% of the country's GDP (IQAir, 2019).

Under the Paris Agreement, Viet Nam has committed in its updated Nationally Determined Contribution (NDC) to cut GHG emissions by 9% in 2030, compared to the BAU scenario using domestic resources, increasing this ambition to 27% against BAU contingent on receiving international support. In order to meet these GHG emissions reduction targets, road transport will have to reduce emissions substantially. The GIZ/WB report also demonstrated that this is possible by employing a mix of diverse policies and investments. Viet Nam can reduce its carbon emissions in the transport sector by up to 9% by 2030 using domestic resources, and by as much as 15-20% with international support and private sector participation. Of this figure, the CO_2 emissions reduction level of 15-20% can be achieved when electric vehicles (EVs) are brought into use at different levels. Scenario 3 pushes the level of ambition and is assuming significant support from international resources and the active participation of the private sector and estimates achieving 30% of electric motorbikes in the

motorbike fleet by 2030; 10% of EVs in bus sales in the period from 2020 to 2030; and 5% of EVs sale share in 2025 and 30% in 2030. These measures would result in a reduction of CO_2 emissions in the transport sector in 2030 of 71.2 million tons of CO_2 or 20% compared to BAU. These results imply that EV adoption has a high potential to reduce GHG emissions in the transport sector. An EV is better for the environment over its entire life cycle than an internal combustion engine vehicle, especially in countries where electricity comes from clean, renewable sources (see Figure E.1).



(a) The best-case scenario in which the electric car is run on clean renewable electricity (e.g. Sweden hydropower)



(b) The worst-case scenario in which EV's battery would be produced in China and the EV would run on one of the EU's most carbon intensive grids (e.g. Poland)

Figure E.1. Lifetime CO_2 emission savings from EVs in European Union

(Source: Transport & Environment, 2020)

As can be seen in Figure E.1, if an electric car is run on clean renewable electricity (e.g. Sweden hydro power), the GHG emission over its entire life cycle can reach 81% lower than a gasoline fueled car and 80% lower than a diesel fueled car. Even in the worst-case scenario, in which EV's battery would be produced in China and the EV would run on one of the EU's most carbon intensive grids, the GHG emission in the lifetime of an EV would still be 22% lower than that of a diesel fueled car and 28% lower than of the gasoline fueled car. These are impressive results from developing EVs in a context where humankind is facing serious climate change issues. For these reasons, EVs and their production have recently emerged as the latest trend in the automobile industry, including at various acclaimed and well-known automobile companies.

The global adoption of e-mobility has been accelerating steadily. Two million EVs were sold globally in 2018, doubling EV sales in 2017. At the end of 2018, the global EV stock was 5.1 million units, the E2W stock at about 260 million units, and the electric bus stock at 460,000 units. In 2019, the global electric car (not including hybrid EVs) stock surpassed 7.2 million vehicles, accounting for 2.6% of global car sales.

In Viet Nam, mobility demand is high and increasing, with 206,673 million passenger-kilometres and 273,097 million ton-kilometres transported in 2018, reaching an annual average growth rate of 10.4% and 5.2% for passenger and freight performance demand in the period of 2014-2018. The high mobility demand and motorisation rate means that reducing GHG emissions and air pollution in the transport sector is a great challenge. Therefore, the Vietnamese Government has been applying a number of solutions to promote sustainable development through four focus areas: sustainable development, green growth, climate change, and environmental protection laws. As mentioned above, EVs have the potential to reduce GHG emissions in the transport sector. Viet Nam can achieve a 20% reduction of CO_2 emissions in the transport sector in 2030 compared to BAU by setting up a clear roadmap for EV adoption in the period from 2020 to 2030. Specifically, Viet Nam would have to reach 30% of E2Ws in the motorbike fleet by 2030; 5% sales share for EVs in 2025 and a 30% share in 2030; and a 10% sales share for EV buses in the period from 2020 to 2030.

The German International Cooperation (GIZ) is collaborating with the Ministry of Transport (MOT), represented through its Department of Environment (DOE), to support Vietnamese partners at national and city levels on promoting low-carbon mobility development and GHG emissions reduction in the transport sector, thereby contributing to the implementation of Viet Nam's NDC. One of the work packages is aimed at supporting the development and improvement of regulations with regards to e-mobility. The goal of this assessment is to review and examine the existing sustainable transport policies and provide a brief overview of air pollution in Viet Nam and its cities. In addition, current issues and challenges with regards to e-mobility development are also identified in order to develop and improve the regulatory framework at both national and local levels.

Existing sustainable transport policies

The existing sustainable transport policies in Viet Nam were promoted through the laws, national strategies, and action plans in four key categories: sustainable development, green growth, climate change, and environmental protection (see Figure E.2). Based on such national strategies and action plans, key orientations for sustainable transport development are deployed at both national and city levels.

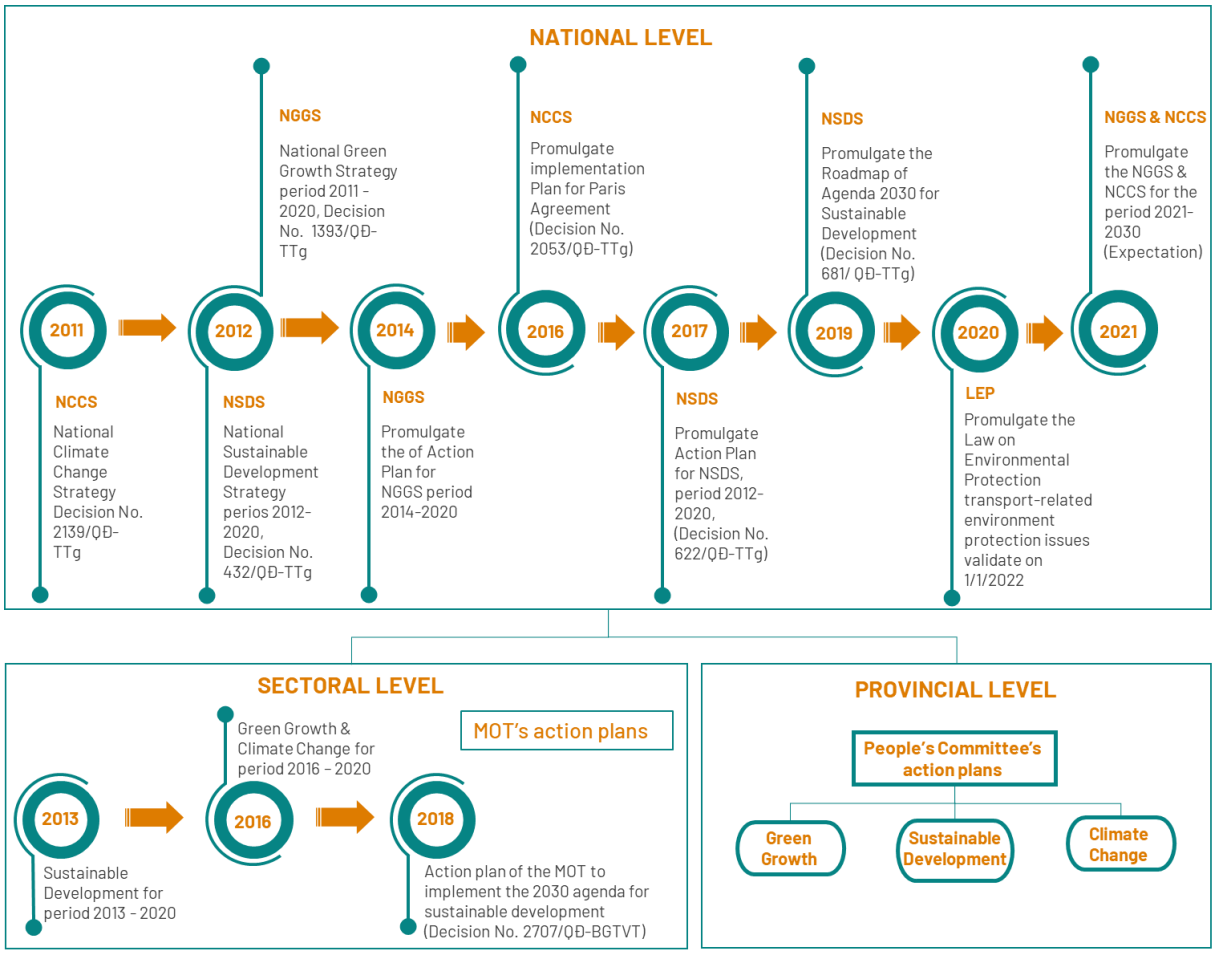


Figure E. 2. Review of existing sustainable transport strategies and action plans in Viet Nam

Under this assessment, the existing sustainable transport policies of eight cities were analysed. Most of the selected cities have promulgated corresponding action plans in aspects of green growth, climate change, and sustainable development. The orientation of EV development was included in strategies under the green growth and climate change categories. At present, only two out of the eight cities have set up detailed targets for EV development, for example, the number of e-motorcycles reaching 5% of total motorcycles in Hanoi by 2030, and the goal of 200 e-buses in circulation by 2025 in Nha Trang.

Table E. 1. Policies related to road EVs in Viet Nam

Items	Government Policy	Types of Electric Road Vehicles					
		E-2 wheelers	*E-3 wheelers*	*E-4 wheelers(*)*	*E-cars*	*E-Buses*	*E-Trucks*
Orientation	Central level	✓ (M)	✓ (O)	✓ (O)	✓ (M)	✓ (M), (O)	■
	Provincial level	✓ (O)	✓ (O)	✓ (O)	■	✓ (O)	■
Target/Road map	Central level	■	■	■	■	■	■
	Provincial level	■	■	■	✓ (O)	✓ (O)	■
Incentives	Central level	■	■	■	■ (M)	✓ (M), (O)	■
	Provincial level	■	■	■	■	✓ (M), (O), (U)	■
Vehicle Management	Central level	✓	■	✓	■	■	■

*Note: *Not passenger cars; these vehicles are used for the transportation of tourists or visitors.*

✓(Yes); ■ (No); M - Manufacture; O – Operation; U - Usage

For EV development, the overall summary of related policies is presented in Table E.1 above. It can be seen that the development of EVs in Viet Nam has mainly stalled at the stage of setting an orientation. Most cities have not set specific targets, incentives or roadmaps for EV adoption.

E-mobility market

The annual growth rate of motor vehicles was 11.17% for the period from 2005 to 2017. In 2018, the number of cars produced domestically reached 263,170 units with a localisation ratio of 15%. The public transport share remains persistently low (below 10%), partly due to the low level of public transport system development and partly due to the convenience and affordability of two-wheeler-based mobility.

The e-mobility market in Viet Nam is at a very early stage. Until now, only e-bikes and e-motorcycles are frequently used and locally produced. According to the Vietnam Automobile Manufacturers Association (VAMA), nearly 500,000 E2Ws were sold in 2018, a 30% increase compared to 2017. A negligible number of HEVs, PHEVs, BEVs have been imported from abroad – approximately 50 vehicles, mainly HEV.

With regards to the domestics E4W market, until now, there are no domestic enterprises which produce and assemble electric cars except for Vinfast. The company announced a plan to present its electric car models to the domestic market in 2021 and export plan to the US market in 2022. Vinfast has also set up a network of E2W battery swapping/renting stations in many cities. In addition, VinFast

has also announced that it will operate Vinbus services in 5 large cities with e-buses produced by VinFast.

In short, with the current inevitable trend for EVs coupled with the Vietnamese Government's efforts to promote low-carbon transport development, the EV market in Viet Nam is a promising market.

Technology and infrastructure

Technology and charging stations

Viet Nam has the capacity to produce EVs locally, in particular E2Ws. Core elements for e-four-wheelers, such as electric engines, are well developed and available. Battery energy storage, however, remains a technical and environmental challenge. It is critical to promptly apply regulations and standards relating to EV batteries, EV service equipment (EVSE) infrastructure, and waste EV battery management (e.g. reuse, recycling, and disposal).

Up to now, there is no EVSE production and installation in Viet Nam, except for some EV charging stations used for testing purposes and Vinfast's small charging points for their e-2-wheelers. Several renowned international EVSE manufacturing companies, such as ABB, Siemens, and Bosch have expressed their support for e-mobility development in Viet Nam.

Since 2019, many buildings in large cities, especially in Hanoi, Ho Chi Minh City, and Da Nang have charging points for e-bikes. In 2019, the LOTUS NC V3 of the Viet Nam Green Building Council was adopted, which added EV charging points as a criterion for obtaining a green building certificate.

National grids

By the end of 2019, the total length of 500 kV lines is 8,496 km, an increase of 2.2 times compared to 2010; the length of the 220-110 kV line increased from 23,156 km to 43,174 km (an increase of 1.9 times); the capacity of transmission substations also increased by about 2.8 times compared to 2010. By the end of 2019, the total installed power source capacity of the whole system reached 54,880MW, an increase of 13% compared to 2018. The scale of Viet Nam's electricity system ranked second in ASEAN and 23rd in the world. The produced and imported electricity of the whole power system reached 240 billion kWh, an increase of 2.35 times compared to 2010. The national commercial electricity output in 2019 reached 209.77 billion kWh, an increase of 2.46 times compared to 2010, corresponding to average commercial electricity growth of 10.5%/year for the whole period of 2011-2019. The continuous development of the national power supply system will create a premise for the gradual promotion of EV use.

Nevertheless, in order to achieve the higher goal of reducing GHG emissions and move towards developing a net-zero-carbon transport system, the promotion of renewable energy as an energy source for EVs is absolutely necessary. In fact, renewable energy is expected to play an increasingly important role in the structure of Viet Nam's national power sources. In 2019, the total capacity of

renewable energy sources accounted for about 9.4% of the system's total power capacity and it is predicted to account for 40.3% by 2045. By the end of 2019, the capacity of renewable energy sources on the power system was 5200 MW, including 4823 MW of solar power and 377 MW of wind power. Before 2019, there were no solar power plants connected to the national power grid. However, within the first 6 months of 2019, 89 solar power plants with a total capacity of 4550 MW were connected. Indeed, these figures are clear evidence that Viet Nam's renewable energy industry is growing fast.

Survey results

Survey results from 1337 respondents showed that motorbikes are the main means of transportation owned and used in Hanoi with 73.3% and 69.8% of ownership and usage. Among the respondents, the share of E2Ws is nearly 14% of the total two-wheelers. 78.4% of EVs have been used for less than 3 years. 44.3% of EVs are used by teenagers to go to school. The main reasons for the focus on teenagers could be the non-requirement for a driver's license and the safety of low-speed vehicles. EV ownership demand is also significantly different between males and females (see Figure E.3). Despite their short life-span of about 2.5 years, 85.9% of EVs are equipped with lead batteries instead lithium-ion batteries due to cost.

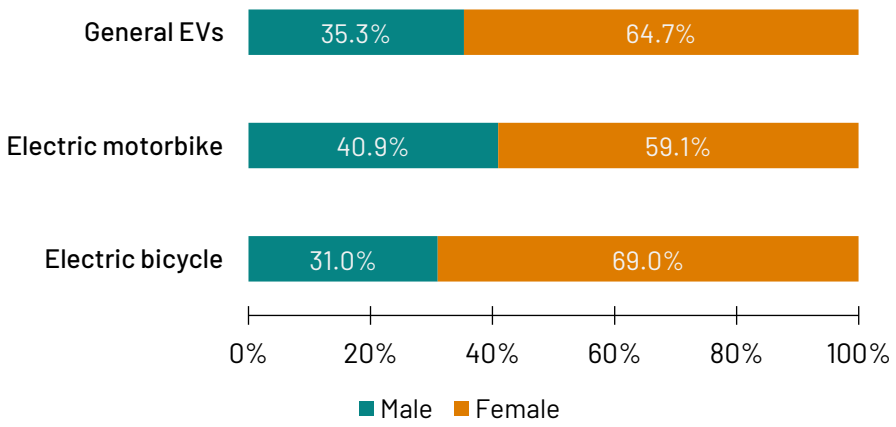


Figure E. 3. Structure of EV ownership by gender

The survey results also indicated that interest in EVs at present is not high. Up to 74.2% of the vehicle owners surveyed said that they have no interest in buying EVs in the future. The demand for EVs is mainly focused on electric motorbikes and electric bicycles (accounting for 90.4% of respondents willing to buy EVs) because they partially meet the criteria of vehicle owners and are quite suitable for pupils, students, retirees, and homemakers. The greatest concern for consumers is the EV price, at approximately 75.7% of the total people surveyed.

The survey results indicated that due to a lack of charging infrastructure, 93.8% of EV owners charged their vehicles at home with the average duration for a full charging of about 6.4 hours. For E2Ws, the average distance travelled per full charging is nearly 50 kilometres. Despite the very low average

vehicle kilometres per day, the lack of charging infrastructure is among the issues customers are concerned about, especially for long-distance travel. The range per charge is the second highest consideration for consumers, at approximately 52.2% of the total people surveyed.

Although there are differences in respondents' answers regarding whether they would be willing to buy an EV, all vehicle owners agreed on the key criteria to be taken into account when purchasing an EV: (i) price; (ii) total mileage when fully charged; (iii) safety; and (iv) environmental problems.

Barriers

According to the survey results, the barriers to adopting EV in Viet Nam are identified and presented in Figure E.4.

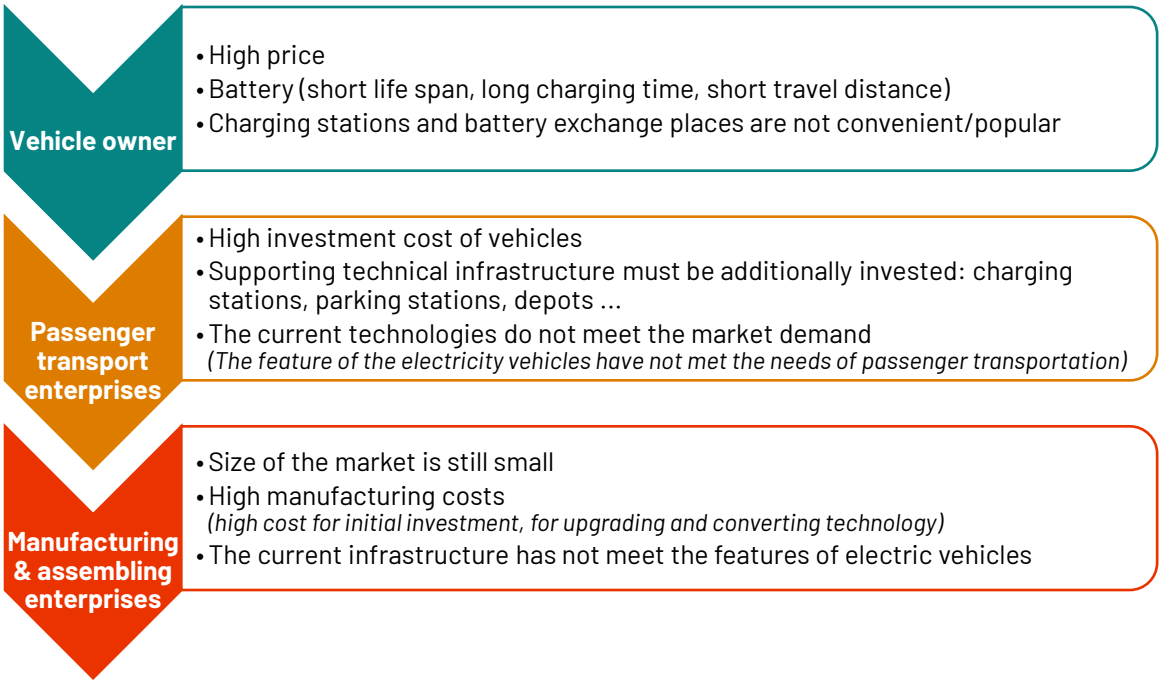


Figure E. 4. Review of existing sustainable transport strategies and action plans in Viet Nam

Market

From transport operators' point-of-view, many barriers limit expansion of the EV market at present, such as: charging issues (74.1%); lack of services (74.1%); lack of incentives (70.4%); lack of EV standards (63.0%); and the small market scale (55.6%).

Policy

There is no specific policy framework dedicated to EV or charging infrastructure for EV except the recent Resolution 55/NQ/TW by the Communist Party of Viet Nam issued on 11 February 2020 providing Guidelines for the National Energy Development Strategy until 2030 with a Vision to 2045, which is the

first official national document that requires the promotion of e-mobility and energy storage in line with global trends.

Viet Nam has neither tax incentives nor price subsidies for EVs. In addition to import duties, electric cars shipped to Viet Nam have been subject to special consumption tax rates ranging from 15-70%, which has increased prices by up to 20%.

Technology and infrastructure

One of the major obstacles to the adoption of EVs is battery and charging infrastructure issues. Notably, there is no charging infrastructure for EVs in Viet Nam. EV batteries must be charged for the vehicle to run and its storage capacity defines the distance that can be travelled on each charge. According to survey results, 60.8% of vehicle owners worry about travel distance per charge in the context where public recharging or exchange stations/points are absent. Therefore, the limited range can be considered an important technical barrier and is a main concern for users.

The average EV charging time is longer than the average refuelling time of conventional vehicles. According to the survey, full charging takes about 6.5 hours, much longer than conventional refuelling. Fast charging with very high power ratings of up to 350 kW could reduce the required charging time. However, for the majority of BEVs today, fast charging is not seen as an important criterion due to higher costs and battery lifetime-reduction stress. In other words, the long charging time for EVs is an inevitable truth; therefore, users need to change their habits to accept it, unless a swapping/renting system like Vinfast is widely implemented.

85.9% of the people surveyed selected lead batteries for their EVs due to the low price. But the lifespan of lead batteries is relatively short, only about 2 to 2.5 years according to survey results, so they are disposed of after use without recall or exchange by manufacturing and trading enterprises. This is because most industrial facilities that manufacture, import and distribute the batteries today do not have battery-recall stations/points; if they do, those stations/points do not comply with Vietnamese regulations.

SWOT analysis of EV adoption in Viet Nam

The assessment also analysed the Strengths, Weaknesses, Opportunities and Threats (SWOT) of EV adoption in order to put forward suitable recommendations for EV development in Viet Nam (see Figure E.5).

Viet Nam is a big market with more than 95 million people and where private motor vehicle ownership is relatively high, especially motorcycles, reaching around 54 vehicles per 100 people. EV has just penetrated Viet Nam in recent years and propaganda for EV benefits and EV support policies are still weak. Nevertheless, the proportion of people surveyed who have a demand for buying EVs is quite

impressive, reaching about 25.8%. This implies that Viet Nam is a promising market for EV development, especially E2Ws.

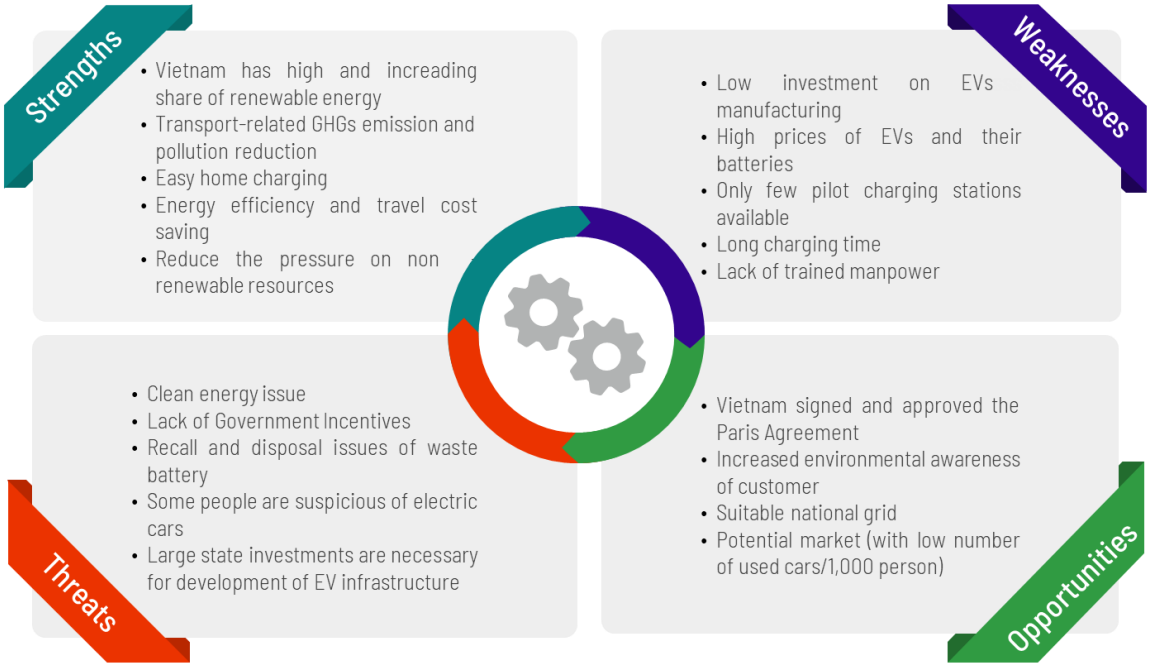


Figure E. 5. Summary of strengths, weaknesses, opportunities, and threats relating to EV adoption in Viet Nam

Viet Nam's 220V main electricity system is likely to be able to charge most EVs at home, bridging the gap for charging infrastructure at present. Besides, Viet Nam also has a huge biomass electricity potential with about 4 billion biogas electricity kWh per year (equivalent to 10% of total renewable energy), which can help to reduce dependence on non-renewable resources.

E-mobility has a low operational cost and causes little noise. The average total annual travel cost of a conventional motorcycle is about 2.6 times higher than that of an e-motorbike in the current context of Viet Nam.

All EVs produce zero direct emissions, which specifically helps improve air quality in urban areas. According to analysis, GHG emission mitigation efficiency in the current context of Viet Nam can achieve from 0.04% to 0.15% when converting from CV to EV. Therefore, EV development in Viet Nam is a promising means to help Viet Nam achieve its commitments in the Paris Agreement on Climate Change. This is also a good opportunity to expand the EV market in Viet Nam.

Proposed evaluation criteria

23 specific sub-indicators grouped into 5 dimension groups have been proposed for the assessment of readiness for e-mobility adoption in big cities in Viet Nam, including:

(1) Potential market:	04 indicators
(2) Pollution situation:	02 indicators
(3) Economic condition:	01 indicators
(4) Policy:	14 indicators
(5) Stakeholder inclusion:	02 indicators

Recommendations

EVs are considered a safe, convenient, and user-friendly means of transport, protecting the environment and solving energy security issues. Consequently, EV adoption is a goal for most countries. To reach emissions reduction goals, EVs should be fully powered by GHG-neutral and renewable energy sources. The share of renewable energy (e.g. solar or wind energy) will need to be increased to ensure EVs are a sustainable success.

For cities with large populations and a scarcity of space for infrastructure, small-sized, light EVs will be beneficial in reducing demand for energy and parking. Moreover, the effectiveness and performance of EVs and charging infrastructure must be maximised to make EVs a viable and useful option for inner-city transportation. Besides, it is essential to have a specific strategy to manage and control the smart grid when the demand for EV use is increasing.

A roadmap for adopting EVs in Viet Nam is proposed and presented in Figure E.6 below. This roadmap was developed with special attention to the real demand of people along with the government's expectations about the milestones of EV development. Furthermore, research on infrastructure and potential development of infrastructure to serve EVs, including energy systems and transport systems were also carefully considered.

Experience from countries with stronger EV market penetration shows that EV promotion policies should not only concentrate on consumers. Policies advancing EVs in niche markets, such as car-sharing and postal fleets and/or green consumers, have proven particularly successful.

In addition to promoting the development of the EV market, the government may also manage battery recycling in order to make EVs a truly eco-friendly choice. Recall and recycle for EV waste batteries will not only avoid a huge burden on landfills but will also help manufacturers secure the supply of critical materials, such as cobalt and lithium, that surely hold the key to a sustainable automotive industry.

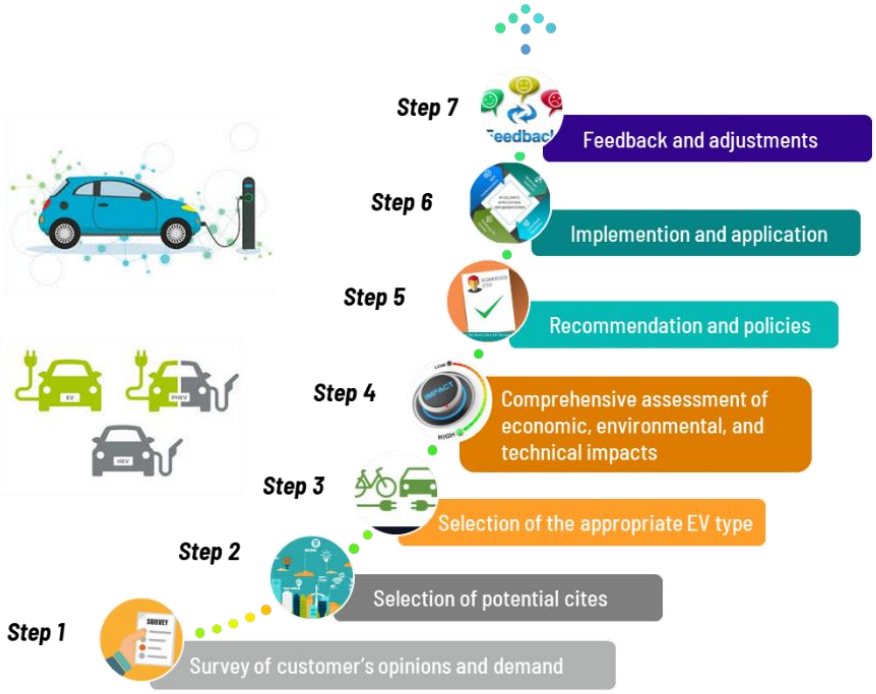


Figure E. 6. Roadmap suggested for EV adoption in Viet Nam

In short, as soon as possible Viet Nam needs to have clear, adequate and comprehensive e-mobility policies and a regulatory framework that provides medium- and long-term stability for the planning of significant future investments.

1. INTRODUCTION

Background

Humankind is facing rapid climate change and fossil fuel depletion. Viet Nam is one of the countries predicted to be most severely affected by climate change with nearly 60% of land area and 70% of the population vulnerable to natural disasters (Oh et al., 2019; Vien, 2011). Viet Nam's fast-growing economy is recognised as a significant cause of GHG emissions contributing to climate change. The transport sector plays a significant role in this trend. A rise in incomes and economic growth has led to rapid motorisation, with 3.9 million registered automobiles and 58.2 million registered motorbikes in 2018 (Transport Development and Strategy Institute, 2018). In consequence, the transport sector is a major consumer of energy in Viet Nam and a significant source of GHG emissions. In 2014, total GHG emissions from the transport sector reached around 30.55 $MtCO_2e$, approximately 10.8% of total CO_2e emissions in Viet Nam (Oh et al., 2019). The higher the mobility demand and motorisation rate, the greater the challenge of reducing GHG emissions in the transport sector.

In this context, Viet Nam demonstrated its commitment to addressing climate change through signing and approving the Paris Agreement in April and October 2016, respectively. The implementation of each party's responsibilities for climate change response is reflected through Nationally Determined Contributions (NDC). The goal of GHG emissions reduction in Viet Nam's first NDC submitted in 2015 was calculated based on baseline data from 2010. Recently, in accordance with Decision 1/CP.21 of COP21 requesting parties to communicate or update their NDCs by 2020, Viet Nam reviewed and updated its NDC for submission to the UNFCCC Secretariat in 2020 based on the actual country context. Compared to the 2015 NDC, the updated contribution in 2020 increased in both amount as well as ratio. Accordingly, GHG emissions reductions increased by 9% compared to the BAU scenarios (baseline year: 2014) in the case of unconditional contribution, and by 27% with international support according to the new mechanisms under the Paris Agreement.

Recognising the importance of the transport sector to deliver on Viet Nam's NDC commitment, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) cooperates with Viet Nam's Ministry of Transport (MOT) and its Department of Environment (DOE) to implement the NDC Transport Initiative for Asia (NDC-TIA) project. The NDC-TIA is funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, and jointly implemented by seven organisations. The NDC-TIA operates in China, India, and Viet Nam and aims at promoting a comprehensive approach to decarbonising transport; i.e. a coherent strategy of effective policies that are coordinated among various sector ministries, civil society and the private sector. In each of the partner countries, the consortium provides support in facilitating and informing stakeholder processes and in developing selected climate actions. This enables partners to make a sectoral contribution towards achieving their NDCs and increasing ambitions in transport-related

sections of long-term strategies and 2025 NDCs. As a regional initiative, the programme disseminates knowledge as well as experiences from China, India, and Viet Nam to the rest of Asia. The consortium connects with regional stakeholders and other Asian countries in order to encourage a comprehensive approach to decarbonising transport. On the global level, the programme will disseminate and share experiences in the UNFCCC process.

In Viet Nam, the goals of the project are to support Vietnamese partners at national and city levels to enhance the transport mitigation ambition in its 2050 vision and NDC, and to improve the policy framework for low-carbon transport. This includes establishing a transparency system for the transport sector and the development of more ambitious climate targets for integration into Viet Nam's 2025 NDC. Furthermore, the consortium supports a pilot city in formulating mitigation strategies (e.g. an electromobility pilot), and the development of a regulatory framework on the national level (e.g. electromobility, fuel economy). The political partner in Viet Nam is the Ministry of Transport (MOT), represented through its Department of Environment (MOT/DOE).

Objectives

The specific objectives of this assessment include the following:

- To review and examine the existing sustainable transport policies with a brief overview of air pollution in Viet Nam and its cities.
- To identify current issues and challenges with regards to electric mobility (e-mobility) development.
- To support developing and improving the regulatory framework relating to e-mobility development at both national and local levels.
- To develop a set of criteria for the selection of cities to implement EV.

This report focuses on electric vehicles (EVs) such as: pure battery electric vehicles (BEVs), hybrid electric vehicles (HEV), and plug-in hybrid vehicles (PHEVs).

Scope

This assessment belongs to work item 2.2.1.1, in the framework of activity A.2.1.1 under work package A.2.1, component 2. Therefore, this report focuses on road motor vehicles at both national and local levels. Eight cities have been selected to represent the local level consisting of 5 municipalities (Hanoi, Hai Phong, Da Nang, Ho Chi Minh City and Can Tho) and 3 other cities (Hue, Nha Trang, and Ha Long).

Methodology

The overall methodology is presented in Figure 1.1.

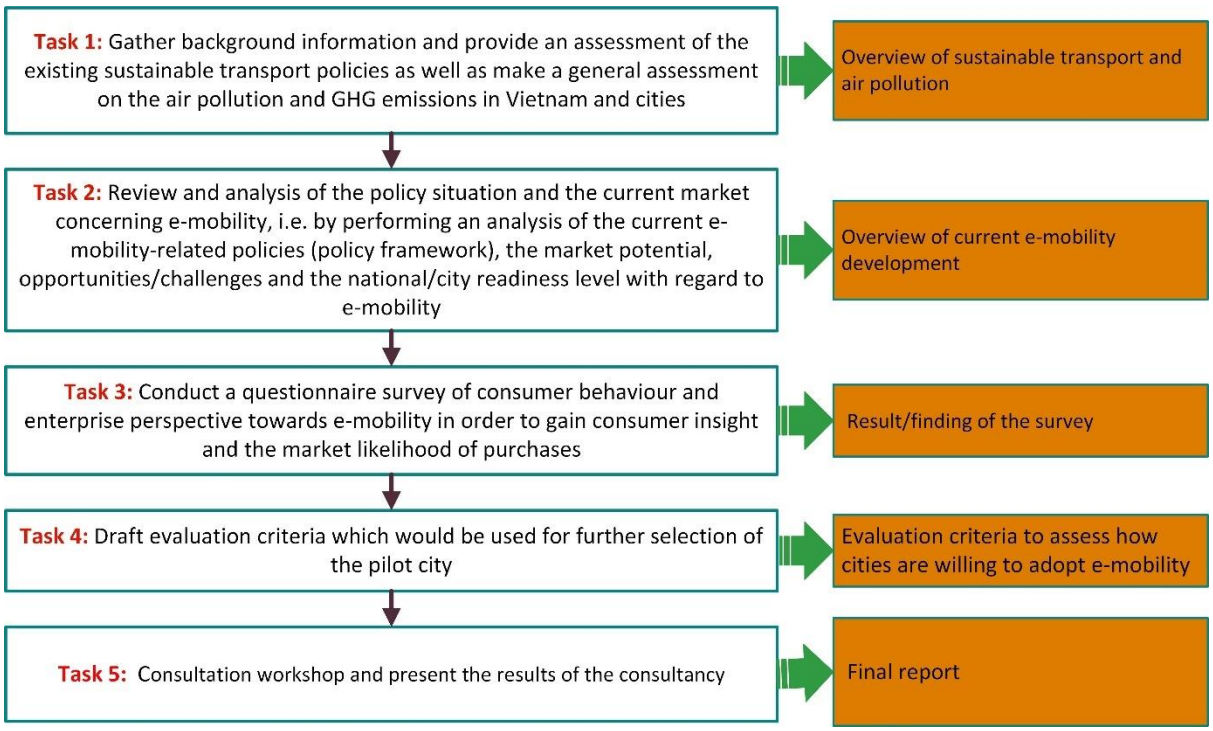


Figure 1.1. Overall approach and methodology

The steps outlined in Figure 1.1 are the main tasks required to achieve the assessment's objectives. Details of the main activities in each task are summarised in Table 1.1.

Table 1.1 . Main activities in each task

Task	Main activities
1	- Review the policies for developing sustainable urban transport in Viet Nam - Review the plans and actions of the transport system (urban transport planning, regulations, and actions in accordance with sustainable transport, public transport development plans, and city-specific financial support. - Develop a general picture of air pollution in Viet Nam and conduct a general assessment of the impacts of transport modes on air pollution at city-specific.
2	- Review policies for e-mobility development in Viet Nam. - Review and summarize the status of the EV market, including statistical data on the allocation transport means at the national- and city-level. The content includes: overview of the EV market (sales trend, market share analysis, technology and infrastructure); current status of vehicles using ICEs; - Review and analyse the current situation of the power grid to assess impacts on future grid infrastructure. - SWOT analysis in terms of incentives, market, and infrastructure. - Establish a Stakeholder map and analyse the participation of stakeholders, in which the responsibility of the stakeholders is illustrated in the form of diagrams or charts;.

Task	Main activities
	- Pilot projects and trial programmes in accordance with EVs.
3	- Develop ideas for the survey: identify the survey participants; choose the survey method; design and test survey questions; complete survey forms. The contents of the survey reflect the challenges and issues mentioned in Task 1 and Task 2. - Conduct internal meetings with MOT/GIZ to discuss and complete the survey plan and questionnaires. - Conduct the survey. - Data process, analyse and present the survey results.
4	- Develop an analysis of potential cities for the adoption of e-mobility. - Based on the results of Task 1, 2 and 3 to test and evaluate each city against the selected indicators: market potential, environmental pollution, economic conditions, policy and stakeholder involvement.
5	- Consultation workshop and presentation of results. - Receive comments after the workshop to complete the final report. - Work with cities to better understand the current situation and review indicators.

2. POLICY FOR DEVELOPING SUSTAINABLE URBAN TRANSPORT IN VIET NAM

2.1. Overview of transportation development in Viet Nam

2.1.1. Transportation infrastructure

Viet Nam has made strong progress in economic growth and poverty mitigation over the past decades. Contributing to this success is the rapid development of transport infrastructure, which the Vietnamese government has determined as a key factor for economic growth. The transportation infrastructure enables people's mobility and freight transport. It improves access of the rural population to essential services (such as health and education facilities) and economic opportunities. The fact is that transportation infrastructure in Viet Nam has undergone the fastest development in the last decades. According to the Ministry of Transport (MOT), since 1992 the length of Vietnam's road network increased significantly and reached over 630,564 km in 2018 (Transport Development and Strategy Institute, 2018). By the end of 2018, the total length of expressways and national highways reached 26,240 km, accounting for 4.2% of the total length of the road network (see Figure 2.1) (TDSI, 2018). There were 14 expressway sections and routes with a total length of 1,007 km. The national highway network had 154 routes with 25,233 km. The total length of asphalt and cement concrete paved roads was 17,476 km, accounting for 69.2% of the total length of national highways.

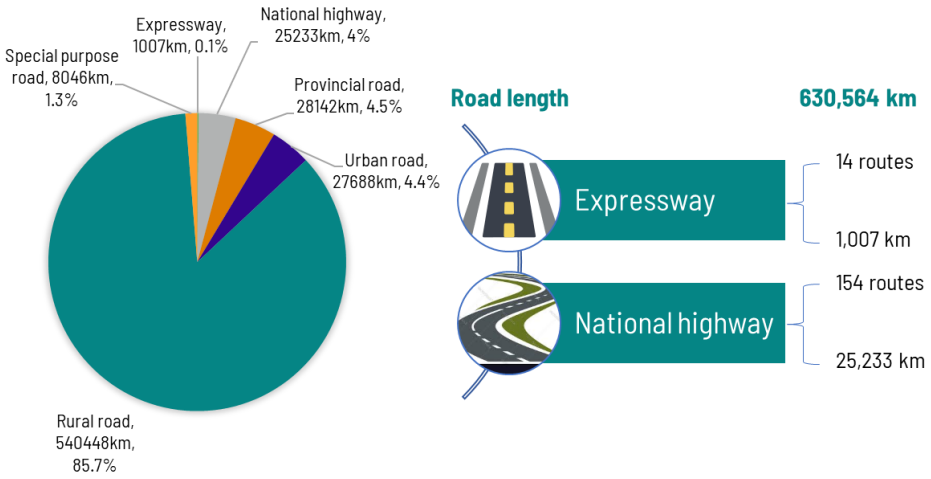


Figure 2.1. Summary of road transport infrastructure in Viet Nam

(Source: Transport Development and Strategy Institute, 2018)

2.1.2. Vehicle fleet characteristics

The entire vehicle fleet in Viet Nam grew strongly during the last decades, in particular, the ratio of road vehicle ownership increased sharply. By the end of 2018, Viet Nam had a population of over 95 million; it also had 3.9 million registered automobiles and 58.2 million registered motorbikes. From 2014 to 2018, the annual average growth rates (AAGR) of cars, motorbikes and mopeds were 13.7% and 9%, respectively (Transport Development and Strategy Institute, 2018). Currently, private two-wheelers are still the main vehicle type in Viet Nam at 92%. The road vehicle fleet composition in Viet Nam is shown in Figure 2.2.

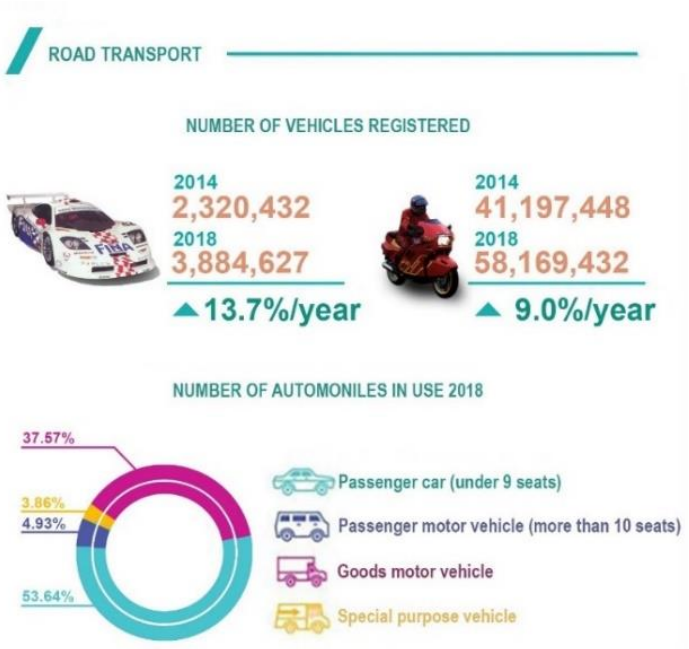


Figure 2.2. Road vehicle fleet composition in Viet Nam

(Source: Transport Development and Strategy Institute, 2018)

2.1.2.1. Motorbikes

Motorbikes are the main means of road transport in Viet Nam and have increased dramatically since 2000. In the period 2008-2018, the number of registered motorcycles grew from more than 25.4 million to 58.2 million, an average annual growth rate of 8,6% (Figure 2.3) (Duc et al., 2019). As a result of this growth, motorcycles currently account for the highest share of the traffic fleet in Viet Nam, at up to 92%.

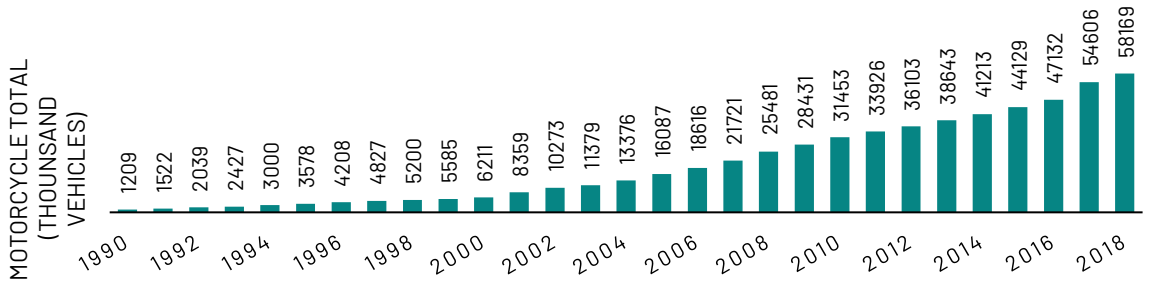


Figure 2.3. The number of motorcycles in Viet Nam in the period 1990-2018

(not including electric motorcycles)

(Source: Duc et al., 2019)

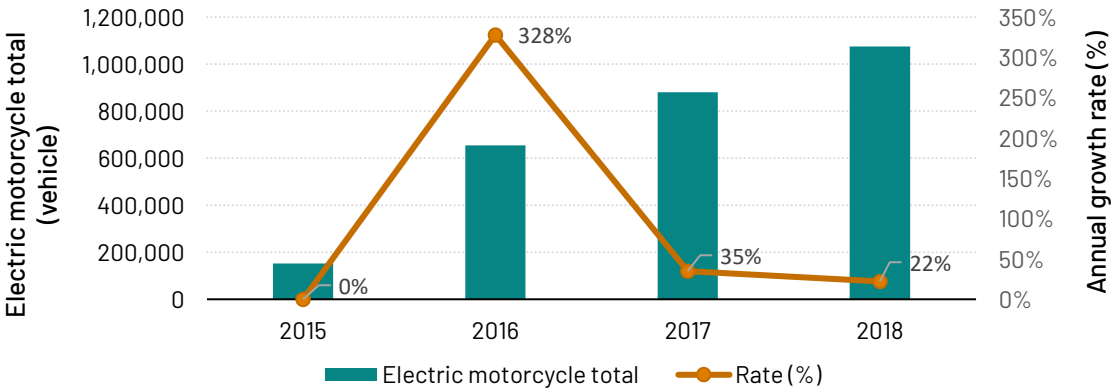


Figure 2.4. The number of electric motorcycles in Viet Nam in the period 2015-2018

(Source: Duc et. al., 2019)

As shown in Figure 2.3, the development of motorcycles in Viet Nam can be divided into three stages:

- 1990-2000: annual average growth rate of 18.4%.
- 2001-2006: annual average growth rate of 20.3%, called the boom period of motorcycles, especially in 2001 with the extensive import of Chinese motorcycles.
- 2007-2017: annual average growth rate of 9.55%.

Regarding electric motorcycles, the number of newly registered vehicles has been surging with a boom year in 2016 at a growth rate of more than 300%. This is a clear sign that this type of environmentally friendly vehicle is becoming more popular.

In short, the demand for motorcycle ownership has decreased significantly in recent years due to the increased demand for car ownership. Nonetheless, motorcycles still account for the largest share of the total traffic fleet in Viet Nam at present (see Figure 2.5).

Another aspect of Viet Nam's motorcycles is that about 66-77% of those registered are in circulation. This ratio is higher than the rate of 51-59% of Delhi (India). It is necessary to use the number of motorcycles in actual circulation instead of the number of registered motorcycles in order to give more accurate results in studies related to the transport sector (see Table 2.1). About five to ten years ago, a large number of Chinese-made motorcycles at very low prices and low quality were supplied to the Vietnamese market. After a few years of usage, the shortcomings of these vehicles became clear (e.g. low durability, poor technical safety), so people gradually stopped using them. Therefore, the average age of motorcycles has remarkably improved in recent years. If in the period 2006-2010, the average age of motorcycles was only from 8 to 10 years, in the period 2014-2018, it has increased significantly to nearly 12 years (Duc et al., 2019).

Moreover, 100% of conventional motorcycles in Viet Nam are fuelled by gasoline. Currently, motorcycles with a cylinder capacity of 175 cm^3 and under account for 99.9% of the total motorcycles in Viet Nam (Institute of Transport Science and Technology, 2018).

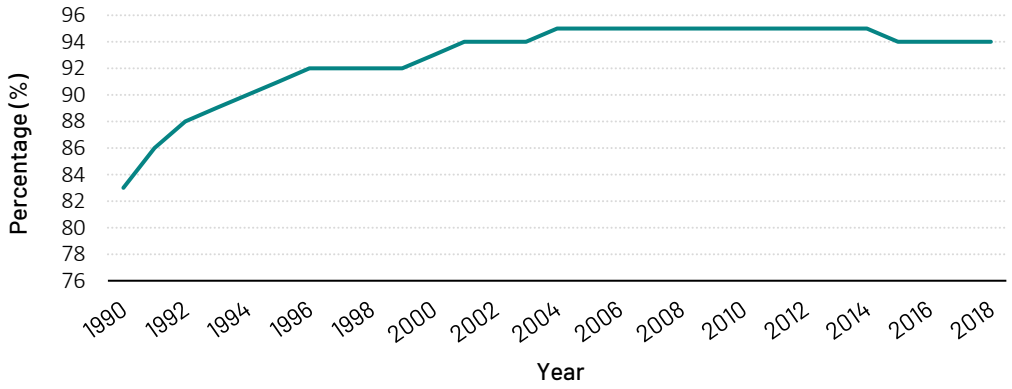


Figure 2.5. The proportion of motorcycles in the mixed traffic flow in Viet Nam

(Source: Duc et al., 2019)

Table 2.1. Distribution of motorcycles in circulation in 8 provinces/cities in 2017

City/Province	Number of motorcycles in circulation (vehicles)	Number of motorcycles in circulation per 100 population
Hanoi	2,985,571	40.24
Ho Chi Minh city	4,458,534	52.80
Hai Phong	778,540	38.97
Da Nang	556,140	52.26
Can Tho	532,030	41.80
Quang Ninh	406,178	32.66

City/Province	Number of motorcycles in circulation (vehicles)	Number of motorcycles in circulation per 100 population
Hue	505,724	43.81
Khanh Hoa	562,540	46.03
Nationwide	36,619,551	39.09

(Source: Duc et al., 2019)

Emissions standards

The level 3 emissions standards have been applied for newly manufactured, assembled and imported motorcycles since 1 January 2017 according to QCVN 77:2014/BGTVT. Earlier motorbikes/mopeds still apply level 2 emission standards according to QCVN 04:2009/BGTVT.

2.1.2.2. Automobiles

Buses

The number of buses in Viet Nam has increased remarkably in recent years with the AAGR reaching 6% in the period 2012-2018 (see Table 2.2).

Table 2.2. Number of buses in Viet Nam by year and by fuel[1]

Year	Number of buses by fuel		Total
	Diesel	*CNG*	
2012	8,403	82	8,485
2013	8,703	103	8,806
2014	9,084	137	9,221
2015	9,554	145	9,699
2016	10,778	270	11,050
2017	11,462	435	11,899
2018	11,616	435	12,053

(Source: Statistics report of the Department of Environment)

Currently, Hanoi and Ho Chi Minh City have the highest bus concentrations in Viet Nam (see Table 2.3).

Table 2.3. Summary of public passenger transport by bus in big cities

Cities/provinces	Total bus population in 2017 (vehicles)
Hanoi	1,785

[1] Only include buses operating on fixed routes.

Cities/provinces	Total bus population in 2017 (vehicles)
Hai Phong	107
Da Nang	150
Ho Chi Minh	2,603 (with 423 CNG fuelled buses)
Can Tho	45

(Source: Statistics report of the Department of Environment)

By the end of 2018, the number of localities with a bus passenger transport system reached 55 of the country's 63 provinces.

Emissions standards

Before 2017, the entire bus fleet in Hanoi only met the Euro II emissions standards. However, bus distribution by emissions standards has changed remarkably since 2017 due to Decision No. 49/2011/QD-TTg on the provision of a roadmap for the application of exhaust emissions standards for manufactured, assembled and imported new cars and motorbikes. Until 2019, the percentage of buses that met high emissions standards increased considerably (e.g. for buses in Hanoi as presented in Figure 2.6). Currently, there are two fuel types used for buses in Viet Nam – diesel and CNG – in which diesel is still the dominant fuel.

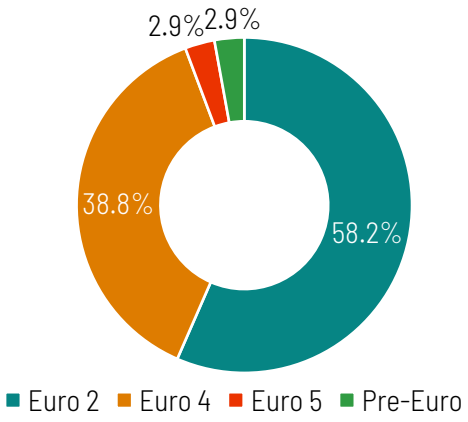


Figure 2.6. Distribution of bus fleet by emissions standards in Hanoi in 2019

(Source: Viet Nam Register, 2020)

Cars

The proportion of households owning a car is only about 2%; therefore, cars account for only a very small share of the vehicle fleet in Viet Nam. However, in recent years, the annual growth rate of cars has been relatively high (see Table 2.4). Up to 2018, the number of passenger cars in circulation in the whole country was 1,756,594 vehicles, accounting for 53.6% of the total automobiles in circulation (Transport Development and Strategy Institute, 2018).

Table 2.4. The annual growth rate of cars in circulation in five central-level cities in Viet Nam for the period 2014 to 2018

Cities	Annual growth rate (%)
Hanoi	10.3
Ho Chi Minh City	11.7
Hai Phong	13.7
Da Nang	18.1
Can Tho	15.9

(Source: Transport Development and Strategy Institute, 2018)

Trucks

By the end of 2018, the number of trucks in circulation in Viet Nam was 1,230,032 vehicles with an AAGR of 13.1%, in which, trucks up to 2 tons accounted for the highest proportion at about 52%, followed closely by trucks from 2 to 7 tons (28%).

2.1.2.3. Number of road motor vehicles in circulation in 8 cities

The number of road motor vehicles in circulation in 8 cities is shown in Table 2.5.

Table 2.5. Number of road motor vehicles in circulation by city/province in Viet Nam

Cities/ provinces	Automobiles in circulation (vehicles)						Motorcycles in circulation in 2017 (vehicles) (*)	Motor vehicles per 1000 inhabitants in 2017 (*)
	Year					Annual average growth rate (%)		
	2014	2015	2016	2017	2018			
Hanoi	376,417	408,713	485,955	584,286	614,301	**13.0**	2,985,571	481.11
Hai Phong	61,935	74,595	88,072	103,274	108,975	**16.2**	778,540	441.41
Da Nang	36,359	41,482	49,908	66,354	71,644	**18.5**	556,140	585.00
Ho Chi Minh	352,365	382,524	455,198	538,955	561,643	**12.4**	4,458,534	591.80
Can Tho	18,216	20,851	25,471	32,486	34,775	**17.5**	532,030	443.52
Thua Thien Hue	16,741	19,201	22,371	27,044	28,667	**14.4**	505,724	461.55
Khanh Hoa	24,317	27,832	32,543	40,872	43,861	**15.9**	562,540	493.71
Quang Ninh	45,096	49,086	57,355	69,192	73,344	**12.9**	406,178	382.25

Note: (*) not including mopeds and electric two-wheeled vehicles.

(Source: Transport Development and Strategy Institute, 2018; Duc et al., 2019)

As presented in Table 2.5. Number of road motor vehicles in circulation by city/province in Viet Nam, from 2014 to 2018, all the cities/provinces considered above have a high AAGR of total automobiles in circulation, all higher than 12%. Da Nang has the highest AAGR (18.5%), followed closely by Can Tho (17.5%).

In brief, the shares of bus, truck and personal car fleets are quite small in the active traffic fleet in Viet Nam compared to motorcycles. The characteristics of the road vehicle fleet in Viet Nam are summarised in Table 2.6.

Table 2.6. Summary of road motor vehicles in Viet Nam

Vehicle categories	Average age (year)	Number of vehicles in circulation 2018	Annual growth rate (%/year)	Vehicle kilometres travelled (VKT) (km/year)	Vehicle distribution by fuel type
Motorbikes	8-10	38,932,977	9	4,276	100% gasoline (except electric motorbikes)
Passenger cars (*9 seats or less*)	7.6	1,756,594	18.2	15,474	93% gasoline 7% diesel
Passenger cars (*10 seats or more*)		161,410	9.4		
Buses	7.5			31,838	14% gasoline 86% diesel
Trucks	16.6	1,230,032	13.1	21,973 (light truck) 31,060 (heavy truck)	100% diesel (heavy truck) 36% gasoline, 64% diesel (light truck)
Source	*Trang, 2015; Kim Oanh, 2015; Nghiem, 2019*	*Duc, 2019; Institute of Transport Science and Technology, 2018*	*Duc, 2019; Institute of Transport Science and Technology, 2018*	*Determined based on the 2016 statistics from DOE*	

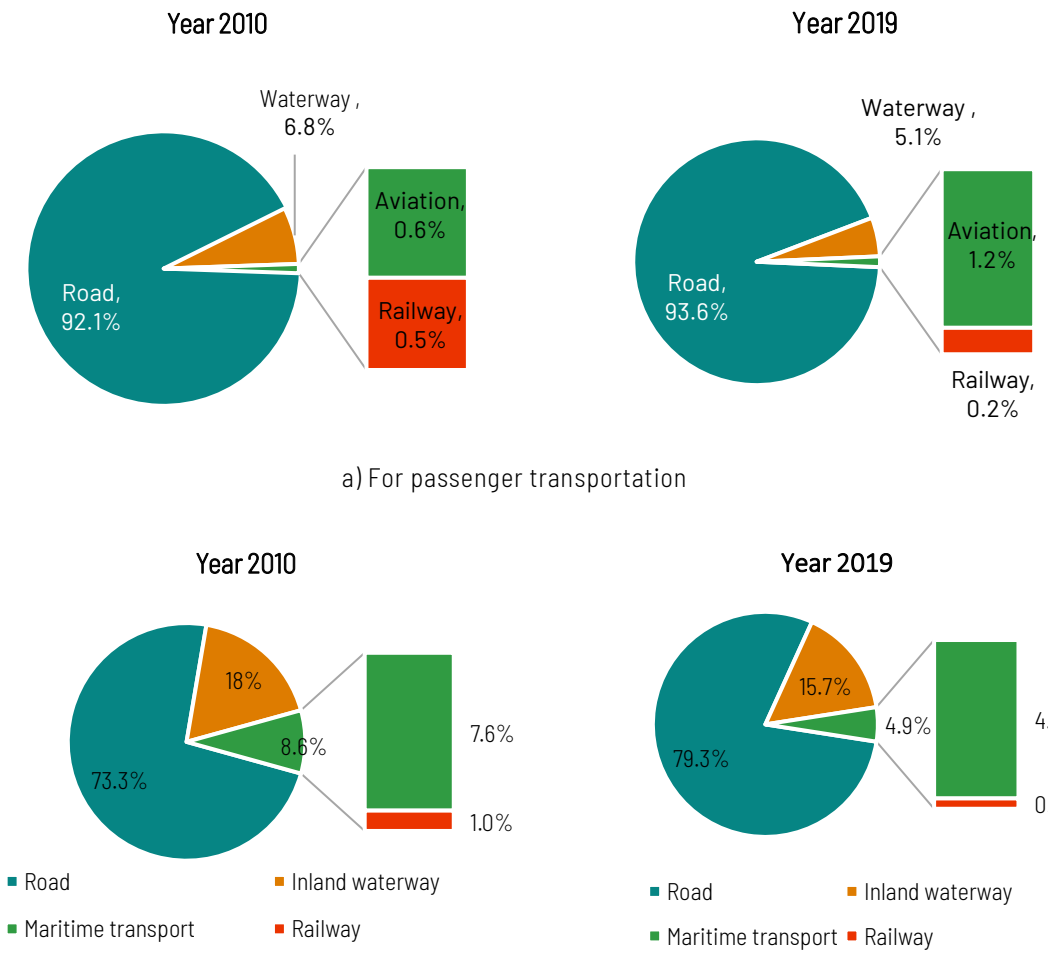
The rapid increase of the road vehicle population has resulted in a growing demand for fuel consumption. Currently, the transport sector with mostly road motor vehicles is fuelled by fossil fuels (diesel and gasoline), and has become the third-highest energy consumer in Viet Nam (approximately 20%). The proportion of gasoline-fuelled automobiles is estimated at about 55% of the total automobiles in circulation.

2.1.3. Share of transportation modes

Since the late 1990s, passengers and freight mobility demand grew faster than GDP. The total shipping capacity of the whole transport industry reached about 4,769 million persons and 1,689,989.6 thousand

tons in 2019 (GSO, n.d.). The GDP contribution of Viet Nam's transportation and storage sector accounted for VND 167.8 trillion, equivalent to 2.78% of the country's total GDP in 2019 (Statista, 2020). In the period 2010-2019, the annual average growth rate (AAGR) of the whole transport industry reached about 8.3% and 8.7% for passenger and freight transport, respectively (GSO, n.d.). These obtained AAGRs are very close to the target set in decision No.318/QĐ-TTg on "Approving the strategy for the development of transportation services through 2020, with orientations toward 2030".

Passenger and freight shares by transport modes are presented in Figure 2.7.



a) For passenger transportation

b) For freight transportation (by aviation transport the figure is very small, below 0.1%)

Figure 2.7. Contribution of transport modes in passenger and freight transport

(Source: General Statistics Office of Viet Nam, n.d.)

Each type of transport has its own purpose in the national transport system. However, due to its mobility and the ability to deliver goods "door to door" road transport plays a dominant role in the transportation of passengers and freight in Viet Nam. As presented in Figure 2.7, road transport occupies the largest market share in Viet Nam, followed closely by waterways. In 2019, the contribution of road transport was about 79.3% of total transported freight and 93.6% of total transported passengers. In addition, the demand for using different transport modes has also changed remarkably

along with socio-economic development. In the period 2010-2019, the demand for both passenger and freight transport by aviation increased, whereas demand decreased in railway transport as demonstrated in Figure 2.8. Specifically, passenger and freight transport demand by aviation has increased significantly with annual average growth rates for passenger transport and freight transport reaching 16.2% and 10%, respectively in the period 2010-2019. The remarkable increase in per capita income (approximately 12% per year in the period 2010-2019), as well as the emergence of many low-cost airlines in recent years, has contributed to this trend.

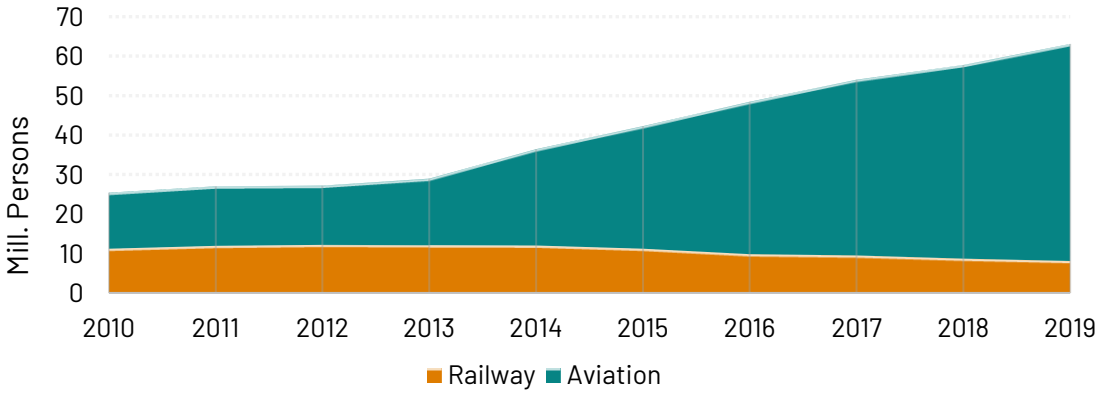
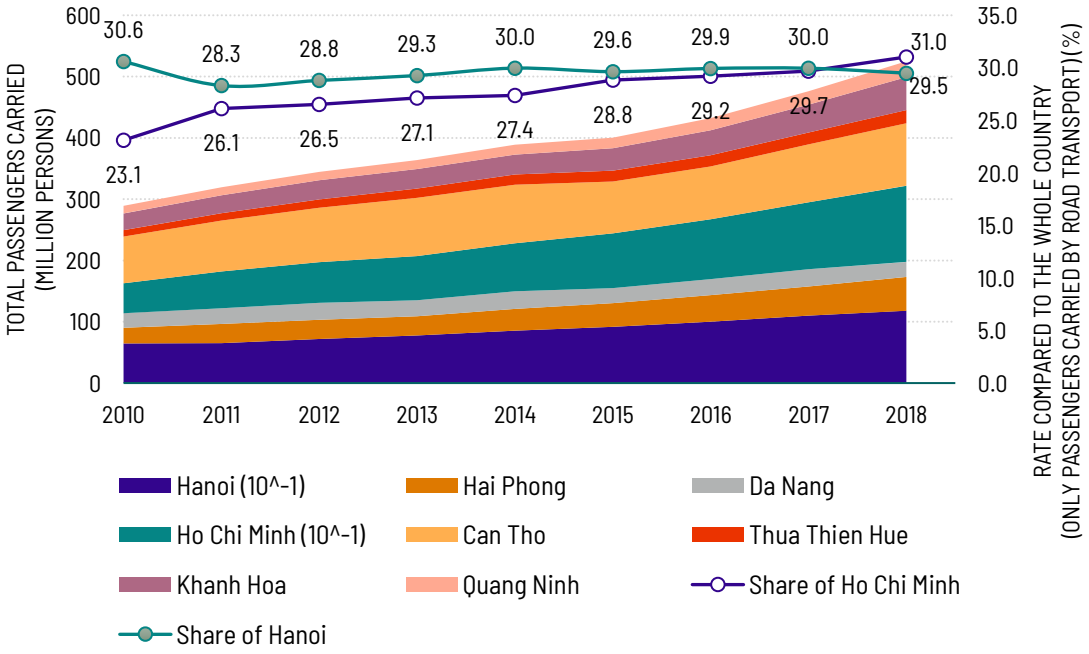


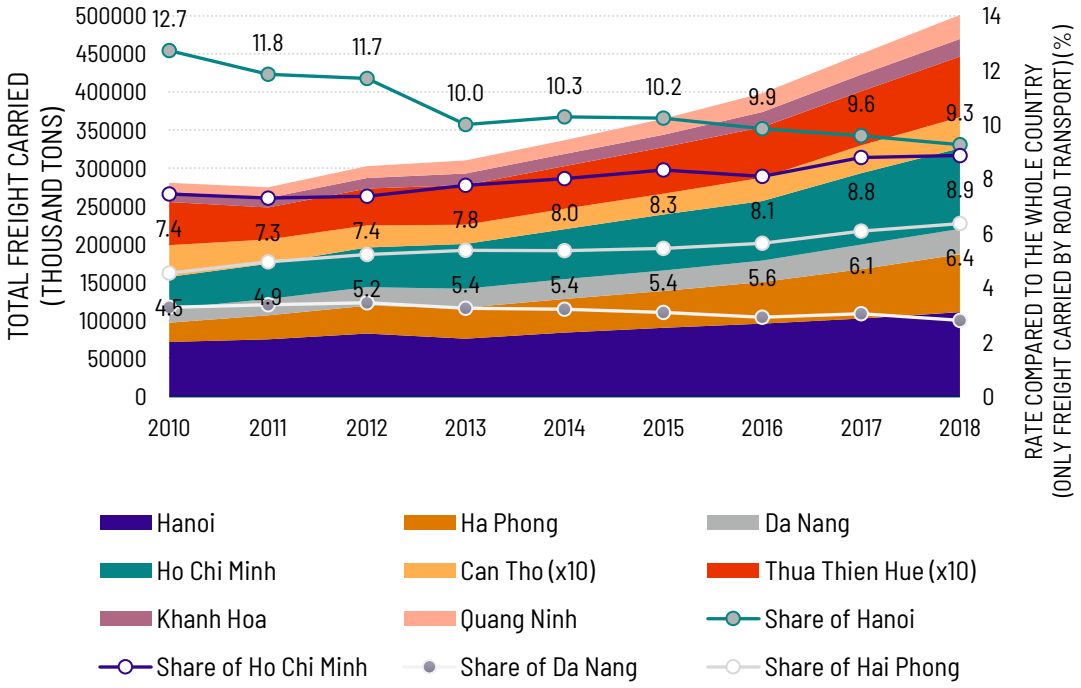
Figure 2.8. Changing trends in passenger transport demand by railway and aviation

(Source: General Statistics Office of Viet Nam, n.d.)

Transportation capacity of road transport by province/city, by year is presented in Figure 2.9.



(a) – Number of passengers carried by road transport by province/city, by year



(b) – Volume of freight carried by road transport by province/city, by year

Figure 2.9. The transportation capacity of road transport by province/city

(Source: General Statistics Office of Viet Nam, n.d.)

As presented in Figure 2.9, the demand for passenger and freight transport by road increased in all big cities/provinces in Viet Nam during the period 2010-2018, especially in Ha Noi and Ho Chi Minh City.

2.2. Transportation and air pollution

2.2.1. Urban air pollution

Air pollution has been threatening the health of people in many parts of the world. New estimates in 2018 reveal that 9 out of 10 people were breathing air containing high levels of pollutants. Both ambient (outdoor) and household (indoor) air pollution are responsible for about 7 million deaths globally per year. In Viet Nam, around 60,000 deaths each year are air pollution-related (WHO, n.d.). According to the Ministry of Natural Resources and Environment (MONRE), most of Viet Nam's major cities are facing increasing air pollution (MONRE, 2016). The particle matter (PM) pollution is at high levels in big cities, especially in areas near major traffic routes. This is the most prominent issue related to air quality in Viet Nam. As an unexpected result, in 2019, the annual mean concentration of $PM_{2.5}$ in Viet Nam, an air pollutant that is regarded as most harmful to human health, ranked 15th in the World (IQAir, 2019). Meanwhile, two big cities, Hanoi and Ho Chi Minh City, ranked high in the ranking of $PM_{2.5}$ pollution levels of major cities in the world; for example, Hanoi is ranked 7th (IQAir, 2019; WHO, 2018). In Southeast Asian countries, Hanoi is the second most polluted capital city for $PM_{2.5}$ pollutions, only after Jakarta,

Indonesia (IQAir, 2019). Among the big cities of Viet Nam, Hanoi is the most polluted city for $PM_{2.5}$ pollution, followed closely by Hue (see Figure 2.10) (IQAir, 2019).

PM2.5: µg/m³	2019 Annual AVG	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Hanoi	46.9	59.3	36.0	50.2	40.3	45.8	36.5	30.4	33.1	48.3	43.2	66.3	72.7
Ho Chi Minh City	25.3	34.1	17.5	22.5	18.1	23.9	18.6	18.9	17.3	26.7	29.8	39.0	37.0
Hue	28.6	--	41.8	53.5	45.2	25.9	12.2	11.1	12.6	25.0	27.0	36.9	37.3
Da Nang	25.9	40.5	28.3	36.0	--	--	22.6	30.0	29.9	18.2	12.0	28.1	26.4

Figure 2.10. The annual mean concentration of PM2.5 in selected big cities in Viet Nam in 2019

(Source: IQAir, 2019)

The fact is that $PM_{2.5}$ concentrations in Viet Nam in 2019 were 3 times above WHO exposure recommendations. Therefore, $PM_{2.5}$ pollution in Hanoi and Ho Chi Minh City can cause health problems for sensitive groups, such as those at risk of experiencing irritation and respiratory problems as demonstrated in Figure 2.11.

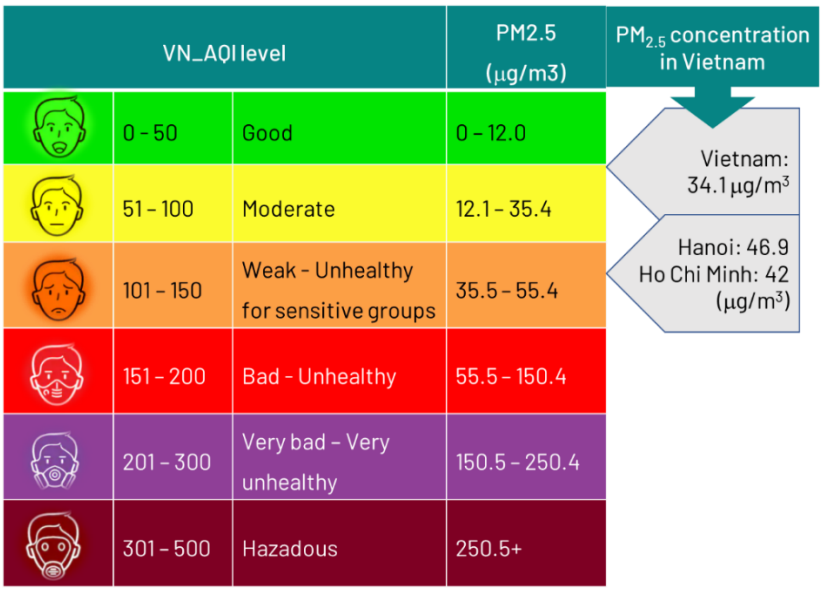


Figure 2.11. The annual average concentration of PM2.5 in Hanoi in 2019 and Ho Chi Minh City in 2016

(Source: IQAir, 2019)

For gaseous pollutants, in general they are still basically within the limits of QCVN 05:2013/BTNMT. However, the concentration of pollutants such as O_3 and NO_2 have shown signs of a remarkable increase in recent years in areas near traffic roads in big cities in Viet Nam (MONRE, 2017).

The increasing trend of ambient air pollutant concentrations such as PM, NO_2 and O_3 has pushed the air quality index (AQI) in Viet Nam to dangerous levels. In some cities, such as Hanoi and Ho Chi Minh City, the number of days with bad AQI in the range of 101 to 200 is relatively high (e.g. 50% of the total days monitored at the Nguyen Van Cu monitoring station in 2014 had bad AQI), sometimes AQI

exceeding 200, equivalent to a very bad level (WHO, n.d.). According to the Centre for Environmental Monitoring (CEM), in early 2021, the 24-hour average concentration of $PM_{2.5}$ in Hanoi was higher than in other cities, and the number of days with bad AQI is still high (CEM, n.d.).

With current air pollution levels, Viet Nam suffers about USD 10.8-13.2 billion worth of economic losses associated with ambient air pollution each year, equivalent to about 5% of the country's GDP (IQAir, 2019).

Rapid development coupled with weak emissions control standards for power plants, vehicles, and industry, and a high and rising share of coal in power generation have all contributed to high levels of air pollution in big cities in Viet Nam. In the transport sector, the high growth rate of the vehicle population has increased total fuel consumption as well as serious environmental pollution issues.

2.2.2. GHG emissions from the transport sector

The transport sector currently contributes about 10.8 % of total CO_2 emissions, and 85% of total CO emissions (Duc & Duy, 2018). At the city level, a study showed that around 46% of dust nanoparticles in Hanoi come from the transport sector (Nghiem et al, 2020). In other words, the transport sector is one of the main causes of air pollution in Hanoi. Greenhouse gas (GHG) emissions from the transport sector have increased at a faster rate than any other energy end-use sector, reaching 7.0 Gt CO_2e in 2010. The total CO_2e emissions worldwide in 2010 was responsible for approximately 23% of total energy-related CO_2 emissions (IPCC, 2014). In 2016, the total of CO_2e reached almost 8 Gt CO_2e, nearly 1.7 times higher than in 1990 (see Figure 2.12).

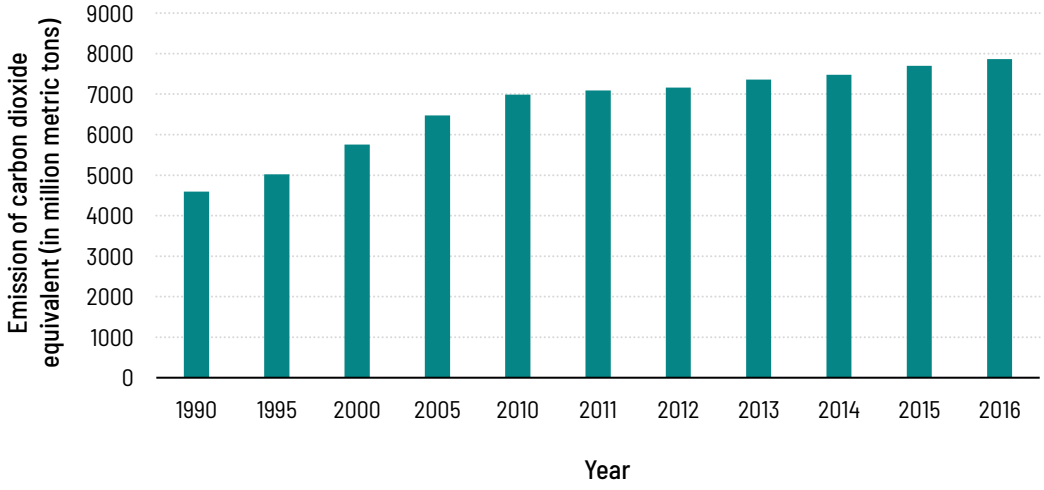


Figure 2.12. Greenhouse gas emissions from the transportation sector worldwide

(Source: Statista 2020)

As shown in Figure 2.12, the GHG total derived from the transportation sector worldwide has strongly increased over the last decades.

In Viet Nam, the transport sector is one of the main contributors to the country's GHG emissions. A study by GIZ and the World Bank showed that the transport sector in 2014 contributed 18% to the country's GHG emissions. The report stated that under BAU conditions, transport sector CO_2 emissions will increase from 33.2 million tons in 2014 to 89.1 million tons in 2030, with the annual GHG emissions rate projected to reach 6-7 %. Throughout this period, road transport was the largest emitter with 26.4 million tons CO_2 in 2014, increasing to 71.7 million tons in 2030 (Table 2.7 and Figure 2.13) (Oh et al, 2019).

Table 2.7. Transport-related CO2 emissions in Viet Nam under the Business-As-Usual scenario

(million tons)

Year / Subsector	2014	2020	2025	2030
Road	26.4	37.9	52.1	71.7
Railway	0.1	0.2	0.2	0.3
Inland waterways and coastal transport	3.5	4.6	6.1	8.2
Aviation	1.1	2.8	3.5	4.3
Other	2.1	2.3	3.2	4.6
Total	**33.2**	**47.7**	**65.1**	**89.1**

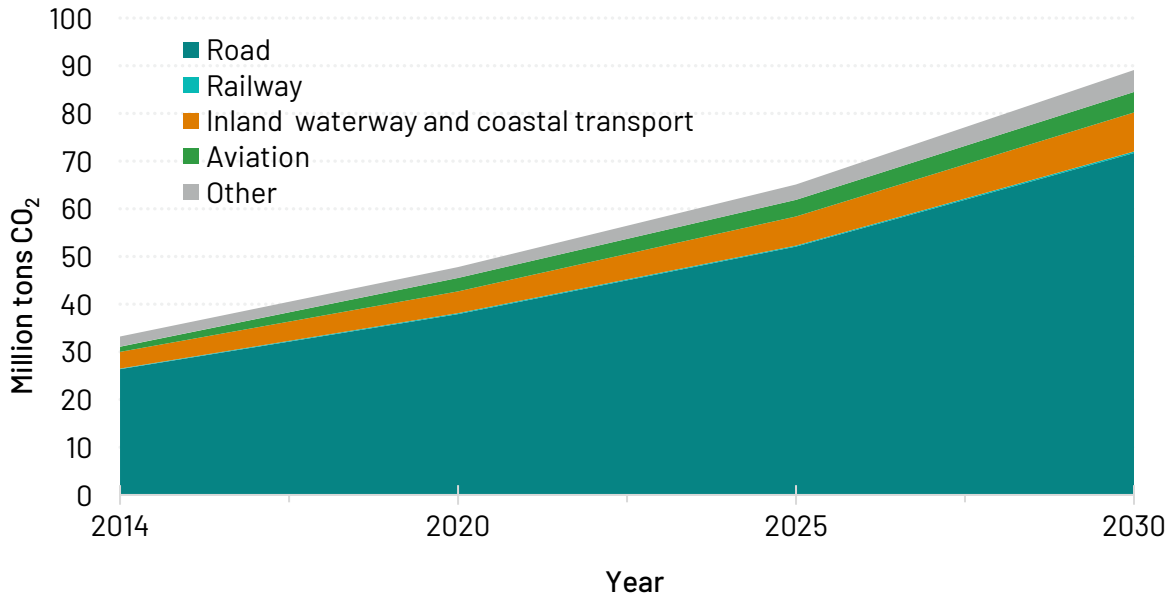


Figure 2.13. Estimated CO2 emissions by transport subsectors under BAU

According to the BAU scenario, road transport is the highest CO_2 emissions source, accounting for 80% of the total transport-related CO_2 emissions, closely followed by inland waterways and coastal

transport, which account for about 10% of total transport-related CO_2 emissions. In contrast, the amount of CO_2 emissions from railways is negligible.

2.3. Review of sustainable transport policies

2.3.1. Existing policies

In Viet Nam, sustainable transport policies are guided by law, national strategies and action plans of four key categories (see Figure 2.14), including: 1) sustainable development, 2) green growth, 3) climate change and 4) environmental protection.

- The promulgation of the 2011-2020 National Sustainable Development Strategy (NSDS) was approved by Decision No. 432/QĐ-TTg in 2012. In addition, the Government of Viet Nam promulgated the Action Plan (Decision No. 622/QĐ-TTg in 2017) and Roadmap (Decision No. 681/ QĐ-TTg in 2019) of Agenda 2030 for Sustainable Development, respectively.
- The 2011-2020 National Green Growth Strategy (NGGS) was promulgated by Decision No. 1393/QĐ-TTg in 2012. Additionally, the Government of Viet Nam also promulgated the 2014-2020 Action Plan for NGGS in 2014. Currently, the Ministry of Planning and Investment (MPI) is formulating a new NGGS for the period 2021-2030. It is expected that the 2021-2030 NGGS will be promulgated in 2021.
- The National Climate Change Strategy (NCCS) was enacted by Decision No. 2139/QĐ-TTg in 2011. Following this, the Government of Viet Nam issued Decision No. 1474/QĐ-TTg on the 2012-2020 Action Plan of the NCCS. Additionally, Viet Nam officially ratified the Paris Agreement on Climate Change in 2016. After this ratification, the Government of Viet Nam quickly promulgated Decision No. 2053/QĐ-TTg on the Implementation Plan for the Paris Agreement. In 2020, the Ministry of National Resources and Environment (MONRE) assessed the implementation of the NCCS during the period of 2011-2020 and proposed measures to accelerate implementation of the Strategy in the period 2021-2030. It is expected that the NCCS in the 2021-2030 period will be promulgated in 2021.
- The Government of Viet Nam promulgated National Environmental Protection Strategy (NEPS) through Decision No. 1216/QĐ-TTg in 2012. Following this strategy, the Implementation Plan for NEPS was promulgated by Decision No. 166/QĐ-TTg in 2014. Furthermore, the Government of Viet Nam approved the Action Plan for Air Quality Management by Decision No. 985a/QĐ-TTg in 2016. Notably, the new Law on Environmental Protection No. 72/2020/QH14 was enacted by the National Assembly of Viet Nam in November 2020. The Law regulates environmental protection issues in transport activities and will take effect on 1 January 2022.

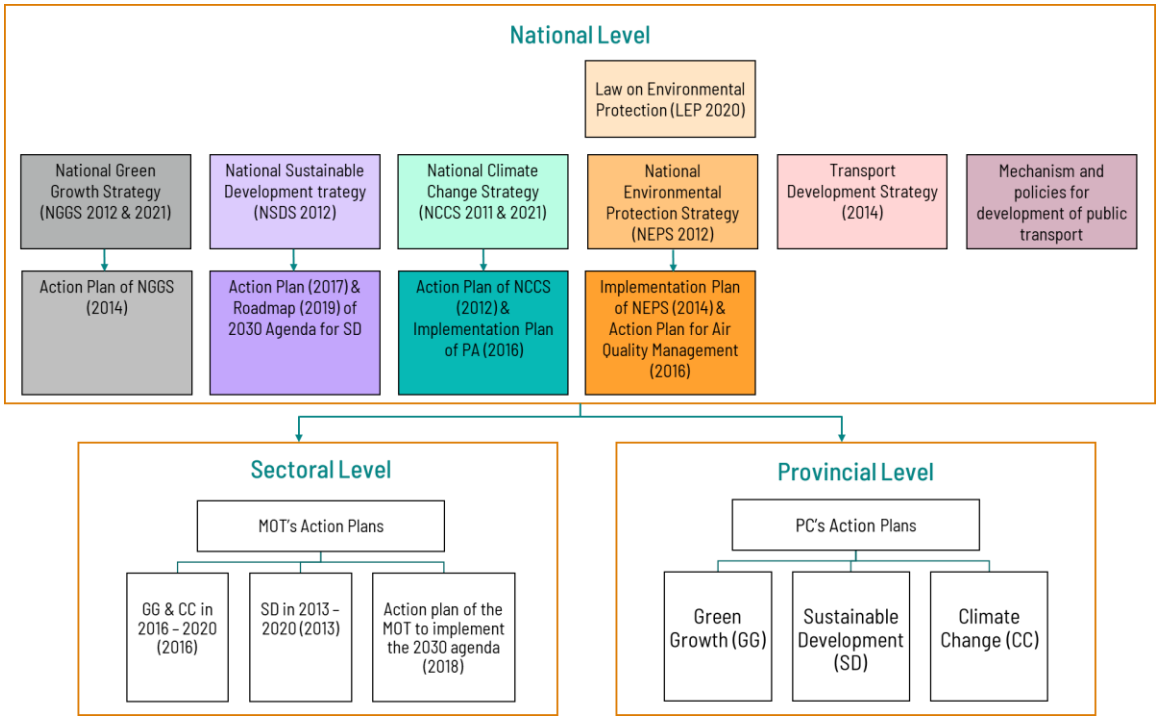


Figure 2.14. Overview of sustainable transport policies in Viet Nam

(Source: Consultant team)

Based on these national strategies and action plans, key orientations of sustainable transport development are summarised in Table 2.8. Among these orientations, there are two common points: i) usage of clean-energy transport vehicles; and ii) encouragement of public transport use.

Table 2.8. Key orientations of sustainable transport development

No.	Items	Orientations of Transport Development
1	Law on Environmental Protection (2020)	▪ Transport vehicles are inspected and certified as complying with environmental standards. ▪ Reduction of impacts on landscape and natural heritage when constructing transport facilities. ▪ Provincial people's committees have to formulate measures for traffic channelisation and control of environmental pollution in order to mitigate air pollution in special-level and level-1 cities. ▪ Promulgation of incentive policies for the development of public transport. ▪ Promulgation of incentive policies for transport vehicles using renewable energy, vehicles with low fuel consumption or low emissions. ▪ Promulgation of the roadmap for termination of fossil-fuelled vehicles and vehicles causing environmental pollution.
2	Green Growth Strategy	▪ Shifting share of fuel usage in the transport sector (towards low-emissions fuel). ▪ Finalising MRV system in the transport sector.

No.	Items	Orientations of Transport Development
		▪ Application of green and energy-saving in the transport sector. ▪ Reasonable and effective development of transport network and system. ▪ Investment of public transport; development of green public transport.
3	Sustainable Development Strategy	▪ Control of emissions from transport vehicles. ▪ Reduction of traffic accidents and fatalities. ▪ Development of public transport, transport infrastructure and system in consideration of climate change, the disabled, females, the children and the elderly.
4	Climate Change Strategy	▪ Development of public transport and control of private vehicles. ▪ Usage of low-emissions fuel and transport vehicles. ▪ Establishment of MRV system in the transport sector.
5	Environmental Protection Strategy	▪ Control of environmental pollution in transport activities under Decision No. 855/QD-TTg dated 06 June 2011. ▪ Control of emissions from motorcycles and mopeds in provinces and cities under Decision No, 909/QD-TTg dated 17 June 2010. ▪ Implementing the roadmap for application of emissions standards for road motorised vehicles. ▪ Encouraging clean-energy and renewable-energy transport vehicles.
6	Viet Nam's updated NDC (2020)	▪ Limits of fuel economy (motorcycles and cars). ▪ Shift of passenger transport from private vehicles to public transport. ▪ Shift of freight transport from road transport to others (railway, IWT and maritime). ▪ Promotion of clean-energy vehicles such as CNG buses, e-motorcycles and e-cars. ▪ Encouragement of biofuel usage. ▪ Increased load factor of trucks.
7	Development strategy of transport services to 2020 and orientations to 2030	▪ Rationally develop in terms of quantity and types of means of transport in the direction of modernity and convenience, meeting technical standards of safety, energy-saving and environmental friendliness. ▪ By 2020, the proportion of public transport in Hanoi will meet about 25% of travel demand, of which urban railways account for 2-3%; in Ho Chi Minh City it will meet about 20% of the travel demand, of which 4-5% is urban railways. ▪ By 2030, the proportion of public transport in Hanoi will meet about 40% of travel demand, of which urban railways accounts for about 17%; In Ho Chi Minh City, it will meet about 35% of travel demand, of which urban railways account for about 18%.
8	Develop public transport services	▪ Prioritise the application of modern, safe and environmentally friendly technologies to equip, control and operate the bus public transport system.

No.	Items	Orientations of Transport Development
	by bus from 2012 to 2020	
9	Mechanism and policies to encourage the development and use of bus public transport	▪ Develop criteria to determine the type of vehicle participating in public transport by bus using clean energy as a basis for exemption from registration fees. ▪ Gradually structure the convoy in the direction of reducing the average age, giving priority to vehicles using clean fuel, ensuring the proportion of vehicles supporting people with disabilities.

(Source: Consultant team)

2.3.2. Development status

In the perspective of the "Avoid-Shift-Improve" (ASI) approach, existing sustainable transport policies are re-grouped as follows:

First of all, "Avoid" refers to improvement measures or policies for the efficiency of the transport system as a whole. Through integrated land-use and transport planning, the need for motorised travel and trip length can be reduced.

Table 2.9. "Avoid" strategy and measures

Sector	Measures/Policies	Target[(a)]	Current Status[(b)]
Intercity transport	Expressway expansion	6411 km (203)	1411 km (2020) (22% compared to established target)
	Waterway upgrade and renovation	6172.5 km (2020)	3316.4 km (2020) (53.7% compared to established target)
	Railway upgrade and renovation	2400 km (2020)	2167 km (2020) (90% compared to established target)
Intra-city transport	Integrated land-use and transport planning	From 1 Jan 2019, national and provincial-level plans will follow an "integrated-planning" approach in accordance with the Law on Planning No. 21/2017/QH14	2021-2030 National Comprehensive plans and Provincial plans are formulated

(Sources of (a) & (b): Draft Final Report of 5 Transport Sub-Sector plans 2021-2030)

Secondly, "Shift" refers to measures and policies for the modal shift from more energy-consuming and polluting transport modes to environmental-friendly ones.

Table 2.10. "Shift" strategy and measures

Sector	Measures/Policies	Target[(a)]	Current Status[(b)]
Intercity transport	Freight Transport: Shift from "Road" to "Railway" and "Waterways"	Share (2020: Road (58.36%), Railway (2.62%), IWT (17.72%); Sea (21.25%) & Air (0.05%)	Share (2019): Road (79.32%); Railway (0.3%), IWT (15.74%), Sea (4.61%) and Air (0.03%) → Did not meet the target
Intra-city transport	Passenger Transport: Shift from "Private Vehicles" To Public Transport	Share of PT: 35%-45% (2020 in big cities), including urban railways	Hanoi & HCM: 9-10% Other cities: <5% Urban railways have not been in operation → Did not meet the target

(Source: (a) Decision No. 1393/QĐ-TTg & Decision No. 318/QĐ-TTg; (b) various reports and documents)

Thirdly, "Improve" refers to measures and policies for vehicle and fuel efficiency.

Table 2.11. "Improve" strategy and measures

Sector	Measures	Target[(a)]	Current Status[(b)]
Intercity travel	Electrification of railway lines	Gradual increase of electric locomotives in 2021-2030 according to the roadmap for the development of high-speed railway transport	Not implemented yet
	Usage of E5 gasoline and B5 diesel	2010: 0.4% of national fuel demand 2015: 1% of national fuel demand After 2025: 5% of national fuel demand	In 2018, the consumption of E5 gasoline accounted for 1% of total national fuel consumption. However, the consumption of E5 gasoline decreased in 2019-2020
Intra-city travel	CNG and LGP buses and taxis	5-20% of the fleet (2020)	400-500 CNG buses total fleet of 10,000 vehicles (4-5% of total fleet) while the number of CNG taxis accounts for only 0.1% of the total taxi fleet
	Usage of e-motorcycles in daily travel	No specific target in the period of 2012-2020 2021-2030: 7% of total annual sales (without international support) & 14% (with international support)	According to the statistics of the Viet Nam Register in 2017, the total number of domestically assembled and imported two-wheelers was 4,134,195 vehicles. The number of e-motorcycles accounts for 7.96% of total domestically assembled

Sector	Measures	Target[(a)]	Current Status[(b)]
			and imported two-wheelers (about 329,102 vehicles)

(Source: (a) Decision No. 318/QĐ-TTg; updated NDC (2020) & Decision 177/2007/QD-TTg; (b) MOT)

In terms of the "Shift" measures, current performance has not met the target. With respect to intercity transport, road transport accounts for about 80% of the overall public transport budget. On the one hand, road transport has played a key role in the transport system in terms of passenger and freight volume, but it is the costliest transport mode for freight transport. On the other hand, railways and inland waterways have lower transport costs for domestic freight transport, but such modes have not been given adequate attention. On average, railways and inland waterways only account for about 2% of public transport overall.

Concerning intra-city transport, public bus passenger transport is not able to compete with private vehicles in terms of speed and travel times. In addition, urban railways have not been put into operation due to construction delays.

2.3.3. Sustainable development policies in eight selected cities

In accordance with the national strategies and action plans, most of the selected cities promulgated corresponding action plans in aspects of green growth, climate change and sustainable development (see Table 2.12).

Table 2.12. Summary of city/provincial action plans for green growth, climate change and sustainable development strategies

Type of Policies		Selected Cities							
Items	*Strategy*	*Hanoi[1)]*	*Hai Phong[2)]*	*Da Nang[3)]*	*HCM[4)]*	*Can Tho[5)]*	*Hue[6)]*	*Nha Trang[7)]*	*Ha Long[8)]*
Promulgation of Action Plan	**Green Growth**	✓ (to 2030)	✓ (to 2020)	X	X	✓ (to 2020)	✓ (to 2020)	✓ (to 2025)	✓ (to 2020)
	Climate Change	✓ (to 2030)	✓ (to 2030)	✓ (to 2020)	✓ (to 2030)	✓ (to 2030)	✓ (to 2020)	✓ (to 2020)	✓ (to 2020)
	Sustainable Development	✓ (to 2030)	✓ (to 2030)	✓ (to 2030)	✓ (to 2020)	✓ (to 2030)	✓ (to 2030)	✓ (to 2030)	✓ (to 2030)
Orientation of GHG emissions reduction	**Green Growth**	✓	✓	X	X	✓	✓	✓	✓
	Climate Change	✓	✓	✓	✓	✓	✓	✓	✓
Target of GHG emissions reduction[(*)]	**Green Growth**	✓ (↓12.14% by 2025, ↓18.71% by 2030)[a)]	X	X	X	X	X	✓ (↓13.2% by 2020, ↓20% by 2025)[a)]	✓ (↓13.2% by 2020)
	Climate Change	X	✓ (↓1.5-2%/year in 2021-2030)	X	X	X	X	X	X
Orientation of electric vehicle development	**Green Growth**	✓ (clean-energy vehicles)	✓ (green-energy vehicles)	X	X	✓ (clean-energy transport)	✓ (renewable energy transport)	✓ (clean-energy public transport)	✓ (clean-energy public transport)

Type of Policies		Selected Cities							
Items	*Strategy*	*Hanoi[1)]*	*Hai Phong[2)]*	*Da Nang[3)]*	*HCM[4)]*	*Can Tho[5)]*	*Hue[6)]*	*Nha Trang[7)]*	*Ha Long[8)]*
	Climate Change	✗	✓ (clean-energy transport/bus)	✓ (encouraging the use of e-MCs)	✓ (pilot install of charge stations)	✗	✗	✓ (low-carbon transport technology)	✓ (clean-energy transport)
Target of electric vehicle development	**Green Growth**	✓ (by 2030, 5% of MCs are e-MCs	✗	✗	✗	✗	✗	✓ (200 e-buses in operation in 2025)	✗
	Climate Change	✗	✗	✗	✗	✗	✗	✗	✗

(Source: Consultant team)

1) Hanoi: Plan No. 228/KH-UBND (2017); Plan No. 149/KH-UBND (2020), Plan No. 242/KH-UBND (2017).

2) Hai Phong: Decision No. 1463/QĐ-UBND (2014); Decision No. 65/QĐ-UBND (2014); Decision No. 3337/QĐ-UBND (2017); Decision No. 565/ QĐ-UBND (2020), Decision No, 2894/QĐ-UBND (2017).

3) Da Nang: Decision No. 1349/QĐ-UBND; Decision No. 3583/QĐ-UBND (2017); Decision No. 3442/QĐ-UBND (2020).

4) Ho Chi Minh: Decision No. 1159 /QĐ-UBND (2017); Decision No. 3924/QD-UBND (2020); Decision No. 815/QĐ-UBND (2015).

5) Can Tho: Decision No. 45/KH-UBND; Plan No. 170/KH-UBND (2017); Plan No. 27/KH-UBND (2018).

6) Hue (Thua Thien Hue province): Plan No. 91/KH-UBND (2015); Decision No. 962/QĐ-UBND (2014); Plan No. 230/KH-UBND (2017).

7) Nha Trang (Khanh Hoa province): Decision No. 2564/QĐ-UBND (2017); Decision No. 201/QĐ-UBND (2016); Plan No. 6676/KH-UBND (2017).

8) Ha Long (Quang Ninh province): Plan No. 6970/KH-UBND (2015); Plan No. 73/KH-UBND (2020); Plan No. 86/KH-UBND (2018).

✓: Yes; ✗: Not yet

Note: (*) According to Decision 1393/QĐ-TTg on Viet Nam Green Growth Strategy (2012), the reduction rate of GHG emissions is 8-10% by 2020, and 20% by 2030 (without international support) and 30% by 2030 (with international support).

According to the Second Biennial Updated Report of Viet Nam (2017), with domestic resources, by 2030, Viet Nam will reduce GHG emissions by 8% compared to the Business-as-Usual (BAU) scenario (estimated at 62.65 MtCO2-e) and this above-mentioned 8% contribution could be increased to 25% (approximately 197.94 MtCO2-e) if international support is received.

2.4. Policies for e-mobility development in Viet Nam

This subsection aims to present a comprehensive review of e-mobility development policies in the following aspects: 1) orientations; 2) targets/roadmaps; 3) incentives; 4) vehicle management; 5) user/driver management; and 6) infrastructure management.

2.4.1. General orientations of clean-energy use and electric vehicle development

Generally speaking, Vietnamese public authorities have realised the importance of clean energy use or vehicles for environmental protection and climate change mitigation. The general orientation of public authorities has been expressed in several legal documents:

- Resolution No. 55-NQ/TW on Orientation of National Energy Development Strategy to 2020, with a Vision to 2045 was promulgated on 11 February 2020 by the Political Bureau (Politburo) of the Central Committee of the Communist Party of Viet Nam. According to point 3 of Item 3 (Key Measures and Tasks), encouragement policy for consumers to use clean and renewable energy is needed, especially in industry and transport. Additionally, it is necessary to push electric transport vehicle development that is suitable to the global trend.
- According to Resolution No. 136/NQ-CP on Sustainable Development issued by the Government of Viet Nam on 25 September 2020, one of MOT's tasks is to push the use of biofuels and clean fuels for motorised transport vehicles.
- The Government of Viet Nam tends to control the number and share of vehicles by type. According to Point 2, Article 33 of Decree No. 10/2020/NQ-CP dated 17 January 2020 on "Automobile Transport Business and Conditions of Automobile Transport Business", provincial-level people's committees have to formulate "Vehicle development and management plans suitable to people's travel demands and current state of road infrastructure in their provinces". Accordingly, Hanoi People's Committee promulgated Plan No. 201/KH-UBND dated 16 October 2020 on Public Passenger Transport Vehicle Development in the period 2021 to 2030. The goal of the plan is to determine the number and share of vehicles by type and by key timelines (2020, 2025 and 2030). Obviously, this regulation may impact the investment and operation of EVs in public passenger transport (e.g., electric buses or electric four-wheelers for the transportation of tourists).
- On 1 June 2016, the Prime Minister promulgated Decision 985a/QD-TTg on the National Action Plan for Air Quality Management to 2020, with a Vision to 2025. As stated in point 5-d of Article 1, one of MOT's tasks is to formulate and promulgate management and development policies for electric transport vehicles.
- On 28 October 2016, the Prime Minister promulgated Decision No. 2053/QD-TTg on the Implementation Plan of the Paris Agreement on Climate Change. According to this Decision, MOT has to carry out mitigation measures for greenhouse gas emissions in the transport sector from 2016-2020 and 2021-2030. In accordance with this Decision, MOT promulgated Decision No. 1456/QD-BGTVT on the Action Plan of Climate Change Adaptation and Green Growth Strategy in the

period 2016-2020. One of MOT's objectives is to push the use of renewable and clean energy in the transport sector.

- On 25 September 2012, the Prime Minister promulgated Decision No. 1393/QD-TTg on Approval of the National Strategy on Green Growth. As per point 3 of Item 3 (Measures), one of the approaches is to change the share of fuel types toward the reduction of fossil fuels and the encouragement of renewable and low GHG-emissions fuels.
- Most recently, the government issued Resolution 140/NQ-CP on the action plan to implement the Politburo's Resolution 55-NQ/TW on Viet Nam's national energy development strategic direction to 2030 with a vision to 2045, which emphasises the reduction of greenhouse gas emissions from energy activities compared to BAU at 15% by 2030, up to 20% by 2045. The MOT is responsible for implementing research and development programmes for transport systems that save energy, use clean energy, and are environmentally friendly.

Table 2.13. List of orientations in legal documents

No.	Legal Documents	Year of Promulgation	Orientations
	General Orientations		
1	Law No. 72/2020/QH14	2020	▪ Promulgation of incentive policies for transport vehicles using renewable energy, vehicles with low fuel consumption or low emissions. ▪ Promulgation of the roadmap for termination of fossil-fuelled vehicles and vehicles causing environmental pollution.
2	Resolution 140/NQ-CP	2020	▪ Implement R&D programmes for transport systems that save energy, use clean energy, and are environmentally friendly. ▪ Develop and implement projects to improve capacity and efficiency in transport; giving priority to the development of modes of mass transit, fuel-saving and environmentally friendly modes; rationally exploit the railways, waterways and multimodal transport system. ▪ Develop and apply standards on fuel consumption for selected types of transport according to conditions and applicability at each stage. ▪ Promote the application of renewable energy, clean fuels (CNG, LPG, LNG, biofuel, electric energy, other potential energy) to replace traditional fuels for vehicles and transport equipment; promote the application of new technologies to improve energy-use efficiency for means and transport equipment. ▪ Develop and complete mechanisms, policies and systems, national technical regulations and standards on fuel consumption and emissions for means of transport.

No.	Legal Documents	Year of Promulgation	Orientations
3	Resolution No. 55-NQ/TW	2020	▪ Encouraging customers to use clean and renewable energy. ▪ Pushing electric transport vehicle development.
4	Resolution No. 136/NQ-CP	2020	▪ The MOT is responsible for pushing the use of biofuels and clean fuels for motorised transport vehicles.
5	Decree No. 10/2020/NQ-CP	2020	▪ Provincial-level people's committees have to formulate vehicle development and management plans suitable to people's travel demands and the current state of road infrastructure in their provinces.
6	Decision 985a/QD-TTg	2016	▪ The MOT is responsible for formulation and promulgation of management and development policies for electric transport vehicles.
7	Decision No. 2053/QD-TTg	2016	▪ The MOT is responsible for carrying out mitigation measures for greenhouse gas emissions in the transport sector in the periods 2016-2020 and 2021-2030.
8	Decision No. 1456/QD-BGTVT	2016	▪ One objective of the MOT is to push the use of renewable and clean energy in the transport sector.
9	Decision No. 1393/QD-TTg	2012	▪ To change market share of fuel types toward the reduction of fossil fuels and encouragement of renewable and low GHG-emissions fuels.
	Orientations for Each Type of Electric Vehicle		
10	Resolution No. 12/NQ-CP	2019	▪ Arrangement of different types of passenger transport modes (including electric or biofuel four-wheeler vehicles) to connect origin/destination points of mass transit by buses, urban railway stations and airport terminals. ▪ To support the development of environmentally-friendly buses in accordance with existing regulations. ▪ To formulate a plan and to allocate budget for the support of public passenger transport by electric buses or other environmentally-friendly buses.
11	Correspondence No. 1318/TTg-CN	2018	▪ To agree with the pilot operation of electric four-wheelers for transportation of tourists or visitors in restricted areas. ▪ Provincial-level people's committees are responsible for the promulgation of regulations regarding operation times and routes.
12	Decision No. 3446/QD-BGTVT	2016	▪ Diversification of bus fleets (including e-buses).
13	Decision No. 1168/QD-TTg	2014	▪ Orientation for production of eco-friendly automobiles (including EVs).
14	Decision No. 280/QD-TTg	2012	▪ To encourage the investment of clean-fuel buses in the operation of public bus passenger transport.

No.	Legal Documents	Year of Promulgation	Orientations
15	Resolution No. 05/2008/NQ-CP	2008	▪ To stop the issue of new vehicle registration licenses for motorised three-wheeled vehicles. ▪ The operation of in-use motorised three-wheeled vehicles (including imported vehicles) are banned in urban areas and on national highways. ▪ Transportation of waste, tourists, war invalids and the disabled by three-wheelers is allowed.
16	Resolution No. 32/NQ-CP	2007	▪ Home-made three or four-wheelers are banned on roads. ▪ Operation of illegal manufacturers of home-made vehicles are suspended.
17	Decision No. 33/2006/QĐ-BCN	2006	▪ To research manufacture of high-quality and exclusive motorcycles, especially clean-fuel motorcycles.

(Source: Consultant team)

Development orientation for each type of electric vehicle

The existing types of electric road vehicles include: i) two-wheelers; ii) three-wheelers; iii) four-wheelers for transportation of tourists/visitors; iv) cars; v) buses; and vi) trucks. Orientations for each type of EV will be reviewed in three following aspects: Manufacturer (M) for sales and Operation (O) for transport business.

- Electric Two-Wheelers: On 13 September 2006, the Ministry of Industry promulgated Decision No. 33/2006/QĐ-BCN on Approval of the Viet Nam Motorcycle Industry Development Strategy to 2015, with a Vision to 2025. According to Point 3a (Manufacturing Development for the Domestic Market), it is necessary to research the manufacture of high-quality and exclusive motorcycles, especially clean-fuel motorcycles.
- Electric Three-Wheelers: In general, three-wheelers (so-called tricycles) are not encouraged in circulation because most are homemade vehicles by local or small manufacturers and they are not in accordance with technical standards. However, three-wheelers (including electric three-wheelers) are accepted for transportation of tourists, waste, war invalids and the disabled (Resolution No. 05/2008/NQ-CP). An electric three-wheeler is defined as a vehicle with a maximum capacity of 4kW (QCVN 14:2015/BGTVT).
- Electric Four-Wheelers for the Transportation of Tourists: As stated in Resolution No. 05/2008/NQ-CP, transportation of tourists by four-wheelers has been allowed by public authorities. According to point 14-i, Item II (Specific Tasks and Measures) of Resolution No. 12/NQ-CP on Reinforcement of Traffic Safety and Prevention of Traffic Congestion, people's committees of five central-level cities need to arrange different types of passenger transport modes (including electric or biofuel four-wheeler vehicles) to connect origin/destination points of mass-transit by buses, urban railway stations and airport terminals. As of January 2018, the pilot operation of electric four-wheelers for the transportation of tourists was carried out in 21 provinces (Correspondence No. 565/BGTVT-VT).

According to Correspondence No. 1318/TTg-CN dated 27 September 2018, the Prime Minister agreed to the pilot operation of electric four-wheelers for the transportation of tourists or visitors in restricted areas. Additionally, provincial-level people's committees are responsible for the promulgation of regulations regarding operation times and routes. The registration of such vehicles is in accordance with Circular No. 15/2014/TT-BCA dated 4 April 2014, and the inspection of technical conditions and safety is guided by Circular No. 86/2014/TT-BGTVT dated 31 December 2014.

- Electric Passenger Cars (under 9 seats): On 16 July 2014, the Prime Minister promulgated Decision No. 1168/QD-TTg on Approval for the Strategy to Develop the Automotive Industry in Viet Nam by 2025 with Orientation to 2035. According to this Decision, encouragement for the production of eco-friendly automobiles (including EVs) is expressed in Article 1, point 4.
- Electric Buses: With respect to "Manufacture", the encouragement of eco-friendly automobiles (including buses) is mentioned in Decision No. 1168/QD-TTg. Regarding the operation of electric buses in public transport, the orientations are mentioned in several legal documents:

– As point 2, Item 3 of Decision No. 280/QD-TTg dated 8 March 2012 on Approval of the Public Bus Passenger Transport Project in the Period from 2012 to 2020, the Government of Viet Nam encourages the investment of clean-fuel buses in the operation of public bus passenger transport.
– Following this Decision, the MOT promulgated Decision No. 3446/QD-BGTVT on 4 November 2016. Point 1-e, Item 3 of Decision 3446, suggests diversifying bus fleets (including e-buses).
– According to point 14h, Item II (Specific Tasks and Measures) of Resolution No. 12/NQ-CP (2019), people's committees of five central-level cities (Hanoi, Hai Phong, Da Nang, Ho Chi Minh City and Can Tho) need to support the development of environmentally-friendly buses in accordance with existing regulations. Additionally, Hanoi and Ho Chi Minh City People's Committees cooperate with MOF and MOT to formulate a plan and allocate budgets for the support of public passenger transport by electric buses or other environmentally-friendly vehicles.

2.4.2. Targets or Roadmaps

In general, the Government of Viet Nam advocates controlling the number and share of road motor vehicles. According to Decision 356/QD-TTg dated 25 February 2013 on the Approval of the Adjusted Planning for Road Traffic Development in Viet Nam by 2020 with a Vision to 2030, there will be 3.2 to 3.5 million automobiles by 2020, including: cars (57%), buses (14%) and trucks (29%). Additionally, the number of expected motorcycles by 2020 is 36 million vehicles. However, there have been no national targets or roadmaps regarding the number and share of EVs or timelines. The share of CNG/LPG taxis and buses was only mentioned in Decision No. 1456/QD-BGTVT dated 11 May 2016 on the Action Plan of Climate Change Adaptation and the Green Growth Strategy 2016-2020. The MOT tends to set a target that the share of CNG/LPG taxis and buses will account for 5%-20% of the total taxi and bus fleet by 2020, respectively. In a five-year plan to 2020, the Ministry of Transport aims to introduce 200 hybrid and 50 plug-in hybrid buses. However, until 2019, the number of CNG buses accounts for about 4%-5% of the total bus fleet, while the share of CNG taxis in the total taxi fleet is only 0.1%. This plan is on top of other pockets of EV initiatives, such as promoting EV for tourist taxis. Viet Nam likely started

looking into private EV adoption during 2018 (Motion Digest, 2017) but nothing happened regarding incentives during 2018-2020.

As mentioned above, the Government of Viet Nam tends to control the number of automobiles, especially for transport businesses as indicated in point 2, Article 33 of Decree 10/2020/ND-CP. Following this regulation, all provinces and central-level cities shall formulate a development and management plan for road vehicles used by transport businesses. For example, the Government of Hanoi is a pioneer in formulating and promulgating the road vehicle development plan. According to Plan No. 201/KH-UBND dated 16 October 2020, Hanoi People's Committee expects the number of buses to increase from 2,900 vehicles in 2021 to 6,800 in 2030. Interestingly, the Government of Hanoi set a target that clean-energy vehicles will account for 5%-20% of the total vehicle fleet.

Table 2.14. Expected number of public passenger transport vehicles in Hanoi

Year	Types of Vehicles			Note (*Share of clean-energy vehicles*)
	Buses	*Taxis*	*Contract-based cars (under 9 seats)*	
2021	2,720 – 2,900	19,265	47,335 – 56,735	**5% - 20%**
2025	4,000 – 5,000	25,000	48,000 – 75,000	
2030	6,700 – 6,800	30,000	49,000 – 78,000	

(Source: Appendix 1, Plan No. 201/KH-UBND)

2.4.3. Incentives

Incentive policies will be reviewed according to three types of activities: i) manufacture (enterprises); ii) operation (enterprises); and iii) usage (residents/users). Generally speaking, the public authorities intend to provide additional incentives for electric buses used for public passenger transport.

- Special Consumption Tax (SCT): Generally, public authorities tend to set a lower level of SCT for electric passenger automobiles in comparison with gasoline- or diesel-fuelled automobiles. According to Law No. 106/2016/QH13 dated 6 April 2016 on Amendments to Some Articles of the Law on Value-Added Tax, the Law on Special Consumption Tax and the Law on Tax Administration, the SCT rates of gasoline- or diesel-fuelled passenger automobiles are in the range of 35% to 150% of the selling price exclusive of SCT, environmental protection tax and VAT tax (depending on cylinder capacity). While rates for electric passenger automobiles are only from 5% to 15% (depending on the number of seats). Note that the SCT rates for electric passenger automobiles are relatively low in comparison with previous regulations. According to Law No. 70/2014/QH13 dated 26 November 2014, electric passenger automobiles are subjected to tax rates of between 10% to 25%.
- Import Tax: On 25 May 2020, the Government of Viet Nam promulgated Decree 57/2020/ND-CP. According to this Decree, a preferential import tax rate of 0% will be levied on inputs, raw materials and accessories that have not yet been domestically produced to serve the manufacture and process (assembly) of prioritised supporting products for the development of the automobile

manufacture and assembly industry. This Decree applies to automobiles in general (including e-automobiles).

- Incentives for Public Transport by Electric Buses:

– Special Consumption Tax: As stated in point c, clause 2, article 5 of Decree No. 10/2020/NQ-CP, automobiles used for public passenger transport business must have a minimum of 12 seats. Bus operators may benefit from Law No. 106/2016/QH13 on Special Consumption Tax if they use mini or small-sized electric buses (12 to 24 seats).

– The most important incentive policy is Decision 13/2015/QD-TTg dated 5 May 2015 on "Incentive Mechanism and Policies for Public Bus Passenger Transport Development". This Decision applies to both normal buses and clean-energy buses. On the one hand, a normal bus means gasoline-fuelled or diesel-fuelled as per clause 4 of Article 3. On the other hand, clean-energy bus means liquefied-gas, natural-gas or electric buses as per clause 5 of Article 3. In addition to this, a refuelling/charging station is part of the infrastructure system for public bus passenger transport (as clause 2, Article 3). There are four types of incentives:

  - Incentives for investment in infrastructure system development: The regulation applies to all types of bus infrastructure (including the infrastructure for e-buses). The investor is prioritised for access to preferential loans: including official development assistance (ODA) loans and preferential credit loans. Additionally, the investor may receive support from provincial or central-level people's committees for loan interest rates. Depending on local resources, provincial people's committees will promulgate specific regulations for investment projects on bus infrastructure development. For instance, Hanoi People's Council promulgated Resolution No. 07/2019/NQ-HDND on Prioritising Mass Transit System Development in 2019. As per clause 1 of Article 1, the term mass transit system means urban railways, BRTs and buses. In terms of investment in mass transit infrastructure, the city budget supports 50% of the loan interest rate in the first 5-year period of investment in infrastructure construction.
  - Incentives for investment in vehicles: First of all, bus operators can be exempted from import duty on domestically unavailable parts and components for the manufacture and assembly of vehicles. Secondly, investment in clean-energy buses is exempted from registration fees. Thirdly, bus operators may receive the support of provincial or central-level people's committees for loan interest rates. Depending on local resources, provincial people's committees will promulgate specific regulations for the procurement of new vehicles. According to Resolution No. 07/2019/NQ-HDND of Hanoi, for example, the city budget will support 50% of the loan interest rate in the first 5-year period of investment in clean-energy buses.
  - Incentives for the operation of public bus passenger transport: Bus operators may receive a subsidy or support for operation costs.
  - Incentives for bus users: Firstly, children aged below 6 and the disabled are exempted from bus fares. Secondly, persons with meritorious services to the revolution, the elderly, and students and pupils may receive a discount for bus fares.

Table 2.15. Financial Incentives following Decision 13/2015/QD-TTg: Normal vs clean-energy buses

Financial Incentives	Applicability	
	Normal buses	*Clean-energy buses*
1. Investment in Bus Infrastructure		
1.1. Access to preferential loans: ODA or concessional loans	Yes	Yes
1.2. Support for loan interest rates	Yes	Yes
2. Investment in Vehicles		
2.1. Exemption from import duty/tax for domestically unavailable parts and components	Yes	Yes
2.2. Exemption from registration fees	No	Yes
2.3. Support for loan interest rates	Yes	Yes
3. Operation in Public Bus Service		
3.1. Subsidy for operation activities	Yes	Yes

- Concerning support through loan interest rates, the Ministry of Finance (MOF) promulgated Circular No. 02/2016/TT-BTC. This Circular contains specific guidance on supporting loan interest rates for organisations or individuals in the implementation of transport vehicle and infrastructure investment projects in the field of public bus passenger transport.
- In terms of registration fees, the MOF has provided guidance on registration fees through the promulgation of Circular No. 301/2016/TT-BTC. As stated in clause 31 of Article 5, clean-energy buses used for public passenger transport are exempted from registration fees. Clean energy buses means liquefied-gas, natural-gas or electric buses.
- Notably, bus operators' investment in building maintenance stations and parking lots are exempted from land rent as per Article 1 of Decision No. 55/2012/QĐ-TTg.

Table 2.16. List of financial incentives

No.	Legal Documents	Year of Promulgation	Financial Incentives
1	Decree No. 57/2020/ND-CP	2020	▪ *Preferential import tax rate* of 0% will be levied on raw materials and accessories that have not yet been domestically made to manufacture, process (assemble) supporting products given priority for the development of the automobile manufacturing and assembly industry.

No.	Legal Documents	Year of Promulgation	Financial Incentives
2	Law No. 106/2016/QH13	2016	*Special Consumption Tax* (SCT) for Electric Passenger Automobiles Under 24 Seats is amended as follows: ▪ 9 seats and below: 15%. ▪ 10 to 15 seats: 10%. ▪ 16 to 24 seats: 5%. ▪ For the transportation of both passengers and freight: 10%. *Note: According to Law No. 70/2014/QH13, SCT for electric passenger automobiles is 25% (9 seats and below), 15% (10-15 seats), and 10% (16-24 seats).*
3	Decision 13/2015/QD-TTg	2015	+) Definition/clarification regarding electric buses: ▪ Charging stations are components of the infrastructure system for public bus passenger transport. ▪ Public bus passenger transport vehicles consist of normal buses and clean-energy buses. ▪ Clean-energy buses means liquefied-gas, natural-gas or electric buses. +) Incentives for the investment of infrastructure: ▪ The investor is prioritised for access to *preferential loans*: including official development assistance (ODA) loans and preferential credit loans. ▪ Depending on local resources, provincial or central-level people's committees shall support *loan interest rates* for investment projects of infrastructure construction for public bus passenger transport. +) Incentives for the investment of vehicles: ▪ *Import tax* is exempted for domestically unavailable parts and components for the manufacture and assembly of vehicles. ▪ Clean-energy buses are exempted from *registration fees*. ▪ Depending on local resources, provincial or central-level people's committees shall support *loan interest rates* for vehicle investment projects. *Note: In addition to these incentives, the investment in mini or small-sized electric buses may benefit from the Law on Special Consumption Tax.* +) Incentives for the operation of public bus passenger transport: ▪ Depending on local resources, provincial or central-level people's committees shall *subsidise* or support operation costs.

No.	Legal Documents	Year of Promulgation	Financial Incentives
4	Circular No. 02/2016/TT-BTC	2016	▪ Guidance on supporting the *loan interest rates* for investment in bus infrastructure and vehicles.
5	Circular No. 301/2016/TT-BTC	2016	▪ Clean-energy buses are exempted from *registration fees.* ▪ Clean-energy buses means liquefied-gas, natural-gas or *electric buses*.
6	Decision No. 55/2012/QĐ-TTg	2012	▪ Building maintenance stations and parking lots are exempted from land rent.

Following the above-mentioned regulations, provincial and central-level people's committees have carried out financial incentive programmes for public bus passenger transport. However, there are differences in policy implementation in each province or city. A summary of incentive policies in five central-level cities is shown in Table 2.17.

Table 2.17. Current status of financial incentives for public passenger transport by electric buses and taxis in eight cities in Viet Nam

Categories of Policy	Hanoi	Hai Phong	Da Nang	HCM	Can Tho	Hue	Nha Trang	Ha Long
1. Promulgation of Investment Attraction Policies for Public Passenger Transport by E-Bus								
1.1. Support for loan interest rates	Yes (implemented)	No	No	No	No	No	Yes (implemented)	No
1.2. Support for bus ticket fares	Yes (but not implemented yet)	No	No	No	No	No	Yes (but not implemented yet)	No
1.3. Allocation of the local budget for supporting the service fees of public transport operation by e-bus	Yes (but not implemented yet)	No	No	No	No	No	No	No
1.4. Support in respect of available land for infrastructure development (location of charging stations, boarding/alighting areas and parking)	No	No	No	No	No	No	No	No

Categories of Policy	Hanoi	Hai Phong	Da Nang	HCM	Can Tho	Hue	Nha Trang	Ha Long
1.5. Support for connection to the power grid	No	No	No	No	No	No	No	No
2. Promulgation of Investment Attraction Policies for Public Passenger Transport by E-Taxi								
2.1. Support for loan interest rates	No	No	No	No	No	No	No	No
2.2. Support in respect of available land for infrastructure development location of charging stations and parking)	No	No	No	No	No	No	No	No
2.3. Support for connection to the power grid	No	No	No	No	No	No	No	No
2.4. Prioritised boarding/alighting areas at bus stations and airports	No	No	No	No	No	No	No	No
2.5. Priority for e-taxis in peak hours and restricted areas	No	No	No	No	No	No	No	No

(Source: Consultant team)

2.4.4. Vehicle management

The Ministry of Transport promulgated several regulations regarding technical standards, safety and environmental protection for EVs, mostly for E2Ws. A list of regulations is shown in Table 2.18.

Table 2.18. List of MOT's national technical regulations for electric vehicles

No.	Legal Document	Content
1	Circular No. 45/2019/TT-BGTVT dated 11 November 2019	1.1. National technical regulation on motors used for *electric bicycles* (**QCVN 75:2019/BGTVT**). 1.2. National technical regulation on traction batteries used for *electric bicycles* (**QCVN 76:2019/BGTVT**).

No.	Legal Document	Content
		1.3. National technical regulation on motors used for *electric motorcycles, mopeds* (**QCVN 90:2019/BGTVT**).
2	Circular No. 26/2019/TT-BGTVT dated 1 August 2019	Including: National technical regulation on traction batteries used for *electric motorcycles, mopeds* (**QCVN 91:2019/BGTVT**).
3	Circular No. 66/2015/TT-BGTVT dated 6 November 2011	Amendment of national technical regulation on electric bicycles (**Amended 1:2015 QCVN 68:2013/BGTVT**).
4	Circular No. 39/2013/TT-BGTVT dated 1 January 2013	National technical regulation on electric bicycles (**QCVN 68:2013/BGTVT**).
5	Circular No. 41/2013/TT-BGTVT dated 5 November 2013	Inspection of technical safety and quality for electric bicycles.
6	Circular No. 86/2014/TT-BGTVT dated 31 December 2014	Conditions of four-wheeled vehicles (including EVs) and drivers for passenger transport in restricted areas.

2.4.5. User/driver management

From the early 2010s, there has been growth in E2Ws in Viet Nam, especially for e-bikes. Generally speaking, students prefer to use e-bikes due to their flexibility, convenience and reasonable costs. According to Road Traffic Law No. 23/2008/QH12 (referred to as the 2008 Road Traffic Law), a driving test and license are not required for riding e-bikes on roads. Additionally, there is no age limit for the riders of e-bikes. As a result, numerous novice riders can use e-bikes for daily travel, especially people aged under 16. To deal with these issues, the Government of Viet Nam amended the 2008 Road Traffic Law. Specifically, the 2008 Road Traffic Law classifies driving licenses for motorised two or three-wheelers into 3 categories: A1, A2 and A3 (see Table 2.19.). However, the Draft Revision of the Law will re-group driving licenses into 4 categories: A0, A1, A and B1.

Table 2.19. Driving licenses with unlimited validity

2008 Road Traffic Law			Draft Revision (*)		
Categories of Driving License	*Types of Motorised Two- or Three-Wheelers*	*Age Limit*	*Categories of Driving License*	*Types of Motorised Two- or Three-Wheelers*	*Age Limit*
Not required	▪ Two-wheelers with cylinder capacity under 50 cm^3	16 and above	A0	▪ Two-wheelers with cylinder capacity under 50 cm^3 ▪ Two-wheelers with power capacity not exceeding 4kW	16 and above
A1	▪ Two-wheelers with cylinder capacity between 50 and 175 cm^3	18 and above	A1	▪ Two-wheelers with cylinder capacity between 50 and 125 cm^3	18 and above

2008 Road Traffic Law			Draft Revision (*)		
Categories of Driving License	*Types of Motorised Two- or Three-Wheelers*	*Age Limit*	*Categories of Driving License*	*Types of Motorised Two- or Three-Wheelers*	*Age Limit*
				▪ Two-wheelers with power capacity between 4 and 11 kW	
A2	▪ Two-wheelers with a cylinder capacity of 175 cm^3 and higher		A	▪ Two-wheelers with a cylinder capacity of 125 cm^3 and higher ▪ Two-wheelers with a power capacity of 11 kW and higher	
A3	▪ Motorised three-wheelers		B	▪ Motorised three-wheelers	

(*)(Source: Draft Law on the MOT website)

2.4.6. Infrastructure Management

Charging stations are the most important infrastructure for electric road vehicles. However, there are no technical regulations or incentive policies for charging stations in Viet Nam. Other charging infrastructure (e.g., connection to the power grid/line, transformers, meters and electric panels) is under the management of the Ministry of Industry and Trade (MOIT) and EVN Group in accordance with the Electricity Law (Consolidated Document No. 03/VBHN-VPQH, dated 29 June 2018) and relevant documents.

2.5. Summary

Transport has played an important role in Viet Nam's economic development. Transport infrastructure development has soared in response to growing demand for passenger and freight transport. Road passenger and freight transport are the most important transport modes, followed by waterways. The rate of road vehicle ownership has increased dramatically in recent years. From 2014 to 2018, the average annual growth rate of passenger cars was 13.4% and for motorcycles 9%. Currently, two-wheeled vehicles are still the main transport mode in Viet Nam today, accounting for 92%.

The rapid increase in the number of road vehicles has contributed to increasing GHG and $PM_{2.5}$ emissions, especially in densely populated areas. In the period 2014-2030, the annual average rate of GHG emissions from the transportation sector is estimated at 6-7%. In the whole country, Hanoi is currently the city with the highest $PM_{2.5}$ pollution, followed by Hue city. Specifically, nano dust emissions related to transportation in Hanoi account for about 46%.

In Viet Nam, sustainable transport development policies are guided by national laws, strategies and action plans under four themes, including: 1) Sustainable development, 2) Green growth, 3) Climate

change and 4) Environmental protection. In general, Vietnamese government agencies are now aware of the importance of using clean energy or green transport modes as a means of protecting the environment and mitigating climate change.

Based on the National Strategy and Action Plan, most of the selected cities have issued respective action plans on green growth, climate change and sustainable development.

3. CURRENT STATUS AND POTENTIAL OF E-MOBILITY DEVELOPMENT IN VIET NAM

3.1. Pilot programmes & Initiatives

3.1.1. Free charging stations and free two-wheeled EVs

Pilot programmes on the deployment of charging stations have been carried out by private enterprises, especially electric vehicle suppliers. From November 2018, free e-motorcycle charging points have been installed at convenience stores of the VinMart+ network by VinFast. In addition, Vingroup and Petrolimex have a comprehensive agreement on the establishment of charging stations for EVs at gas stations. Up to 2020, VinFast intends to deploy 30,000 to 50,000 charging stations in all of Viet Nam's provinces. For electric cars, the first quick charging system was opened in Da Nang in December 2017. This pilot project is funded by Central Power Corporation in cooperation with Mitsubishi. The charging system allows battery charging to its maximum capacity in just half an hour. The system was manufactured in Japan at the cost of USD 31,000.

In several cities, some pilot programmes on the usage of electric bikes have been conducted by private enterprises and international organisations. For example, BeforeAll and BooVironment installed three free charging stations in Hanoi in 2016. In terms of vehicle supply, a pilot project (Easy Move) was implemented at the campus of Ho Chi Minh National University. 100 e-bikes are parked at a station in the university village. Students can experience e-bike services at no charge in the first three months. They need to install the mobile app Easy Move and use QR codes to unlock the bikes. A similar initiative by UNDP, Viet Nam MBI, Ecotek and the Government of Hue city has been proposed. According to this initiative, a pilot programme of e-bike sharing was carried out from October to November 2020 at Ecopark, including the provision of 500 e-bikes, the installation of 50 charging stations, and a control centre.

3.1.2. Pilot operation of electric three-wheelers for the transportation of waste

A pilot of electric three-wheelers for the transportation of waste is being carried out in a number of provinces. For instance, Nga Hai Ltd. invested VND 1.2 billion for 33 vehicles in Cao Bang city (Cao Bang province) in August 2019. In Hue city (Thua Thien Hue province), HEPCO operated 40 electric three-wheelers for the transportation of waste in the city centre in the period 2019-2020. During 2020-

2022, 60 new vehicles will be operated in other areas of Hue city. In October 2019, the Da Nang Urban Environment Company implemented a pilot of 15 electric tricycles for garbage collection. Generally speaking, the operation of such electric three-wheelers is more effective than that of a garbage bin manually operated by garbage workers. However, there are some legal issues regarding the operation of three-wheelers, such as legal procedures for vehicle registration, technical regulations and driving licenses.

Table 3.1. Pilot operation of electric three-wheelers for the transportation of waste

No.	Location	Year of Pilot Operation	Operators	No. of electric three-wheelers
1	Cao Bang city, Cao Bang province	2019	Nga Hai Ltd. (private)	30
2	Ha Tinh city, Ha Tinh province	2017	Ha Tinh urban facility & environment JSC.	10
3	Hue city, Thua Thien Hue province	2019	Hue urban facility & environment JSC.	40
4	Da Nang city	2019	Da Nang urban environment JST	15

(Source: tnmtcaobang.gov.vn; baohatinh.vn; baotainguyenmoitruong.vn; baogiaothong.vn)

3.1.3. Pilot operation of electric four-wheelers

From the 2000s, electric four-wheelers have been used for the transportation of tourists and visitors in restricted areas, such as golf courses, recreational parks and resorts. As per Resolution No. 05/2008/NQ-CP, Chairpersons of provincial people's committees have been assigned to promulgate regulations regarding operation times and areas for motorised four-wheelers. As of January 2018, pilots of electric four-wheelers have been widely carried out for the transportation of tourists or visitors in 21 provinces and central-level cities (including Hanoi, Hai Phong, Da Nang, Ho Chi Minh City, Can Tho, Khanh Hoa, Thua Thien Hue, and Quang Ninh). There are 637 operators (including 50 enterprises and 587 business households) with 2,302 EVs. Based on these pilots, additional provinces will deploy pilots of electric four-wheelers in the future.

In terms of electric cars, Mitsubishi is cooperating with the Ministry of Industry and Trade to study efficient EV usage and public policy programmes that can support the speedy adoption of sustainable automotive technology. Under the agreement, the Japanese carmaker will share its knowledge on tax and subsidies related to these vehicles, and will conduct research on charging infrastructure and the country's road system. Mitsubishi plans to introduce EVs to the local market as part of a long-term strategy, but for now, Viet Nam's existing support policies for EVs remain severely underdeveloped.

3.1.4. Pilot operation of electric buses

Up to now, electric buses have not been used for the operation of public passenger transport in Viet Nam. However, Vingroup announced an operation plan for electric buses in Hanoi, Ho Chi Minh City and Phu Quoc island (Kien Giang province). In 2019, Vingroup established VinBus Ltd. with the charter capital of VND 1,000 billion. VinBus will be responsible for the operation of electric buses. Tentatively, VinBus will formulate and operate 15 e-bus lines, including 10 in Hanoi and 5 in Ho Chi Minh City. The number of projected electric buses is from 150 to 200 vehicles.

In October 2020, the Ministry of Transport sent Official Correspondence No. 10250/BGTVT-VT to Hanoi and Ho Chi Minh City people's Committees regarding the operation of public passenger transport by electric buses. According to the MOT, the development of public passenger transport by electric buses is compatible with orientations and strategies in Viet Nam, such as Decision No. 1168/QD-TTg on Automobile Industry Development, Decision No. 985a/QD-TTg on the National Action Plan of Air Quality Management, and Resolution No. 12/2020/NQ-CP on Reinforcement of Traffic Safety and Prevention of Traffic Congestion.

3.2. Stakeholder Mapping

To easily understand the structure and functioning of the e-mobility system, it is necessary to present an overview of relevant stakeholders on three levels: the political level, the strategic level and the operational level (as illustrated in Figure 3.1).

The objective of stakeholder analysis is to capture possible development scenarios for a specific action, policy or technology, by mapping supporters and opposers, identifying the interests of various stakeholders and considering partnerships as well as the power structure of all stakeholders.

3.2.1. National level

3.2.1.1. Political Level

At the national level, the national government issues all administrative decisions to execute long-term development plans, annual socio-economic development plans, projects and other legal decisions of the Viet Nam General Assembly.

Under the national government, several branches are closely involved in the Vietnamese EV industry. Ministries such as the Ministry of Planning and Investment (MPI), Ministry of Finance (MOF), Ministry of Trade and Industry (MOIT), Ministry of Transport (MOT), Ministry of Science and Technology (MOST) and the Ministry of National Resource and Environment (MONRE) are major governmental authorities directly related to electric mobility. They are responsible for strategic policy, long-term investment issues, standards, and subsidy policy in the EV industry.

1) MPI: The Ministry of Planning and Investment is the national designated authority for Green Climate Fund financial proposals.

2) MOF: The Ministry of Finance is mainly involved in 'improve' policies (though pricing instruments it will have an impact on the shift from fossil energy to electric energy).

3) MOIT: The Ministry of Industry and Trade is responsible for policymaking related to energy saving, energy efficiency and energy use, including electricity, coal, oil and gas, new energy, and renewable energy. In addition, the MOIT is also responsible for issuing standards for automobile manufacturing and assembling enterprises.

4) MOT: The Ministry of Transport is responsible for all transport regulations including the regulation on the usage of energy-efficient vehicles (for example EV in Viet Nam). MOT thus plays a key role in updating regulations concerning energy-efficient vehicles.

According to Decree No. 12/2017/ND-CP by the Prime Minister, which defines the regulatory functions, duties, powers and organisational structure of the MOT, the responsibilities of the MOT with respect to environmental management in the transport sector are elaborated as follows:

- Organise a review for the Strategic Environment Assessment and Environmental Impact Assessment reports of projects that are subject to approval within the competence of the MOT.
- Provide certification standards for environmental facilities of road, railway transport, inland waterways, maritime and aviation, including leadership in supervising and certifying environmental standards for cars and other motor vehicles.
- Stipulate technical regulations and energy consumption norms for transport means; guide, inspect and supervise compliance with energy consumption norms for transport means.

5) MOST: The Ministry of Science and Technology is in charge of the development and issuance of fuel quality, vehicle emission standards, and vehicle standards.

6) MONRE: The Ministry of Natural Resources and Environment is in charge of all regulations concerning the environment and is also the key ministry for climate change. MONRE plays an important role when applying for climate finance and is also a potential ally for convincing the MOT to update regulations on energy-efficient vehicles. MONRE is also the core ministry for policies concerning battery recycling and re-usage.

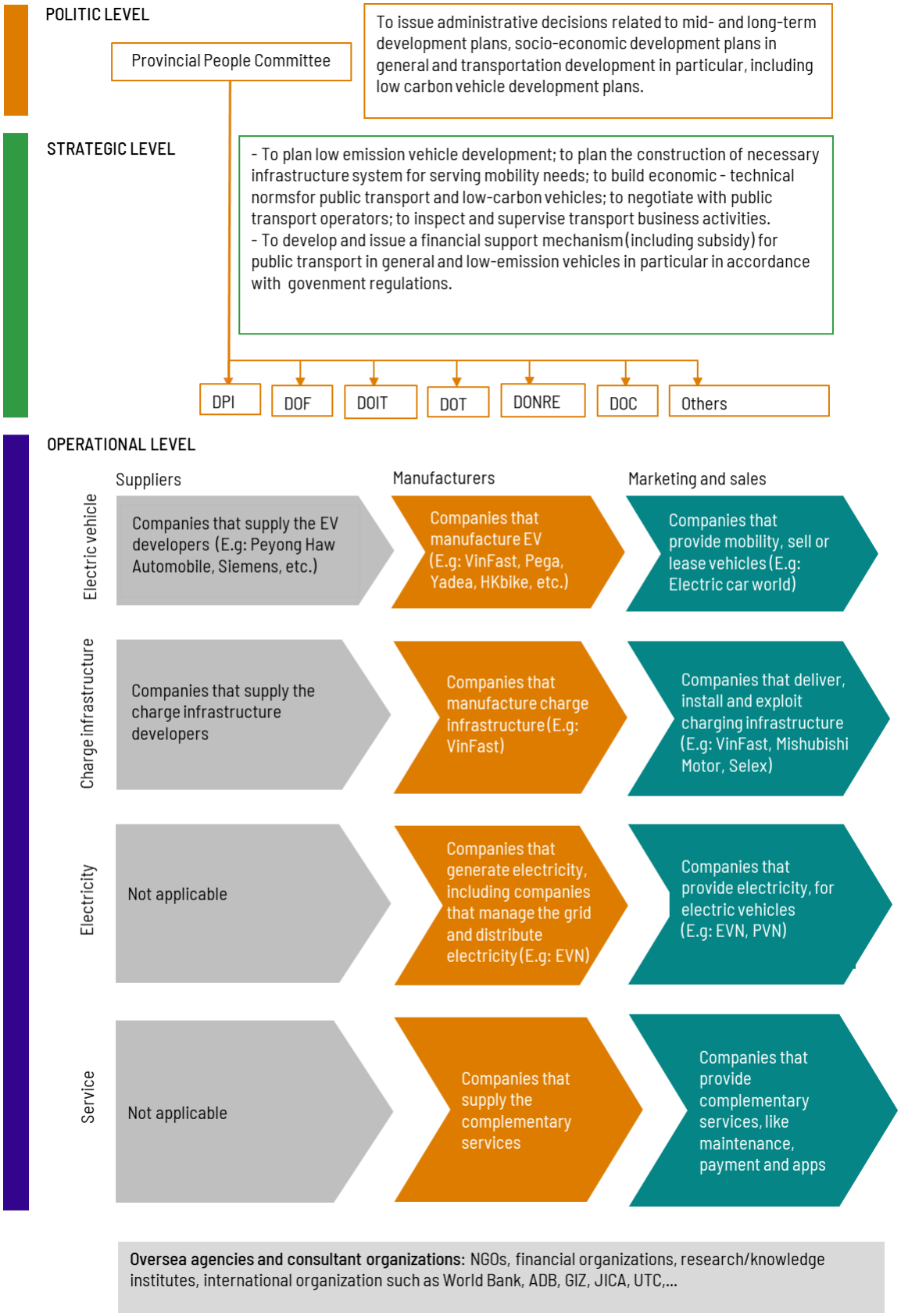


Figure 3.1. Stakeholder mapping in electric mobility in Viet Nam

(Source: Consultant team)

3.2.1.2. Strategic Level

Under MOIT, the Electricity Regulatory Authority of Viet Nam (ERAV) is responsible for presiding over and coordinating smart grid development in Viet Nam. Every year, power sector entities have to report the status of their projects to the ERAV. It was established to regulate the power market, including the supervision of electricity pricing and the monitoring of supply and demand balances. Furthermore, the ERAV promotes energy security, efficiency, and conservation, resolves licensing issues and addresses dispute resolution procedures. However, it is managed by MOIT, which also manages EVN, so ERAV lacks full functional independence. Moreover, ERAV's functions are limited given that the main responsibility for regulating and monitoring the energy sector and its SOEs lies with the General Directorate of Energy (GDE) under MOIT. GDE is responsible for strategy and policy formulation regarding national development and planning of each energy sub-sector, including electricity. Regarding the development of the electricity sector, GDE organises the appraisal of the National Power Development Plan and related sub-sector plans, such as hydropower plans for rivers, plans for small-sized hydropower works, and plans for new and renewable energies. Besides, the Science and Technology Department (DOST) of MOIT has related responsibilities in the field of energy efficiency, product and manufacturing standards as well as technical and economical standards for electricity power operations. This also makes it relevant for both solar power and solar thermal applications.

Under MOT, the Department for Environment (established in 2008) is the focal agency responsible for the implementation of environmental measures in the transportation sector. The Viet Nam Register is the body responsible for type approval, vehicle inspection and emissions standards enforcement. The Directorate for Roads of Viet Nam (DRVN) is one of the organisations assisting the MOT to perform state management functions in the road sector.

3.2.2. City level

3.2.2.1. Political level

Viet Nam is divided into 58 provinces and 5 centrally-controlled municipalities (Hanoi, HCMC, Can Tho, Da Nang, and Hai Phong), each of which is controlled by a People's Council elected by residents. This council assigns a People's Committee that acts as the executive arm and is responsible for formulating and implementing the provincial government's plans.

Regarding the regulation and demonstration projects, subsidy policies, and operations at city level, the Provincial People's Committee (PC) is the most important entity in the decision system of the EV industry as it launches almost all policies on new-energy vehicles. PCs decide whether to provide support through policies, subsidies (including subsidies to providers of charging infrastructure, manufacturers, and bus companies), as well as funding for technological innovation.

3.2.2.2. Strategic level

From the city level, DPI, DOF, DOIT, DOT and DONRE under the PC, are responsible for not only managing EV operation and promotional projects but also for project coordination.

- The Department of Planning and Investment (DPI): The DPI is one of the most important agencies in urban development and economic investment. The DPI is responsible for the overall management of investment and development projects in the province/city.
- The Department of Finance (DOF): The DOF is responsible for developing long-term, five-year and annual programmes and plans in the financial sector according to the city's master plan as well as the socio-economic development master plan. It develops a plan for decentralising revenue sources and spending tasks of each provincial/city budget level and builds the allocation norms of local budget expenditure estimates. In addition, it develops a regime for collecting fees and charges for activities in the province/city, including the transportation sector.
- The Department of Science and Technology (DOST): The role of DOST is to participate in the management of standards, metrology, and quality.
- The Department of Transport (DOT): The DOT is responsible for managing the transport infrastructure system within the province/city (excluding highways, national highways, and national railway and aviation infrastructure) as well as traffic control. The DOT is responsible for establishing technical standards and procedures related to system operations, as well as design verification and monitoring.
- The Department of Natural Resources and Environment (DONRE): The DONRE is responsible for air quality management within the city or province.

3.2.2.3. Operational level

Stakeholder analysis at the operational level focuses on four main components: (i) EVs; (ii) charging infrastructure; (iii) electric energy; and (iv) service. Each component is split into three steps: (1) suppliers (who provide original equipment); (2) manufacturers; and (3) companies related to marketing and sales.

- Electric vehicles

The EV chain consists of companies with their main focus on development, manufacturing or marketing and sales of EVs. Viet Nam presents itself as a behind runner in the field of e-mobility, therefore, it is hard to find key companies that are dominant in the e-mobility industry. The most known in Viet Nam is VinFast, which has taken the lead in the transition towards electric mobility in recent years. Vinfast's production seems to create an OEM ecosystem surrounding itself. For example, an OEM lead by Peyong Haw Automobile Ltd. is committed to investing in Hai Phong and will produce parts for a number of car companies, such as BMW, Ford, Audi, GM, Hyundai, Kia and others. Other

involved firms are YMP Plus Co. Ltd, Dong Yang Vina Industry Co. Ltd., and MiChang Viet Nam Co. Ltd (Vietnam Investment Review, 2018).

In terms of manufacturing, Vinfast aims to dominate the electric motorbike market and gradually enter the market for electric buses and electric cars. In electric bus manufacturing, VinFast has signed two contracts on the supply of technology and spare parts with Siemens Viet Nam. The first line of electric buses is expected to debut in early 2021. With electric motorbike manufacturing, VinFast has accelerated electric MC market development since its first product, VinFast Klara, was marketed in November 2018 and about 30,000 VinFast electric MCs were sold in 2019. Prior to that, consumers were familiar with Pega or HKbike.

In the field of electric cars, through R&D, Vinfast is expected to redirect from conventional combustion engines towards electric engines in the period 2025-2030. VinFast diversified its product scope in an attempt to compete with both mid-high-level competitors (such as Mercedes-Benz, BMW, Audi, Lexus) and lower-lever competitors through their electric models. The company has bought technology and services from Germany's BMW, Italian design house Pininfarina, and supplier groups Bosch and Siemens.

Besides Vinfast, other automobile manufacturers have long been operating in Viet Nam. In 2017, Mitsubishi Motors Viet Nam gifted four electric cars to the Da Nang Department of Industry and Trade (DOIT) and one electric car to MOIT in Hanoi. Mitsubishi Motors Viet Nam is developing new charging stations in Da Nang and Hoi An (Quang Nam). In 2019, the Fuso trademark (Germany) introduced light trucks using electric motors to the international market, including Viet Nam.

In terms of marketing and sales, several companies operating as multi-brand dealers have provided different brands of EVs. One company that stands out is "Electric Car World", which sells about 500 electric four-wheelers annually (Pastoor, 2018).

- Charge infrastructure

In accordance with IEA (2018), there are three popular charger levels: (i) level 1 chargers up to 3.7 kW; (ii) level 2 chargers with 3.7-22 kW (slow chargers); and (iii) level 3 chargers of more than 22 kW (fast chargers). A basic 2-wheeler uses level 1 chargers, while 3-wheelers use level 2 units. Passenger cars use all levels of chargers with home-charging generally done at 3.7-7.4 kW and public charging at 11-22 KW. Small urban trucks typically use up to 50 kW chargers, but versions with higher charging options are also available. Buses have level 3 charging with "slow" chargers at 20-50 kW and fast chargers at up to 400 kW (Grütter & Kim, 2019).

Table 3.2. Vehicles and charging Systems

Vehicle	Charging system	Participation of stakeholders in Viet Nam
Two-wheelers	Battery swap	Selex, VinFast
	Slow overnight charging	Home-based or work-based facility
	Fast charging	VinFast
Three-wheelers	Battery swap	No
	Slow overnight charging	Depots of enterprises
	Fast charging	No
Passenger cars	Slow overnight charging	No
	Fast charging	A pilot programme of Mitsubishi and CPC
Trucks	Slow overnight charging	No
	Fast charging	No
	Opportunity charging including ultra-fast charging	No
	Overhead wiring (trolley bus)	No
Buses	Battery swap	No
	Slow overnight charging	No
	Fast charging	No
	Opportunity charging including ultra-fast charging	No
	Overhead wiring (trolley buses)	No

Developers of charging infrastructure solutions are rare in Viet Nam. Until now, there have only been a few pilot projects on installing charging infrastructure; for example, Mitsubishi Motors Viet Nam completed the installation of the first charging station for EVs in Hanoi and two fast-charging stations for Da Nang DOIT in 2017. At the same time, the Central Power Corporation (CPC) under the Vietnam Electricity Group (EVNCPC) put into operation a quick charging station in Da Nang. DHL is planning to create several fast charging points for private use.

In an attempt to advance the market for EVs, VinFast cooperated with Austria-based electrified transportation firm Kreisel Electric to develop a battery pack solution for electric cars and buses so VinFast can deliver a total package including EV, charging infrastructure, and services. Previously, VinFast also collaborated with the state-run company PVOil, one of the largest oil distributors in the

country, to develop 30,000-50,000 charging stations across Viet Nam by 2020. So far, however, only 200 charging stations at VinMart+ convenience stores have been put into operation.

- Electricity and grid

Electricity is mainly produced in Viet Nam by EVN, which contributes up to 58% of the national power generation sources. Furthermore, it holds a monopolistic responsibility for transmission, distribution and system operation. Petro Viet Nam (PVN) is the second largest power company owning 13% of production capacity. The remaining shares of generation capacity are held by other big SOEs; for example, Vinacomin (coal-fired power plants), foreign investors mostly using a "Build-Own-Transfer" (BOT) model, and other domestic investors using an independent power plant (IPP) model. Generated electricity from IPPs is sold to EVN under long-term contracts. Besides the field of power supply, EVN also plays an important role in the placement of charging infrastructure.

- Other organisations

Other than the above stakeholders, many other organisations are currently working with researchers and projects in electric mobility. They consist of civil society entities, academic institutes, the private sector and international donors.

- Civil society: The public entity or civil society relevant in the field of transport and climate change in Viet Nam are mostly NGOs. They play an important role in supporting and implementing e-mobility plans/policies at a practical level. They consist of Vietnamese non-governmental organisations and Climate Change (VNGO&CC), the Vietnam Clean Air Partnership (VCAP), the Viet Nam Automobiles Manufacturing Association (VAMA), and the Vietnam Auto Motorcycle Bicycle Association (VAMOBA).
- Academic entities: The key transport researchers in Viet Nam include transport-related universities and research institutes such as the University of Technology (Hanoi, Da Nang, HCMC), and the University of Transport (Hanoi, HCMC), TDSI, NIEM, etc.
- The private sector: At the practical level, the private sector is a key to success in putting policies/plans into practice.
- International donors and international development agencies: International support/cooperation is vital to the development of sustainable transport. Various donors offer financial and technical support to Viet Nam to tackle the crucial problems in the transport sector and implement sustainable transport projects/programmes. They include GIZ, KfW, JICA, AusAID, World Bank, and ADB.

3.3. Overview of the e-mobility market in Viet Nam

In the context of fossil fuel depletion and significant environmental pollution related to the transport sector, EVs are rapidly emerging and offer a promising solution for alleviating the health and environmental burdens caused by the transport sector in what is called a "clean disruption". EVs are

not completely emissions-free, but they have much lower CO_2 emissions than ICE vehicles. In fact, EVs have a clear potential to lower CO_2 emissions close to zero when they run on solar and wind energy. EVs are gaining momentum in light of recent announcements by many countries on banning ICE car sales in the near future. Norway has decided to ban sales of ICE cars by 2025. More recently, the UK Government made an official announcement of a ban on sales of ICE cars after 2030. California has also decided to ban ICE cars starting in 2035, and other states in the US are considering following California's lead (Greenpeace, n.d.).

Classification of EVs

For e-mobility, there are three main types of EVs classed by the degree that electricity is used as their energy source (see Figure 3.2).

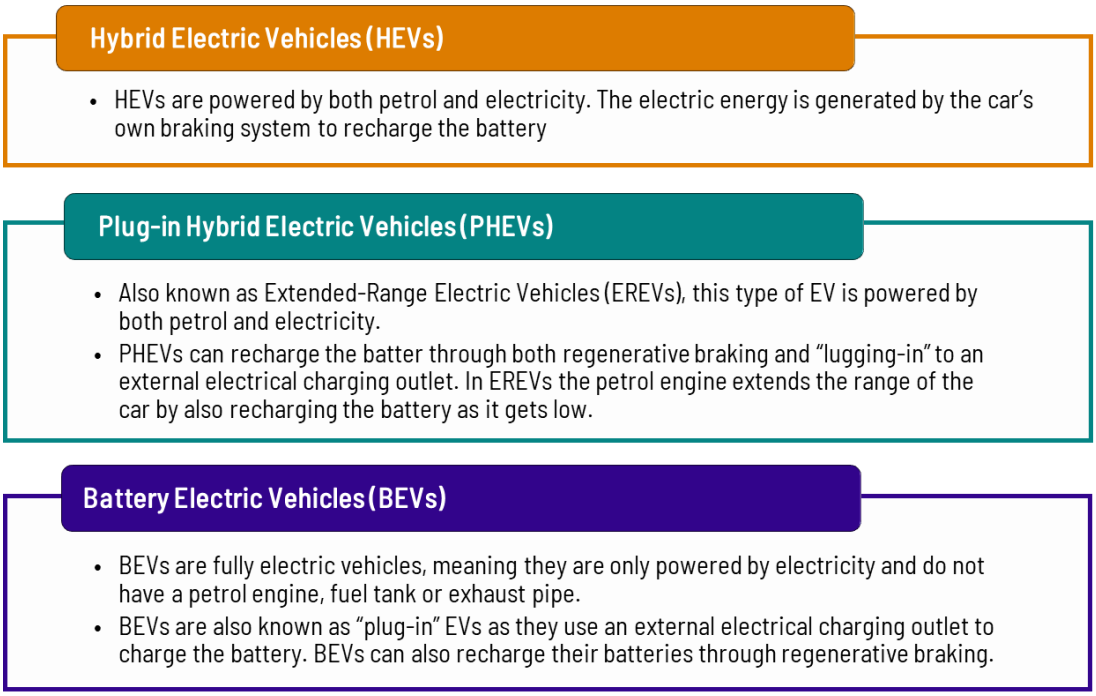


Figure 3.2. Overview of EV types

Market overview

The EV market in Viet Nam is barely in its infancy (Fogel, n.d.). In Viet Nam, the current number of electric three-/four-wheelers operating is negligible. According to the MOT, as of 2014, there were 621 electric cars operating in four cities in Viet Nam: Hanoi, Ha Long, Da Nang and Hue. By the end of 2015, the total number of electric cars was over 1,086 vehicles. These electric cars are primarily low-speed three-/four-wheelers imported from China for transporting visitors within hotel compounds, resorts, golf courses, and tourist cities. In 2017, one of Viet Nam's leading EV distributors "Electric Car World" sold only 500 cars, mostly to the tourism industry (Pastoor, 2018).

Currently, other than the announcement from two local companies belonging to Vingroup (Vinfast and Vinbus) on producing electric cars and electric buses, there has been no information about other EV production plans in Viet Nam. In late 2019, Vingroup announced that it will bring to the market four more models of e-2-wheelers, one model of electric buses and 2 models of electric cars, and will start to export EVs to the US market from 2021. Vingroup has also set up R&D centres on EVs and battery and digital technologies for e-mobility, such as connected and autonomous vehicles. It has also announced it will stop using lead-acid batteries for its e-bikes and will only use Li-ion batteries.

Compared to 4-wheeler electric cars, E2Ws (motorbikes, scooters) have been widely used and some have been produced locally in Viet Nam. According to the Viet Nam Association of Motorcycle Manufacturers (VAMM), nearly 500,000 E2Ws were sold in 2018, a 30% increase compared to 2017. Most E2Ws are imported from China, Japan, and Korea. Others are manufactured by domestic enterprises such as Vinfast. In late 2018, Vinfast supplied the local market with its first e-motorbike model, Klara, with two battery options (lithium-ion and lead). In 2019, it introduced Klara A2 with a battery swapping option offered by its widespread VinMart+ outlets in many cities. By the end of 2019, VinFast's E2Ws sales reached 50,000 units with the average price of only about VND 12.5 million (USD 545).

At a cost of only 50% of a gasoline motorcycle, e-motorbikes such as the VinFast Klara may become the most effective products for investment. Since 2020, to make it easier for customers to use as well as to increase its presence in the market, VinFast announced the provision of additional battery chargers for its e-models at a cost of VND1.1 million (USD 48). For the latest generation of E2Ws, each month customers pay VinFast a battery rental fee of VND 220,000 for one battery, or VND 350,000 for two batteries. As a result, the cost of the original vehicle is reduced, and the customer does not bear the risk during use. If the battery is damaged, VinFast will be held responsible for replacing it (Nguyen, 2020). In addition, VinFast is also committed to producing 500,000 cars and one million e-scooters annually by 2025 (The ASEAN Post Team, 2018).

The involvement of Vinfast as a local enterprise strongly supports the expansion of the EV market in Viet Nam, especially for E2Ws. The growth in sales and fleet of electric 2-wheelers in Viet Nam in comparison with other countries according to the Electric Vehicle Outlook 2020 by BloombergNEF is demonstrated in Figure 3.3.

As can be seen in Figure 3.3, there has not been any sudden increase in E2W sales and fleet in Viet Nam during the period 2010-2019. However, with the current inevitable trend for using EVs and the Vietnamese Government's efforts to promote low-carbon transport development, the EV market in Viet Nam is projected to reach 26,951,318 units by 2030, a significant increase from the estimated 3,269,671 units in 2019 (Marketsandmarkets, 2021).

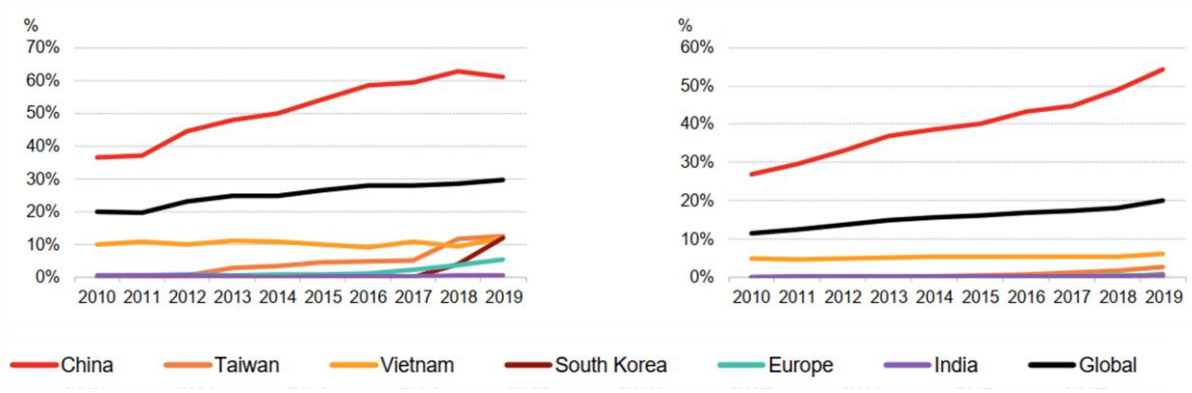


Figure 3.3. Electric two-wheeler sales and fleet in the period of 2010-2019

(a) – Electric two-wheeler sales share by country; (b) - Electric two-wheeler fleet share by country

The EV outlook for Viet Nam and other south-east Asian countries in relation to the world is shown in Table 3.3. Viet Nam is a potential market for e-mobility development in the coming years as the EV market share in Viet Nam is always higher than any other south-east Asian country. This share is only 10 to 33 percentage points lower than the global rate.

Table 3.3. The EV outlook for Viet Nam and other south-east Asian countries

Region/segment	EV market share in 2025				EV market share in 2030				EV market share in 2040			
	2Ws	*Passenger vehicles*	*Commercial vehicles*	*Bus*	*2Ws*	*Passenger vehicles*	*Commercial vehicles*	*Bus*	*2Ws*	*Passenger vehicles*	*Commercial vehicles*	*Buses*
Global	32%	13%	LCV: 8% MCV: 2% HCV: 1%	61%	43%	31%	LCV: 17% MCV: 6% HCV: 4%	70%	77%	58%	LCV: 30% MCV: 19% HCV: 10%	77%
Indonesia	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Similar	Much lower	Lower	Lower
Thailand	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Lower	Lower	Similar	Lower	Similar	Similar
Malaysia	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Lower	Similar	Lower	Lower	Similar
Philippines	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Much lower	Similar	Much lower	Lower	Lower
Viet Nam	Lower	Much lower	Much lower	Much lower	Lower	Much lower	Lower	Lower	Higher	Lower	Similar	Similar

Legend			
Higher	More than 10 pp higher relative to global rate	Similar	Within ± 10 pp of the global rate
Lower	Within -10 to -33 pp of the global rate	Much lower	More than 33 pp lower than the global rate

(Source: BloombergNEF)

3.4. Technology and infrastructure

3.4.1. Charging infrastructure

A robust EV-charging infrastructure is critically needed to enable the rapid growth of EVs. EVs can be charged at home, at work, or at public charging points. The charging infrastructure (or EV supply equipment – EVSE) depends on the inter-relationships between vehicle stock, driving needs, charging equipment usage and technical capabilities (e.g. rated power and connectivity protocols). The diversity of EV types (e.g. two/three-wheelers; passenger light-duty vehicles – PLDVs; light-commercial vehicles – LCVs) and their activity profiles (e.g. commuting, urban logistics, road freight, public transit) are the main determinants of EV charging patterns as presented below:

- *For electric LDVs:* region-specific factors such as population density, charging behaviour and driving range have direct implications on the geographical location of the EVSE and on charging rates.
- *For electric buses (e-buses):* having higher energy consumption per kilometre driven and driving longer daily mileages than LDVs, e-buses are equipped with larger batteries. To recharge them within a reasonable time frame, fast (≥ 50 kW) charging is common practice for e-buses. Yet, there is quite a degree of variation in the daily mission profile of buses (depending on region-specific ridership trends, occupancy factors and degree of urbanisation), with consequential impacts on the supporting EVSE infrastructure (International Energy Agency, 2020).
  - For electric buses covering relatively short distances (less than 150 km/day), a typical 50 kW fast charger can fully charge a 110 kilowatt-hour (kWh) e-bus in about two hours at a depot.
  - In large cities with higher ridership, service frequency and daily mileage, there is a stronger case for short-duration opportunity charging (e.g. at destinations and depots) at higher power rates.
- *For electric trucks (e-trucks):* deploying charging infrastructure poses a unique challenge due to their high power and energy requirements, especially for long-haul trucks. To fully charge a commercial 550 kWh battery capacity equipped long haul truck would require as much energy as the average daily energy consumption of 55 households in the European Union. In order for an e-truck to recharge in a reasonable amount of time, ultra-fast charging is being developed, reaching power rates of more than 500 kW up to a few megawatts (MW). This means an additional dimension to EVSE deployment challenges and their impacts on electricity networks, particularly at the distribution level (International Energy Agency, 2020).
- *For E2Ws:* equipped with small-sized batteries, these are easy to charge.

Nowadays, many countries have included a mandatory requirement for EV charging points in their building codes. In Viet Nam, there is no EVSE production and installation, except for some EV charging stations used for testing purposes. The Viet Nam Industry Agency has installed one EV charging station as part of a joint project with Mitsubishi to test Mitsubishi's EVs in Viet Nam. The Central Power

Company of EVN has designed, produced, and installed 2 charging stations powered by a tracking garage rooftop PV panel as part of a research and development programme with two Mitsubishi i-MiEVs. Several renowned international EVSE manufacturing companies, such as ABB, Siemens, and Bosch have expressed their support for e-mobility development in Viet Nam.

Since 2019, many buildings in big cities, especially in Hanoi, Ho Chi Minh City, and Da Nang have charging points for e-bikes. In 2019, the LOTUS NC V3 of the Viet Nam Green Building Council was adopted, introducing EV charging points as a criterion for obtaining a green building certificate. Vinfast and PV Oil have recently agreed to add charging points to 50 PV Oil fuel stations, which is a signal of this transition.

3.4.2. The existing state of the grid

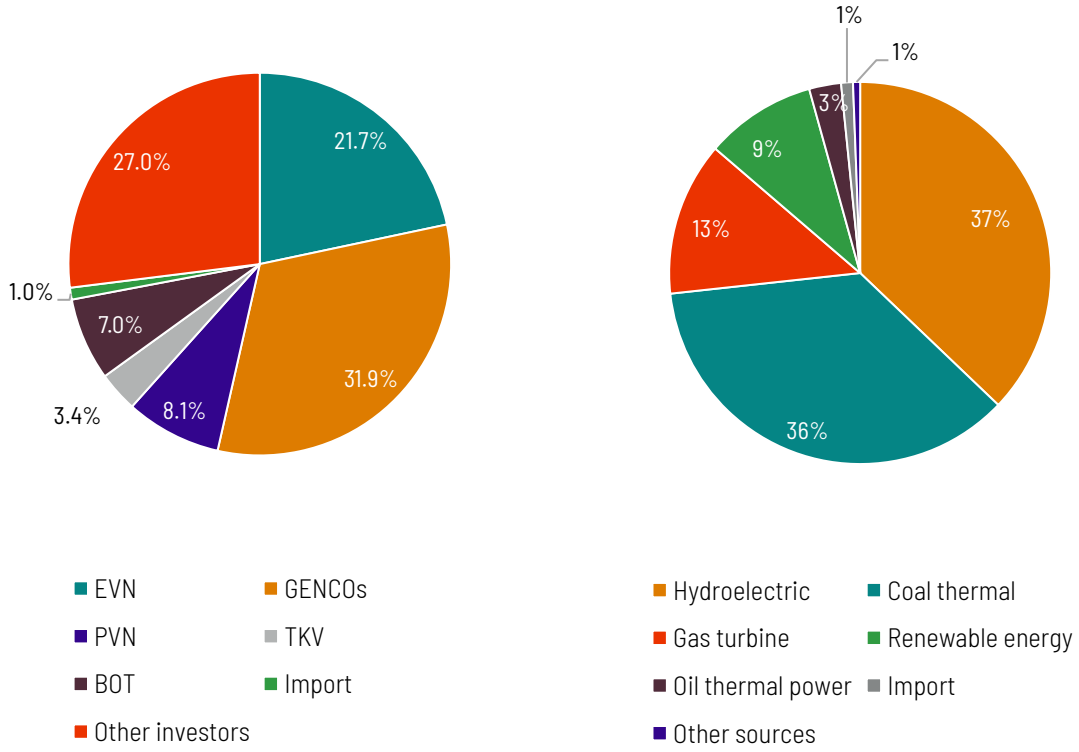
As the EV market grows stronger and more powerful, the requirements on the quantity and capacity of charging stations will increase sharply. The power sources from these charging stations will mainly come from the national grid. Therefore, in the EV research and development roadmap, the infrastructure's ability to accommodate EV development, in particular the current state of power sources, power grids and power system expansion plans in Viet Nam, should be studied thoroughly.

Power sources

By the end of 2019, the total installed power source capacity of the whole system reached 54,880MW, an increase of 13% (6,320MW) compared to 2018. The scale of Viet Nam's electricity system ranked second in ASEAN (after Indonesia) and 23rd in the world.

The produced and imported electricity of the whole power system reached 240 billion kWh, increasing 2.35 times compared to 2010 (101.4 billion kWh). The national commercial electricity output in 2019 reached 209.77 billion kWh, an increase of 2.46 times compared to 2010 (85.4 billion kWh), corresponding to average commercial electricity growth in 2011-2019 of 10.5%/year (an increase by 10.97%/year in 2011-2015 and by 9.49%/year in 2016-2019). The largest load capacity of the whole system (P_{max}) in 2019 was 38,249 MW. The average commercial electricity output per capita increased by 2.2 times, from 982 kWh/person (2010) to 2,180 kWh/person (2019).

The transmission grid system has received a large amount of investment, basically meeting the requirements of connection, releasing capacity of power source projects and enhancing the transmission capacity of the whole power system. The power backup rate was 43% in 2019, and the power system in 2019 ensured power supply for load needs.



a) According to the owner

(GENCO - Power Generation Joint Stock Corporation; EVN - Vietnam Electricity Group; PVN - Vietnam Oil and Gas Group; TKV - Vietnam National Coal and Mineral Industries Group)

b) According to the type of power source

Figure 3.4. Power capacity structure of the whole system by the end of 2019

(Source: Le et al., 2020)

Regarding renewable energy: by the end of 2019, the capacity of renewable energy sources on the power system reached 5200 MW including 4823 MW of solar power and 377 MW of wind power. The total capacity of renewable energy sources accounts for about 9.4% of the system's total power capacity. Before 2019, there were no solar power plants connected to the 110kV grid and above. However, in the first 6 months of 2019, 89 solar power plants with a total capacity of 4550 MW were connected to the national grid.

A summary of the current status of power sources through statistics on installed capacity of power plants, as well as a development plan for power capacity are provided in Appendix 4.

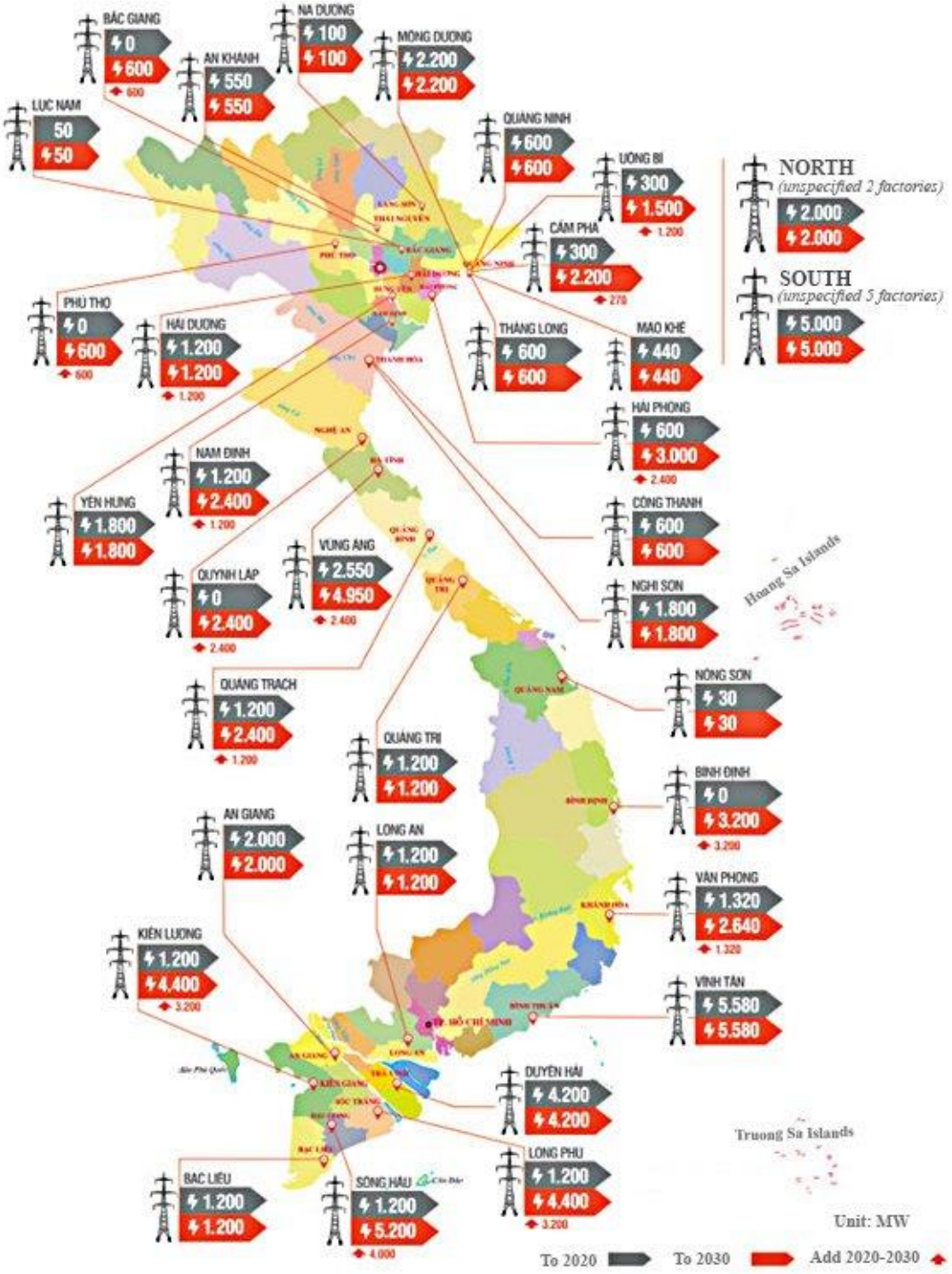


Figure 3.5. Power source development plan for the period 2020-2030 *(Unit: MW)*

(Source: Produced from data of Institute of Energy, 2021)

Power grid

By the end of 2019, the total length of 500 kV lines was 8,496 km, an increase of 2.2 times compared to 2010; the length of 220-110 kV lines increased from 23,156 km to 43,174 km (an increase of 1.9 times). The capacity of transmission substations also increased by about 2.8 times compared to 2010.

The 500kV power grid is the backbone of the Vietnamese electricity system with a length of more than 1500 km running from the north to the south. This system plays a very important role in the national energy balance and affects power supply reliability of each region. In 2019, the total electricity output transmitted from the north through the central to the south reached nearly 11 billion kWh, accounting for nearly 10% of the south's demand.

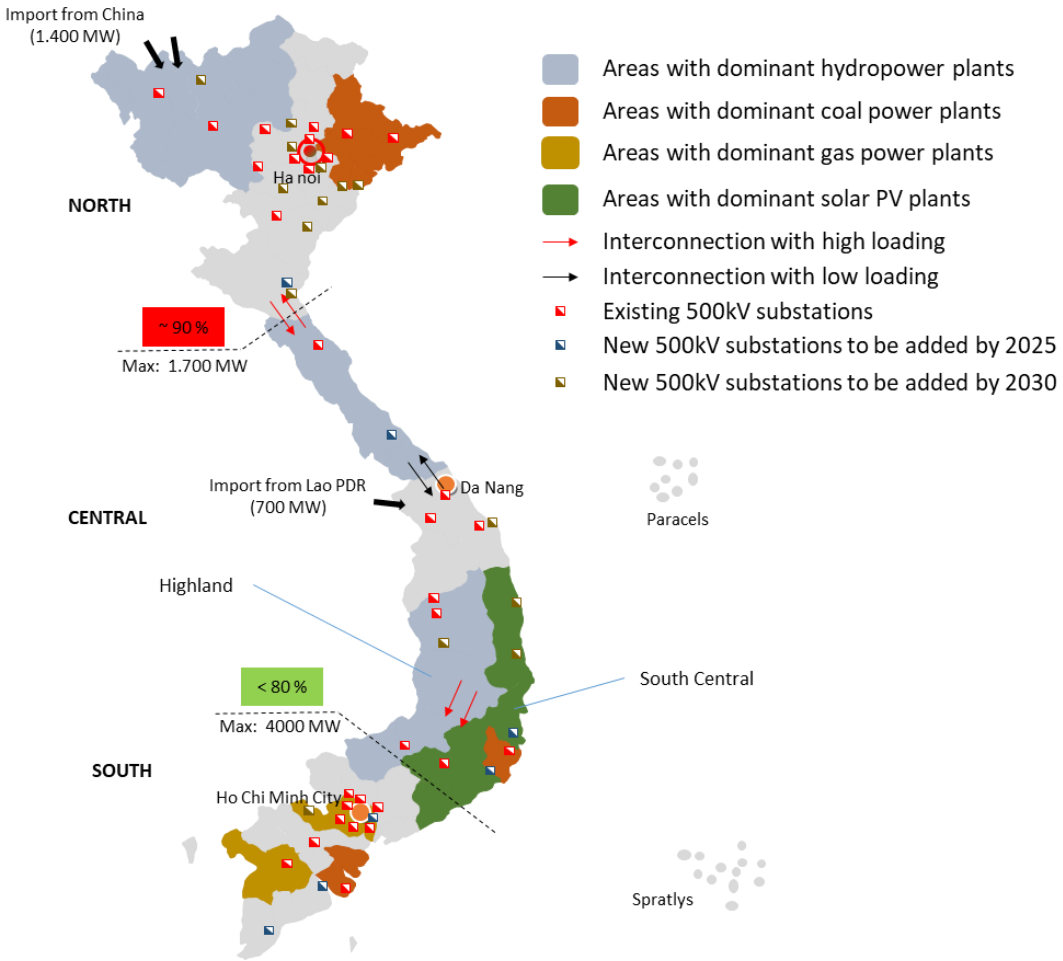


Figure 3.6. Transmission among regions

(Source: Le et al., 2020)

- *Northern region*

In the Northern mountainous area, there are 500kV stations at Lai Chau and Son La, which are in charge of collecting hydroelectricity capacity and transmitting it to the Northern load centre. From

2021 to 2025, the regional transmission grid will continue to be built, notably with the 500kV Lao Cai station and the 500kV Lao Cai - Vinh Yen transmission line.

The load centre of Hanoi is currently being supplied with electricity from four 500/220kV transformer stations (Hiep Hoa, Dong Anh, Pho Noi, Thuong Tin) and Hoa Binh hydropower. In the 2021-2025 period, the 500kV transmission line Thuong Tin - West Hanoi - Vinh Yen will be completed. It will create a 500kV loop circuit supplying electricity around Hanoi. Newly built substations supplying electricity to the area will be connected to this circuit, such as the 500kV Long Bien, West Hanoi, Thai Nguyen, Vinh Yen, Bac Ninh, Son Tay, Dan Phuong, South Hanoi. Bac Giang, and Bac Ninh-2 transformer stations. To supply electricity for the above-mentioned loop, 500kV lines will be built connecting sources such as: Moc Chau hydropower plant - West Hanoi, Lao Cai - Vinh Yen, Bac Giang - Bac Ninh, Nho Quan - Hung Yen Long Bien, Thai Binh - South Hanoi, and Gas turbine plant Thai Binh - Hung Yen.

In the Northeast region, there is only the 500kV Quang Ninh station, in Ha Long city. In the 2021-2030 period, 500/220kV sub-stations in Hai Phong and Gia Loc will be built. After 2030, new 500/220kV stations will be built in Hai Phong 2 and Quang Ninh 2. In the area with many thermal power sources, excess capacity is currently being transmitted mainly through two 500kV dual-circuit lines of Quang Ninh - Hiep Hoa and Quang Ninh - Pho Noi.

In the south of Hanoi, the 500kV Nho Quan station supplies electricity to the area. It is expected that new 500/220kV transformer stations will be built in Nam Dinh and Thai Binh, as well as 500kV transmission lines Thanh Hoa - Nam Dinh - Thai Binh - Pho Noi in the period 2021-2025.

- *North-Central Region*

The North-Central region receives electricity from the 500kV Vung Ang station and the 500kV Ha Tinh station. New 500/220kV stations in Nghi Son, Thanh Hoa, Nghi Loc (Nghe An) are planned to be built from 2021 to 2030.

- *Central Highlands region*

The Central Highlands region currently has 3 substations: 500kV Pleiku, Pleiku 2, and Dak Nong that supply power to the regional load and collect the capacity of local power sources and hydroelectricity from Lao. In the 2021-2025 period, a new Krong Buk 500/220kV transformer station and 500kV transmission line Dung Quat - Krong Buk - Tay Ninh will be built to increase transmission capacity in the Central Highlands.

- *South-Central Region*

The regional grid currently has the 500kV Di Linh hydropower station, the 500kV Vinh Tan station and 4 circuit lines of 500kV Vinh Tan to Song May and Tan Uyen, the 500kV Thuan Nam station and the 500kV line Thuan Nam - Vinh Tan. In the coming period, the provinces of Binh Dinh, Phu Yen, Khanh Hoa will build new stations – 500/220kV Binh Dinh, Van Phong (Khanh Hoa) – for the period 2021-2030, and stations at Tuy Hoa (Phu Yen) and Dien Khanh (Khanh Hoa) after 2030. These power stations are responsible for gathering renewable energy sources and also serving as the power supply for regional loads.

- *Central-Central region*

The Central-Central region receives electricity from 500kV substations in Da Nang, Thanh My and Doc Soi. New 500/220kV power stations, including at Quang Tri, are planned to be built in the period of 2021-2030 and Phu Loc (Hue), Hoa Lien (Da Nang), Duy Xuyen (Quang Nam) stations are planned to be built after 2030. In the 2021-2025 period, the 500/220kV Huong Hoa station will be built to gather wind power sources in the Quang Tri area and from Lao hydroelectric plants.

- *Southern region*

The area around Ho Chi Minh City now has a relatively complete power transmission grid with 500 kV circuits surrounding the city with 9 existing 500/220kV stations (Cau Bong, Tan Dinh, Tan Uyen, Song May, Phu My, Nha Be, Phu Lam, Duc Hoa, and Chon Thanh).

The South-western region is currently powered by the 500kV O Mon and My Tho stations. Two 500kV stations connecting the Long Phu and Duyen Hai power sources have been put into operation, along with the 500kV Long Phu - O Mon - My Tho, Duyen Hai - My Tho, My Tho - Phu Lam, and My Tho - Nha Be lines. The 500kV electricity grid in the South-western region will be developed on a large scale, largely to relieve the regional power capacity for Ho Chi Minh City.

A summary of the existing state of the grid in selected cities/provinces is presented in Table 3.4.

Table 3.4. Summary of the existing state of the grid in selected cities/provinces

Cities /provinces	Load demand P_{max} (MW)	Power transformer stations - PTS (MVA)	Power distribution lines (km)		Thermal (MW)	Hydro-electric (MW)	Total installed capacity (MW)
			110kV	*<110kV*			
Hanoi	4287	03 PTS 500kV (5100 MVA) 13 PTS 220 kV (6750 MVA) 56 PTS 110 kV (6898 MVA)	841,9	31951	-	-	-
Quang Ninh	1165	01 PTS 500kV (900MVA) 06 PTS 220kV (1375 MVA)	836	4452	5274	-	5274

Cities /provinces	Load demand P_{max} (MW)	Power transformer stations - PTS (MVA)	Power distribution lines (km)		Thermal (MW)	Hydro-electric (MW)	Total installed capacity (MW)
			110kV	*<110kV*			
Ha Long	305	01 PTS 500kV (900MVA) 01 PTS 220kV (250 MVA) 09 PTS 110kV (485 MVA)	n/a	375	1200	-	1200
Đa Nang	474	01 PTS 500 kV (1400 MVA) 02 PTS 220 kV (625 MVA) 10 PTS 110 kV (890 MVA)	180,86	917,54 (22kV)	-	-	-
Hue	274	02 PTS 220kV (500 MVA) 12 PTS 110kV (523 MVA)	417,59	1743,17 (22kV); 163,02 (35kV)	-	420,7	420,7
Nha Trang	363	02 PTS 220kV (1000 MVA) 14 PTS 110kV (785 MVA)	286,33	286,33 (110kV); 2164,2 (22kV); 85,95 (35kV)	90	42	132

Power quality and reliability of power supply

From 2015 to now, in general, the reliability of the electrical system and the quality of voltage have been improved significantly. For example, with the 500kV power system, the availability of the electricity system increased from 98.5% in 2015 to 99.3% in 2019. In terms of voltage quality, the voltage deviation value was 8.41 in 2015, and decreased to only 0.024 in 2019.

The reliability of the power supply continuously improved from 2016 to 2019. In 2016, the System Average Interruption Duration Index – SAIDI – was 1641 minutes; by 2019, this indicator was only about 648 minutes (a decrease of more than 2.5 times). Power loss decreased from 10.15% in 2010 to 6.5% in 2019.

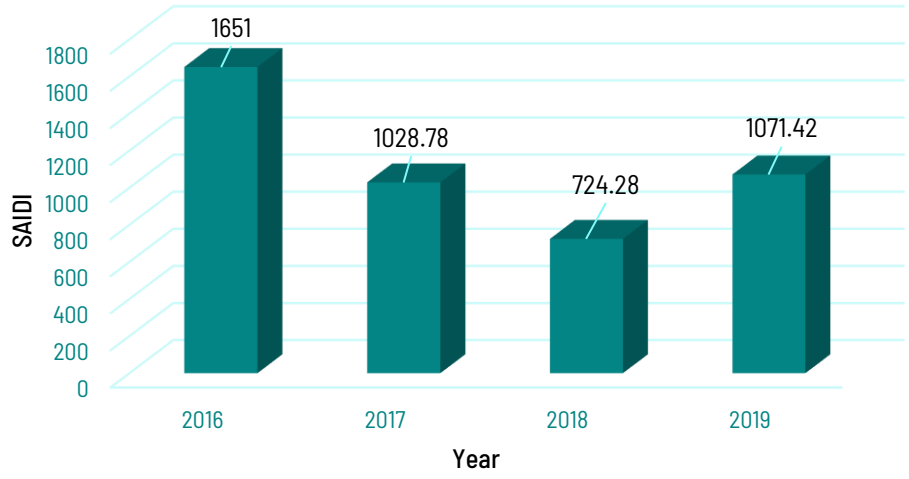


Figure 3.7. System average interruption duration index – SAIDI

(Source: Institute of Energy, 2021)

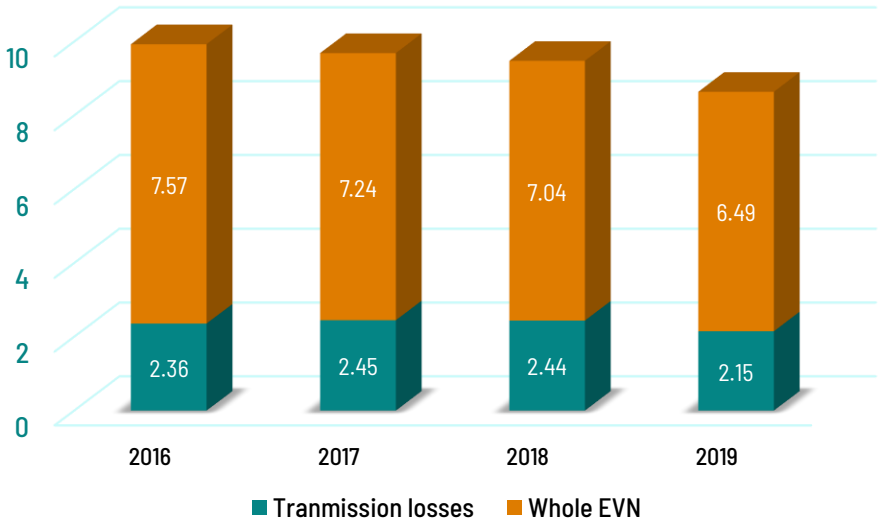


Figure 3.8. Electricity losses on the whole system

(Source: Institute of Energy, 2021)

Characteristics of electricity demand in Viet Nam

Electricity sold by type of customer at different tariffs 2016 (158 TWh).

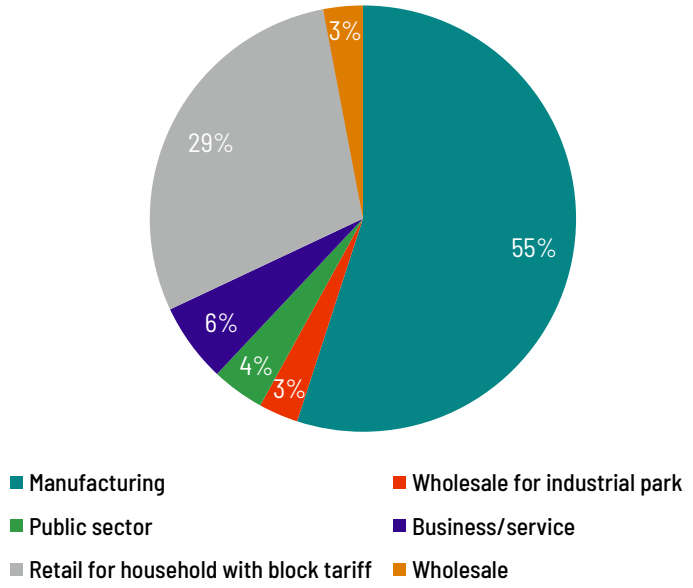


Figure 3.9. Characteristics of electricity demand in Viet Nam

(Source: Le et al., 2020)

The production load accounted for the largest proportion of the electricity system's demand (55%), while domestic load with the retail tariff was second largest (29%). The share of wholesale electricity accounted for only a small percentage (3%).

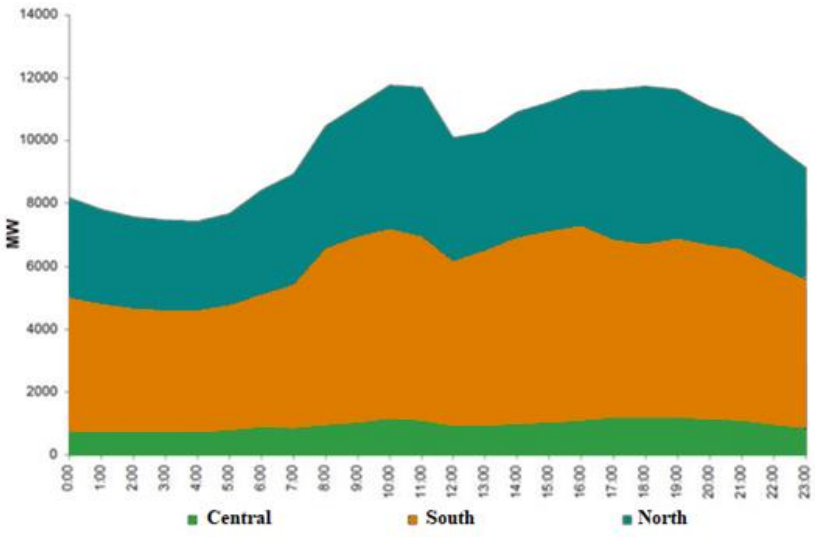


Figure 3.10. Typical daily load of the 3 regions in 2009

(Source: Institute of Energy, 2016)

The load graph of the whole power system has two peaks, which are in the morning from 10:00 to 11:00 and in the evening from 18:00 to 19:00 (see Figure 3.10). The demand for electricity in Viet Nam is very high. The total electricity demand increased by 10-11% per annum in the last decade.

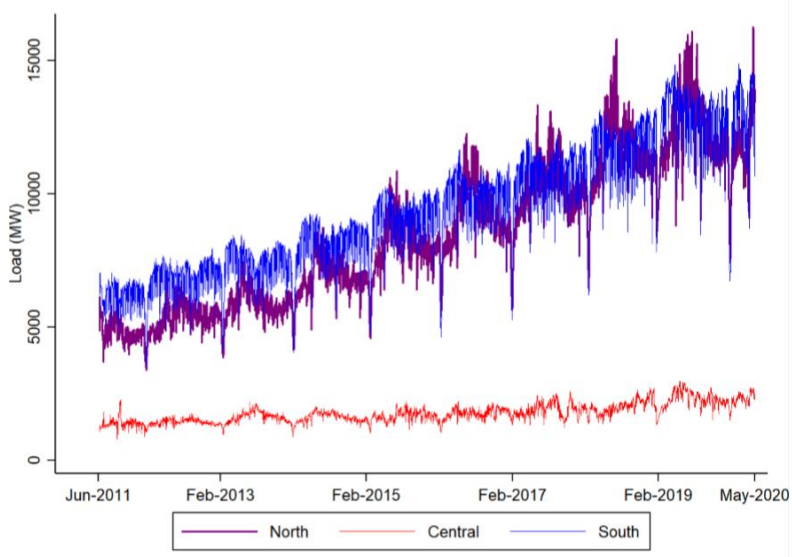


Figure 3.11. Electricity load profile in Viet Nam

(Source: Le et al., 2020)

Electricity price

Viet Nam's electricity retail price has decreased over time and is among the lowest in ASEAN.

Table 33.5.3.6. Average electricity tariffs *(US cent/kWh)*

	Viet Nam	Indonesia	Malaysia	Thailand	Singapore	Philippines
Residential	**10.59**	11.00	10.00	12.41	19.97	18.67
Business - medium	**13.44**	11.00	13.58	11.00	14.30	12.23
Business – large	**12.36**	8.36	9.60	11.00	14.02	11.98
Industrial - medium	**7.81**	8.36	8.29	8.36	13.05	11.69
Industrial - large	**7.41**	7.47	7.76	8.36	12.72	11.63

(Source: Le et al., 2020)

Table 3.6. Tariffs for businesses

	Day duration	Electricity sold for manufacturing in kWh (2015)	Share (%)	Average price in 2019 (VND/kWh)
Retail	Normal hours	53,452,787,808	62	1596.75
	Off-peak hours	18,572,700,748	22	1030.25
	Peak hours	14,066,267,294	16	2917,5
	Total	**86,091,755,850**	**100**	
Wholesale for industry parks	Normal hours	2,852,198,411	58	1486.5
	Off-peak hours	1,097,065,750	22	941.25
	Peak hours	948,796,461	19	2720.25
	Total	**4,898,060,622**	**100**	
Services	Normal hours	6,788,683,235	69	2579
	Off-peak hours	1,249,841,935	13	1510
	Peak hours	1,819,597,506	18	4413
	Total	**9,858,122,676**	**100**	

(Source: Le et al., 2020)

Table 3.7. Tariffs for residential users

	Monthly avg. electricity sold (kWh)	Share (%)	No. of households	Share (%)	Price for each block in 2019
Total	**4,649,850,034**	**100**	**25,890,449**	**100**	
From 0 to 5 kWh	102,513,451	2	3,912,610	15	1678
From 51 to 100 kWh	408,707,245	9	5,317,811	21	1734
From 101 to 200 kWh	1,381,170,884	30	9,548,396	15	2014
From 201 to 300 kWh	909,226,110	20	3,748,858	14	2536
From 301 to 400 kWh	524,599,707	11	1,523,317	6	2834
From 401 kWh and above	1,323,632,637	28	1,839,457	7	2927

(Source: Le et al., 2020)

The industrial electricity price is lower than the domestic consumption price, which reflects the government's view on promoting the development of the manufacturing industry through low energy prices. Much higher prices are applied for retail and services.

Moreover, in order to contribute to levelling the load graph, there are always subsidies between peak and off-peak users, as well as between subsistence users (consuming less than 100kWh/month) and large residential users.

Forecasts on load demand and the Viet Nam power system's ability to meet demand

In 2019, national energy production was 240 billion kWh. The maximum national capacity of P_{max} in 2019 was 38.2GW. Statistics and forecasts of energy production and peak loads in the period 2015-2030 are presented in Figure 3.12.

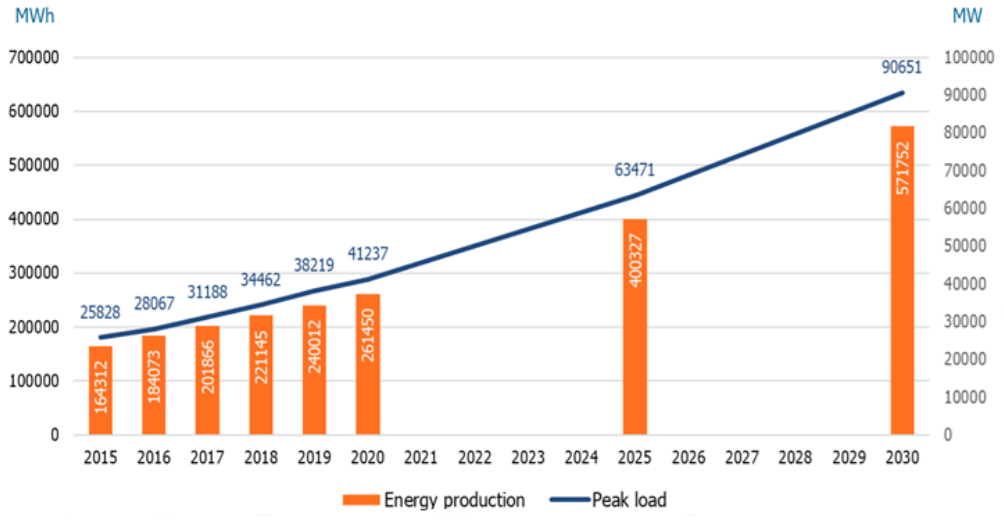


Figure 3.12. Energy production (MWh) and peak load (MW) in 2015-2030

We remark that the average growth rate of energy production was 10.07% in the period 2016-2020. The average growth rate forecast for the period 2021-2025 is 8.57% and for the period 2026-2030 7.39%.

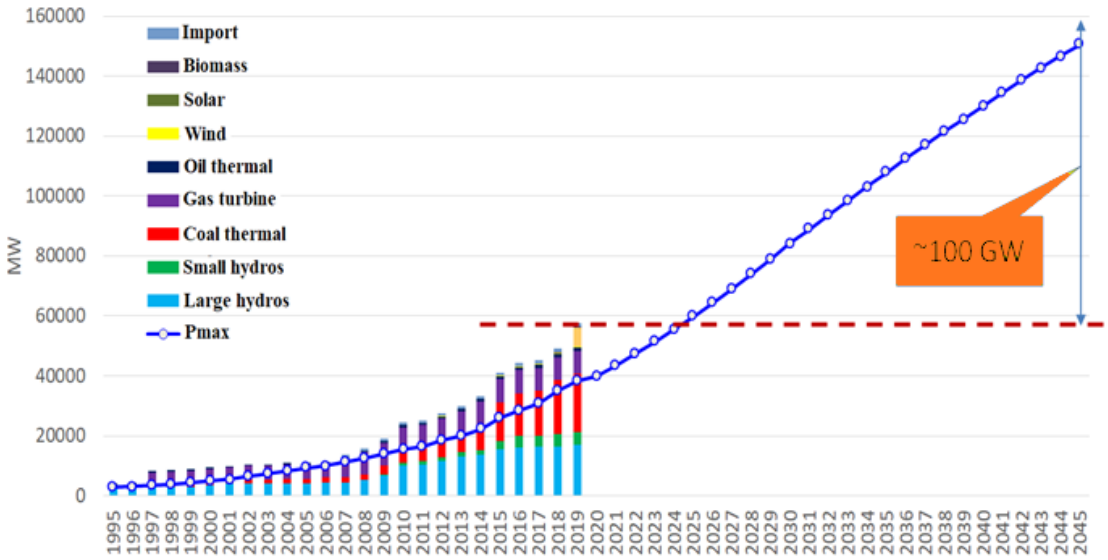


Figure 3.13. Total installed capacity (MW) and peak load (MW)

Forecast calculations for the coming years is presented in Table 3..

Table 3.8Forecast for total installed capacity and peak load

Parameters	Year					
	2020	*2025*	*2030*	*2035*	*2040*	*2045*
Total installed capacity (GW)	59,1	103.2	138.1	181.6	222.9	272.3
Pmax (GW)	39.89	59.7	84.2	107.9	130.1	150.5

Parameters	Year					
	2020	*2025*	*2030*	*2035*	*2040*	*2045*
Back-up capacity (GW)	19.21	43.5	53.9	73.7	92.8	121.8
Back-up capacity (%)	32.50	42.15	39.03	40.58	41.63	44.73

Summary:

Viet Nam is in a period of development and power load remains high in the long term. National peak load growth averaged over 10.7%/year in the past 10 years.

Viet Nam's electricity system is increasingly diversified, using different types of power sources. The average power capacity growth over the past 10 years is 11.7%/year.

Viet Nam has great potential for developing renewable energy for electricity generation (up to 855GW). Renewable energy will play an increasingly important role in the structure of national power sources (expected to account for 40.3% by 2045).

3.4.3. Management of waste EV batteries

Developing an effective waste management strategy for EV batteries is crucial as they rely on a shortlist of finite critical materials with few substitutes. Batteries are often discussed in the framework of the waste hierarchy: reducing first, followed by reusing, recycling, recovering energy, and treatment and disposal. Also known as a cascading approach, this is a guiding philosophy used by policymakers for the sustainable management of many types of solid waste (International Energy Agency, 2020).

A good electric car battery has a lifespan of about 5 years (Da, 2016), but the durability of an e-bicycle battery is relatively short, only about 2 to 2.5 years (according to the survey results). In fact, most e-bikes and e-motorbikes in Viet Nam use lead batteries (85.9%) (see Figure 3.14), in which the lead (PB) content accounts for about 70% of the weight of the battery. For most modern electric vehicles, batteries are lithium-based and rely on a mix of cobalt, manganese, nickel, graphite and other primary components. Both lithium-ion and lead batteries belong to the list of hazardous waste according to Vietnamese regulations, which are in harmony with the Basel Accord (see Table 3.9). Therefore, waste batteries from EVs must be recognised as hazardous waste and must be managed according to a particularly special process. If waste batteries are not recalled and treated suitably, a large amount of heavy metal will cause serious environmental pollution and negatively impact human health.

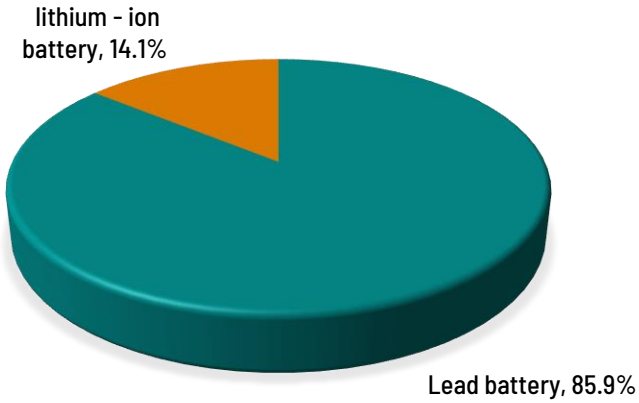


Figure 3.14. EV ratio according to battery type

(Source: Consultant team, 2020)

Table 3.9 List of hazardous waste relating to batteries and accumulators in Viet Nam

Vietnamese HW code	HW type	Threshold of HW
19 06 01	Lead batteries	**
19 06 02	Ni-Cd batteries	**
19 06 03	Batteries and accumulators contain mercury	**
19 06 04	Electrolyte from batteries and accumulators	**
19 06 05	Other batteries and accumulators	**

(Source: Circular No. 36/2015/TT-BTNMT "Hazardous waste management")

Note: (**) denotes always identified as HW in all cases, no threshold required.

In Viet Nam, waste batteries are managed as hazardous waste (HW) according to Decree No. 38/2015/ND-CP dated 24 April 2015 on "Management of waste and discarded materials" and Circular No. 36/2015/TT-BTNMT dated 30 June 2015 on "Management of hazardous wastes". In addition, the recall and disposal of discarded products needs to comply with regulation No. 16/2015/QD-TTg dated 22 May 2015 on "Providing regulations on recall and treatment of discarded products" and Circular No. 34 /2017/TT-BTNMT dated 4 October 2017 on "Recall and treatment of discarded products". The map of stakeholders in HW management according to the law in Viet Nam is summarised in Figure 3.15.

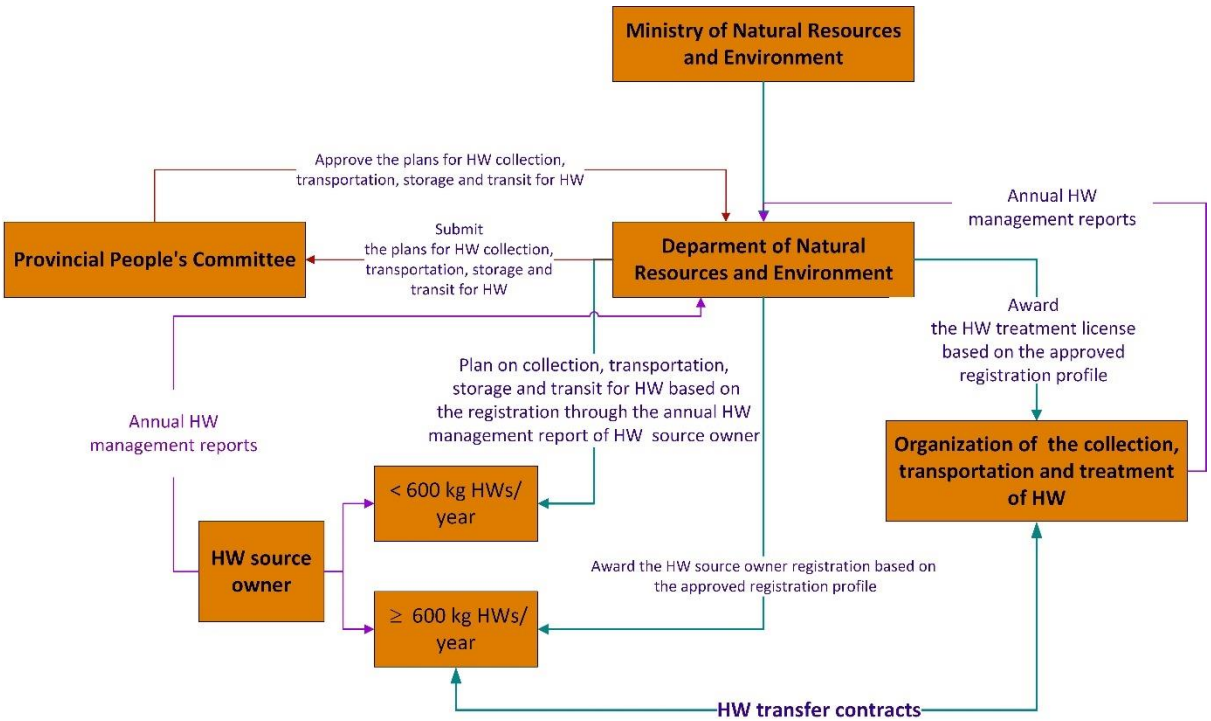


Figure 3.15. Map of stakeholders in HW management in Viet Nam

According to Vietnamese legislation, all industrial facilities are required to enter into an agreement with a service provider regarding the collection, transport and treatment/disposal of HW generated by industrial facilities. HW must at the minimum be collected every six months. In fact, the enforcement of these regulations is still very weak in Viet Nam. Most industrial facilities that manufacture, import and distribute batteries have no battery-recall stations, and even if they do, those stations do not comply with the regulations in Viet Nam {Le,T., & Anh,L. 2019}.

Currently, following the leading brands in the world such as Tesla and Gogoro, VinFast is the first car company in Viet Nam implementing the policy of renting and exchanging electric motorcycle batteries. This solution can help manage batteries effectively, avoid indiscriminate battery disposal that harms the environment, and bring greater benefits to customers.

3.5. Summary

On the basis of the analysis presented above, it can be concluded that Viet Nam can be considered as a region with little activity in the EV sector. The stakeholder mapping provides an overview of the EV activities that are currently underway and shows what is still lacking in Viet Nam. At present, Viet Nam has an electric motorcycle segment with a limited number of original production and supply firms. However, these businesses are learning from technology suppliers to make more complete products for electric scooters and electric bicycles. Currently, densely populated Vietnamese cities are facing the need to reduce emissions and will be potential markets for EV development. In addition, the

combination of the development of public transport and private EVs can help Vietnamese cities shift from using vehicles with internal combustion engines to EVs.

One challenge, however, is the limited network of charging stations and the absence of businesses supplying charging station infrastructure. The fact that the central and local governments lack incentives related to charging infrastructure may discourage companies to invest in this field, except for VinFast which is taking advantage of its convenience store system VinMart+ spread throughout major cities.

In addition, Viet Nam also shows few opportunities in the field of manufacturing EVs or supplying original equipment for EVs; expertise and capacity in this area is limited. Besides, the current electricity service and grid supply also have many limitations due to its dependence on state-owned enterprises. Finally, the shortcomings in developing the EV market in Viet Nam lie in additional services such as payment systems, information provision services and automatic charging station technology. Therefore, the EV market in Viet Nam is in its infancy. Other than the announcement from two domestic companies under Vingroup on electric car and electric bus production, there is no information on EV production plans by other companies in Viet Nam.

Viet Nam is in a period of development, the electricity load in the long term is still high, and the peak national load growth over the past 10 years is 10.7%/year. As the EV market grows stronger, the requirements on the number and capacity of charging stations will increase dramatically. Therefore, in the EV research and development roadmap, the responsiveness of EV infrastructure and plans to expand the development of the electric system in Viet Nam need to be studied carefully.

4. BARRIERS AND THREATS TO E-MOBILITY ADOPTION IN VIET NAM

4.1. Consumer insights and the likelihood of e-mobility adoption

4.1.1. Survey methodology

The research objective of the survey is to better understand vehicle owner's consumer behaviour and other related issues. The study also provides views and assessments on vehicle owners, manufacturing, assembling, commercial and passenger transport enterprises on difficulties and barriers to the development of the EV market in Viet Nam.

The survey was conducted from 19 October 2020 to 18 November 2020. The researchers conducted direct interviews with vehicle owners in 12 districts of Hanoi (Ba Dinh, Tu Liem, Cau Giay, Dong Da, Hai Ba Trung, Hoan Kiem, Hoang Mai, Long Bien, Nam Tu Liem, Tay Ho, Thanh Xuan, and Ha Dong). Before the interviews, the researcher informed the interviewees of the purpose and content of the survey,

and the commitment to confidentiality (i.e. the survey results would only be used for the study, not for commercial purposes, and the information would not be given to third parties). In addition to the direct survey, an online survey was also set up on https://www.surveymonkey.com/ to attract more vehicle owners to participate. More details about the survey methodology are presented in Appendix 1.

4.1.2. Survey results

The survey conducted a total of 1337 direct interviews and online surveys via the website https://www.surveymonkey.com/. Compared to the original target of 996 direct interviews and online surveys, the number of responses surpassed the goal. Regarding enterprises, 38 passenger transport enterprises and 4 manufacturing, assembling and trading enterprises participated in the survey. Although the number of enterprises participating in the survey is small due to their information security regulations, it still met the needs of the survey. Figure 4.1 presents detailed information on the number of vehicle owners participating in the survey.

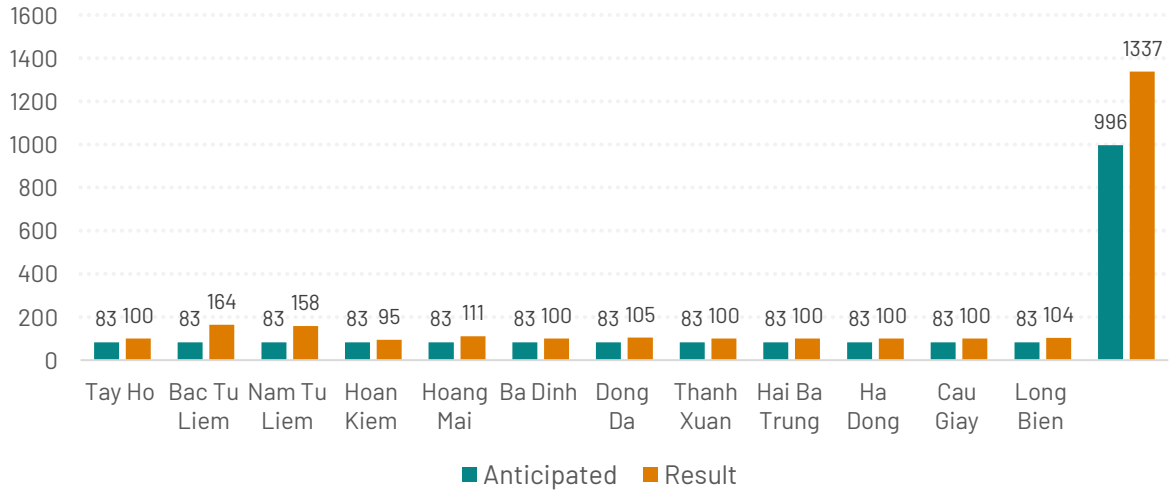


Figure 4.1. The number of vehicle owner respondents

4.1.2.1. Vehicle owner demographics

Vehicle owner's gender and age

In this study, the gender distribution of the surveyed vehicle owners is quite even, 50.3% female and 49.9% male.

Vehicle owners participating in the survey are from 16 years old and above. The age structure of the surveyed vehicle owners included all five age groups as designed in the survey questionnaire. Specifically, the group of vehicle owners from 20 to under 30 and the group from 30 to under 40 are the two groups that have the highest proportion, accounting for 31.9% and 27.7% of respondents, respectively. The remaining groups have a lower proportion but all over 10%. The figure below shows the age structure of vehicle owners participating in the survey.

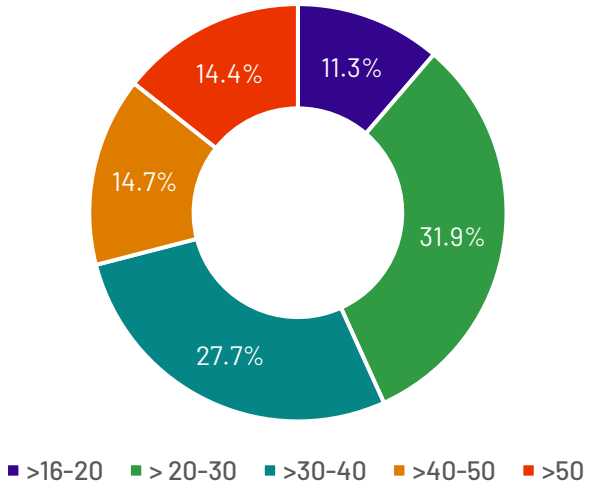


Figure 4.2. Age of the vehicle owners participating in the survey

Employment and income

A profession is a job that takes a lot of time or generates the main income for vehicle owners. At the time of the survey, many owners shared that they had lost their jobs due to the impacts of the Covid-19 pandemic.

Survey results showed that most vehicle owners are contract workers (companies, enterprises, etc.) or freelancers, accounting for 31.9% and 27.7% of the respondents, respectively. Vehicle owners belonging to the 3 remaining groups are all higher than 10%. Thus, the sample of respondents selected for the survey includes all types of employment.

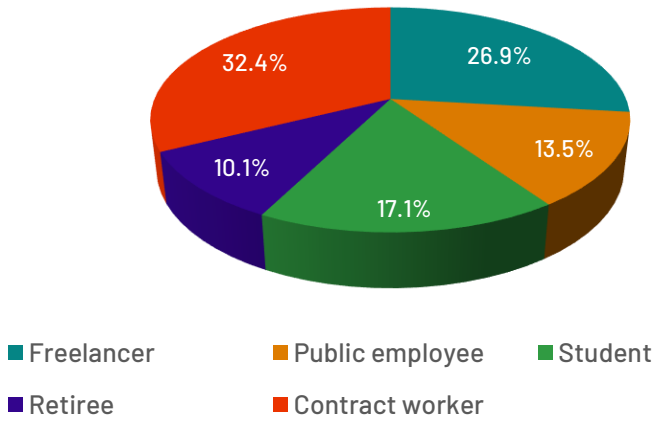


Figure 4.3. Employment types of vehicle owners participating in the survey

Based on the structure and rates of personal income tax in accordance with the current law, the survey divides the income of vehicle owners into five main groups as follows:

- Under or equal to 5 million VND/month
- Over 5 ≤ 11 million VND/month
- Over 11 ≤ 16 million VND/month
- Over 16 ≤ 21 million VND/month
- Over 21 million VND/month.

The majority of vehicle owners have an income level of below 11 million VND/month (76.5%), of which 51.5% of respondents are earning between 5 and 11 million VND/month. Only 23.5% of the respondents reported an income level higher than 11 million VND/month. Many vehicle owners shared that at the time of the survey, their income was significantly reduced due to the impact of the Covid-19 pandemic, which forced them to switch from full-time to part-time employment. Some even became unemployed since the number of available jobs significantly dropped.

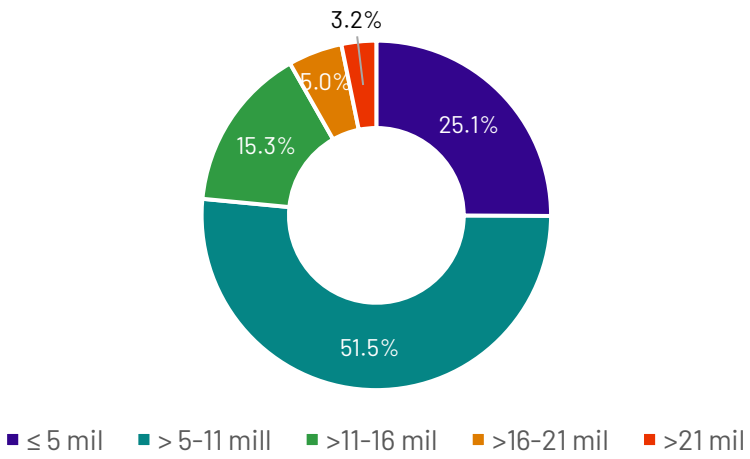


Figure 4.4. Income structure of vehicle owners participating in the survey

Education level

The vehicle owners' education level is the diploma/certificate recognised at the time of the survey. According to survey results, 66.3% of the respondents have vocational school/college or higher qualifications; the rest graduated from high school, secondary school or primary school. No illiterate vehicle owners participated in the survey. The group of vehicle owners with a university/college degree accounts for the highest percentage (39.0%) and the group with the lowest percentage are vehicle owners with primary education (2.3%). More information about the educational structure of the respondents is shown in the figure below.

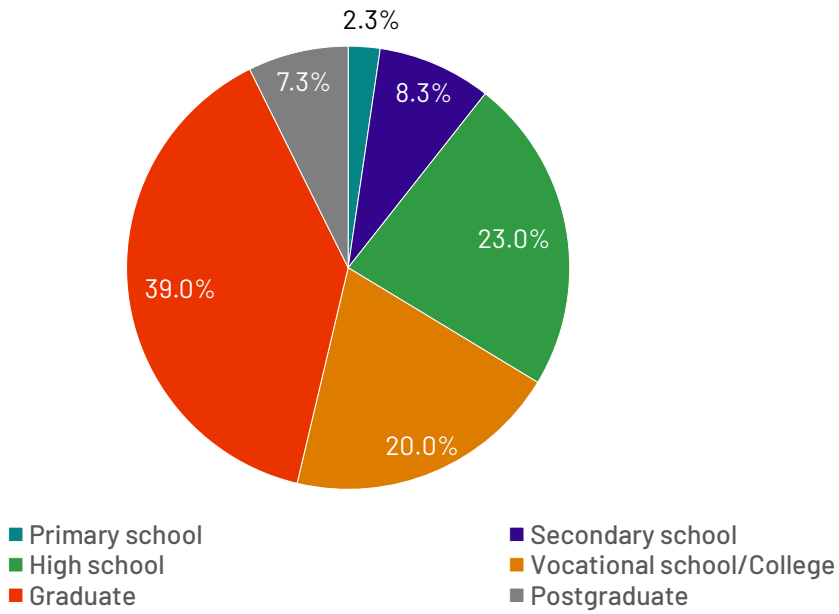


Figure 4.5. Education levels of vehicle owners participating in the interview

In addition, vehicle owners were also asked whether they felt that the environment was being polluted by exhaust from the operation of vehicles. 97.8% of the respondents said yes, 0.7% said no and 1.6% did not know. These figures show that the majority of vehicle owners are concerned about the environment, air pollution and related issues.

Vehicle ownership and main means of transport

Vehicle ownership means that the vehicle owner's name is written in the transport registration certificate or he/she is the person that owns the vehicle. There are vehicle owners who own many means of transport at the same time, but there also can be vehicle owners who do not own any means of transport. In addition, vehicle users are sometimes not the vehicle owners.

Survey results show that motorbikes are the most owned means of transport and are also used as the main means of transport in Hanoi.

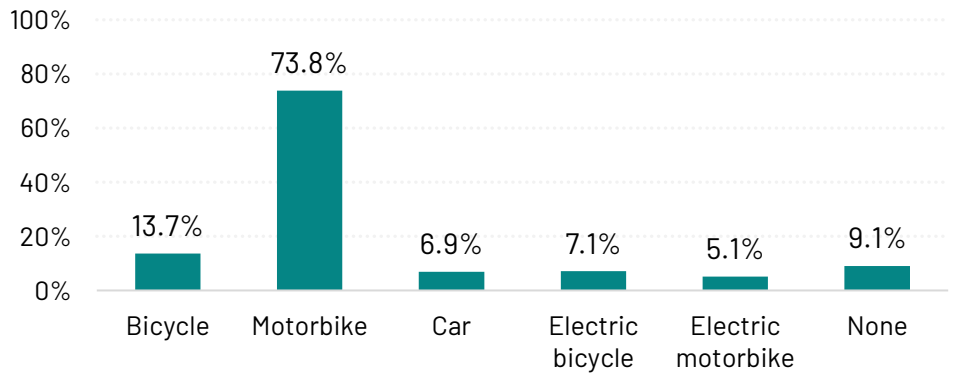


Figure 4.6. Current status of vehicle ownership

According to the survey, 73.8% of respondents own motorbikes, but only 69.8% use motorbikes as their main means of transport. For bicycles, the ownership proportion was 13.7% while the proportion using bicycles as their main means of transport was only 8.2%. The ownership proportion of EVs was 12.2% (of which electric motorbikes were 5.1% and electric bicycles were 7.1%). 7.6% of vehicle owners chose EVs as their main means of transport (electric motorbikes: 4.3%, electric bicycles: 3.3%). None of the respondents were using electric cars.

Owners of bicycles and public transport users were mainly pupils, students, and retirees who belong to the passive/low-income social group. There is a very small proportion (1.1%) of respondents who use taxis and online car services (for example, Grab) as their main means of transportation. The rate for motorbike taxis is 1.3% (see Figure 4.7).

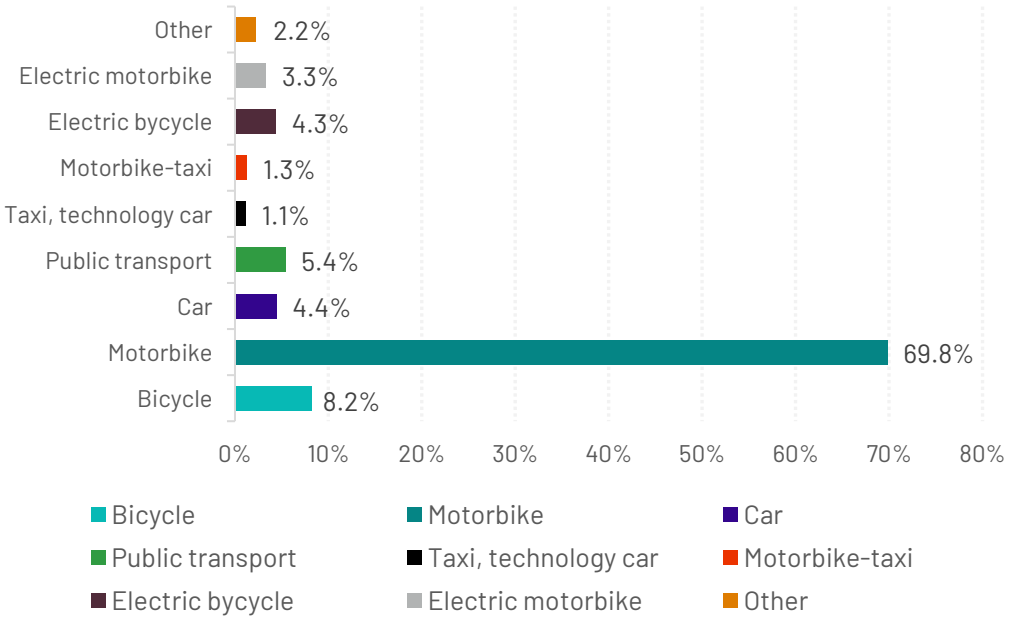


Figure 4.7. Structure of vehicle ownership and main means of transportation

Frequency of vehicle usage

Vehicle owners were asked about their frequency of vehicle usage. 90.0% of surveyed people said that they used their main means of transport daily, 4.9% said that they used them 3-4 days/week, the ratio for 1-2 times/week and less than 1 time/week are 3.9% and 1.2% respectively.

Regarding the purpose of using transport, such as (1) going to work/office; (2) going to school; (3) employment (taxi driver, shipper, etc.); and (4) other purposes (going to the market, going out....), 48.2% of vehicle owners use a vehicle to go to work. The remaining purposes had lower and fairly similar ratios at 19.5%, 17.1%, and 15.2% for the purposes of employment, other purposes, and going to school, respectively. On average, a vehicle owner travels around 3 trips/day. There were special cases of vehicle owners who travel more than 10 trips/day. Most of these cases were vehicle owners who use their means of transport for business purposes (taxi drivers, shippers, etc.).

Regarding average travel distance, up to 74.1% of one-way trips are less than 10km/trip. Looking at the characteristics of Hanoi, it is understandable that most of the trips within the city are less than 10km.

Table 4.1. Summary of survey responses

Content	Unit	Value
Gender of EV owners	*%*	*100*
Male	%	35.3
Female	%	64.7
Employment type of EV owners	*%*	*100*
Freelancer	%	17.6
Public servant	%	6.9
Student	%	50.0
Retired	%	6.9
Contract workers (companies, manufacturing enterprises)	%	18.6
Age of EV owners	*%*	*100*
≥16 and ≤ 20	%	44.1
>20 and ≤ 30	%	13.7
>30 and ≤ 40	%	15.7
>40 and ≤ 50	%	14.7
>50	%	11.8
Income of EV owners	*%*	*100*
≤ VND 5 million	%	52.0

Content	Unit	Value
>5 and ≤ 11	%	35.3
>11 and ≤ 16	%	7.8
>16 and ≤ 21	%	3.9
>21	%	1.0
Educational level of EV owners	*%*	*100*
Primary school	%	1.0
Secondary school	%	15.7
High school	%	49.0
Vocational school/ College	%	13.7
Graduate	%	16.7
Postgraduate	%	3.9
Frequency of vehicle use	*%*	*100*
Every day	%	90.0
3-4 days/week	%	4.8
1-2 times/week	%	3.9
> 1 week/time	%	1.3
Purpose		*100*
To go to work	%	48.2
To go to school	%	15.2
Employment (For example: driver, shipper, etc.)	%	19.5
Other purpose (such as: go to the market, go out, etc.)	%	17.1
Daily average trips		
Min	Trip	1
Max	Trip	>10
Average	Trip	3.09
Average distance per trip		
Less than 5km	%	32.2
From 5km to less than 10km	%	41.9
From 10km to less than 15km	%	14.1
From 15km to less than 20km	%	6.6
More than 20 km	%	5.2

Current status of EV use

Currently, EVs in Hanoi are mainly electric bicycles and electric motorbikes. According to the survey results, 102 vehicle owners use EVs as their main means of transport (equivalent to 7.6% of respondents, out of which 4.3% use electric motorbikes and 3.3% use electric bicycles). None of the vehicle owners use electric cars.

For owners of EVs, 85.9% of them use lead batteries and only 14.1% use Lithium-ion batteries. The results also show that 100% of vehicle owners use EVs with charged batteries. With the current technology and charging methods, the survey indicates that the average charging time is 6.44 hours per charge. There were outliers with 12 hours charging where the vehicle owners plug the charger in at all times except when in use. Overnight battery charging is quite popular for E2W owners in Hanoi.

Based on the survey results, EVs can travel an average distance of about 51km fully charged; in special cases, some EVs can go up to 100km fully charged, but some only 10km fully charged.

According to the 23 vehicle owners using EVs with lithium-ion batteries, there were two methods of charging for 220V lithium-ion batteries: personal charging at home and public charging at supermarkets or residential areas. The ratio of personal at-home charging was 93.8% while public charging only accounts for 6.2%.

Table 4.2. EV battery information

No.	Information	Unit	Min	Max	Average
1	Battery replacement	time	0	4	0.57
2	Charging time	hour	2	12	6.4
3	Average travel distance on a full charge	km	10	100	51

Regarding the number of years using EVs, about 53.1% of E2Ws have been used for the past 1-3 years, 25.3% for less than 1 year while almost no E2Ws have been used for more than 10 years. The proportion of E2Ws used for 5-10 years is only 4.9%.

4.1.2.2. Enterprise characteristics

Gender of enterprise owners

77% of passenger transport enterprise owners surveyed were male, only 23% were female. All manufacturing, assembling and trading enterprises were owned by males.

The survey also shows that 68.8% of surveyed passenger transport enterprises had workforces with less than 10% female workers. There were no enterprises with over 50% female workers.

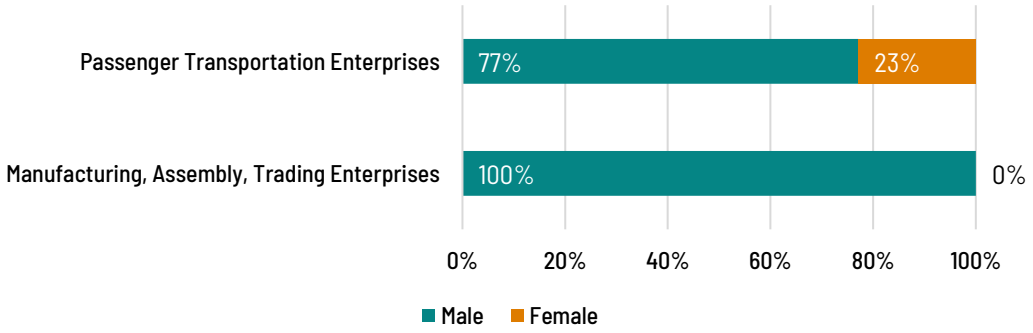


Figure 4.8. Gender of enterprise owners

Enterprise size

Categorised by charter capital and the number of employees, the size of passenger transport enterprises ranged from small to medium to large. Manufacturing, assembly and trading enterprises were mostly medium to large scale. Detailed information on the size of enterprises based on charter capital and number of employees is shown in Figure 4.9.

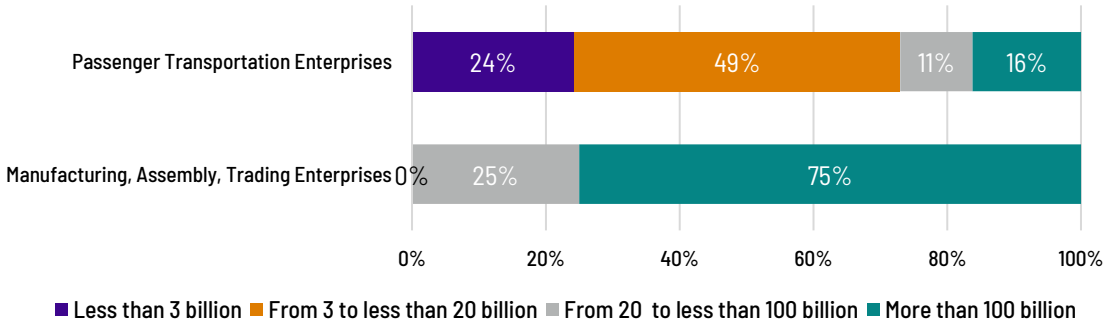


Figure 4.9. Charter capital structure of surveyed enterprises

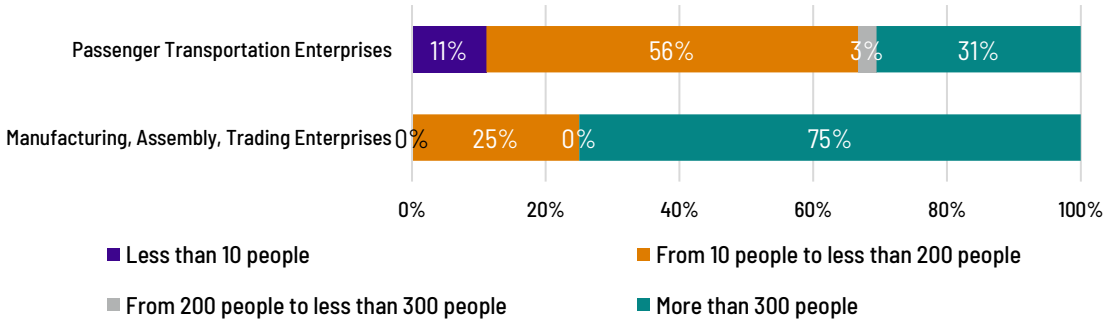


Figure 4.10. Enterprises by size of workforce

Type of enterprise

According to the survey results, the passenger transportation, manufacturing, assembly, and trading enterprises surveyed were mainly domestic private enterprises. State-owned enterprises and FDI enterprises accounted for a small proportion.

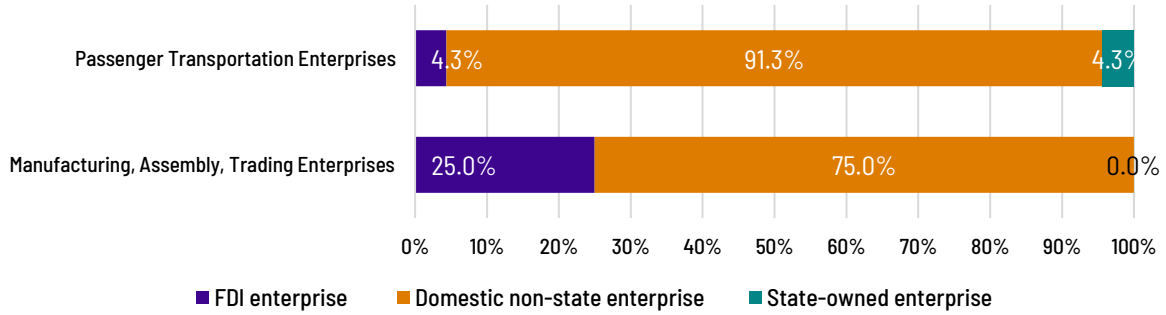


Figure 4.11 Enterprise types

4.1.2.3. Consumer behaviour

The vehicle owners were asked about the need to buy EVs in the future, of which 74.2% said that they would not buy EVs and 25.8% said they would. Of the 25.8% who would buy EVs, 14.9% wanted to buy electric motorbikes, 8.5% wanted to buy electric bicycles and only 2.5% wanted to buy electric cars. The EV demand of the respondents is shown in the figure below.

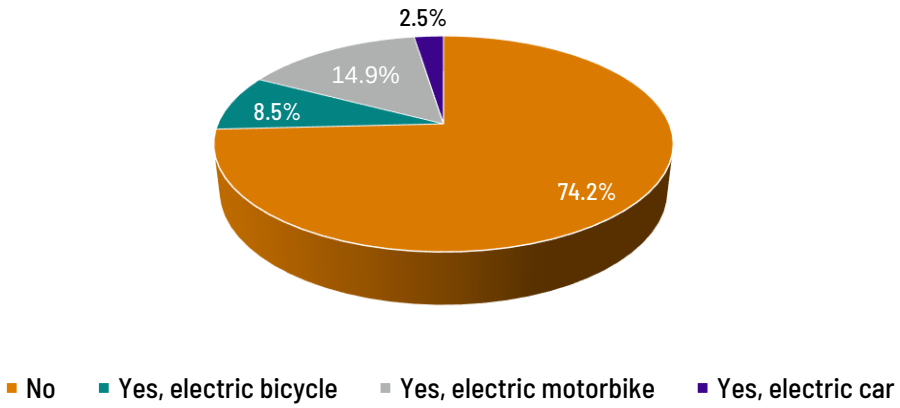


Figure 4.12 Vehicle owners' demand for EVs

Demand for EVs by age and by gender

The age group that had the most demand for EVs was the group under 16 years old, accounting for almost 25%. The lowest demand was from 40-50-year-olds, at only 5.2%. Detailed information on the breakdown of age groups with a demand for EVs is shown in Figure 4.13.

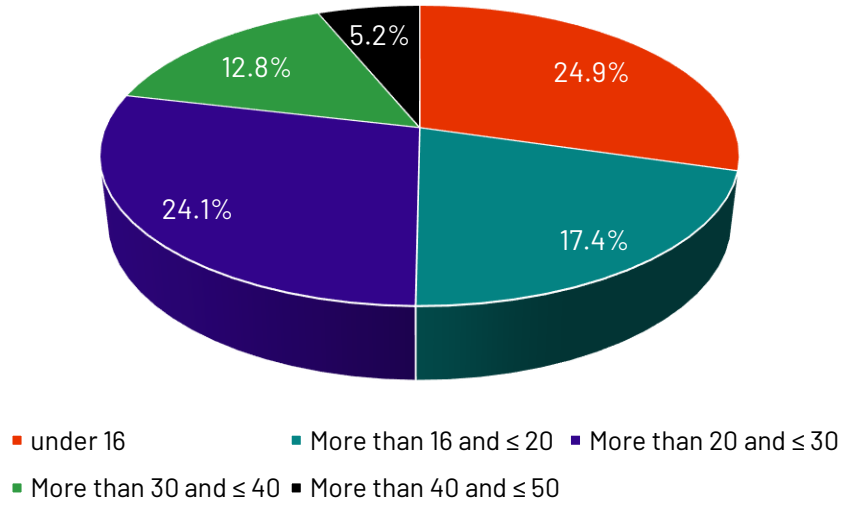


Figure 4.13. Demand for EVs by age

Among vehicle owners who intended to buy EVs, there was a big difference between demand for EVs by those over the age of 50 and those between 18 and 50. While vehicle owners over the age of 50 were more likely to say they would rather buy electric bicycles, vehicle owners between the ages of 18 and 50 preferred electric motorbikes. The ratio for choosing to buy an electric motorbike is relatively similar across all age groups between 18 to 50 years old. As for electric cars, the percentage of vehicle owners who would like to buy an electric car was very small, below 15% for all age groups and even 0% for the group over 50 years old. For electric bicycles, the higher the age group, the higher the percentage of respondents that intended to buy electric bicycles with the lowest being over 20%. For detailed information on the demand for EVs by age groups, see Figure 4.14.

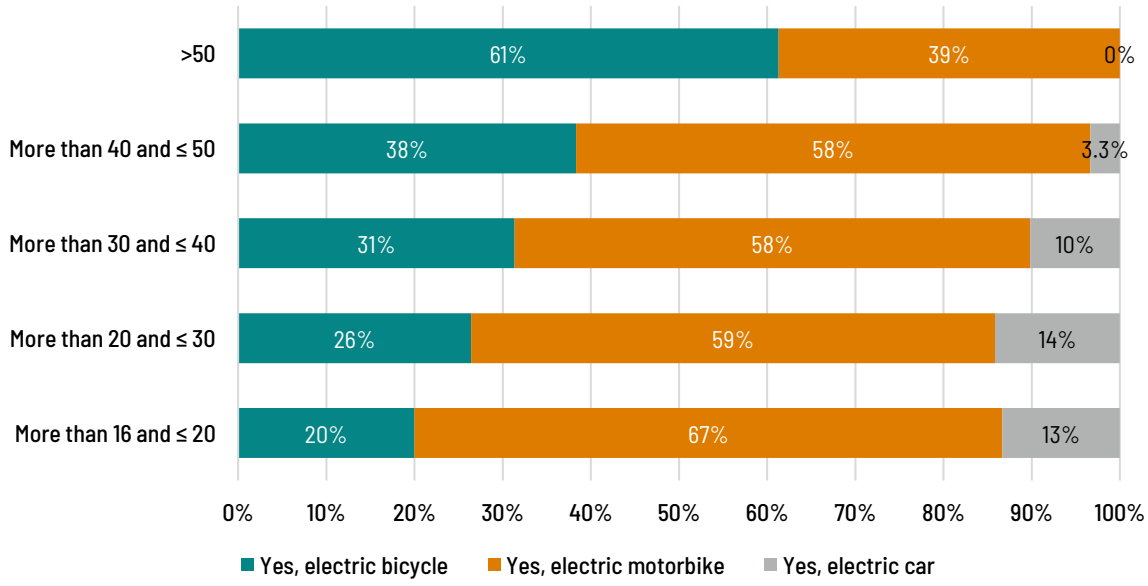


Figure 4.14. Demand for EVs by age and by EV type

The results showed that there was not much difference in EV demand between men and women. While women tended to prefer electric motorbikes, in contrast, men had a higher demand for electric cars. Figure 4.15 presents more details on gender differences regarding EV demand.

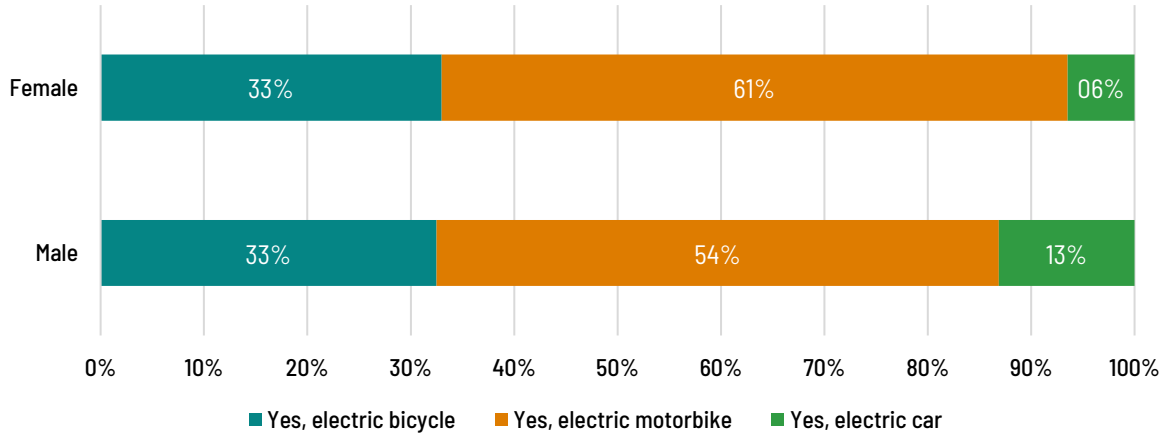


Figure 4.15. Demand for EVs by gender

Demand for EVs by income

It is noteworthy that the majority of vehicle owners to buy electric cars are in the student group and also the group with incomes below VND 5 million/month. They are the groups that show a strong interest in technology and innovation, hence, they were very interested in electric cars. These groups could be potential buyers of electric cars in the future. However, they intended to buy electric cars after 5 years.

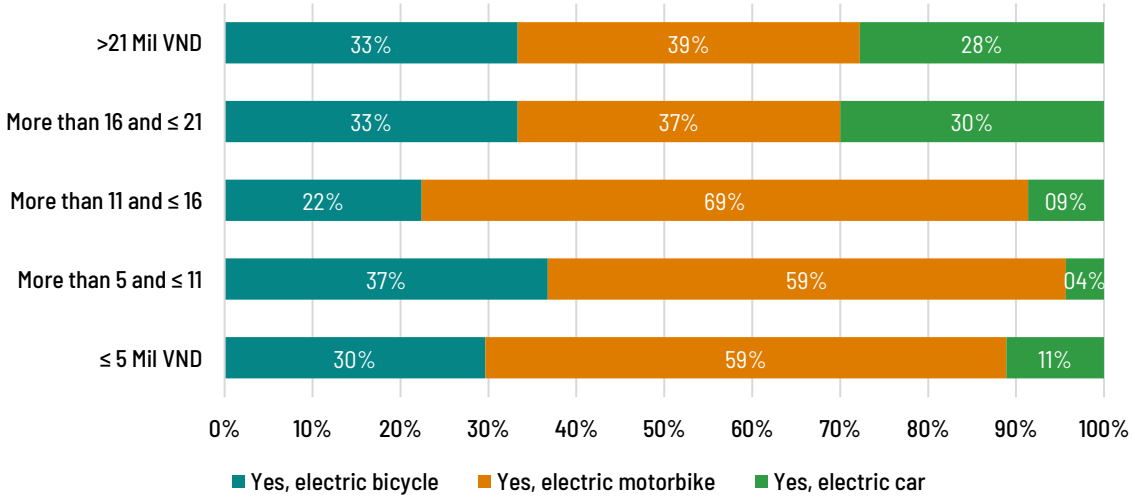


Figure 4.16. Demand for EVs by income

Retired vehicle owners were more likely to say that they would buy electric bicycles (64%) because electric bicycles' are quite suitable for their age, income and travel habits. Meanwhile, pupils, students, contract workers, and public employees tended to have more demand for electric motorbikes at a rate of about 60%.

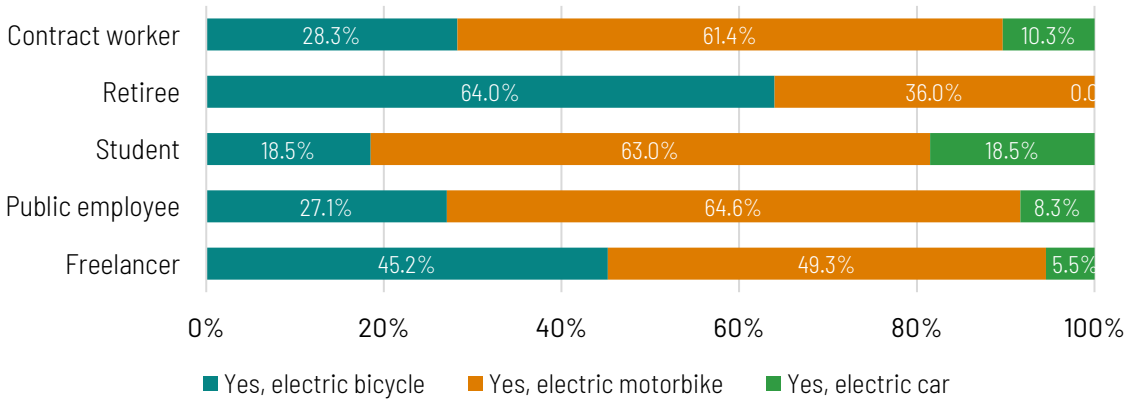
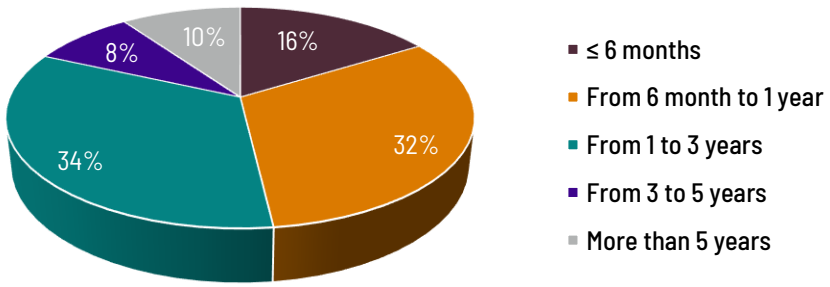


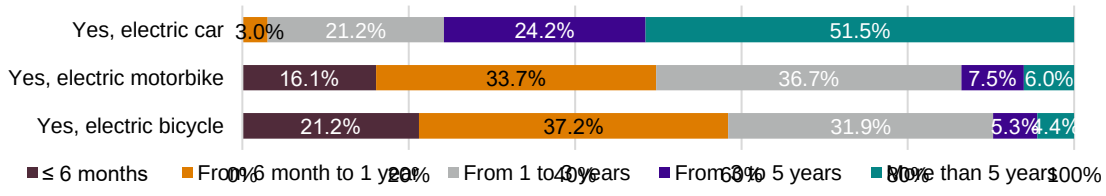
Figure 4.17. Demand for EVs by employment

Demand for EVs by time of purchase

When vehicle owners were asked about the expected time of purchase, up to 48.1% intended to do so within the next year (mostly E2Ws), and 51.9% intended to do so after one year. Most respondents with a demand for electric cars said that they would make the purchase after 5 years. For more information about time of purchase, see Figure 4.18.



(a) – EVs in general



(b) – by EV type

Figure 4.18 Demand for EVs by time of purchase

Demand for EV by uses

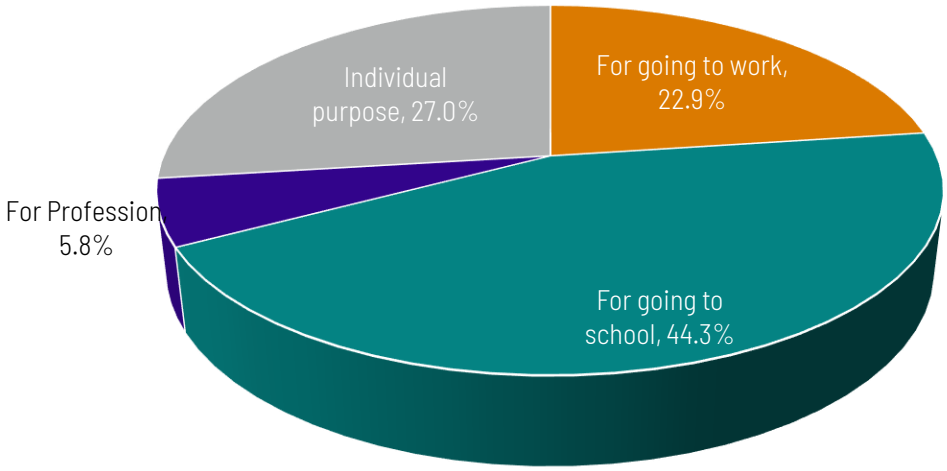


Figure 4.19 Demand for EVs by use

Of those who intended to buy EVs, up to 44.3% would use them to go to school, 27% for other purposes (go to market, going out, etc.), 22.9% for going to work, and 5.8% for professional purposes (drivers, shippers, etc.), which indicates that the use of EVs for work purposes is not popular at present or in the future. Information about the structure of EV uses is summarised in Figure 4.19.

Criteria for buying EVs and their importance

All respondents intending to buy an EV were asked about the three most important criteria for buying an EV and to evaluate each criterion's importance.

Responses from 345 vehicle owners who agreed to buy an EV showed that the three most important criteria were: (i) the price of the vehicle; (ii) the total range when fully charged; and (iii) safety at 75.7%, 52.2% and 46.4%, respectively. Other criteria, such as minimising environmental pollution (35.4%), maintenance costs (17.4%), infrastructure for EVs (14.25), convenience (13.9%), battery replacement cycle (12.8%), design (11.6%), power consumption per unit of travel distance (11.3%), and new trendy technology (9.3%) were also identified, but at a much lower level compared to the above three criteria. Detailed information on the three most important criteria is shown in Figure 4.20.

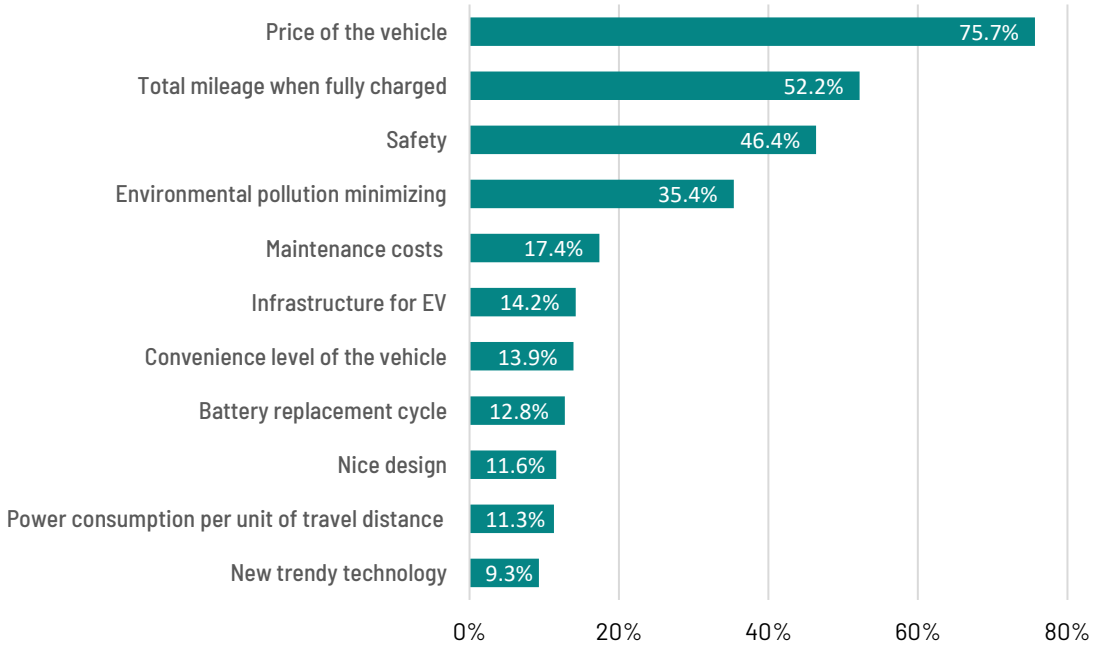


Figure 4.20. Criteria for buying an EV

In addition, the above-mentioned criteria are evaluated on a scale of 1 to 5, 1 being not so important and 5 extremely important. Accordingly, (i) price of the vehicle, (ii) total range when fully charged, (iii) safety and (iv) minimising environmental pollution are also the criteria considered by vehicle owners. For detailed information, see Figure 4.21.

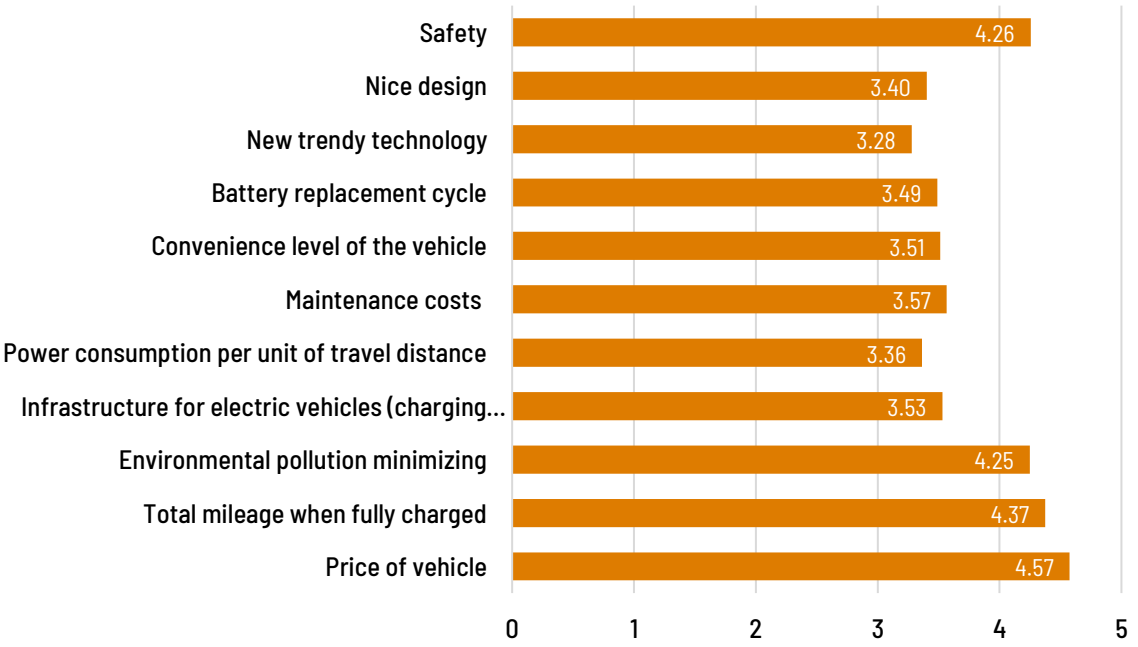


Figure 4.21. The importance of criteria when buying an EV

992 vehicle owners who said they did not intend to buy an EV were asked about the 3 most important reasons for this decision. They were: (i) The price of the vehicle; (ii) range; and (3) safety issues (charging, traveling, explosions and flooding) with respective rates of 66.0%, 60.8% and 48.8%. Other reasons mentioned include: EVs are unsuitable for their work needs, such as carrying heavy cargo; no need to change their current vehicles; concerned with the handling of battery waste and used accumulators. For detailed information on these reasons, see Figure 4.22.

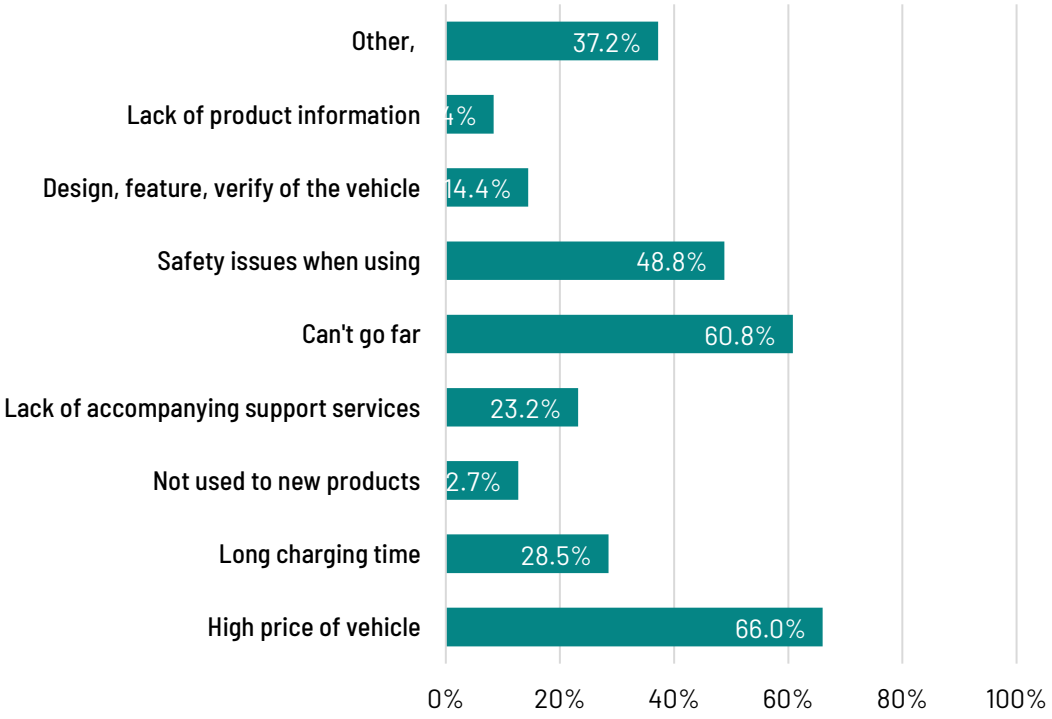


Figure 4.22. Main reasons for not buying EVs

Overall, the common concerns of vehicle owners who did/did not intend to purchase EVs were: (i) the price of the vehicle; (ii) total range when fully charged; (iii) safety; and (iv) environmental problems.

4.1.2.4. Barriers identified through the survey results

- Vehicle owners

The survey results show that there were three factors considered to be the biggest barriers to the EV market in Viet Nam: (i) vehicle price; (ii) battery technology; and (iii) supporting technical infrastructure (charging stations, battery replacement and exchange, etc.). Other barriers were also considered as being important but at a lower level (see Figure 4.23).

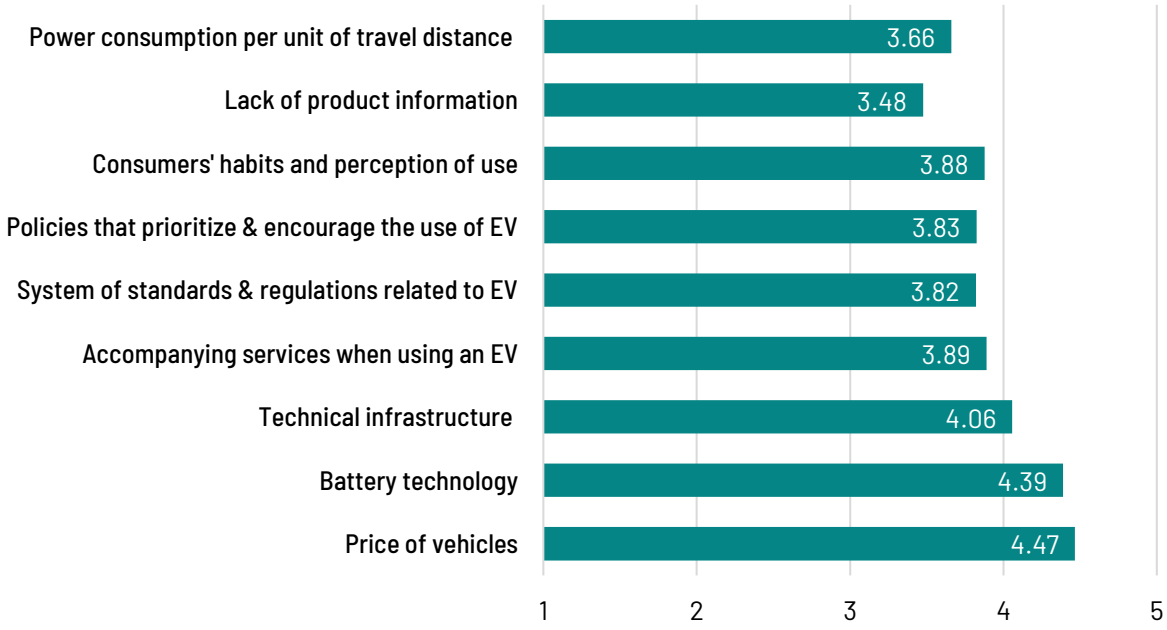


Figure 4.23. Barriers for EV development in Viet Nam from vehicle owners' perspectives

Regarding opinions on incentives and support when buying EVs, the proportion of vehicle owners preferring discounts was the highest and that for subsidised maintenance costs was the lowest. In all hypothetical cases of incentives and support, the proportion of owners intending to buy an EV ranged from 21% to 45%. For information on incentives and levels of incentives preferred, see the following table.

Table 4.3. Expected levels of incentives and support for buying EVs

No.	Incentives and support	Agree	Disagree	Levels of incentives and support expected by respondents intending to purchase EVs
1	Price discount for electric motorbikes and electric bicycles	45.2%	54.8%	30%
2	Tax and fee reduction (registration tax, registration fee, license plate fee, etc.)	27.9%	72.1%	47%
3	Interest support for instalment purchases	24.0%	76.0%	36%
4	Preferential treatment when replacing batteries	23.6%	76.4%	45%
5	Reduced electricity prices at centralised charging stations compared to household electricity prices	21.8%	78.2%	42%
6	Subsidies for maintenance costs	27.9%	72.1%	43%

- Passenger transport enterprises

To accomplish this task, the consultant team conducted a survey of 38 passenger transport companies to understand the key barriers to the development of the EV market in Viet Nam. The businesses surveyed included public passenger transport enterprises, fixed-route passenger transport enterprises and non-fixed route passenger transport enterprises.

From the perspective of passenger transport service providers, the three biggest barriers to developing EV passenger transport in Viet Nam were: (i) High product price; (ii) Lack of supporting technical infrastructure (charging stations, battery exchange, etc.); and (iii) Current technology not meeting market requirements (time-consuming batteries, lack of charging stations, etc.). Other barriers were also rated very high and important (see Figure 4.24).

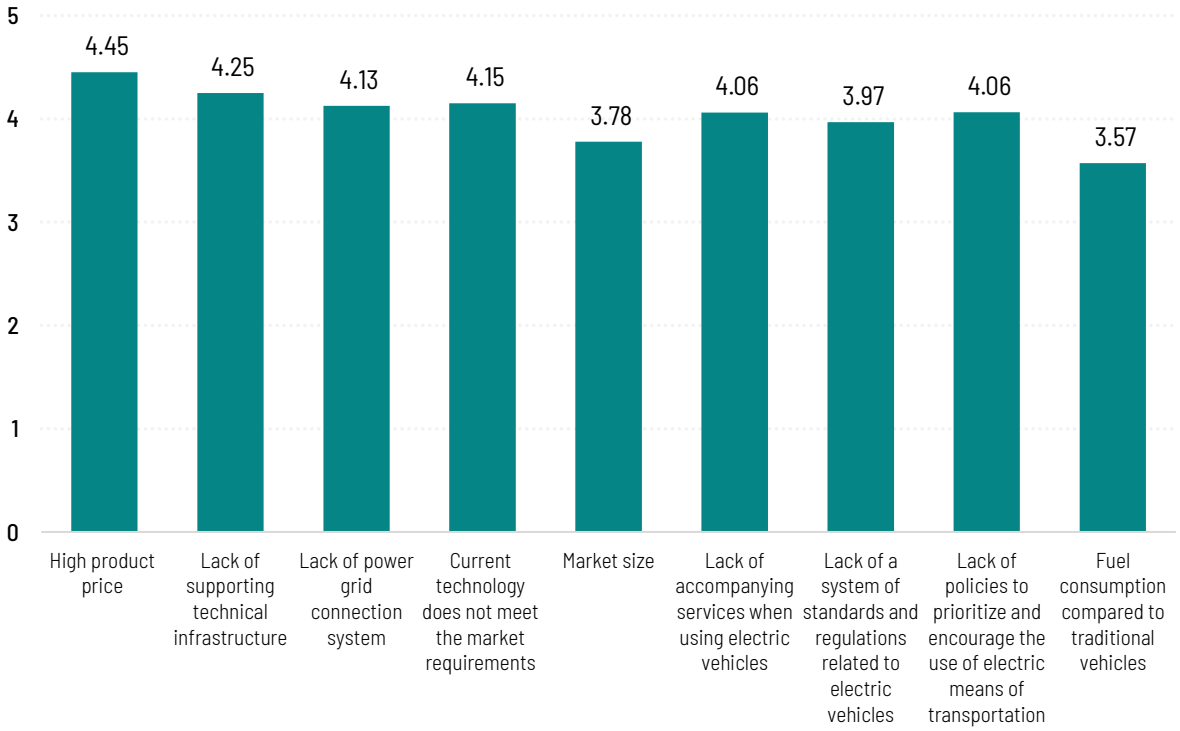


Figure 4.24. Barriers to the development of EV passenger transportation in Viet Nam

With these barriers, passenger transport enterprises proposed policies to prioritise and support the EV market in Viet Nam. The three most important support policies that passenger transport enterprises were: (i) Mechanisms and policies to support investment procedures for implementing administrative procedures when converting to EVs; (ii) Policy on preferential loans for investment when converting from traditional vehicles to EVs; and (iii) Policy on environmental protection (emissions quotas, etc.). For detailed information on assessing the importance of policies to promote the EV market in Viet Nam, see the figure below.

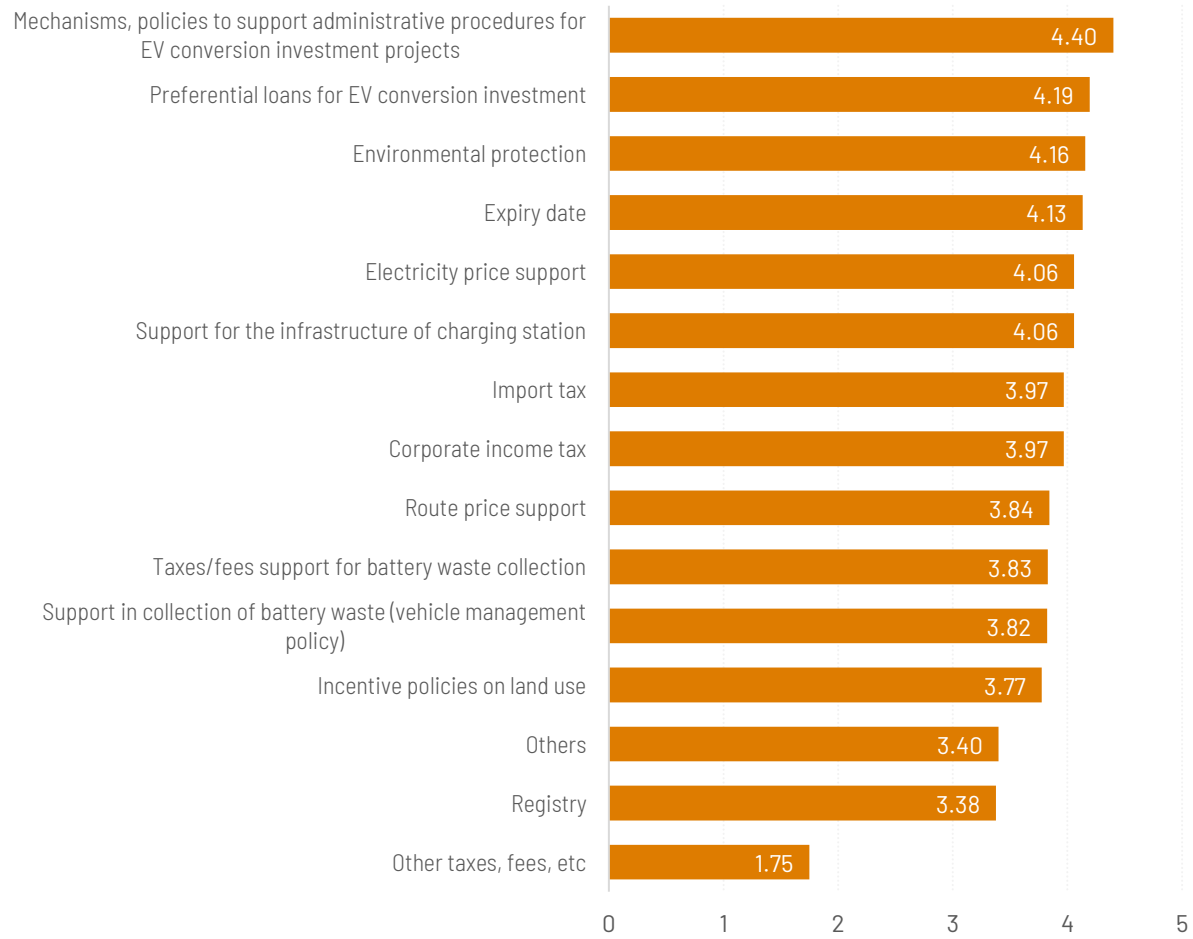


Figure 4.25. Importance of priority and support policies for developing the electric passenger transport market in Viet Nam

- **Manufacturing, assembling and trading enterprises**

Unlike passenger transport enterprises and vehicle owners, the biggest barriers for manufacturing, assembling and trading enterprises were a lack of policies to prioritise and encourage the use of EVs.

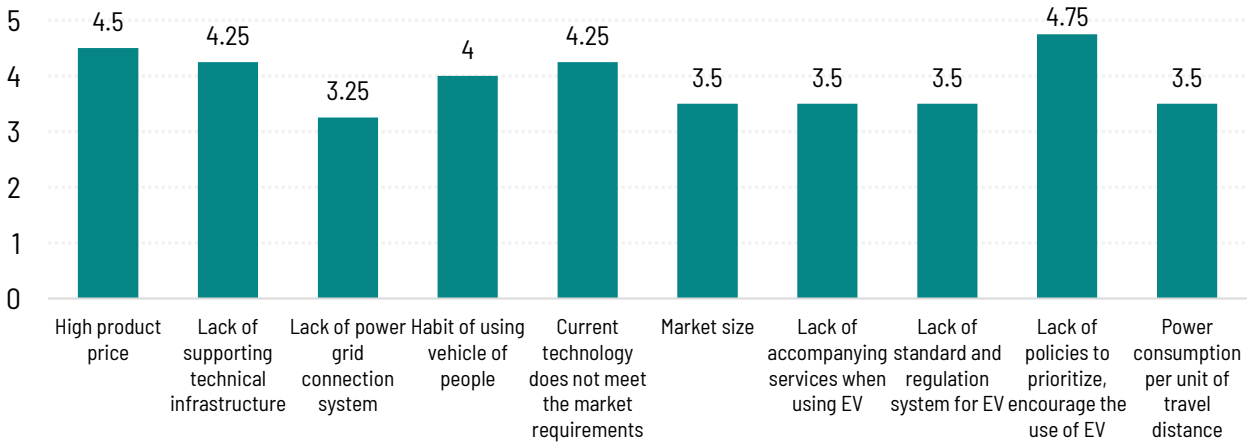


Figure 4.26. Barriers to the development of the EV market in Viet Nam from the perspective of manufacturing, assembling and trading enterprises.

For policies that need to be prioritised and supported, manufacturing, assembling, and commercial enterprises were particularly interested in policies on registry, import tax, support for the collection of battery and accumulator waste, and environmental protection (emissions quotas, etc.). For detailed information, see the figure below.

Figure 4.27. The importance of priority and support policies for the development of the EV market in Viet Nam.

Although there is considerable potential for e-mobility adoption in Viet Nam, there are still many barriers and challenges at present. Barriers and challenges include low incomes in comparison with the high prices of EVs; the lack of charging infrastructure; the lack of government support and incentives; and the high share of non-renewable resources such as coal. Brief descriptions of these barriers are given in Section 4.2.

4.2. Barriers to e-mobility development in Viet Nam

Based on the overview analysis of e-mobility development policies, EV market, infrastructure and the survey results, the barriers to e-mobility development in Viet Nam are summarised as follows.

4.2.1. Market barriers

Price

From a consumer perspective, the survey consistently found that price was a major barrier to EV sales. About 66% of consumers thought that the high price of EVs was the most important reason preventing them from buying an EV.

Viet Nam has low income levels with average GDP per capita at just USD 2,800. This is generally still too low to support individual electric car ownership.

The main transport mode for individual trips is motorcycles. Currently, the country has over 50 million motorcycles, and they are the primary source of air pollution in urban areas. Therefore, switching from conventional motorcycles to electric ones seems to have more potential than switching to electric cars.

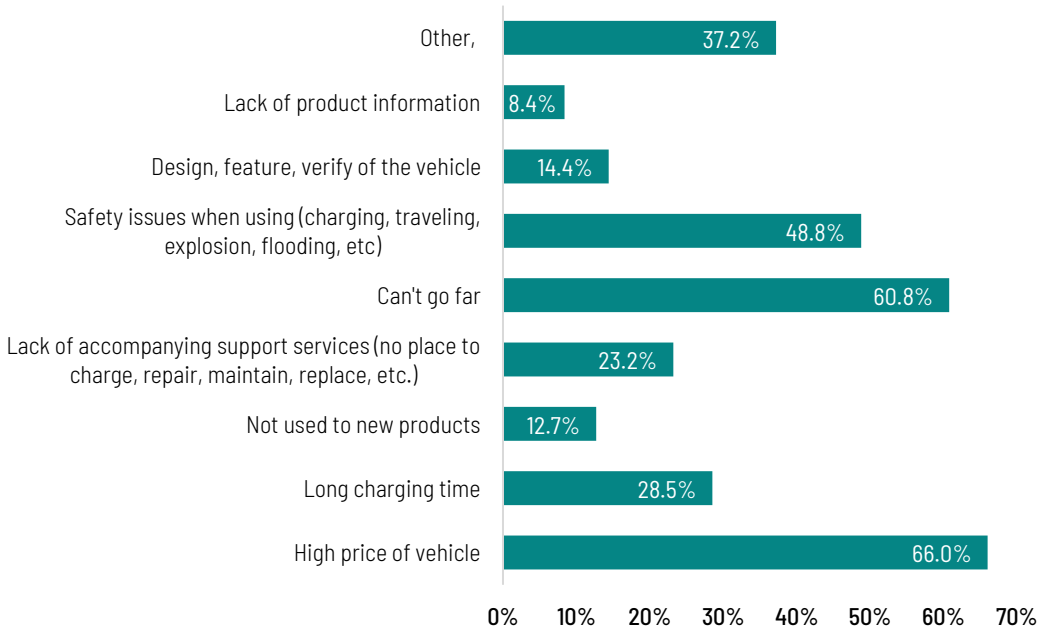


Figure 4.28. Reasons for not buying EVs from a consumer perspective

(Source: Consumer Interview Survey, 2020)

From a business point of view, transport operators share the same opinion; 85.2% of transport operators indicate less willingness to purchase an EV because of the high price.

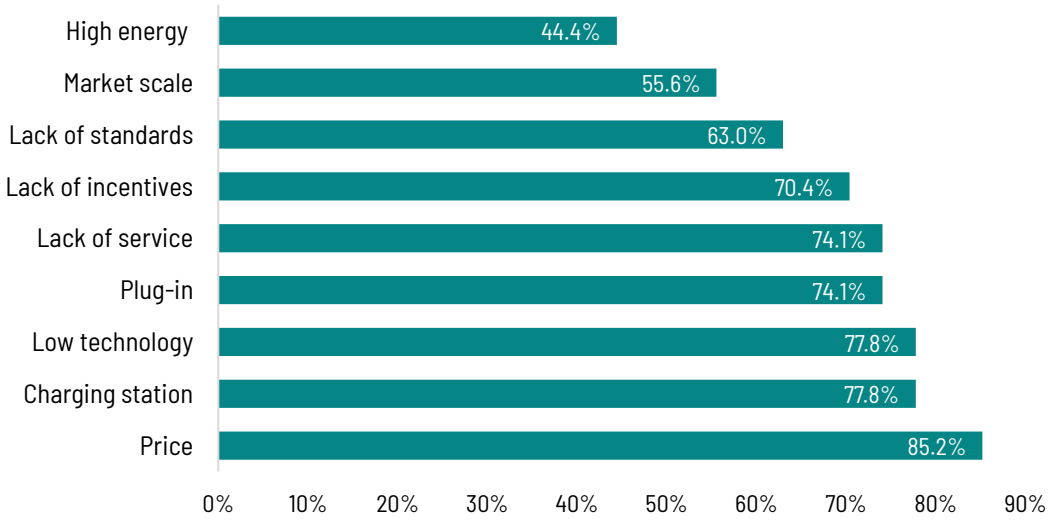


Figure 4.29. Barriers to the EV market in Viet Nam from transport operators' point of view

(Source: Consumer Interview Survey, 2020)

Battery and charging infrastructure

If EVs are to reach a broad market, the development of public electric charging infrastructure is essential. In the above survey, 60.8% would not consider purchasing an EV because the battery system does not allow vehicles to run over long distances and because the public charging system is still incomplete. Battery technology is also another concern. According to the survey, 85.9% of electric motorcycles are using lead batteries and, therefore, do not significantly reduce emissions.

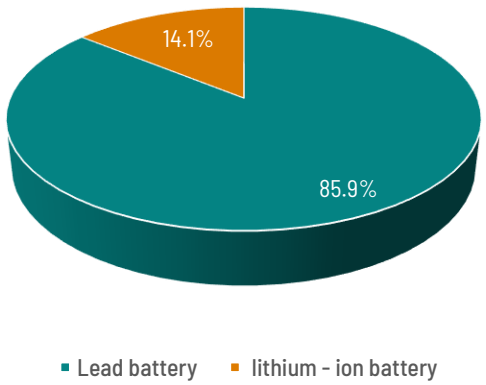


Figure 4.30. Limitations of battery technology in electric motorcycles

(Source: Consumer Interview Survey, 2020)

Transport operators also ranked charging stations as the second most important barrier in line with low technology (e.g. long recharging times and lack of charging stations). About 77.8% of respondents complained about charging stations and technology (see Figure 4.29).

There are virtually no EV charging stations in Viet Nam. Until the Vietnamese Government develops a plan for building a charging network, there will be little progress in this area. The lack of charging infrastructure will negatively impact EV sales. Tesla also has no current plans to build its Supercharger network anywhere in Southeast Asia. Vietnamese consumers who plan to purchase an EV in the near future will need to provide their own charging system.

Safety issues

Safety issues, such as explosions and flooding also impact consumer behaviour. About 48.8% of consumers worry about safety and have decided not to use EVs as a result (see Figure 4.28).

Weak local EV production

EV manufacturers and sales companies are rare in Viet Nam. The biggest EV service company is Electric Car World Co., Ltd., which has annual sales of over 500 EVs, most with less than 16 seats and without doors. These have been sold to tourism companies, hotels, and households engaged in tourism services.

The largest local EV manufacturer is Vinfast. The company is Viet Nam's first domestically-backed company committing to manufacture automobiles, including EVs. Mitsubishi Viet Nam plans to introduce and produce EVs in the future. Nevertheless, Viet Nam's current policies do not encourage domestic enterprises to produce EVs.

Other barriers

From transport operators' point of view, many barriers limit their access to EV use; for example, plug-in issues (74.1%); lack of services (74.1%); lack of incentives (70.4%); lack of EV standards (63.0%); and the small market scale (55.6%) (Figure 4.29).

4.2.2. Policy barriers

Viet Nam has neither tax incentives nor price subsidies for EVs. In addition to import duties, EVs shipped to Viet Nam have been subject to special consumption tax rates ranging from 15-70%, which has increased prices by up to 20%.

Under free trade agreements in which Viet Nam is a signatory, some EVs have been protected from tariffs since 2018. These include EVs from Korea and China. EVs from Japan are taxed at 4%, while Tesla cars from the US are taxed at 70% under most-favoured-nation status.

The Nationally appropriate mitigation action for buses (NAMA bus project) is registered by Viet Nam under the United Nations Framework Convention on Climate Change (UNFCCC), in which the target is for e-buses to make up 10% of newly purchased buses by 2030. However, at present, there are no special policies or incentives for EVs in Viet Nam. The updated Nationally Determined Contribution

(NDC) has referred to solutions for the reduction of GHG emissions by using clean fuels and EVs. However, specific policies for e-mobility development have not been clearly described.

4.2.3. Technical and infrastructure barriers

4.2.3.1. Technical barriers

EV batteries must be charged for the vehicle to run and its storage capacity determines the distance that can be travelled on each charge. In Viet Nam, 60.8% of respondents are concerned about range per charge in the context of a lack of public recharging or exchange stations/points (see Figure 4.28). Therefore, limited power storage capacity is one of the users' major concerns for EV and is considered an important technical barrier.

On another note, 85.9% of respondents chose lead batteries for their EVs due to the low price. However, the lifespan of lead batteries is relatively short, only about 2 to 2.5 years according to survey results.

4.2.3.2. Infrastructure barriers

Charging stations

Currently, the biggest obstacles Viet Nam must overcome to facilitate EV adoption are battery and charging infrastructure issues. Among these obstacles, the limited availability of rapid-charging stations is the biggest barrier. In fact, rapid-charging stations are still very rare in Viet Nam. Most E2Ws are charged at home or at the workplace. There are no public charging stations in Viet Nam, including rapid-charging stations. Since the end of 2014, many companies in Viet Nam have considered providing charging stations for e-bikes and e-motorbikes and expected to establish 10-minute quick charge stations at e-bike stores or on the road. However, all of these remain as projects on paper (Nguyen & Nguyen, 2015). In fact, charging times can be reduced through the battery swapping option, but this method is only suitable for electric 2- and 3-wheeler vehicles. Moreover, it requires costly infrastructure and a larger amount of batteries. Also, flexibility is limited as battery swap systems are often tied to certain vehicle brands (Grütter & Kim, 2019). For these reasons, this approach faces implementation difficulties in the current context of Viet Nam. In 2019, Vinfast marketed Klara A2 with a battery swapping option offered by its widespread VinMart+ outlets in many cities. Unfortunately, this battery swapping system has not been working efficiently since it only services Vinfast's vehicles and the battery swapping cost is high. In addition, customers are concerned about the energy capacity of the batteries.

Vietnamese consumers who plan to purchase an EV in the near future will need to provide their own charging system (Stephen.F, n.d.). As an unexpected result, the lack of charging infrastructure has been negatively impacting the EV market. Therefore, the EV market will not be able to make progress unless the Vietnamese Government develops a comprehensive plan for building a rapid-charging network.

Power source

As the economy continues to grow, Viet Nam could soon be affected by chronic power shortages. The government's solution is to build more coal-fired power plants, forecasting that coal-fired power capacity will be about 56% of the total electricity capacity of the whole system by 2030. This means that coal will become the main source of supply accounting for more than half of the power capacity in Viet Nam by 2030. Meanwhile, it is likely that all charging stations will use the national electricity grid if they are deployed in Viet Nam. This implies that EV development in Viet Nam will not be able to achieve an impressive environmental performance. If the current development trend on power sources is maintained, the development of EVs will only be a solution to reduce air pollution in densely populated cities while total GHG emissions of the whole country will not be significantly reduced unless Viet Nam uses "clean electricity" for the national grid.

Repair and maintenance workshops

In Viet Nam, current EV owners are disappointed about the low number of support centres or workshops for EV repair and maintenance in comparison to those for CVs. Furthermore, EV-related repair and maintenance procedures can be complicated, and only a few trained mechanics are capable of fixing EV-related issues. This indeed is another barrier to EV adoption in Viet Nam.

4.3. SWOT analysis

The results of the SWOT analysis regarding EV development in Viet Nam are summarised in Figure 4.31.

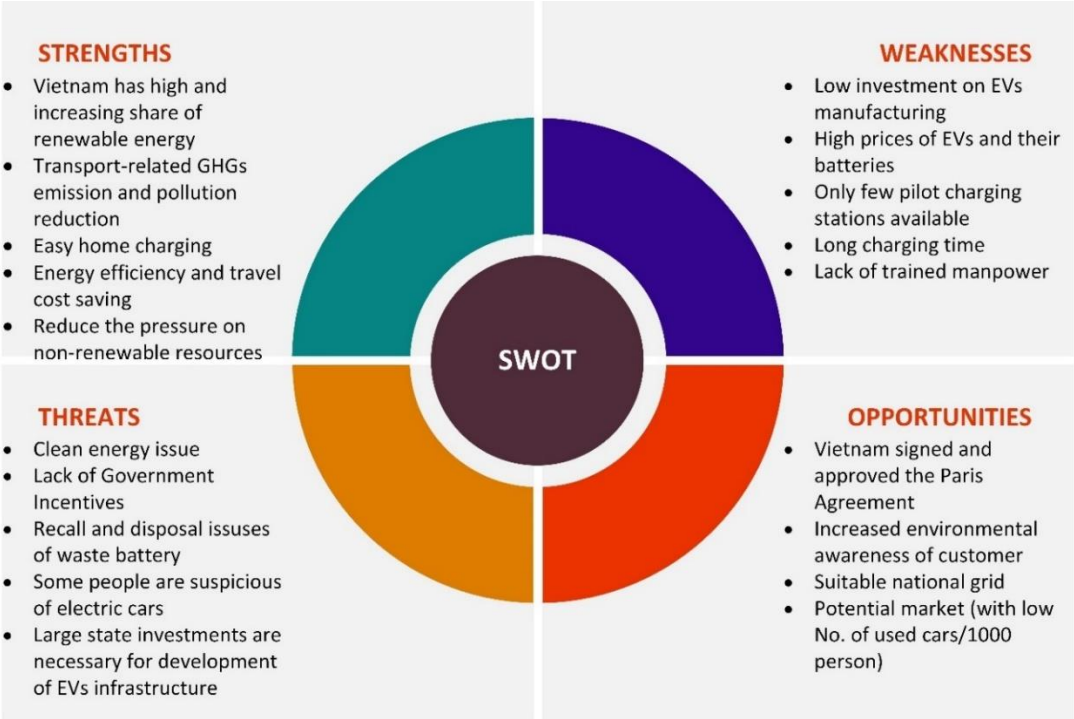


Figure 4.31. SWOT analysis of EV development in Viet Nam

4.3.1. Strengths

- *Viet Nam has a high and increasing share of renewable energy*

In the first 6 months of 2019, 89 solar power plants with a total capacity of 4550 MW were connected to the national grid. By the end of 2019, the total capacity of small-scale hydro-power had reached 3,674 MW, for wind power it was 377 MW, biomass 325 MW, and solar power 4,696 MW. The total capacity of renewable energy sources accounts for about 9.4% of the system's total power capacity. It is predicted that renewable energy will play an important role in the national power structure and is expected to account for 40.3% of total power capacity by 2045.

Electricity biomass is a strength of an agricultural production country like Viet Nam. Biomass electricity production potential is quite large. The agricultural sector produces about 4 billion m^3 of biogas per year, equivalent to approximately 4 billion kWh of biomass electricity (PV GAS, n.d.). In Viet Nam, biomass electricity is mainly produced at households or livestock farms. Therefore, this energy source is suitable for the at-home EV charging habit of Vietnamese people. In other words, EV development will create a good opportunity to coordinate closely with renewable energy development.

- *Transport-related GHG emissions and pollution reduction*

All EVs produce zero direct emissions, which specifically helps to improve air quality in urban areas. The benefit of GHG emissions reduction by converting from CVs to EVs could be significantly enhanced when clean energy is used. This has been clarified through using the Life Cycle Assessment (LCA) technique, which has been conducted by many researchers around the world. The LCA is an approach considering whole environmental impacts during all stages of vehicle life, including extraction of raw materials and energy sources, material processing, vehicle manufacture, distribution (transport), use (motion) including maintenance and repair, and finally recycling or disposal. Through LCA, researchers contend that EVs typically produce fewer life cycle emissions than CVs because emissions are lower for electricity consumption than for burning gasoline or diesel. For example, using the average data of 28 European countries, Ivan et.al (2018) found that the average CO_2e emissions level during the life cycle of a BEV of 138g/km is 33% less than for a conventional gasoline car (Evtimov et al, 2018). This emissions reduction efficiency depends strongly on the electric source (e.g. thermal power, nuclear energy, etc.) and battery type.

In addition, according to the analysis conducted by the consultant team, GHG emissions efficiency in the current context of the selected cities can reach 0.04% to 0.15% when converting from CVs to EVs (see Table 5.2). As a result, EV adoption is a very promising direction to help Viet Nam achieve its goals in the Paris Agreement.

Noise pollution reduction is also considered a strength of EV development. Nowadays, traffic noise pollution has become a major environmental issue that plagues urban residents in developing countries, including Viet Nam. According to MONRE, at major road routes, the noise level always

exceeds the permitted level as regulated in QCVN 26:2010/BTNMT even for the time frame of 6 a.m. to 9 p.m.

Meanwhile, EVs have a significantly lower noise level in comparison to CVs, especially during the start-and-stop process and at low speeds where engine noise dominates. Consequently, large-scale deployment of EVs will contribute to reducing noise pollution in Viet Nam, especially in cities where speeds are generally low. As EVs are far quieter than CVs, driving EVs creates a more peaceful environment for us all.

- *Easy home charging*

In addition to public charging, EVs can be home-charged in private parking spaces. Charging at home creates convenience for EV owners. With approximately 93.8% of charging done at home (according to survey results), vehicle timer apps or smartphone apps can be used to utilise cheaper night-time electricity.

In addition, home EV charging allows integration of local renewable electricity and promotes the development of self-supplied electricity systems; for example, private photovoltaic systems, or biomass electricity from private electricity generators. This helps to reduce reliance on non-renewable resources such as fossil fuels.

- *Energy efficiency and travel cost savings*

In Viet Nam, most vehicles run on fossil fuels (mainly diesel and gasoline). According to MOIT, the transport sector is the country's third highest energy consumer (approximately 20%), mainly fossil fuels (diesel and gasoline). However, at present, domestic oil production only meets approximately 40% of the total fuel demand and 60% must be imported. In addition, the fuel stock is decreasing day by day on a global scale. Therefore, fuel efficiency is also an issue discussed by countries around the world, including Viet Nam. Nowadays, people are trying to invent fuel-efficient technologies and EVs are one such invention. Conventional gasoline vehicles only convert about 17–21% of the energy stored in gasoline to power the wheels, whereas an electric motor is typically between 85% and 90% efficient (Suman, Chyon & Ahmmed, 2020). This means that EVs can convert most electricity provided into useful work. For EVs, energy losses only occur in the charging and discharging of the battery and power transmission from battery to motor.

In addition, BEVs' direct use of electricity makes them more efficient than the hydrogen fuel supply chain and fuel cell drive trains. This leads to lower specific electricity demand over the full fuel chain per kilometre.

One of the main economic benefits of using an EV is the relatively low cost of fuel (electricity) compared with gasoline. This conclusion was demonstrated by calculating the annual average total travel costs for both e-motorcycles and motorcycles fuelled by gasoline as shown in Table 4.4.

Table 4.4. Travel cost savings through using e-motorcycles instead of motorcycles fuelled by gasoline

	Motorcycle	E-motorbike
Energy/fuel	Gasoline	Electricity
Battery type	-	Lead battery (12V – 12A)
Fuel/energy consumption	2.41 litter/ 100km	7.37 kWh/ 100km[(1)]
Average price	14,000 VND/1 litter	1,734 VND/1kWh
Vehicle kilometres travelled (VKT) (km/year) (according to Table 2.6)	7,400	7,400
Annual travel cost total (VNĐ)	2,496,760	946,048

Note: [(1)] determined based on the survey results; the average fuel/energy price was calculated based on the current unit price in Viet Nam as of 26 November 2020.

As presented in Table 4.4, the annual average total travel cost using conventional motorcycles is about 2.6 times higher than for e- motorcycles.

- *Reduction of pressure on non-renewable resources*

The whole world is facing fossil fuel depletion and air pollution issues due to burning fossil fuels. Developing EVs will create more motivation for the promotion of renewable energy development and reduce dependence on non-renewable energy sources.

4.3.2. Weaknesses

- *Low investment in EV manufacturing*

Due to the lack of special policies and incentives for EV production in Viet Nam (as mentioned in section 4.2.2), domestic investment in EV manufacturing is still very low. Recently, the Ministry of Finance proposed a tax cut for electric cars under nine seats from 70% to 50% in order to promote the EV market in Viet Nam.

- *High prices of EVs and their batteries*

According to the survey, 75.7% of respondents considered the prices of EVs and their batteries as the most important issue affecting their decision to purchase EVs. The fact is that the prices of EVs are still relatively high, especially EVs equipped with environmentally friendly batteries such as lithium-

ion batteries, which have a total life cycle cost of nearly 2.5 times more than lead batteries (Evtimov et al, 2018).

- *Only a few pilot charging stations are available*

One major obstacle for the adoption of EVs at the moment is the battery and charging infrastructure issue. It is notable that there is virtually no charging infrastructure for EVs in Viet Nam (as analysed in section 4.2.3.2). In addition, the current business model for EV charging services is risky because the stores installing the charging systems are usually not committed (i.e. they can change their business model any time). In 2019, Vinfast provided a battery swapping option for its Klara A2 model but the swapping scheme was unfortunately not very effective. Indeed, the business model for charging services through charging stations or the battery swapping option needs to be studied more carefully.

- *Long charging time*

According to the survey results, full charging takes about 6.5 hours, a lot longer than refuelling time. Fast charging with very high power ratings of up to 350 kW could reduce the time required. However, for the majority of BEVs, fast charging is not seen as a standard due to higher costs and battery lifetime-reduction stress.

As mentioned in section 4.2.3.2, charging times can be reduced by using the battery swapping option, but it is difficult to apply in the current context of Viet Nam. In other words, a long charging time for EVs is inevitable; therefore, users will need to change their habits and accept the situation.

- *Lack of trained manpower*

Skilled manpower plays an important role in any organisation. Their skills enable the organisation to achieve its goals. Currently, EVs are a very new technology in Viet Nam, so there is a lack of trained and skilled manpower to start EV-related businesses. This greatly hampers the after-sales and maintenance services and is a major weakness to EV development at present.

4.3.3. Opportunities

- *Viet Nam signed and approved the Paris Agreement*

The Vietnamese Government has enforced various initiatives to protect the environment through its resources and international cooperation. Viet Nam is committed to addressing climate change and signed the Paris Agreement in 2015 under the UNFCCC and submitted its NDC. This shows that the Government of Viet Nam has recognised the importance of global environmental protection and the responsibility of each country in this general task.

As mentioned above, EVs are truly an environmentally friendly option to reduce GHG emissions in the transport sector. Therefore, building a clear roadmap for the deployment of EVs in Viet Nam between 2020 and 2030 can help the country achieve a GHG emissions reduction of 27% in the transport sector by 2030 compared to BAU. In other words, developing e-mobility in Viet Nam is a feasible solution to enable Viet Nam to reach the goals it committed to in the Paris Agreement.

The fact is that the Government of Viet Nam has recognised the importance of using clean energy and means to protect the environment and mitigate climate change. This has created a solid foundation for the development of EVs in Viet Nam.

- *Increased environmental awareness of consumers*

Customer awareness on CV-related air pollution is enhanced. Around 97.8% of the total people surveyed were aware that the air around them was polluted and transportation is among the causes. Therefore, the Vietnamese public may support the idea of using EVs as a solution to improve air quality. This could be one strength that EV suppliers can exploit to expand the market.

- *Suitable national grid*

Currently, the 500kV power grid is the backbone of the Vietnamese electricity system with a length of more than 1500 km running from the North to the South. This system plays a very important role in the national energy balance and affects the power supply reliability of each region. Therefore, electricity is supplied almost nationwide with a stable power source. The target for the power sector by 2030 is to raise the total grid capacity to 138.093 MW, which is nearly 3.5 times higher than the current load demand. In other words, the current electric power infrastructure is sufficient to supply EV charging stations. Therefore, if grid capacities are not exceeded and the stability of the grid can be guaranteed, the existing electricity transport and distribution infrastructure can handle the additional electric load caused by EV charging. In short, there is no need for a completely new electric grid. EV infrastructure can easily be extended. Additionally, the 200-plus-volt grid system in Viet Nam also enables EV owners to charge their vehicles at home.

- *Potential market (with low number of used cars/1000 people)*

Viet Nam is a potential market with around 96.2 million people (in 2019). Private motor vehicle ownership is relatively high, especially for motorcycles at around 54 vehicles per 100 people. EV has just penetrated Viet Nam in the past few years and the propaganda on EV benefits as well as EV support policies are still weak. However, the proportion of people surveyed with a demand for EVs is quite impressive, at about 25.8%. This implies that Viet Nam is a promising market for EV development, especially E2Ws. The recent study by Nissan on Viet Nam's consumers also showed that Vietnamese consumers possess one of the strongest demands for EVs in ASEAN.

Up to now, the EV market in Viet Nam is unsaturated. Therefore, the company that moves fast in this business will have more extensive opportunities and can easily take over the market by fulfilling customers' requirements.

4.3.4. Threats

- *Clean energy issues*

By the end of 2019, the power capacity from coal-fired thermal power accounted for 36.1% (see Figure 3.7). The contribution of coal-fired thermal power to the national grid will continue to increase in the short term for Viet Nam, predicted at about 56% in 2030. Therefore, current EV development cannot bring as much environmental benefit as expected. Unless the Vietnamese Government uses clean energy for charging stations (e.g. solar energy, wind energy, and other renewable energy sources), the goal of reducing GHG emissions through EV development in Viet Nam will probably not be achieved.

- *Lack of government incentives*

Viet Nam has not yet promulgated tax incentives or subsidies for EVs. As analysed in section 4.2.2, the lack of government incentives and specific guidance for EV development will discourage enterprises from entering this promising yet challenging market.

- *Waste battery recall and disposal issues*

According to the survey results, 85.9% of EVs in Viet Nam are equipped with lead batteries. The lifespan of this battery is quite short, at only about 2-3 years. Therefore, the disposal of used lead batteries has been causing a major environmental challenge due to hazardous components such as lead and acid. This must be managed as hazardous waste.

In Viet Nam, regulations on hazardous waste management have been promulgated since 2005 in the Law on Environmental Protection, but enforcement of these regulations is still very weak. Most industrial facilities that manufacture, import and distribute batteries have no battery recall stations, and even if they do, they do not comply with the regulations in Viet Nam.

- *Suspicion of EVs*

According to the survey, about 48.8% of respondents were suspicious about EV safety features. For this reason, they currently have no intention of buying EVs. In addition, some people were also sceptical about the vehicle's ability to reduce GHG emissions, especially when electricity is produced mainly from fossil fuels.

- *The necessity for large state investment to develop EV infrastructure*

There are four main groups of stakeholders that have been the most active in advancing EV infrastructure:

Government (national and local) – The government provides policy support, fiscal and non-fiscal incentives, and mitigates risks to advance the deployment of EV, including EVSE.

Manufacturers – Private companies are taking the lead in manufacturing charging equipment demanded by the Vietnamese market.

Service providers – Private entities, public companies, and utilities are acting as charging service providers.

Electric utility distribution companies – Both public and private utilities provide a connection to the grid and supply power for charging EVs.

Therefore, it is extremely necessary to have synchronous coordination between these four main stakeholder groups. This means that large state investment is necessary for the development of EV infrastructure. The reality in Viet Nam has proven that some companies have failed to implement their charging infrastructure development plans because they do not have sufficient financial resources and lack cooperation.

4.4. Summary

Although EV demand potential in Viet Nam is significant, many barriers and threats to e-mobility adoption still exist. From the point of view of transport operators, the major existing barriers which limit the current expansion of the EV market are charging problems, the lack of EV services, the lack of support and incentives as well as the lack of standards relating to EVs. In terms of policy, Viet Nam currently does not have a specific policy framework for e-mobility development, except the recent Government Resolution 55/NQ/TW. In addition, Viet Nam has neither tax incentives nor price subsidies for EVs. Besides import duties, EVs shipped to Viet Nam are subject to special consumption tax rates ranging from 15-70%, thus forcing EV prices up by 20%.

At present, Viet Nam lacks EV charging infrastructure, one of the biggest barriers to e-mobility development. Regarding the recall of waste batteries in Viet Nam, most industrial facilities that manufacture, import and distribute the batteries have not been able to comply with the regulations in Viet Nam. This has crucially diminished the environmentally friendly attribute of EVs.

The survey results have demonstrated that the share of EV ownership in the districts of Hanoi only reached about 12.2% (only including E2Ws). 78.4% of the current EVs have been used for under 3 years. The demand for EVs is still low; about 74.2% of the people surveyed do not intend to buy EVs in the

future. Many young people are interested in buying electric cars, but only after 5 years. In addition, important criteria that vehicle owners keep in mind when buying EVs are: (i) the price of EVs; (ii) the travel distance per each full battery charge; (iii) safety; and (iv) environmental issues.

The SWOT analysis clearly presented the strengths, weaknesses, opportunities and challenges of the development of e-mobility in Viet Nam as follows:

- Strengths: The renewable energy industry in Viet Nam is flourishing, and therefore will strongly support e-mobility development in reducing pollution and GHG emissions. Therefore, Viet Nam can easily achieve the goals as set out in its NDC. In addition, using EVs is energy efficient and saves operating costs. Thereby, the development of EVs will contribute to reducing the pressure on non-renewable resources, which are gradually becoming scarce and exhausted.
- Weaknesses: Currently, investment in the development of e-mobility in Viet Nam is still weak; the cost of EVs and their batteries is still high; charging times are long while there are only a few pilot public charging stations. Also, trained manpower is still limited.
- Opportunities: The participation of Viet Nam in the Paris Agreement on climate change creates a good opportunity for e-mobility development in the country. Consumers' environmental awareness has been raised and the demand for private car ownership is still high – both create opportunities to expand the EV market in Viet Nam. In addition, Viet Nam has a 220V grid system, which makes it easy for owners to charge EVs at home.
- Challenges: The lack of support and incentive policies from the government is a key challenge when EV infrastructure development requires large state investment. The issues related to clean energy, recovery and/or disposal of waste batteries as well as scepticism about EVs are considerable challenges for e-mobility adoption in Viet Nam.

5. EVALUATION CRITERIA FOR THE SELECTION OF E-MOBILITY PILOT CITIES

5.1. Proposing evaluation criteria

There have been several approaches to evaluate readiness for the development of e-mobility at the country and city levels. For example, Schickram and Lienkamp (2013) developed the E-mobility Potential Index (EMPI) to evaluate the potential of EVs in cities with various quantitative parameters. Five criteria are introduced:

1) EV consumption
2) Environmental impact
3) EV costs
4) Infrastructure
5) Socio-Demographic condition

This approach is purely based on quantitative data (Appendix 2).

In 2019, ADB published a report "E-Mobility Options for ADB Developing Member Countries" to review the EV market and assess the potential of EV projects (Grütter and Kim, 2019). Experts used a group of indicators in order to make a preliminary assessment of the electric mobility potential in developing countries, including market expansion, GHG impact, local pollution impact, financial conditions and policy (Grütter and Kim, 2019). This method used both qualitative and quantitative methods to measure the particular interest of countries to promote EVs.

In this study, due to a great limitation regarding data availability, especially EV statistics, the indicators will be utilised from the EMPI and the key findings from the aforementioned ADB's 2019 report will be used to provide a higher level of insight into the potential and effects of introducing EVs in particular cities. This may help EV makers and local governments make the right decisions in order to realise sustainable solutions for individual mobility in selected cities.

This section evaluates to what extent Vietnamese cities are prepared to move toward e-mobility and identifies barriers that exist for a sustainable transition. The analysis is based on 23 indicators and sub-indicators formed by questions and sub-questions. The indicators assess the city-enabling framework in five dimensions: (i) Potential market; (ii) Pollution situation; (iii) Economic condition; (iv) Policy; and (v) Stakeholder inclusion (see Figure 5.1). Indicators track characteristics of the enabling environment for EV deployment as well as the degree of civil society involvement in investment.

Figure 5.1. Dimensions of the Enabling Environment for Electric Mobility Transition

This study gives three levels: "High", "Medium", and "Low" for each evaluated city through a series of lead questions and quantitative measurement. Cities ranking medium show acceptable boundary conditions and therefore have the potential for a sustainable and successful introduction of EVs. Table 5.1 shows the indicators used for each dimension.

Table 5.1. List of indicators and lead questions

Indicator	Lead Question
Dimension I – Potential market	
1) Number of electric 2-wheeler (E2W) ownership	Does the city stay above E2Ws per 100 inhabitants equivalent to the current Viet Nam average?
2) Number of electric four-wheeler (E4W) ownership	Does the city stay above E4Ws per 100 inhabitants equivalent to the current Viet Nam average?
3) Existence of charging system for EVs	Does the city have public charging system for EVs or plans to install one?
4) Number of projects related to EVs	Does the city have a plan or deploy projects related to EVs?
Dimension II – Pollution Situation	
1) Air quality	Does the city have high air pollution?
2) Impact of current EVs on GHG emissions	Have GHG emissions been significantly reduced by EV penetration rate?
Dimension III – Economic Conditions	
1) GRDP per capita	Does the city stay above GRDP per capita compared to the current country average?
Dimension IV – Policy	
1) Climate change policy	
1.1. GHG emissions trajectory	Will the city's per capita emissions in the BAU scenario for 2030 stay below Viet Nam's per capita emissions?
1.2. Existence of GHG emissions reduction targets	Does the city have binding emissions reduction targets?
1.3. Strength of GGH emissions reduction targets	Does the city plan to stay below emissions levels equivalent to Viet Nam's current plan?
1.4. Action plan for GHG mitigation	Does the city have an action plan to implement climate mitigation targets?
2) Air pollution reduction polity	
2.1. Existence of air pollution reduction targets	Does the city have binding air pollution reduction targets?
2.2. Action plan for air pollution reduction	Does the city have an action plan to implement air pollution reduction targets?
3) Clean energy policy	
3.1. Political focus of clean energy policy	Does the city government consider decarbonisation a main political priority in its clean energy policy?
3.2. Energy efficiency targets in transport	Has the city government set energy efficiency targets?

Indicator	Lead Question
3.3. Renewable energy targets by source	Has the city government set targets for renewable energy technology (hydropower/bio/CNG/electric)?
4) Subsidy policy for environmental friendliness vehicles	
4.1. Operational subsidies for transport operators using clean energy vehicles	Does the city have a commitment or plan to subsidise the operation costs of clean energy vehicles?
4.2. Electricity subsidies	Does the city commit to or plan to reduce the electricity price for the charging system?
4.3. Support for loan interest	Does the city commit to or plan to support loan interest rates for the EV fleet?
4.4. Exemption from registration fees (clean-energy vehicles)	Does the city commit to or plan to exempt registration fees for EV fleets?
4.5. Financial incentives for EV charging stations	Does the city commit to or plan to support charging stations?
Dimension V – Stakeholder Inclusion	
1) Organisation activity in e-mobility	Does the organisation predominantly engage with e-mobility issues?
2) Openness of the EV market	Are citizen groups or small enterprises active in e-mobility?

The evaluation criteria proposed above are in accordance with the availability of data in Viet Nam, so they can easily be applied to assess the readiness of cities in Viet Nam for developing e-mobility. These criteria can also be easily used to identify existing barriers to a sustainable transition.

5.2. Interpreting the evaluation criteria

5.2.1. Dimension I: Market potential

The potential market for EVs is defined as a significant market share of EVs in line with good public charging infrastructure, resulting in faster market adoption. It is measured through four indicators including E2Ws, E4Ws, availability of charging systems and the number of projects related to EVs. The following is a detailed explanation of each indicator.

5.2.1.1. Electric two-wheeler ownership

By product, the E2W market is dominated by e-scooters, e-bikes and e-motorcycles. In accordance with TDSI (2018) cited from the NTSC, there were a total of 1,075,630 e-motorcycles in 2018.

E2W ownership (E2WO) is one of the most important indicators in defining the availability of e-mobility in each city. Almost all the selected cities have E2WO higher than that in Viet Nam, which is a good sign for EV potential in these cities (see Figure 5.2).

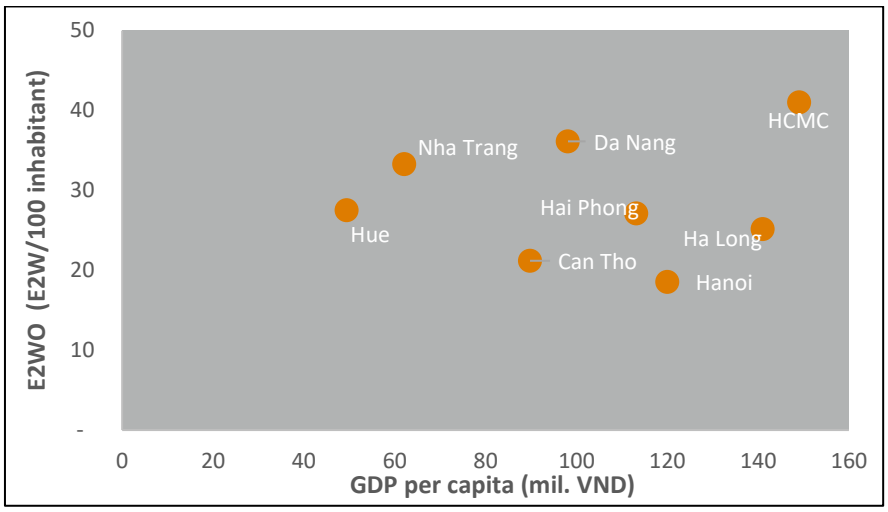


Figure 5.2. E2W ownerships and GRDP per capita in the selected cities

(Source: Adapted from different sources)

(Note: The GRDP of Hue, Nha Trang and Ha Long were derived from provincial GRDP)

5.2.1.2. Electric Four-Wheel Vehicles

In this study, E4W vehicles consist of electric buses and tourist electric four-wheel vehicles. The relationship between E4W ownerships and GRDP per capita in the selected cities is presented in Figure 5.3.

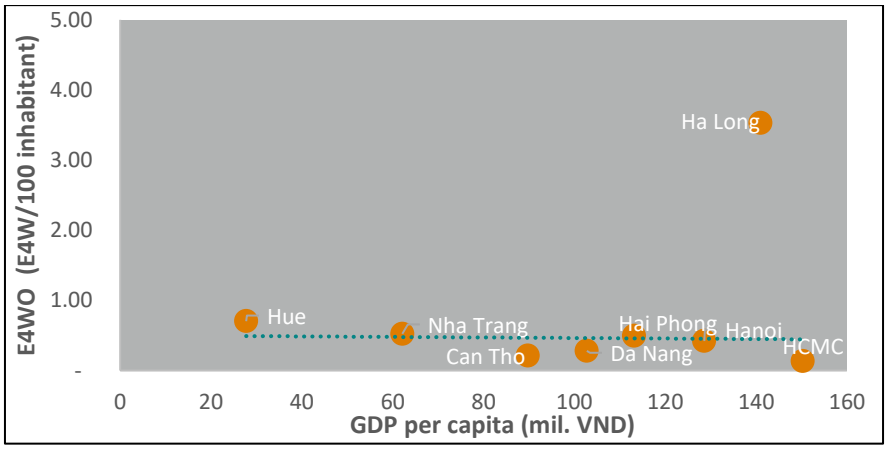


Figure 5.3. E4W ownerships and GRDP per capita in the selected cities

(Source: Adapted from different sources)

(Note: The GRDP of Hue, Nha Trang and Ha Long were derived from provincial GRDP)

5.2.1.3. Charging infrastructure

The availability of charging stations is another important indicator to evaluate the development of EVs. For E2Ws, more than 200,000 charging stations have been put into operation to serve E2V VinFast products, they are plotted mainly in Hanoi and Ho Chi Minh City. Most E2Ws are charged at home or at the workplace.

For E4Ws, only several pilot projects have been deployed in Hanoi and Da Nang. Currently, VinFast has focused on electric buses in the two largest markets of Hanoi and HCMC and plan to build depots with charging stations.

With the data provided from prevailing publications, it can be seen that all cities have a shortage of public charging stations for EVs.

5.2.1.4. Number of projects related to electric vehicles

Recently, there has been a focus on promoting EVs in several cities. In 2019, IFC conducted a project on e-buses for Ho Chi Minh City. The objective of this study is to help HCMC explore the potential implementation of e-buses through a commercial analysis and a phased adoption programme starting with a pilot phase.

At the same time, Hanoi is planning to restructure the bus network around Metro line 3, in which three bus routes will be selected for electrification with a total of 60 electric buses.

In 2020, another project was funded by ADB focusing on last-mile logistics. The project outcome is to reduce emissions and local pollutants by using electric last-mile delivery vehicles. The pilot project will be developed primarily in Hanoi, Hai Phong and Hue in 2021. Since 2016, Hai Phong has also piloted electric 4-wheeler vehicles and electric buses.

5.2.2. Dimension II: Pollution Situation

Pollution threatens the health of people. In Viet Nam, around 60,000 deaths each year are air pollution-related (WHO, n.d.). Electric vehicles have no direct or combustion emissions, and not only reduce GHG emissions but also reduce local pollutants, including particle matter, nitrogen oxide, and sulphur dioxide. Clean air in cities is not achievable with the use of diesel vehicles. Therefore, the more pollution the city has, the higher potential e-mobility measures should be applied.

In addition, if GHG emissions reduction is not significant due to a small EV penetration rate, an increase in EV size is needed.

5.2.2.1. Air Pollution

Several cities in Viet Nam are struggling with alarming levels of air pollution. The two biggest cities, Hanoi and Ho Chi Minh City, are now among the top 15 polluted cities in Southeast Asia {IQAir. n.d.}. Air pollution levels can be assessed using the air quality index (AQI) as illustrated in Figure 5.4. The meanings of AQI values domains are shown in Figure 2.11. Some web sources or applications that can be used to look up AQI data for cities are:

- Moitruongthudo.vn
- Cem.gov.vn
- vn.usembassy.gov
- Epa.gov
- Hanoi smart city
- Pam air
- Airvisual
- Airnet
- Envisoft
- Aqicn
- Windy
- BreezoMeter
- Google maps
- Google earth

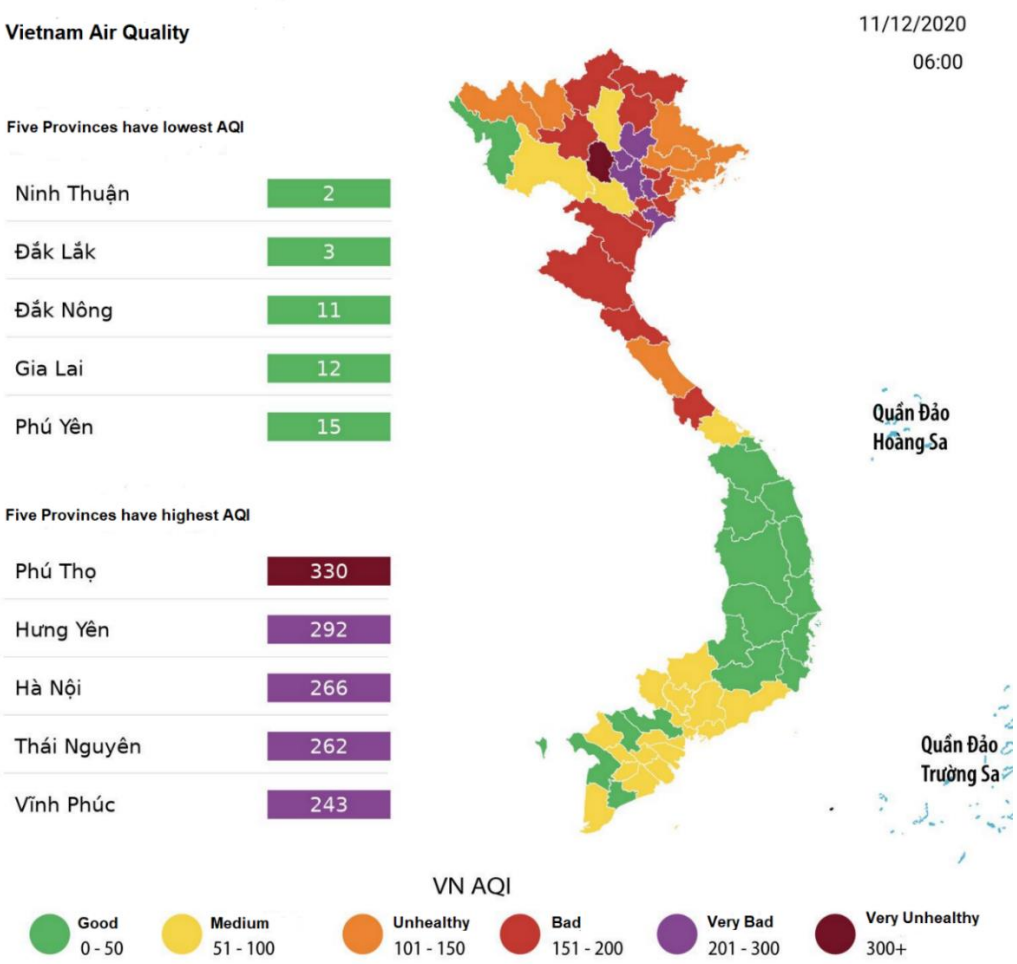


Figure 5.4. Air Quality by province and city, 2020

(Source: PAMair, 2020)

5.2.2.2. Impact of current EVs on GHG emissions

To evaluate the impact of current EVs on GHG emissions in each city, one indicator for comparing the well-to-wheel (WtW) CO_2 emissions between battery EV (BEV) and internal combustion engine vehicles (ICEV) is adapted from Schicram et al. (2013). Not considered in this evaluation are environmental impacts due to the production and recycling of vehicles. Urban transport modes are taken into account, which consist of passenger cars, taxis, motorcycles, urban buses and urban delivery trucks. Heavy trucks and intercity buses are eliminated due to their extended journeys.

The results show that Hanoi and HCMC can reduce their GHG emissions more than other cities, but the overall reduction is negligible. Therefore, these cities need to strive for solutions that encourage e-mobility.

Table 5.2. GHG impact of all vehicles

GHG impact	Hanoi	HCMC	Hai Phong	Da Nang	Can Tho	Hue
Emissions with ICEV (tons)	6.651.135	6.384.451	1.318.179	758.545	410.874	320.037
Emissions with EVs (tons)	6.641.138	6.376.864	1.317.401	758.089	410.607	319.912
Reduction (%)	0.15%	0.12%	0.06%	0.06%	0.06%	0.04%

5.2.3. Dimension III: Economic Condition

It was found that economic conditions have influenced early adopters of EVs (Deloitte, 2011). Therefore, GRDP per capita is favourable for the successful introduction of EVs. An average GDP per capita and average household expenditure for vehicle ownership at the national level will be used as reference levels. Cities with a higher rate of GRDP per capita compared to that of the country will have greater potential to transition to EVs.

5.2.4. Dimension IV: Policy

Dimension IV is described by three indicators and twelve sub-indicators. Addressing climate change is the main driver for renewable energy policy and policies promoting low-carbon transport.

This section evaluates what extent cities are prepared to move towards electric mobility to fulfil the country's objectives. The indicators assess the city-enabling framework in four indicators: (i) climate change policy; (ii) air pollution policy; (iii) clean energy policy; and (iv) e-mobility subsidies. Detailed explanations of each indicator are presented in the following sections.

5.2.4.1. Climate Change policy

Emissions data and business-as-usual (BAU) scenarios were published in the Updated Nationally Determined Contribution (updated NDC) in 2020. Viet Nam's GHG emissions in 2014 were 2484 $MtCO_2e$ (including LULUCF) and per capita emissions were 2,84t CO_2e. Between 2010 and 2014, Viet Nam reduced emissions by 10.5 $MtCO_2e$ by implementing a series of policies focusing on energy-saving and energy efficiency.

The analysis of dimension IV highlights that with respect to the GHG emissions trajectory, current scenarios show a significant increase in carbon emissions and therefore a sustainable path would require counteractions.

The Vietnamese Government is concerned about climate change and has expressed the willingness to tackle emissions nationally in its National Climate Change Strategy (NCCS, 2011), Vietnamese Green Growth Strategy (VGGS, 2012) and its updated NDC (2020), and has formulated emissions reduction targets. According to the VGGS, overall emissions are supposed to be cut without international assistance by 1.5-2%/year from 2020 until 2050 compared to BAU, which would lead to an increase of Viet Nam's emissions to 391 $MtCO_2e$ by 2030. The internationally communicated pathway by the updated NDC in 2020 is more conservative and states that by 2030 Viet Nam will reduce its BAU-GHG emissions of 927.9 $MtCO_2e$ by 9%, which would result in 844 $MtCO_2e$.

Sub-indicators used to measure climate change policy indicators include: GHG emissions trajectory, the existence of GHG emissions reduction targets, the strength of GHG emissions reduction targets, and action plans for GHG mitigation.

5.2.4.2. Air pollution reduction policy

In order to control air pollution, respond to climate change, and implement the Law on Environmental Protection 2014, the Prime Minister issued Decision No. 985a/QD-TTg dated 1 June 2016, approving the National Action Plan on air quality management to 2020, with a Vision to 2025.

Synchronising with solutions to control air pollution and reduce GHG emissions, a number of localities have issued policies to encourage and support the development of environmentally friendly modes of transport to reduce emissions.

The sub-indicators used to measure the air pollution policy indicator include:

- Existence of air-pollution reduction targets for PM_{10} and $PM_{2.5}$
- Action plan for reducing PM_{10} and $PM_{2.5}$

5.2.4.3. Clean Energy Policy

In the long term, Viet Nam will move towards a renewable energy transition that will probably be supported by intelligent use of fossil fuels, natural gas, hydro or electricity which is a low-carbon dispatchable source. Several selected cities are seemingly interested in this field.

The sub-indicators used to measure clean energy policy indicators are:

- The political focus of clean energy policy
- Energy efficiency targets in transport
- Renewable energy targets by source

5.2.4.4. Subsidy policy for environmentally friendly vehicles

This indicator covers the situation of e-mobility incentives and is described by five sub-indicators.

There is no financial support from either central or local government on electricity prices for charging systems.

In terms of financial incentives for the EV fleet, it is observed that some cities are finding solutions to promote clean energy vehicles. For example, Hanoi, Hai Phong, HCMC, Can Tho and Nha Trang provide support for loan interest rates for public transport operators but only Hanoi and HCMC have provided them in practice.

In addition, all cities have a plan to exempt registration fees for clean-energy vehicles but they have not been implemented, except in Hanoi and HCMC.

The sub-indicators used to measure clean energy policy indicators are:

- Operational subsidies for transport operators that use clean energy vehicles
- Electricity subsidies
- Support for loan interest
- Exemption from registration fees (clean-energy vehicles)
- Financial incentives for EV charging stations

5.2.5. Stakeholder inclusion

There is generally an environmental consciousness among civil society but there are only a limited number of organisations that are specifically active in the field of e-mobility. Most civil society movements have been active around the negative consequences on the environment.

Currently, several international organisations are interested in e-mobility in Viet Nam. For example, UN Environment is currently active in Viet Nam on the introduction of electric two and three-wheelers as well as electric light-duty vehicles. The World Bank, ADB, GIZ and JICA are also interested in promoting e-mobility in Viet Nam. However, the involvement of these organisations is still not focused at the city level.

5.3. Reference value to rate the level of proposed evaluation criteria

The indicators result in a "High" or "Medium" or "Low" evaluation for e-mobility transitions. Several of these indicators require a benchmark to be meaningful. National indices and databases were used as a means of comparison.

Table 5.3. List of benchmarks for the indicators

Indicator	Benchmark	Data sources
Dimension I – Potential Market		
1) Number of E2W ownership	E2W ownership per 100 inhabitants is 1.3% in Viet Nam.	NTSC (2019) and different sources
2) Number of electric four-wheeler (E4W) ownership	E4W ownership per 100 inhabitants is 0.15 in Viet Nam.	MOT (2020)
Dimension III – Economic Condition		
1) GRDP per capita	Viet Nam nominal GDP per capita in 2014 was 43,402,444 VND.	GSO website
Dimension IV – Policy		
1) Climate change policy		
1.1. GHG emissions trajectory	Viet Nam's GHG emissions in the base year 2014 were 284 $MtCO_2e$, equivalent to 3.13 tCO_2e per capita. By 2020, Viet Nam's GHG emissions will reach 927.9 tCO_2e.	Viet Nam Government (2020), Updated NDC
1.3. Strength of GHG emissions reduction targets	Viet Nam's GHG emissions from the transport sector in the base year 2014 were 0.343 tCO_2e per capita. Carbon emissions from transport per capita rise sharply to 0.824 tCO_2e in 2030.	World Bank and GIZ (2019)

Table 5.4 Reference values to rate the readiness level for e-mobility adoption in a pilot city

Measure/criteria			The value range for different levels					
			Low		*Medium*		*High*	
Measure	Criteria	Sub-criteria/unit	Value	Point	Value	Point	Value	Point
Market potential	Electric two-wheeler ownership	Number of E2W/1000 people	< 20	1	20-40	2	> 40	3
	Electric four-wheeler ownership	Number of E4W/1000 people	< 1	1	1-5	2	> 5	3
	Charging system for EVs	Qualitative	No	1	Yes, but not popular	2	Popular	3

	Number of projects related to EVs	Number of potential projects	No	1	Yes, only 1-2 projects	2	Yes, higher than 2 projects	3
Air pollution situation	Air quality	Air quality index (AQI)	< 100	1	100-150	2	> 150	3
	Impact of current EVs on GHG emissions	tCO_2e reduction	< 2%	1	2-5%	2	> 5%	3
Economic conditions	GRDP per capita	Average GRDP of city /Average GRDP of nation	1-1.5	1	1.5-2	2	> 2	3
Policy	Climate change policy	GHG emissions trajectory	NA	1	LM	2	M	3
		Existence of GHG emissions reduction targets	NA	1	LM	2	M	3
		Strength of GHG emissions reduction targets	< 5%	1	5-10%	2	> 10%	3
		Action plan for GHG mitigation	NA	1	LM	2	M	3
	Air-pollution reduction policy	Existence of air-pollution reduction targets	NA	1	LM	2	M	3
		Action plan for air-pollution reduction	NA	1	LM	2	M	3
	Clean energy policy	Political focus of clean energy policy	NA	1	LM	2	M	3
		Energy efficiency targets in transport	NA	1	LM	2	M	3
		Renewable energy targets by source	NA	1	LM	2	M	3
	Subsidy policy for environmentally friendly vehicles	Operational subsidies for transport operators using clean energy vehicles	NA	1	M	2	I	3
		Electricity subsidies	NA	1	M	2	I	3
		Support for loan interest	NA	1	M	2	I	3

		Exemption from registration fees (clean-energy vehicles)	NA	1	M	2	I	3
		Financial incentives for EV charging stations	NA	1	M	2	I	3
Stakeholder inclusion	Organisations' activity in e-mobility	Number of organisations active in e-mobility	NA	1	1-5 organisations	2	> 5 organisations	3

(Note: NA – not available; LM – mentioned but very little; M – mentioned a lot but not implemented; I – implemented)

Application of the proposed evaluation criteria for assessing cities is given in Appendix 3 through an example of a pilot city (city A). Accordingly, the readiness level for e-mobility development of city A has been evaluated according to each individual scale, including: (i) Market potential; (ii) Pollution situation; (iii) Article economic events; (iv) Policy; and (v) Stakeholder involvement.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Viet Nam has been committed to addressing both climate change mitigation and adaptation since 2016 through signing the Paris Agreement. The content of Viet Nam's NDC has been comprehensively reflected in its corresponding plans, which identify the tasks requiring the most ambitious and continuous efforts in line with national conditions and adjustments of Viet Nam's commitments to implement the Paris Agreement, which are geared towards a low carbon and climate-resilient economy. In 2020, the Vietnamese Government reviewed and updated its NDC based on the actual country context. In the updated NDC, Viet Nam will have reduced its GHG emissions by 9% compared to the BAU scenario (the base year of 2014) by 2030 with its own domestic resources. This contribution can be raised to 27% with international support through bilateral as well as multilateral cooperation and the implementation of new mechanisms under the Paris Agreement.

In Viet Nam, the transport sector plays a critical role in the socio-economic development with its GDP contribution reaching about 2.78% in 2019. The country's vehicle fleet has been rapidly growing at an annual growth rate of about 13.7% and 9% for automobiles and motorbikes, respectively. With these growth rates, Viet Nam has a high traffic density with more than 3.2 million automobiles and 36.6 million motorbikes in circulation in 2018. Motorcycles are the main means of transport in Viet Nam, reaching about 92% of the total vehicle fleet in circulation. The fast growth rate of road vehicles has exerted negative impacts on the environment and life quality. In fact, the transport sector has been

identified as one of the main emissions sources causing air pollution with a CO_2 emissions annual growth rate of 6 to 7%. Therefore, the transport sector is one of the key sectors targeted to achieve the climate change mitigation goals.

In recent years, Viet Nam has been promoting EV development as a potential solution for reducing GHG emissions as well as for reducing the pressure on fossil fuel sources in the transport sector. Setting up a clear roadmap for EV adoption in Viet Nam in the period 2020-2030 (e.g. achieving 30% of E2Ws in the motorbike fleet by 2030; 5% sales share for EVs in 2025 and a 30% share in 2030; and a 10% sales share for EV buses in the period from 2020 to 2030) Viet Nam can achieve a reduction of CO_2 emissions in the transport sector of 20% by 2030 compared to BAU. This clearly shows the high potential of GHG emissions reduction through EV development in the transport sector in Viet Nam. However, e-mobility is still at a very early stage in Viet Nam. There is no specific policy framework on the deployment of EVs and their charging infrastructure except the recent Resolution 55/NQ/TW by the Communist Party of Viet Nam issued on 11 February 2020, which provides Guidelines for National Energy Development Strategy until 2030 with a Vision to 2045. In this Resolution, support policy for consumers to use clean and renewable energy is mentioned, especially in the industry and transport sectors. This is the first time an official national document has been promulgated which refers to promoting EV development in line with the global trend. Therefore, it is necessary to support the development and improvement of regulations on e-mobility in Viet Nam.

The main goal of this assessment is to review and examine existing sustainable transport policies with a brief overview of air pollution in Viet Nam and its cities. In addition, current issues and challenges with regards to e-mobility development are also identified in order to develop and improve the regulatory framework at both national and local levels. The approach used to achieve the goals above is presented in Figure 6.1.

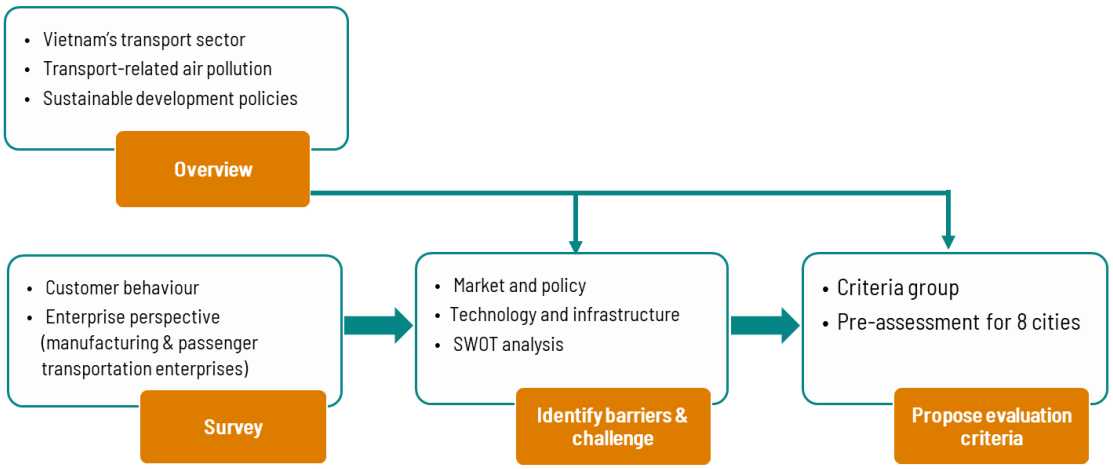


Figure 6.1 Summary of main activities

To achieve these goals, official documents were gathered to provide deeper insights on sustainable transport development policies, vehicle fleet characteristics, and transport-related air pollution as well as current e-mobility development. It was found that Viet Nam promoted sustainable transport policies through national strategies and action plans of three key categories including: sustainable development, green growth, and climate change with the first national strategy being the National Climate Change Strategy in 2011. At the local level, the assessment focused on five central-level cities and three others, including Ha Long, Hue and Nha Trang. Most selected cities promulgated their own action plans in conformity with national strategies and action plans. However, the orientation of EV development was only included in the Green Growth and/or Climate Change strategies in eight selected cities. Most of these cities have included the orientation of EV development in the Green Growth Strategy, except for Da Nang and Ho Chi Minh City. Inclusion of EV development in the Climate Change Strategy was only deployed in five out of eight selected cities, not including Hanoi, Can Tho, or Hue. At the present time, only two out of the eight selected cities have set up detailed targets for EV development; for example, the number of e-motorcycles reaching 5% of the total motorcycles by 2030 in Hanoi; the goal of having 200 e-buses in circulation by 2025 in Nha Trang.

EV market

The EV market in Viet Nam is in its infancy. Until now, only e-bicycles and e-motorcycles have been widely used and some have been produced locally. Current E2W sales in Viet Nam are about 500,000 units per year with an annual growth rate of around 30%. Previously, the E2W market was dominated by imported vehicles. However, domestically assembled E2Ws have been increasing strongly since the end of 2018 with the participation of a local enterprise, namely VinFast. Currently, VinFast is the only local enterprise producing and assembling EVs, including electric 2/4-wheeler vehicles. Electric 3/4-wheelers are primarily low-speed and imported from China for transporting visitors within hotel compounds, resorts, golf courses, and tourist cities. Other than the aforementioned electric 3/4-wheelers, there are no electric cars in circulation in Viet Nam at present.

The market for e-mobility development in Viet Nam in the upcoming years is promising. The estimated EV share in Viet Nam is always higher than other countries in Southeast Asia, and only lower by -10% to -33% in comparison to the global rate.

Consumer behaviour

A survey was conducted to gather statistical information about consumer behaviour and enterprises' perspectives towards e-mobility in order to gain consumer insights and the likelihood of purchases. Questionnaires were meticulously designed for each subject group surveyed including customers, enterprises, and managers.

Findings on consumer behaviour suggested that E2Ws only accounted for nearly 14% of the total two-wheelers in circulation. Most e-bikes and e-motorbikes in circulation have been used for less than 3

years, reaching 78.4%. In which, most EVs are used by teenagers to go to school (44.3%). EV ownership demand is also significantly different between males and females; specifically, females have higher e-bike ownership demand. 85.9% of EV users selected EVs equipped with lead batteries instead of choosing ones equipped with lithium-ion batteries due to the low price of lead batteries. 93.8% of EV owners charged their EV batteries at home with an average duration for a full charge at around 6.4 hours. The biggest concern of consumers is the EV price (75.7%) followed closely by range per full charge (52.2%). The key criteria to consider when buying an EV for customers in Viet Nam are: (i) price of vehicle; (ii) total range when fully charged; (iii) safety; and (iv) environmental problems.

Barriers

Barriers to EV adoption in Viet Nam were identified based on desk research as well as surveys. Charging infrastructure, specific legal frameworks, and policies relating to e-mobility are the biggest barriers to EV adoption in Viet Nam.

Charging infrastructure for EVs is seriously lacking for both E2Ws and electric four-wheelers. Up to now, the number of rapid-charging stations for E2Ws is still very low in Viet Nam. Most E2Ws are charged at home or at the workplace; there are no public rapid-charging stations in Viet Nam. The lack of charging infrastructure has been negatively impacting the EV market. Therefore, the EV market will only make limited progress unless the Vietnamese Government develops a comprehensive plan for building an EV charging network.

In addition, there are no EV-specific legal frameworks or policies relating to e-mobility development in Viet Nam. It is clear that tax and tariff policies have a powerful effect on vehicle selection, including EVs. EVs originating from ASEAN, South Korea and China are exempted from tariffs, while Japanese cars face a 4% tariff. Tesla cars from the US are taxed at 70% under Most Favoured Nation treatment. Besides import duties, EVs shipped to Viet Nam are subject to special consumption tax rates ranging from 15-70%, thus forcing prices up by 15-20%.

Barriers that prevent consumers from choosing EVs include (in order of decreasing importance): the high price of EVs (66%); limited range per charge (60.8%%); safety issues (48.8%); long charging time (28.5%); lack of accompanying support services (23.2%); and others (e.g. lack of product information, habit of not using new products, EV design).

Opportunities

A SWOT analysis was performed to identify strategic goals and directions for developing EVs in Viet Nam. This analysis showed that besides the barriers mentioned above, there are many opportunities to enlarge the EV market in Viet Nam:

- Viet Nam signed the Paris Climate Change Agreement in which the government committed to reducing GHG emissions by at least 9% compared to BAU in 2030. This is also a good opportunity to expand the EV market in Viet Nam. With the current proportion of BEVs in the road vehicle fleet, GHG emissions efficiency has already reached 0.04% to 0.15%.
- Viet Nam applied the 0% import tariff for accessories and spare parts for car manufacturing. This contributed to promoting domestic vehicle manufacture.
- Recently, the Ministry of Finance suggested cutting tariffs levied on e-cars with less than nine seats to 50% from the previous 70% in order to boost the local EV market.
- Viet Nam has a 200-plus-volt grid system; thus, it is easy for EV owners to charge EVs at home. Public rapid charging stations can also be set up.
- Customer awareness of conventional vehicle-related air pollution is increasing; i.e. 97.8% of respondents were aware of the issue. This is a good opportunity for EV suppliers to exploit and expand their EV market.
- Viet Nam is a promising market with high private vehicle ownership demand, at 95% and 76% for 2-wheelers and cars, respectively.
- There are currently almost no competitors.

Proposed evaluation criteria

In order to evaluate to what extent Viet Nam's cities are prepared to move towards e-mobility and to identify barriers that exist for a sustainable transition, 23 indicators and sub-indicators were selected. The indicators assess the city-enabling framework in five dimensions:

(1) Potential market:	4 indicators
(2) Pollution situation:	2 indicators
(3) Economic condition:	1 indicator
(4) Policy:	14 indicators
(5) Stakeholder inclusion:	2 indicators

With the current inevitable trend for EVs coupled with the Vietnamese Government's efforts in promoting low-carbon transport development, Viet Nam is a promising market for EVs.

6.2. Recommendations

The ultimate goal in using EVs is for them to be fully powered by alternative and renewable energy sources. Therefore, it is necessary to increase the share of renewable energy (e.g. solar or wind energy) in the national power system.

In the current context of Viet Nam, HEVs should be considered an interim step and intermediate vehicle before transitioning all internal combustion engine-based vehicles to EVs. For cities with large populations and land scarcity for infrastructure, small-sized EVs should be widely used because they have been proven to save energy and parking space. In addition, it is essential to develop a specific strategy to manage and control the smart grid when demand for EVs is increasing.

Based on the experience of leading countries, policies aiming to create a steady foothold for EVs in the market should not only concentrate on consumers. Instead, these policies should aim at niche markets such as the car-sharing market and postal fleets, and/or focus on green consumers. The fact is that EV-related policies are more effective in achieving social benefits when they are focused on green consumers and niche markets that have already been utilising suitable management strategies, accessible loans and financing, and appropriate incentives.

For cities, it is necessary to have clear steps for developing and expanding the e-mobility market. The development of transportation infrastructure should be the priority, followed closely by technology and EV standards.

In addition to promoting the development of the EV market, the government also needs to manage waste batteries closely in order to guarantee that e-mobility is an eco-friendly choice. Recall and recycling of EV waste batteries will not only avoid a huge burden on landfills, but it will also help manufacturers secure the supply of critical materials, such as cobalt and lithium. This plays an important role in maintaining a sustainable automotive industry.

In short, as soon as possible, Viet Nam needs to have a clear, adequate and comprehensive e-mobility policy and regulatory framework that provides medium- and long-term stability for the planning of significant future investments.

APPENDICES

Appendix 1. Survey methodology

Objectives of the study

The objective of the survey is to better understand owner's EV consumer behaviour and other related issues. The study also analyses the views and assessments of vehicle owners on difficulties and barriers to the development of an EV market in Viet Nam from the perspective of consumers and direct users of vehicles.

Methodology

An overview of the survey is presented in Figure A 1.

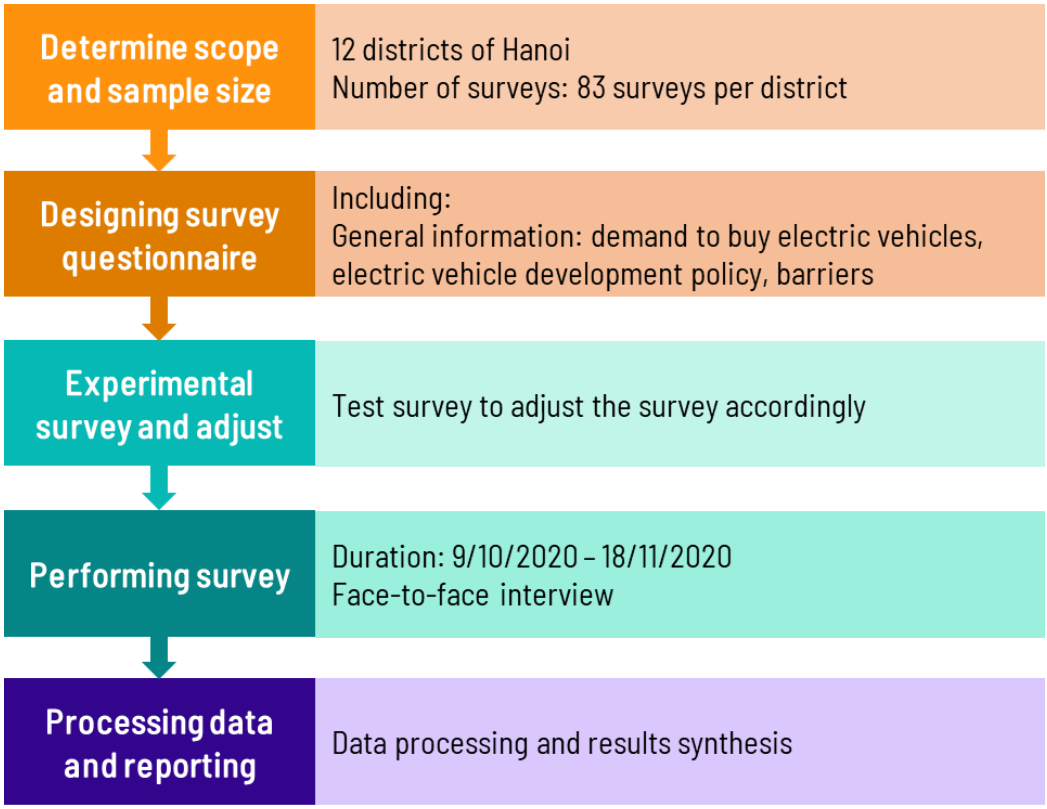


Figure A 1. Overview of the survey

Step 1 - Determine the minimum number of responses (sample size)

The survey is carried out in 12 districts of Hanoi (Ba Dinh, Tu Liem, Cau Giay, Dong Da, Hai Ba Trung, Hoan Kiem, Hoang Mai, Long Bien, Nam Tu Liem, Tay Ho and Thanh Xuan).

To determine the sample size, the consultant chose the second method of the two methods below:

Method 1: Determine the sample size without knowing the total quantity in advance

Determine the sample size by the following formula:

$$n = \frac{z^2(p.q)}{e^2} \quad (1)$$

Where:

n: Sample size
Z: distribution value corresponding to the selected confidence (if the confidence level is 95%, z-value is 1.96; confidence level is 90%, z-value is 1.64 ...)
p: the estimated percentage of the total quantity
q: = 1 - q
e: Sampling tolerance

Table A 1. Sample size with the confidence of 95%, sampling tolerance 1-10%

Sampling tolerance	Sample size
1%	9604
2%	2401
3%	1067
4%	600
5%	384
6%	267
7%	196
8%	150
9%	119
10%	96

Method 2: Determine the sample size when knowing the total quantity in advance

Determine the sample size by the following formula:

$$n = \left[\frac{1}{N} + \frac{N-1}{N} \frac{1}{P.Q} \left(\frac{k}{z_{1-\alpha/2}} \right)^2 \right]^{-1} \quad (2)$$

Where:

n: Sample size

N: Total quantity

P: is the estimated percentage of the total quantity. Usually, the ratio p and q are estimated at 50%/50%. That is the greatest possibility that could have happened overall Q:= 1-P

k: Sampling tolerance

$Z_{1-\alpha/2}$: Distribution value corresponding to the selected confidence (if the confidence is 95% then Z value is 1.96, if the confidence is 90%, the Z value is 1.64 ...).

On the basis of the above formula, build a sample size selection table with a confidence of 90% with sampling tolerance from 1-10% as follows:

Table A 2. Sample size determination with the confidence of 90%

Sample quantity	Sampling tolerance									
	1%	*2%*	*3%*	*4%*	*5%*	*6%*	*7%*	*8%*	*9%*	*10%*
300	287	255	214	175	142	115	94	78	65	55
400	378	323	261	205	161	128	102	83	69	58
500	465	386	300	229	175	136	108	87	71	59
600	551	442	333	247	186	143	112	90	73	61
700	634	494	362	263	195	148	115	91	74	61
800	715	542	387	276	201	152	117	93	75	62
900	794	586	408	287	207	155	119	94	76	63
1.000	871	627	428	296	212	158	121	95	77	63
2.000	1.542	914	544	347	237	171	128	100	80	65
3.000	2.075	1.078	598	369	247	176	131	102	81	66
4.000	2.508	1.184	630	380	252	178	133	102	81	66
5.000	2.868	1.258	650	388	255	180	134	103	82	66
6.000	3.171	1.313	664	393	257	181	134	103	82	67
7.000	3.430	1.356	675	397	259	182	135	104	82	67
8.000	3.654	1.389	683	399	260	183	135	104	82	67
9.000	3.849	1.417	690	402	261	183	135	104	82	67
10.000	4.021	1.439	695	403	262	183	135	104	82	67
20.000	5.032	1.551	720	412	265	185	136	105	83	67

Sample quantity	Sampling tolerance									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
30.000	5.493	1.592	729	414	267	186	137	105	83	67

From the table above and the number of vehicle owners (the first column on the left side of the table), select the sampling tolerance value and the number of vehicle owners to be surveyed can be found.

Selection of the sample size

Based on population information from the 2019 statistical yearbook in 12 districts of Hanoi: Ba Dinh, Bac Tu Liem, Cau Giay, Dong Da, Hai Ba Trung, Hoan Kiem, Hoang Mai, Long Bien, Nam Tu Liem, Tay Ho and Thanh Xuan. These are districts with specific populations. Therefore, sampling should be done according to the overall known sampling method. Within the scope of this project, the sample size is determined with 90% confidence and 9% sampling tolerance, so the number of vehicle owners for the survey in each district is 83 vehicle owners/district.

Table A 3. A sample size of the survey with 90% confidence and 9% sampling tolerance

District	Population	Confidence	Tolerance	Sample size
Ba Dinh	243.200	90%	9%	**83**
Hoan Kiem	153.000	90%	9%	**83**
Tay Ho	166.800	90%	9%	**83**
Long Bien	294.500	90%	9%	**83**
Cau Giay	280.500	90%	9%	**83**
Dong Da	422.100	90%	9%	**83**
Hai Ba Trung	311.800	90%	9%	**83**
Hoang Mai	443.600	90%	9%	**83**
Thanh Xuan	286.700	90%	9%	**83**
Nam Tu Liem	240.900	90%	9%	**83**
Bac Tu Liem	333.700	90%	9%	**83**
Ha Dong	353.200	90%	9%	**83**
Total	**3.530.000**	**90%**	**9%**	**996**

Step 2: Develop the survey questionnaire

The survey questionnaire is designed according to the TOR objectives of the project "Developing e-mobility policy mechanisms and roadmap for national and city levels."

The contents of the questionnaire for vehicle owners include 3 parts. Some terms and definitions were clarified by the research team in the questionnaire design process.

Table A 4. Structure of the questionnaire

No.	Question	Contents	Note
1	Part 1: General information of the vehicle owner	- General information of the vehicle owner: Gender, Profession, Age, Income, Education Level - Current state of vehicle ownership, main means of transport and characteristics of the use of vehicle	- Profession is a job that takes up a lot of time or generates the main income for vehicle owners. - The income of vehicle owners in the survey is the income at the time of the survey. - Educational level of the vehicle owner is the diploma/certificate recognised at the time of the survey. - Vehicle ownership means the vehicle owner is named in the vehicle registration certificate or is the person who has the right to own a vehicle. - Electric vehicle includes: electric bicycle, electric motorcycle and electric car. - One turn is your journey from point A to point B. - Using means of transport is the regular and continuous use of a means of transportation by the owner. - Vehicle owner's age is the current age of the vehicle owner.
2	Part 2: Survey of consumer behaviour	- Profession is a job that takes a lot of time or generates income. If the vehicle owner agrees to the purchase of an EV and related information when the vehicle owner buys an EV. Select criteria that are important to the purchase of EVs and evaluate their importance.	- The vehicle owner's willingness to purchase an EV is the vehicle owner's answer at the time of the survey.
3	Part 3: Survey about EV development policy in Viet Nam	To survey vehicle owners' perceptions on the barriers to the development of the EV market in Viet Nam and the willingness to purchase EVs by vehicle owners with expected support and incentives.	- Levels of support and discounts are compared with the price at the time of the survey.

Step 3: Testing of the survey and adjusting the questionnaire accordingly

Before the official survey, the research team conducted an experimental survey to review the questionnaire and correct it before conducting the official release.

Step 4: Conducting the survey

The official survey took place from 19 October 2020, to 18 November 2020. The surveyors conducted direct interviews with vehicle owners in 12 districts of Hanoi city. Interviews were conducted directly. Before the interviews, the surveyor told the interviewees the purpose, contents and information of the survey, and the commitment to confidentiality. Interviewees were informed that the survey results would only be used for the study not for commercial purposes, and that survey information would not be provided to third parties.

In addition to the direct survey, an online survey was also set up at https://www.surveymonkey.com/ to attract more vehicle owners to participate.

Step 5: Processing data and reporting

Survey data was entered and processed using excel software.

Appendix 2. EMPI – E-mobility Potential Index

Introduction

EMPI is a set of indicators developed by Schickram and Lienkamp (2013) to evaluate the potential development of BEV electric cars in major cities. In order to successfully introduce BEV into a city, not only does the population have to accept the new technology, the city itself has to be ready and provide supporting boundary conditions. In other words, deriving the key principles "sustainability", "user consent" and "readiness", the authors have proposed a set of performance evaluation indicators (KPIs) to evaluate the potential and the likelihood of success of EV projects in the city.

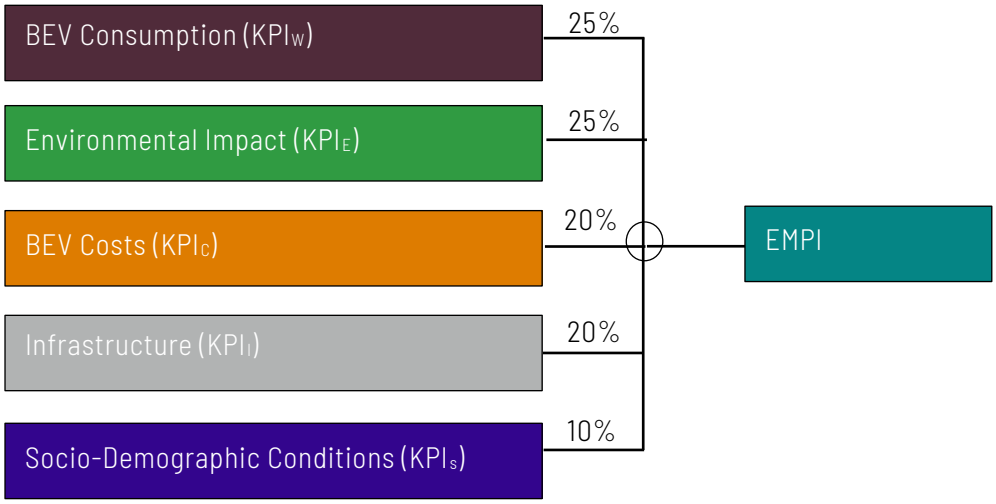
- The BEV Consumption (KPI_W): to successfully introduce BEV into a city, not only does the population have to accept the new technology, the city itself has to be ready and provide supporting boundary conditions.
- The Environmental Impact (KPI_E): analyses the global balance of CO2 emissions between the usage of BEV and internal combustion engine vehicles (ICEV) and locally respects any pressure for urgent improvements of the air quality due to pollution. Not considered in this evaluation are environmental impacts due to the production and recycling of the vehicles.
- The BEV Cost (KPI_C) gives an economic forecast for the introduction of BEV in each city by comparing the total cost of ownership (TCO) of a reference BEV and an equivalent ICEV.
- The Infrastructure indicator (KPI_I) gives an economic forecast for the introduction of BEV in each city by comparing the total cost of ownership (TCO) of a reference BEV and an equivalent ICEV.
- The Socio-Demographic Conditions (KPI_S) give an economic forecast for the introduction of BEV in each city by comparing the total cost of ownership (TCO) of a reference BEV and an equivalent ICEV.

Weight and Evaluation Standards

The weighting of the five KPI aims to reflect their influences on the mentioned key topics “sustainability”, “readiness” and “user acceptance”. KPI_W is considered a major KPI due to its direct influence on the range and costs of the BEV (further described in IV), which are of the highest importance to potential customers according to a worldwide survey conducted by Deloitte (2011). The KPI_E, clearly revealing the effects of BEV on the environment, is seen as another major KPI. Both KPIs together are therefore assigned a 50 % contribution to the EMPI, resulting in 25 % each. KPI_C and KPI_I are given a 20 % share each since they are considered to have equal importance, higher than KPI_S with 10 %.

The EMPI is defined as:

$$EMPI = 0.25 * (KPI_W + KPI_E) + 0.2\,(KPI_C + KPI_I) + 0.1KPI_s \quad (1)$$



The EMPI reveals an overall score between 0 and 100 for each evaluated city, with the critical value defined as 50. Only cities that exceed this value are considered to show acceptable boundary conditions and therefore the potential for a sustainable and successful introduction of BEV.

Table A 5. EMPI and performance indicators

Value	Indicator ability
100	Perfect
90	Excellent
80	Excellent
70	Good
60	Good
50	Acceptable
40	Improvements needed
30	Poor
20	Poor
10	Very poor
0	Extremely poor

BEV Consumption (KPI_W)

The overall energy consumption W_{BEV} is the sum of the consumptions for driving $W_{lái\ xe}$, heating/air conditioning W_{AC}, and auxiliaries

$$W_{BEW} = W_{lái\ xe} + W_{AC} + W_{hỗ\ trợ} \quad (2)$$

For the calculation of $W_{lái\ xe}$, an accurate simulation model is available. The necessary load for the heating and/or the air conditioning depends on the temperature, humidity, solar radiation and driving speed.

Having simulated the overall energy consumptions for all cities, the physically lowest possible value of $W_{BEV, min}$ = 13 kWh/100 km and the highest simulated value of $W_{BEV, max}$ = 33 kWh/100km are assigned to the indicator values 0 and 100. A consumption of $W_{BEV, 50}$ = 23 kWh/100 km is accepted. Thus, KPI_W can be described as follows:

$$KPI_W(W_{BEV}) = 50 \times \begin{cases} 1 + \frac{W_{BEV,50} - W_{BEV}}{W_{BEV,50} - W_{BEV,min}} & \text{if } W_{BEV} \leq W_{BEV,50} \\ 1 - \frac{W_{BEV,50} - W_{BEV}}{W_{BEV,50} - W_{BEV,max}} & \text{if } W_{BEV} > W_{BEV,50}. \end{cases} \quad (3)$$

Environmental Impact (KPI_E)

The emissions balance Embal compares the well-to-wheel (WtW) CO2 emissions between BEV and ICEV:

$$Em_{bal} = \frac{Em_{BEV}}{Em_{ICEV}}, \quad (4)$$

where Em_{BeV} is the emissions per distance for the reference BEV and Em_{ICEV} the emissions per distance for a reference ICEV. Em_{BEV} is defined as

$$Em_{BEV} = Em_{WtT,BEV} \times W_{BEV}, \quad (5)$$

Inserting (5) into (4) results in the definition of the emissions balance:

$$Em_{bal} = \frac{Em_{WtT,BEV} \times W_{BEV}}{(Em_{WtT,ICEV} + Em_{TtW,ICEV}) \times (W_{Fuel} \times LHV_{Petrol})}. \quad (6)$$

A new performance indicator $PI_{Em,bal}$ is introduced and is defined as:

$$PI_{Em,bal}(Em_{bal}) = 50 \times \begin{cases} 1 + \frac{Em_{bal,50} - Em_{bal}}{Em_{bal,50} - Em_{bal,min}} & \text{if } Em_{bal} > Em_{bal,50} \\ 1 - \frac{Em_{bal,50} - Em_{bal}}{Em_{bal,50} - Em_{bal,max}} & \text{if } Em_{bal} \leq Em_{bal,50}. \end{cases} \quad (7)$$

BEV Cost (KPI_C)

KPI_C is defined by key performance indicators:

$$KPI_C = 0.5PI_{TCO} + 0.15\ PI_{GDP} + 0.35PI_{Enc} \quad (8)$$

The TCO performance indicator PI_{TCO} compares the total costs between BEV and ICEV.

$$PI_{TCO} = \frac{TCO_{BEV}}{TCO_{ICEV}} \times 100 = \frac{CostAcq_{BEV} + CostOwn_{BEV}}{CostAcq_{ICEV} + CostOwn_{ICEV}} \times 100 \quad (9)$$

The performance indicator PI_{GDP} reflects the wealth level of a city and is dependent on the individual gross domestic product GDP.

Efforts of the government to encourage BEV are evaluated in the performance indicator PI_{Enc}. The evaluation is done with a matrix taking into account financial subsidies and other incentives and will not further be described in detail here.

Infrastructure (KPI_I)

The capability of the road network to deal with the amount of vehicles in a city is evaluated as PI_{road}, which is dependent on the ratio between the total road length lRoad and the total number of vehicles.

$$PI_{Road} = x \times 10\ m^{-1} \quad \text{with } x = \min\left\{\frac{l_{Road}}{n_{Veh}}; 10\ m^{-1}\right\} \quad (10)$$

The importance of the rail network I_{Rail} is introduced and corresponds to an importance IRail = 1 for those very dense cities. However, the value then decreases linearly with decreasing population density and can be represented by:

$$I_{Rail} = \frac{\text{PopDens}}{11000} \text{ for PopDens} = \min\{\text{PopDens}; 11000\} \quad (11)$$

The evaluation of the public transport system PI_{PT} relies on the availability of rapid rail transport, and is a function of the evaluated length of the railway available $l_{Rail,eval}$ and I_{Rail}:

$$PI_{PT} = 50 + \left(50 \times l_{\text{Rail, eval}} \times I_{\text{Rail}}\right) \quad (12)$$

$$l_{\text{Rail, eval}} = \begin{cases} \frac{l_{\text{Rail}} - 50}{50} & \text{if } l_{\text{Rail}} < 50 \\ \frac{l_{\text{Rail}} - 50}{250 - 50} & \text{if } l_{\text{Rail}} \geq 50 \end{cases} \text{ for } l_{\text{Rail}} = \min\{l_{\text{Rail}}; 250\} \quad (13)$$

The next performance indicator is the PI_{Charge}, an indicator of a city's commitment to building up charging infrastructures for BEV. It is determined with a qualitative evaluation of the current and planned to charge infrastructure and includes as well special treatments such as dedicated lanes for BEV.

The overall key performance indicator for Infrastructure KPI_I is thus a weighted sum of PI_{Road}, PI_{PT} and PI_{Charge}:

$$KPI_I = 0.3 * PI_{road} + 0.3*PI_{PT} + 0.4 * PI_{charge} \quad (14)$$

Socio-Demographic Conditions (KPI_S)

The Human Development Index (HDI), prepared by the United Nations, is a standardised reference value between 0 and 100 that indicates the degree of development and economic impacts on human living conditions of a country. Considered factors for the HDI are: life expectancy, education level, alphabetisation and standard of living. Since high living standards are favourable for the successful introduction of BEV, the performance indicator PIHDI defines a value of HDI = 67 as acceptable, leading to the linear dependency:

$$PI_{HDI} = 1.5\ HDI - 50 \text{ where } HDI = \max\{HDI; 33\} \quad (15)$$

The Mercer Quality of Living Index QoL is a city-specific index that includes 10 key categories for quality of living (e.g. socio cultural environment or housing). PI_{QoL} is defined as:

$$PI_{QoL} = 1.5\ QoL - 50 \text{ where } QoL = \max\{QoL; 33\} \quad (16)$$

Furthermore, it is assumed that the government plays a key role for the introduction of electromobility. The corruption index I_{Cor} is hereby a strong factor to forecast the success and failure of major public projects and can be directly taken as the value for the performance indicator PI_{Cor}:

$$PI_{cor} = 10I_{cor} \quad (32)$$

KPI_S is defined as:

$$KPI_S = 0.5 * PI_{HDI} + 0.2 * PI_{QoL} + 0.3 * PI_{Cor} \quad (33)$$

Appendix 3. Application of proposed evaluation criteria for test assessment for city A

Data was collected from a variety of studies on the transport sector, GHG-inventories, scenarios, legislation on transport and energy, annual reports and research papers. Some statistics were referred to from prevailing publications, official statistics, and from related agencies' documents.

1. Result of Dimension I: Potential Market

The potential market of EVs is defined as a significant market share of EVs in line with good public charging infrastructure, resulting in faster market adoption. It is measured through four indicators including E2W, E4W, availability of charging systems and the number of projects related to EVs. The results of the indicators for dimension I are summarised in Table A.6.

Table A 6. Summary of indicators ratings for potential market

Dimension I – Potential Market	City A
1) Number of E2W ownership	+
2) Number of electric four-wheeler (E4W) ownership	++
3) Existence of charging system for EVs	++
4) Number of projects related to EVs	++

Note: (++) - High potential; (+) - Potential; (o) – Low potential

2. Result of Dimension II: Pollution Situation

The results of the dimension II group for city A are presented in Table A.7.

Table A 7. Summary of indicators ratings for the pollution situation

Dimension II – Pollution Situation	City A
1) Air quality	++
2) Impact of current EVs on GHG emissions	++

Note: (++) - High potential; (+) - Potential; (o) – Low potential

3. Result of Dimension III: Economic Condition

The results of Dimension III are presented in Table A.8.

Table A 8 . Summary of Indicators Ratings for Economic Condition

Dimension III – Economic Condition	City A
1) GRDP per capita	++

Note: (++) - High potential; (+) - Potential; (o) – Low potential

4. Result of Dimension IV: Policy

Table A 9. Summary of indicator ratings for policy

Dimension IV – Policy	City A
1) Climate change policy	++
2) Air pollution reduction Policy	+
3) Clean energy policy	+
4) Subsidy policy for environmental friendliness vehicles	+

Note: (++) - High potential; (+) - Potential; (o) – Low potential

A detailed explanation of each indicator as follows:

Table A 10. Indicator ratings for climate change policy

City	Explanatory note	GHG emissions trajectory	Existence of GHG emissions reduction targets	Strength of GHG emissions reduction targets	Action plan for GHG mitigation
A	In the Green Growth Plan, the city has set a target to reduce GHG emissions by 2030 compared to BAU. The city has established some possible solutions such as public transport development (Metro, BRT, bus), use of CNG buses, promotion of e-bikes and e-MC. Through policy measures, City A has proposed a specific GHG emissions reduction target by 2030.	++	++	+	++

Table A 11. Indicator ratings for air-pollution reduction policy

City	Explanatory note	Existence of PM_{10} and $PM_{2.5}$ emissions reduction targets	Action plans for the reduction of PM_{10} and $PM_{2.5}$ emissions
A	In the Green Growth Promotion Plan, City A proposed a solution to reduce air pollution. However, in this plan, the specific goal of reducing air pollution emissions reduction does not exist.	0	++

Table A 12. Indicator ratings for Clean Energy Policy

City	Explanatory note	The political focus of clean energy policy	Energy efficiency targets in transport	Renewable energy targets by source
A	City A is considering a project for vehicle investment, organisation of public passenger transportation with clean energy buses (electric buses).	++	+	+

Table A 13. Indicator ratings for Subsidy Policy

City	Explanatory note	Operational subsidies for the transport operators	Electricity subsidies	Support for loan interest	Exemption from registration fees	Financial incentives for EV charging stations
A	City A subsidised for developing bus using clean energy.	++	0	++	++	0

Assessment results on the readiness for e-mobility development in City A.

Table A 14. The readiness for e-mobility development in City A

Measures	Readiness level
Measure I – Market potential	
1) Electric two-wheeler ownership	+
2) Electric four-wheeler ownership	++
3) Charging system for EVs	++
4) Number of projects related to EVs	++
Measure II – Air pollution situation	
1) Air quality	++
2) Impact of current EVs on GHG emissions	++
Measure III – Economic conditions	
1) GRDP per capita	++
Measure IV – Policy	
1) Climate change policy	++
2) Air pollution reduction polity	+
3) Clean energy policy	+
4) Subsidies policy for environmentally friendly vehicles	+
Measure V – Stakeholder inclusion	
1) Organisation activity in e-mobility	++
2) Openness of the EV market	++

Conclude

As can be seen in Table A.14, City A is evaluated at 69% HIGH potential readiness for e-mobility adoption.

Appendix 4. Current situation and planning for developing power sources in Viet Nam

Table A 15. Installed capacity of power plants belonging to EVN and EVN units

No	Plant	Number of generators	Design power (MW)	Available capacity (MW)	Owner
Hydroelectric		***85***	***11,774***	***11,772***	
1	Son La	6	2400	2400	EVN
2	Lai Chau	3	1200	1200	EVN
3	Ban Chat	2	220	220	EVN
4	Huoi Quang	2	520	520	EVN
5	Hoa Binh	8	1960	1960	EVN
6	Tuyen Quang	3	342	342	EVN
7	Pleikrong	2	100	100	EVN
8	Ialy	4	720	720	EVN
9	Sesan 3	2	260	260	EVN
10	Sesan 4	3	360	360	EVN
11	Tri An	4	400	400	EVN
12	Thac Mo	1	75	75	EVN
13	Ban Ve	2	320	320	EVNGENCO 1
14	Khe Bo	2	100	100	EVNGENCO 1
15	Trung Son	4	260	260	EVNGENCO 2
16	Quang Tri	2	64	64	EVNGENCO 2
17	A Vuong	2	210	210	EVNGENCO 2
18	Buon Tua Srah	2	86	86	EVNGENCO 3
19	Buon Kuop	2	280	280	EVNGENCO 3
20	Srepok 3	2	220	220	EVNGENCO 3
21	Song Tranh 2	2	190	190	EVNGENCO 1
22	An Khe - Ka Nak	4	173	173	EVNGENCO 2
23	Song Ba Hạ	2	220	220	EVNGENCO 2
24	Song bung 2	2	100	100	EVNGENCO 2
25	Song bung 4	2	156	156	EVNGENCO 2
26	Dong Nai 3	2	180	180	EVNGENCO 1
27	Dong Nai 4	2	340	340	EVNGENCO 1
28	Thac Mo	2	150	150	EVNGENCO 2

No	Plant	Number of generators	Design power (MW)	Available capacity (MW)	Owner
29	Da Nhim	4	160	160	EVNGENCO 1
	Song Pha	5	7.5	6	EVNGENCO 1
30	Da Nhim MR	1	80	40	EVNGENCO 1
31	Ham Thuan	2	300	300	EVNGENCO 1
32	Da Mi	2	175	175	EVNGENCO 1
33	Dai Ninh	2	300	300	EVNGENCO 1
Coal Thermal Plant		***36***	***12,673***	***12,555***	
1	Pha Lai 1	4	440	400	EVNGENCO 2
2	Pha Lai 2	2	600	580	EVNGENCO 2
3	Uong Bi	2	630	617	EVNGENCO 1
4	Ninh Binh	4	100	100	EVNGENCO 3
5	Hai Phong	4	1200	1200	EVNGENCO 2
6	Quang Ninh	4	1200	1200	EVNGENCO 1
7	Nghi Son 1	2	600	600	EVNGENCO 1
8	Mong Duong 1	2	1080	1080	EVNGENCO 3
9	Thai Binh	2	600	600	EVN
10	Vinh Tan 2	2	1245	1200	EVNGENCO 3
11	Vinh Tan 4	3	1800	1800	EVN
12	Duyen Hai 3	1	688	688	EVN
13	Duyen Hai 1	2	1245	1245	EVNGENCO 1
14	Duyen Hai 3	2	1245	1245	EVNGENCO 1
Oil thermal plant		***6***	***867***	***846***	
1	Thu Duc	3	169.5	153	EVN
2	Can Tho	1	37	33	EVNGENCO 2
3	O Mon	2	660	660	EVNGENCO 2
Gas turbines		***29***	***3,170***	***2,926***	
1	Ba Ria	10	388	334	EVNGENCO 3
2	Phu My 1	4	1140	1090	EVNGENCO 3
3	Phu My 2	6	949	860	EVNGENCO 3
4	Phu My 4	3	468	440	EVNGENCO 3
5	Thu Duc	2	75	70	EVN
6	Can Tho	4	150	132	EVNGENCO 2

(Source: Le et al., 2020)

Table A 16. Capacity of different types of power sources planned until 2030

Target/year	2020	2025	2030
Load demand (MW)	39826	59778	84203
Total installed capacity (MW)	59304	103318	138093
Total installed capacity (wind and sun)	7470	22660	38700
Ratio renewable energy sources (wind and sun)	12.60	21.93%	28.02%
Total installed capacity (no wind, no sun)	51834	80658	99393
Ratio backup sources (no wind, no sun)	30.2%	34.9%	18.0%
Where:			
Domestic coal thermal power	13681	16841	16961
Imported coal thermal power	6150	18302	21162
Gas turbine +Domestic gas thermal power	7097	13058	10636
Existing gas turbines switch to LNG	0	803	4147
Gas turbine uses new LNG	0	1500	10100
Flexible source using LNG (ICE+SCGT)	0	0	1400
Thermal power + oil gas turbine	1933	337	138
Hydroelectricity	17531	19731	19731
Small hydroelectricity (under 30MW)	3600	4800	5000
Onshore + nearshore wind power	730	9220	16110
Offshore wind power	0	0	3100
Solar power (MW)	6740	12840	18890
Biomass electricity and other renewable energies	570	1440	2830
Storage hydroelectricity and storage batteries	0	0	1200
Imported from China	700	1700	1700
Imported from Laos	572	2746	4989

(Source: International Energy Agency, 2020)

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