ERIA Research Project Report 2024, No. 15

Policies and Infrastructure Development for the Wider Penetration of xEVs in ASEAN Countries – Phase II

Edited by

Naoko Doi
Alloysius Joko Purwanto
Shigeru Suehiro
Toshiya Okamura
Kazuhisa Takemura
Masami Iwai
Akira Matsumoto
Keita Katayama
Takao Imanishi

Economic Research Institute for ASEAN and East Asia

Policies and Infrastructure Development for the Wider Penetration of xEVs in ASEAN Countries – Phase II

Economic Research Institute for ASEAN and East Asia (ERIA)
Sentral Senayan II 6th Floor
Jalan Asia Afrika No. 8, Gelora Bung Karno
Senayan, Jakarta Pusat 10270
Indonesia

ERIA Research Project FY2024 No. 15
Published in September 2024

Disclaimer:

This report was prepared by the Working Group for the 'Study on Policies and Infrastructure Development for the Wider Penetration of xEVs in ASEAN' under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. Members of the Working Group discussed and agreed to utilise certain data and methodologies.

Foreword

In East Asia Summit (EAS) countries, progress has been made in recent years towards electrifying the transport sector. Electric vehicles (EVs) are considered the important technological options for those EAS countries towards air quality improvement in urban areas, energy security enhancement for shifting away from oil dependence, and climate change mitigation – if these are coupled with low-carbon power generation sources.

In view of the future expansion of EVs on the road, policymakers in the EAS region have to prepare the necessary policies, programmes, plans, economic incentives, and focused areas of services and accelerate the decarbonisation of the power sector.

This report provides an EV policy overview of India, Indonesia, Malaysia, Singapore, Thailand, and Viet Nam, in addition to Brazil and New Zealand. It also provides estimation results of the life cycle impacts of EV deployment on carbon dioxide emissions. The report offers selected cases of EV charging systems in Japan, the United States, and Europe.

I hope the report will provide a good basis for ASEAN countries for understanding the necessary policy and measures, as well as business and infrastructure development, for the wider diffusion of EVs.

Toshiyuki Sakamoto

Director

The Institute of Energy Economics, Japan

Acknowledgements

This analysis was implemented by a Working Group under the Economic Research Institute for ASEAN and East Asia (ERIA). It was a joint effort of the Working Group members from Indonesia and the Institute of Energy Economics, Japan (IEEJ). We would like to acknowledge the support provided by everyone involved. We would especially like to express our gratitude to the members of the Working Group.

Valuable insights were obtained from several government officials and analysis that were an integral part of implementing this study. The implications reflect the results from the IEEJ/ERIA analysis and do not represent the official views from the analysed countries.

Naoko Doi

Senior Research Director

The Institute of Energy Economics, Japan

List of Project Contributors

Dr Alloysius Joko Purwanto, Energy Unit, Research Department, Economic Research Institute for ASEAN and East Asia

Mr Juniko Parhusip, Directorate of Electricity Business Supervision, Directorate General of Electricity, Ministry of Energy and Mineral Resources, Indonesia

Mr Huzaimi Nor Bin Omar, Technology Solutions Group, Malaysian Green Technology and Climate Change Corporation

Dr Mohammad Abdul Muizz Faix Hazwan bin Haji Mat Yassin, Sustainable Energy Division, Department of Energy, Prime Minister's Office, Brunei Darussalam

Mr Akira Matsumoto, Senior Researcher, Climate Change Group, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Ms Masami Iwai, Senior Researcher, Energy Efficiency Group, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Mr Kazuhisa Takemura, Senior Researcher, Energy Efficiency Group, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Mr Takao Imanishi, Executive Researcher, Energy Efficiency Group, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Mr Keita Katayama, Senior Researcher, Climate Change Group, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Mr Toshiya Okamura, Senior Researcher, Energy Efficiency Group, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Mr Shigeru Suehiro, Senior Researcher, Manager, Energy Data and Modeling Center, The Institute of Energy Economics, Japan (IEEJ)

Dr Naoko Doi, Senior Research Director, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)

Table of Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

AEDP	Alternative Energy Development Plan
APS	Advanced Policy Scenario
ASEAN	Association of Southeast Asian Nations
BAU	business as usual
BEV	battery electric vehicle
BOI	Board of Investment (Thailand)
cc	cylinder capacity
CO_2	carbon dioxide
COE	Certificate of Entitlement
EAS	East Asia Summit
ERIA	Economic Research Institute for ASEAN and East Asia
EV	electric vehicle
EVCS	electric vehicle charging station
FTA	free trade agreement
GHG	greenhouse gas
GW	gigawatt
GWh	gigawatt hour
HEV	hybrid electric vehicle
ICE	internal combustion engine
IEA	International Energy Agency
IEEJ	Institute for Energy Economics, Japan
km	kilometre
kWh	kilowatt hour
LCA	Life Cycle Assessment
LPG	liquefied petroleum gas
MOT	Ministry of Transport (Viet Nam)
NDC	Nationally Determined Contribution
NEVPC	National Electric Vehicle Policy Committee

PLDV	passenger light-duty vehicle
PHEV	plug-in hybrid electric vehicle
R&D	research and development
SPBKLU	public electricity battery exchange station
SPKL	public electricity charging station
TtW	tank-to-wheel
WtT	well-to-tank
WtW	well-to-wheel
xEV	electrified vehicle

Executive Summary

The main findings from the analysis are summarised below.

Chapter 1

The deployment of electric vehicles (EVs) is considered an important option to move away from oil dependence, improve local air quality, and mitigate climate change. Some countries, such as Indonesia and Thailand, consider EVs an important option for developing manufacturing. Indonesia has laid out a plan for developing the battery manufacturing industry with the use of local resources, whilst Thailand aims to become a regional hub for the EV manufacturing industry. Each country's current plan and/or target, as well as the key economic incentives for the wider diffusion of EVs, is summarised below:

- Indonesia has set a target to abandon sales of internal combustion engine (ICE) vehicles by 2040. Indonesia also intends for alternative vehicles to account for 20% of total vehicle production by 2025.
- The luxury tax rate is differentiated by the powertrain. EV owners can enjoy zero luxury tax. An electricity off-peak rate is provided to EV owners.
- Malaysia has outlined the electrification of the transport system under the 'Low Carbon Mobility Blueprint 2021-2030'. In the blueprint, Malaysia aims to increase the share of EV sales of passenger vehicles. The targets are 9% in 2025 and 15% in 2030.
- EV-specific incentives are planned in the blueprint. Excise tax and value-added tax are (planned to be) exempt for EV owners.
- Singapore has set a step-by-step approach to electrify road transport, with the target that all passenger cars and taxis will be registered as clean energy vehicles (including electric, hybrid, or hydrogen fuel cell vehicles), and half of buses and taxis will be electrified by 2030.
- As the incentives for EVs, the following are provided: (1) Electric Vehicle Early Adoption Incentive, (2) Vehicle Emissions Scheme, and (3) Commercial Vehicle Emissions Scheme.
- Thailand has announced a new roadmap to lead the country to become a hub of EVs in Association of Southeast Asian Nations (ASEAN) countries in 5 years. Under the roadmap, the country has planned to set a target to produce 250,000 EVs and 3,000 electric public buses by 2025 and to increase EV production to 30% of total annual automotive production or about 750,000 units out of 2.5 million units by 2030.

- Battery electric vehicles (BEVs) have a 5–6 year tax exemption period, whilst plug-in hybrid electric vehicles (PHEVs) and hybrid electric vehicles (HEVs) receive a 5%–12.5% tax reduction, depending on fuel economy.
- Viet Nam does not have a policy or goal relating to the introduction of EVs. The excise tax rate is differentiated by the powertrain (EVs at 3% and ICE vehicles at 70%).
- Brazil has indicated plans to grant reductions to its industrialised products tax for hybrid cars, EVs, and flex hybrid cars (specific figures will be discussed later) to promote their use. However, no specific targets have been set for the introduction of EVs. In Brazil, flex HEVs account for the highest percentage amongst all electrified vehicles (xEVs) registered as small cars (passenger vehicles and light commercial vehicles) in 2022, with BEVs accounting for 17.2%, flex HEVs 48%, HEVs 13.8%, and PHEVs 21%.
- For EV owners, two incentives are provided: (1) state tax discount and (2) urban building and property ownership tax discount.
- The Indian government has set a goal of increasing the penetration rate of electric vehicles to 30% by 2030. This is expected to reduce greenhouse gas (GHG) emissions by 4% compared to the business-as-usual (BAU) scenario. In addition, think tanks NITI Aayog and RMI India estimate that the EV sales self-sufficiency rate by 2030 will be 80 % for two- and three-wheelers, 50% for four-wheelers, and 40% for buses.
- Various incentives are provided under the scheme called FAME II (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India), spurring the growth trends of both two-wheelers, and three-wheelers.
- In New Zealand, the 'Decarbonising Transport Action Plan 2022–25'[1] was formulated to achieve a functional and low-emission transport system with a high degree of liberty like the current one, to increase the ratio of zero-emission vehicles amongst all light vehicles to 30% by 2035.
- A clean car discount has been introduced to lower the purchase price of low-emission vehicles. The higher the vehicle emissions, the higher the fee imposed. In contrast, low-emission vehicles can receive rebates.

Chapter 2

GHG emission sources related to automobiles are diverse. We should consider not only emissions when driving automobiles but also emissions during the production and disposal of vehicles, including the mining of raw materials and manufacturing of parts. Furthermore, the amount of these emissions varies greatly depending on the powertrain

[1] https://www.transport.govt.nz//assets/Uploads/MOT4716_Emissions-Reduction-Plan-Action-Plan-P04-V02.pdf

type, and the overall amount of emissions will change depending on that kind of powertrain type that will penetrate in the future.

This study provided a comprehensive scenario analysis for vehicle electrification from the views of the Fuel Cycle (Well-to-Wheel (WtW)) and Vehicle Cycle (Life Cycle Assessment (LCA)), and found:

- The emissions-related BEV are small on the WtW basis but large in the production process.
- Countries with fast-growing car penetration have a higher proportion of emissions from the production process.
- The decarbonisation of the power generation mix affects the emissions in both the fuel cycle and vehicle cycle.

Chapter 3

EV adoption usually takes place in cities. China, the top EV market, and many early EV market countries are experiencing challenges in mounting Level 2 AC chargers in muti-dwelling apartments and multi-storey office buildings in cities. Those apartments and buildings have dedicated parking spaces or floors, and allocating EV charging spaces and power supply can be challenging. Unless there are enough dedicated EV charging spaces, residents and workers feel reluctant to adopt EV use. By EV type, the following trends are observed as the practices that can promote an increase in charging systems.

- Increasingly, European countries and many cities in the United States have adopted charging space and power capacities in building codes.
- One of the unique programmes for electric two- and three-wheelers is the development of battery-swapping and the associated battery-as-a-service. Battery-as-a-service business players are interested in battery management/degradation assessment/recycling and life cycle management. They are also interested in improving the charging business by offering stationary battery use and minimising electricity capacity charge. Battery manufactures and energy service providers are also planning the aggregation of the use of EV batteries for grid balancing.
- For four-wheelers, Tesla demonstrated battery-swapping as an alternative to the supercharger service in 2013, allowing the Model S to swap battery in 90 seconds rather than waiting half an hour with a Tesla Supercharger. With the battery-swapping robot, the technology was considered a breakthrough in battery-swapping, but Tesla abandoned the swapping idea in 2015 due to a lack of customer interest. China's premium EV manufacturer, NIO, offers a battery-swapping model with a battery-leasing service.

Introduction

In East Asia Summit (EAS) countries, progress has been made in recent years towards electrifying the transport sector. Electric vehicles (EVs) are considered as important technological options for EAS countries for air quality improvement in urban areas, energy security enhancement for shifting away from oil dependence, and climate change mitigation – if these are coupled with low-carbon power generation sources.

In view of EV penetration's great impact on energy security enhancement, air quality improvement, and climate change mitigation, and for the successful implementation of those plans, concerted efforts will be essential to involve all stakeholders, including policymakers, electric utility companies, and representatives from private companies.

Besides, it is important to estimate the impacts of EVs on carbon dioxide emissions derived throughout the value chain, including battery production, assembly, usage, and disposal. The decarbonisation of electricity generation is an essential precondition for those EAS countries to realise the expected full benefits from electrifying the transport system.

Methodologies of the Project

The study will conduct both quantitative and qualitative analysis with a focus on six EAS countries – Indonesia, Malaysia, Singapore, Thailand, Viet Nam and India – in relation to the wider diffusion of EVs.

Firstly, the study will analyse policies and regulations as well as economic incentives for the wider diffusion of EVs (including passenger vehicles) and other alternative vehicles outside the selected countries, such as Brazil and New Zealand, and compare with the practices by the six EAS countries to draw implications for the six EAS countries.

Secondly, the study will estimate the life cycle impact of EV deployment on carbon dioxide (CO_2) emissions by 2040. The study will cover the CO_2 emissions from passenger vehicle stocks of the analysed countries for each year up to 2040. The life cycle assessment will include those CO_2 emissions from the production, usage, and disposal of ICEs, HEVs, BEVs, and PHEVs of passenger vehicles.

For usage, well-to-wheel analysis conducted in 2021 study will be utilised. Production and disposal analysis will be conducted using data from the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model (GREET). Analysis will be conducted by scenario (Reference and HEV-bridge Scenario, and BEV Ambitious Scenario).

Thirdly, the study will analyse the outstanding cases of the introduction of EV charging infrastructure development. The cases include countries outside of the six EAS countries that can provide implications for EAS countries to follow.

Finally, the study will formulate recommendations for EAS countries to formulate necessary policies for the wider diffusion of EVs, infrastructure development, and the reduce of CO_2 emissions in supply chains.

Chapter 1

EV Policies

This chapter provides an overview of electric vehicle (EV) policies in the selected Association of Southeast Asian Nations (ASEAN) countries. The chapter investigates the EV policies and targets, the current status of EV introduction, the EV reuse plan, and battery reuse policy.

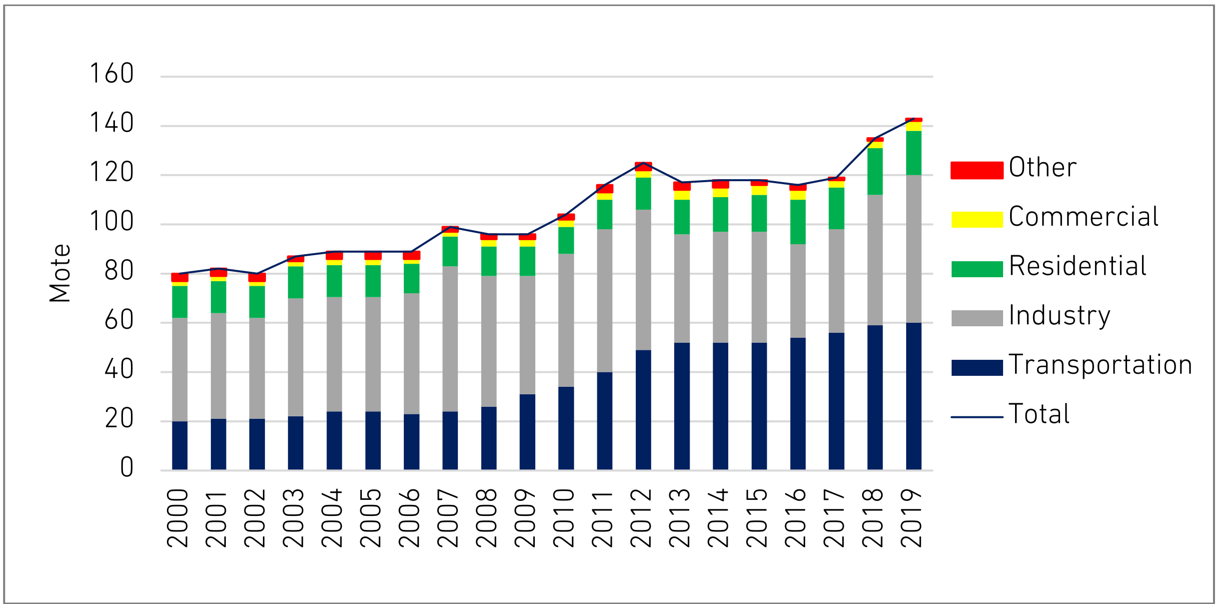
1. Country Policies

1.1 Indonesia

1.1.1. Decarbonisation policy of the transport sector

The transport sector accounts for approximately 40% of Indonesia's total energy consumption, and the amount is increasing (Figure 1.1).

Figure 1.1. Development of Final Energy Consumption by Consuming Sectors



Mtoe = million tonnes of oil equivalent.
Source: Indonesia (2021), *Indonesia Long-term Strategy for Low Carbon and Climate Resilience 2050*. https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf

Indonesia has set three measures to decarbonise the transport sector in its long-term plan:

- electrification of transport
- supplying more biofuels for diesel substitute
- gasoline substitution

In particular, the country puts priority on electrifying vehicles and is working not only on using EVs but also manufacturing them in the country as a national initiative. More information is provided in the EV policy and target section. Indonesia plans to utilise fatty acid methyl-ester and bio-hydrocarbon or green diesel for biofuels, and bioethanol and crude palm oil-based gasoline as gasoline substitutes. The government introduced biofuels derived from crude palm oil in 2011, which are blended with petroleum diesel and called B20 (20% biodiesel plus 80% petroleum diesel).

1.1.2. EV policy and targets

To reduce the expected potential increase in oil imports and to nurture the domestic automobile manufacturing industry, the country has set a target to abandon the sale of gasoline-powered two-wheelers by 2040 and internal combustion engine (ICE) vehicles by 2050.[2] Indonesia also intends for alternative-powered vehicles to account for 20% of total vehicle production by 2025.[3]

As Table 1.1 shows, Indonesia is electrifying both four-wheeled and two-wheeled vehicles. In January 2019, Indonesia released an automotive industry roadmap regarding the number of units of EVs produced. It has set a target for low-carbon emissions vehicles to account for 30% (or 1.2 million units) of the total four-wheeler production target of 4 million units in 2035. It has set a target to produce 15 million two-wheelers in total in 2035, 30% of which will be electric.

In 2022, Indonesia will produce 1,470,146 vehicles, of which 23,775 will be electric vehicles (EVs and HVs), or 1.61% of the total. The current situation is that there is still a large gap between the most recent target of 2,000,000 units of production and the LCEV ratio of 20% in 2025.[4] Whilst the production targets in the EV roadmap include exports, more widespread adoption of EVs within the country is essential for meeting the targets.

[2] Ministry of Energy and Mineral Resources of the Republic of Indonesia.[Ini Prinsip dan Peta Jalan Pemerintah Capai Net Zero Emission] https://ebtke.esdm.go.id/post/2021/10/11/2986/ini.prinsip.dan.peta.jalan.pemerintah.capai.net.zero.emission

[3] Indonesia: 20% EV by 2025. https://www.globalfleet.com/fr/connected-technology-and-innovation/asia-pacific/features/indonesia-20-ev-2025?a=YHE11&t%5B0%5D=Lithium%20ion%20battery&t%5B1%5D=Hyundai&t%5B2%5D=Mitsubishi&curl=1

[4] https://www.gaikindo.or.id/indonesian-automobile-industry-data/

Indonesia has formulated Presidential Regulation, No. 55 Year 2019 Regarding Acceleration of Battery-Based Electric Vehicle Program for Road Transportation. Aside from promoting EVs for energy security enhancement and environmental purposes, Indonesia's EV policy is to focus on domestic manufacturing. Taking advantage of the availability of essential metals domestically, Indonesia aims to become an EV manufacturing hub.

Table 1.1. Indonesia's EV Targets

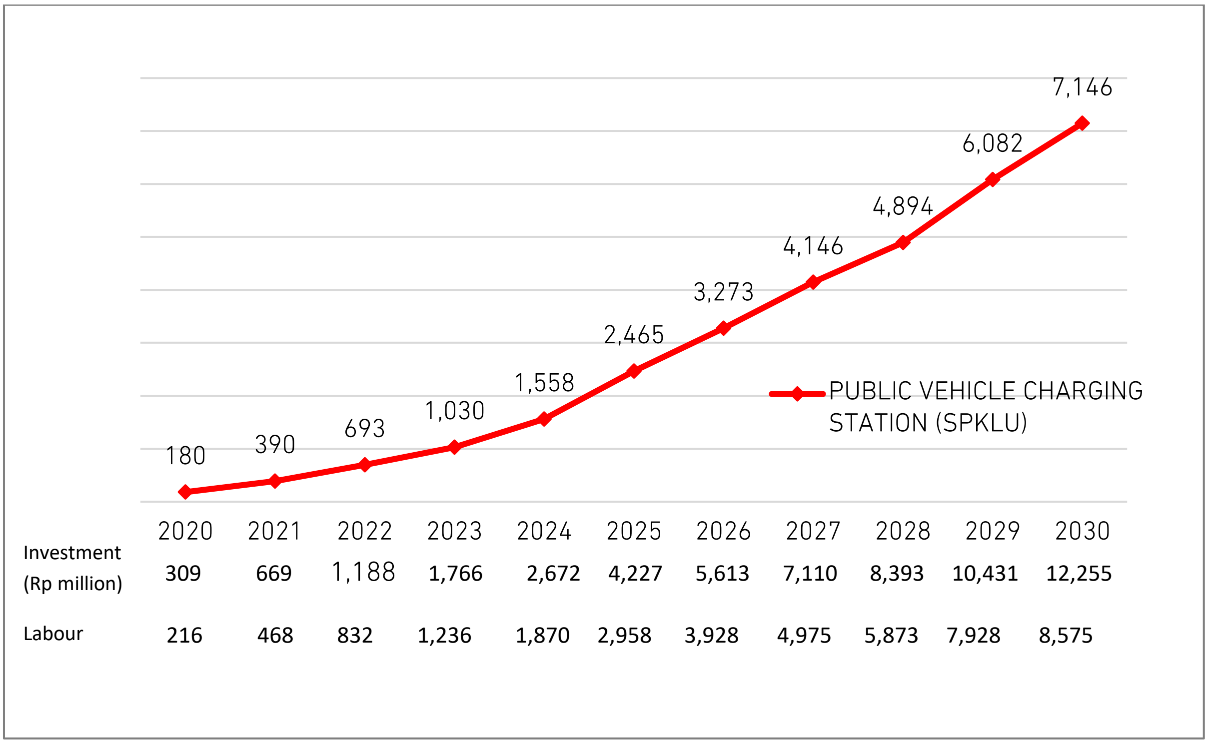
Item			2020	2025	2030	2035
Motor Vehicles						
	Production	Total (Units)	1,500,000	2,000,000	3,000,000	4,000,000
		LCEV (%)	10	20	25	30
		LCGC (%)	25	20	20	20
	Sales	Total (Units)	1,250,000	1,690,000	2,100,000	2,500,000
	Export	Total (Units)	250,000	310,000	900,000	1,500,000
Motorcycles						
	Production	Total (Units)	8,000,000	10,000,000	12,500,000	15,000,000
		Electric Motorcycles (%)	10	20	25	30
	Sales	Total (Units)	7,500,000	9,000,000	11,000,000	13,000,000
	Export	Total (Units)	500,000	1,000,000	1,500,000	2,000,000

LCEV = low-carbon emissions vehicle, LCGC = low-cost green car.
Source: Kementerian Perindustrian Republic Indonesia (2019), *Roadmap on Low Carbon Emission Vehicle.* Indonesia-Japan Automotive Seminar, 29 January, presentation slide. https://www.jetro.go.jp/ext_images/indonesia/pdf/automotiveseminar_29Jan2019/presentation_kemenperin.pdf

Indonesia has formulated Ministerial of EMR Regulation No. 13 Year 2020 Regarding Provision of Charging Infrastructure for Battery-based Electric Vehicles. There are two types of charging facilities: private electricity installations and public electric charging stations (SPKLU). The target for private electricity installations is to install 31,859 units[5] by 2030. The target for public electricity charging stations is to increase their number to 7,146 units by 2030 (Figure 1.2). There is also a target to increase the number of swap battery stations for 2-wheelers to 22,500 locations by 2035 (Figure 1.3).

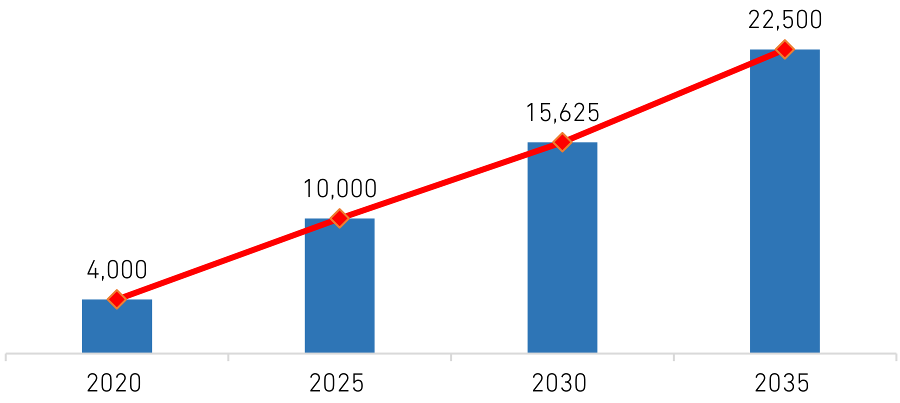
[5] https://peraturan.bpk.go.id/Home/Details/171112/pp-no-74-tahun-2021

Figure 1.2. Roadmap of Charging Station Infrastructure in Indonesia



SPKLU = Stasiun Pengisian Kendaraan Listrik Umum (public electric vehicle charging station).
Note: SPKLU locations include shopping centres, malls, office areas, airports, gas stations, apartments, and taxi pools.
Source: Direktorat Jenderal Ketenagalistrikan Kementerian Energi dan Sumber Daya Mineral Republik Indonesia (2020), *Penyediaan Infrastruktur Pengisian Listrik Dan Tarif Tenaga Listrik Untuk Kendaraan Bermotor Listrik Berbasis Baterai.* Peluang dan Tantangan Pengembangan Mobil Listrik Nasional presentation slide. https://gatrik.esdm.go.id/assets/uploads/download_index/files/683a2-bahan-presentasi-pak-hendra-1-.pdf

Figure 1.3. Roadmap of Swap Battery Stations in Indonesia



	2020	2025	2030	2035
Junior Moter Listrik	800,000	2,000,000	3,125,000	4,500,000
Investment (Rp million)	342	885	1,336	1,974
Labour (org)	400	1,000	1,563	2,250

SPKLU locations include:

Shopping Centers, Malls, Office Areas, Airports, Gas Stations, Apartments, and Taxi Pools

SPBKLU = Stasiun Penukaran Baterai Kendaraan Listrik Umum (public electric battery exchange station).
Note: SPKLU locations include shopping centres, malls, office areas, airports, gas stations, apartments, and taxi pools.
Source: Direktorat Jenderal Ketenagalistrikan Kementerian Energi dan Sumber Daya Mineral Republik Indonesia (2020), *Penyediaan Infrastruktur Pengisian Listrik Dan Tarif Tenaga Listrik Untuk Kendaraan Bermotor Listrik Berbasis Baterai.* Peluang dan Tantangan Pengembangan Mobil Listrik Nasional presentation slide. https://gatrik.esdm.go.id/assets/uploads/download_index/files/683a2-bahan-presentasi-pak-hendra-1-.pdf

1.1.3. Current status of introduction of EVs

Table 1.1.2 shows the number of HEVs, PHEVs, and BEVs registered in Indonesia from 2019 to 2022. In the most recent year, 2022, HEV/PHEV sales totalled 10,354 units (4.12 times higher than the previous year), whilst BEV sales totalled 10,327 units (15 times higher than the previous year). Considering that the number of automobiles sold in the same year was 1,480,040, EVs accounted for 1.96% of the total. Although the sales volume is approaching the target of 1,690,000 units for 2025, the percentage of EVs is still low, as is the production volume.

Table 1.2. Registrations of HEVs, PHEVs, and BEVs in Indonesia, 2019–2022

Year	2019	2020	2021	2022
Total EVs	351	1,234	3,193	20,681
HEVs/PHEVs	351	1,114	2,508	10,354
BEVs	0	120	685	10,327
Total Passenger Vehicle Sales	1,030,126	532,027	887,202	1,048,040

BEV = battery electric vehicle, EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: GAIKINDO. Indonesian Automotive Industry Data. https://www.gaikindo.or.id/indonesian-automobile-industry-data/

1.1.4. Current status of EV charging infrastructure

As of December 2022, there were reportedly 257 locations and 588 public electric vehicle charging stations (SPKLU) in Indonesia. This was 1.3 times the number of locations and 2.3 times the number of units installed in the previous year, compared to 197 locations and 267 units in the previous year.[6] Also, the Indonesian Ministry of Energy and Mineral Resources (ESDM) has set a target of installing 1,030 EV chargers by 2023[7] and 31,859 by 2030.[8]

1.1.5. Vehicle registration fees

Indonesia has two types of registration taxes: the vehicle ownership tax (BPKB) and the vehicle registration fee (STNK).

A BPKB is required when owning a vehicle. It is a one-time tax charged when a vehicle ownership certificate is issued. The amount varies between two-wheelers and four-wheelers as follows:

- two-wheelers and three-wheelers: Rp225,000 (US$16)
- four-wheelers: Rp375,000 (US$26)

A STNK is a tax charged upon vehicle registration that must be renewed every 5 years. The amount varies between two-wheelers and four-wheelers as follows:

- two-wheelers and three-wheelers: Rp100,000 (US$7)
- four-wheelers: Rp200,000 (US$14)

[6] https://indonesia.postsen.com/local/512142/Total-SPKLU-Infrastructure-in-Indonesia-Increases-120-Percent.html
[7] https://www.esdm.go.id/en/media-center/news-archives/ini-target-ketenagalisrikan-nasional-tahun-2023
[8] https://www.esdm.go.id/en/media-center/news-archives/pln-engages-private-sector-to-install-more-charging-stations

1.1.6. Economic incentives for owners of xEVs

There are three types of economic incentives for xEV owners: reduced value-added tax, reduced luxury tax, and discounted electricity rates.

(1) Value-added tax (VAT) reduction

In April 2023, the government issued Regulation No. 38 of the Minister of Finance for 2023 on VAT on the delivery of four-wheeled battery-based electric vehicles and battery-based electric vehicles for certain buses. This significantly reduced the VAT on purchases of EVs from 11% to 1%. The reduction is valid from April to December 2023 and applies to motorcycles, automobiles, and buses.

(2) Lower luxury tax rates

The luxury tax has been reduced based on Government Regulation No. 73 of 2019 (GR-73) put into force in 2019, which set the luxury tax rate for PHEVs, BEVs, and FCEVs to 0% to spur EV sales (PWC, 2019).

However, as shown in Table 1.3, the tax rates for HEVs, PHEVs, and BEVs were revised in October 2021 to differentiate between the various EVs.

Whilst the tax rate remained at 0% for BEVs, it was raised for PHEVs and HEVs. As Finance Minister Sri Mulyani Indrawati said, 'investors in EV manufacturing in Indonesia feel that EVs are not as competitive as they should be because their tax rate is not differentiated from PHEVs' (DDTC News, 2021). The revision is presumably intended to differentiate the tax rate of BEVs from HEVs and PHEVs.

(3) Electricity tariff discount

As an economic incentive for using EVs, Indonesia's state power company, PLN, offers a 30% electricity tariff discount between 10:00 p.m. and 5:00 a.m. for those who own EVs (PLN, 2022). This system not only curbs evening peak electricity rates as an economic incentive for EV owners but also increases power consumption during the low demand, night-time hours.

Table 1.3. Indonesia's Luxury Tax on EVs, Plug-in Hybrids, and Hybrids

Category		CO_2-g/km	Gasoline/Diesel (l/km)	Tax Rate
Incentive Programme	BEV/FCEV	-	-	0%
	PHEV	≦100	28	5%
	Full hybrid	<100	23/26	6%
		100–125	18.4/20	7%
		125–150	15.5/17.5	8%
	Mild hybrid	<100	23/26	8%
		100–125	18.4/20	10%
		125–150	15.5/17.5	12%

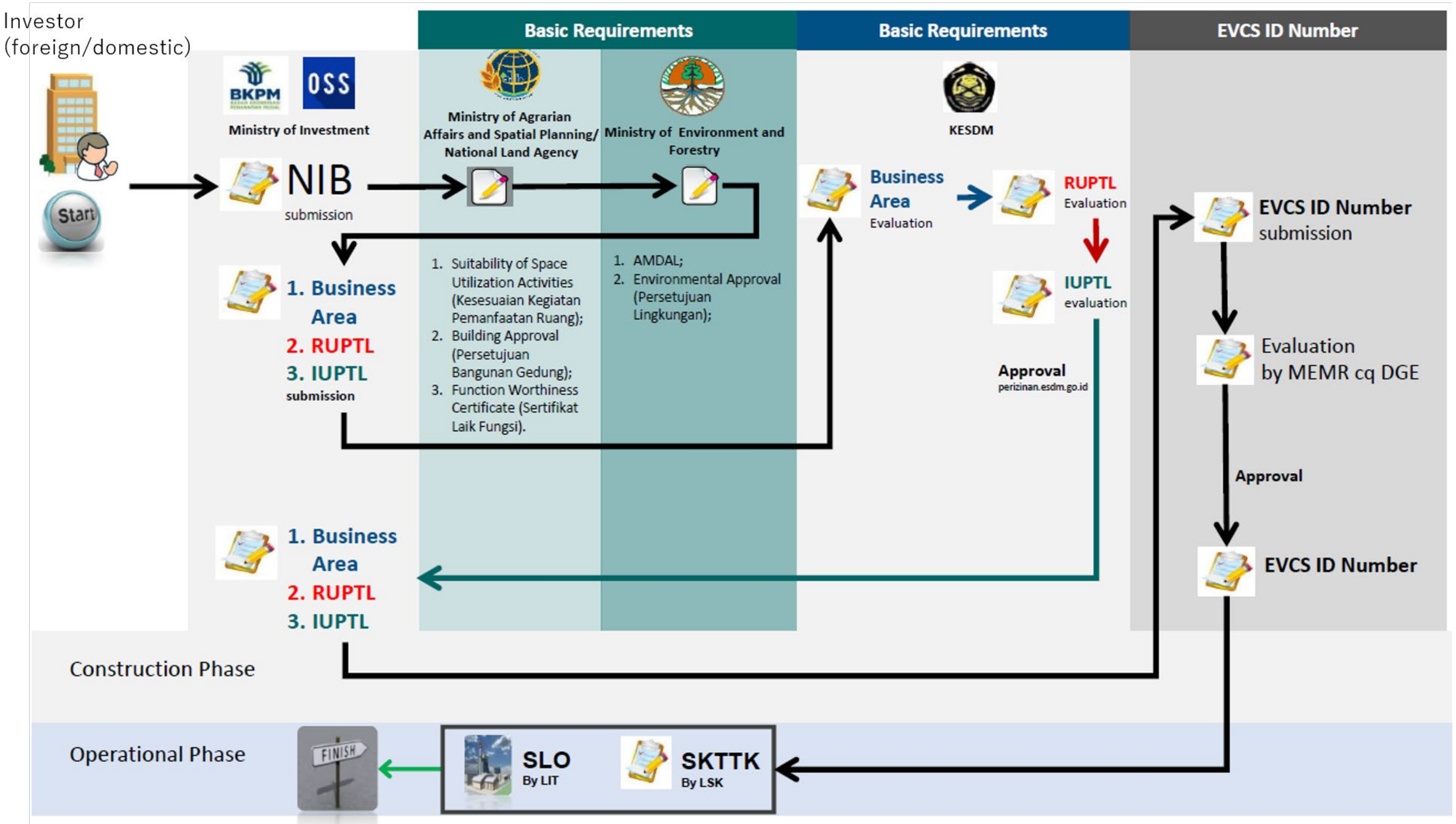
BEV = battery electric vehicle, FCEV = fuel cell electric vehicle, km = kilometre, l = litre, PHEV = plug-in hybrid electric vehicle.

Source: Indonesia, Central Government (2021), Government Regulation (PP) Number 74 of 2021 Concerning Amendments to Government Regulation Number 73 of 2019 Concerning Taxable Goods Classified as Luxury in the Form of Motor Vehicles Subject to Sales Tax on Luxury Goods. https://peraturan.bpk.go.id/Home/Details/171112/pp-no-74-tahun-2021

1.1.7. Provisions for charging infrastructure development

A business permit must be obtained for operating a SPKLU business. Power companies applying for a permit must fulfil requirements related to the suitability of space utilisation activities, building approval, and environmental approval. The application scheme is shown in Figure 1.4.

Figure 1.4. Business Permit Application Scheme



DGE = Directorate General of Electricity, EVCS = electric vehicle charging station, ID = identification, IUPTL = Izin Usaha Penyediaan Tenaga Listrik, RUPTL = Rencana Usaha Penyediaan Tenaga Listrik, MEMR = Ministry of Energy and Mineral Resources, OSS = online single submission, SLO = Sertifikat Laik Operasi, SKTTK = Sertifikat Kompetensi Tenaga Teknik Ketenagalistrikan

Source: Directorate General of Electricity (2022), EV Regulation in Indonesia. Presentation slide at first online meeting, 27 February.

1.18. Economic Incentives for Manufacturers

There are three major economic incentives in place for manufacturers.

(1) Corporate tax reduction

A tax reduction is provided for varying lengths of time depending on the amount of capital expenditure, acting as an incentive for industries designated as pioneer industries (Regulation No. 150/PMK.010/2018 (PMK-150) (Table 1.4).

Table 1.4. Conditions for Corporate Tax Reduction

Provision	New Capital Investment: Rp100 billion up to <Rp 500 billion	New Capital Investment: ≧Rp500 billion
Corporate Income Tax Reduction Rate	50%	100%
Concession Period	5 years	5–20 years
Transition Period	25% CIT reduction for the next 2 years	50% CIT reduction for the next 2 years

Investment (IDR)	Period in Years
500 billion up to < 1 trillion	5
1 trillion up to < 5 trillion	7
5 trillion up to < 15 trillion	10
15 trillion up to < 30 trillion	15
≧ 30 trillion	20

CIT = corporate income tax.
Note: The corporate income tax rate in Indonesia is 22%.
Source: BDO Indonesia (2018), 'Tax Holiday Revamped', Newsletter, 19 December.

The EV businesses eligible for the tax reduction are shown in Table 1.5.

Table 1.5. EV Operators Eligible for Tax Reductions

No	Indonesia Standard Industrial Classification (KBLI)	Type of Production
1	29100	Manufacturing of four-wheeled or more electric vehicles that are integrated with batteries and electric motors
2	29300	• Manufacturing of four-wheeled or more electric motor vehicles
		• Manufacturing of electric motor for four-wheeled or more electric motor vehicles
		• Manufacturing of flexy engines that are compatible with 100% biodiesel for four-wheeled or more motor vehicles
		• Manufacturing of two main components minimum for engines of four-wheeled or more vehicles (i.e. piston, cylinder head, cylinder block, camshaft, crankshaft, and connecting rod that are integrated with manufacturing of four-wheeled or more motor vehicles
		• Manufacturing of electric power control units for four-wheeled or more electric motor vehicle
3	30912	• Manufacturing of batteries for two-wheeled or three-wheeled electric motor vehicles
		• Manufacturing of electric motors for four-wheeled or three-wheeled electric motor vehicles
		• Manufacturing of electric power control units for four-wheeled or three-wheeled electric motor vehicles

Source: Indonesia Ministry of Finance (2020), Minister of Finance Regulation Number 130/PMK.010/2020 of 2020 Concerning Providing Corporate Income Tax Reduction Facility. https://peraturan.bpk.go.id/Home/Details/148016/pmk-no-130pmk0102020

The programme provides corporate tax reductions for 5–20 years depending on the amount of investment, thereby stimulating Indonesia's economic growth and boosting new capital investment in the auto industry.

(2) Income tax incentives

Table 1.6 lists the automotive manufacturing industries covered. Thirty percent of capital investment in the following auto manufacturing businesses can be deducted from taxable income, by deducting 5% per annum for 6 years. This serves as an economic incentive to make new investments and expand businesses.

Table 1.6. Eligible Auto Manufacturing Businesses

Eligible to			
1	Four or more wheeled vehicle industry	29100	Public transportation for >42 passengers and/or trucks
2	Car body industry for four or more wheeled vehicle industry and trailer and semi-trailer industry	29200	Manufacturing of parts of cars or vehicle car bodies
3	Manufacturing of spare parts and accessories for four or more wheeled vehicles	29300	Engines and engine parts, brake systems, axles and propeller shafts, transmission/clutch systems, steering systems, injectors, water pumps, oil pumps, fuel pumps, forging components, die casting components, stamping parts, etc.
4	Manufacturing of components and equipment for two- or three-wheeled motorcycles	30912	Engines and engine parts, die casting components, brake systems, transmission systems

Source: Indonesia Ministry of Finance (2016), Law of the Republic of Indonesia Number 9 of 2016 Regarding Prevention and Mitigation of Financial System Crisis. https://www.kemenkeu.go.id/media/6727/law-of-the-republic-of-indonesia-number-9-of-2016.pdf

The following policies are also being implemented:

- Special credit for electric vehicles by PT. BRI Persero with an interest rate of 3.8% per year and a tenor of 6 years.
- PT. PLN Persero provides a 100% discount for electricity upgrade for the owners of electric cars and a 75% discount for the owners of electric motorcycles.
- Promotion provided by Automotive Holdings Berhad (APM) in the form of free charger units for the purchase of EVs and free insurance for 1 year.

1.2. Malaysia

1.2.1. Decarbonisation policy in the transport sector

Malaysia formulated the National Transport Policy (NTP) 2019–2030 (Prime Minister's Office of Malaysia, 2019) to implement policy thrusts and strategies to strengthen its economic competitiveness, make a strong social impact particularly on inclusiveness and accessibility, and, at the same time, mitigate the negative environmental impact of the transport system. NTP 2019–2030, the guideline for maintaining sustainable transport networks and services, consists of five policy thrusts and 23 strategies. The five policy thrusts are:

- Strengthen governance to create a conducive environment for the transport sector
- Optimise, build, and maintain transport infrastructure, services, and networks to maximise efficiency
- Enhance safety, integration, connectivity, and accessibility for seamless journeys
- Advance towards a green transport ecosystem
- Expand the global footprint and promote the internationalisation of Malaysia's transportation services

1.2.2. EV policy and targets

Malaysia's Ministry of Environment and Water has outlined the electrification of the transport system under the 'Low Carbon Mobility Blueprint 2021-2030'. The blueprint entails Malaysia's overall strategies related to the transport sector, including fuel economy improvement, EV and low emissions vehicle adoption, greenhouse gas (GHG) emissions reduction, and modal shifts towards energy efficient systems.

According to Low Carbon Nation Aspiration (Aspirasi Rendah Karbon) 2040, which is part of the National Energy Policy 2022-2040 (Dasar Tenaga Negara, or DTN) published in September 2022, Malaysia aims to expand the share of EVs in the country's car market to 38% by 2040.[9]

In the blueprint, Malaysia aims to increase the share of EV sales in passenger vehicles. The targets are 9% in 2025 and 15% in 2030 (Table 1.7).

[9] https://www.epu.gov.my/sites/default/files/2022-09/National%20Energy%20Policy_2022_2040.pdf

Table 1.7. Target Sales Shares of EVs in Malaysia

Year	Current Status	Targets (2030)
Passenger vehicles	30,414 (BEVs: 700)	15%
Motorcycles	2,071	15%
Buses	35	10,000

BEV = battery electric vehicle.
Source: Country Report of Malaysia (First Meeting of ERIA Research Project in FY2021).

To facilitate the sales increase, Malaysia plans to expand charging systems and install 10,000 units (AC: 9,000 units, and DC: 1000 units) by 2025.

The public sector will lead the EV deployment as part of public procurement. In the time between 2021–2022, the share of EVs in the public procurement was targeted to account for 10% and is targeted to increase to 50% (2023–2025). From 2025 to 2030, Malaysia's government will establish local product qualifications for tender participation.

The blueprint includes the plan for economic incentives for BEVs and PHEVs as summarised in Table 1.8.

Table 1.8. Economic Incentives for the Purchase of EVs in Malaysia

Year	2021–2022	2023–2025	2026–2030
BEVs	100% import and excise duty exemption for complete built units – for sales of maximum 10,000 units	50% exemption	
PHEVs	100% import and excise duty exemption for complete built units – for sales of maximum 90,000 units	75% exemption	50% exemption

BEV = battery electric vehicle, PHEV = plug-in hybrid electric vehicle.

Source: Ministry of Environment and Water (2021), *Low Carbon Mobility Blueprint 2021-2030*. https://www.mgtc.gov.my/wp-content/uploads/2021/11/Low-Carbon-Mobility-Blueprint-2021-2030.pdf

For charging infrastructure, the Malaysian government has set a target of 9,000 AC charging points and 1,000 DC charging points to be installed nationwide by 2025.

In 2020, the National Automotive Policy 2020 (NAP 2020) was officially launched. The policy aims to develop Malaysia as a leader in the automotive manufacturing industry. NAP 2020 focuses on next-generation vehicles (NxGV), Industrial Revolution 4.0 (IR 4.0), and mobility-as-a-service (MaaS) (Christopher and Lee Ong, 2020).

1.2.3. Fuel economy regulation

In the National Automotive Policy published in 2014, the Malaysian government announced plans to make the country a centre for the production of energy-efficient vehicles. Malaysia's energy-efficient vehicle standards set fuel economy requirements based on displacement, albeit as voluntary targets.[10] Malaysia has a labelling system in place to raise public awareness of fuel economy, promote the spread of low gas emission vehicles, and achieve a sustainable society.

Table 1.9. Labelling by Type of Car

	Type of Car	Total Weight (kg)	Fuel Economy (ℓl/100 km)
A	Micro Car	≤800	4.5
	City Car	801–1,000	5.0
B	Super Mini Car	1,001–1,250	6.0
C	Small Family Car	1,251–1,400	6.5
D	Large Family Car Compact Executive Car	1,401–1,550	7.0
E	Executive Car	1,551–1,800	9.5
F	Luxury Car	1,801–2,050	11.0
J	Large Four Wheel Car	2,051–2,350	11.5
Others	Others	2,351–2,500	12.0

Source: Abidin, S.F.Z. et al. (2020), 'Vehicle Fuel Economy Improvement through Vehicle Optimization in 1-D Simulation Cycle towards Energy Efficient Vehicle (EEV)' *International Journal of Integrated Engineering*, 12(8), pp.365–75. https://publisher.uthm.edu.my/ojs/index.php/ijie/article/view/5558/3784.

[10] https://www.itf-oecd.org/sites/default/files/docs/implementing-asean-fuel-economy-roadmap_1.pdf

Furthermore, the National Low Carbon Mobility Blueprint 2021-2030 sets national targets focusing on small cars.

- 2021–2023: 144 g-CO_2/km (6.2 l/100 km equivalent)
- 2024–2026: 123 g-CO_2/km (5.3 l/100 km equivalent)
- 2027–2030: 95 g-CO_2/km (4.1 l/100 km equivalent)

1.2.4. Current status of the introduction of EVs and charging infrastructure

According to the *New Straits Times*,[11] Liew Chin Tong, Deputy Minister of Investment, Trade and Industry, said that there were 902 chargers and 21,659 EVs, including hybrids, nationwide as of the end of 2022.

1.2.5. Vehicle registration fees

According to the Road Transport Department,[12] Malaysia's vehicle licensing fees vary depending on whether asset registration has been made. The fee is RM150 for cars below 1,500 cc without asset registration (Table 1.10).

There is a road tax of RM20 for private sedans of 1,000 cc and below (Table 1.11). A payment of excise duties and sales tax will also be required (Table 1.12).

Table 1.10. Vehicle Licensing Fees in Malaysia (RM)

	Without Asset Registration	With Asset Registration
Private cars <1,500 cc	150.00	200.00
Private cars >1,500 cc	300	350
Company cars	500.00	550.00
Motorcycles	5.00	20.00
Trucks/machinery	60.00	110.00
Statutory body vehicles	500.00	550.00

cc = cylinder capacity.
Source: Malaysia Road Transport Department, 'Vehicle Licensing Fee'. https://www.jpj.gov.my/en/web/main-site/kenderaan11-en/-/knowledge_base/vehicle/vehicle-licensing-fee

[11] https://www.thestar.com.my/news/nation/2023/02/20/govt-fine-tuning-suggestions-to-increase-ev-cars-as-official-vehicles

[12] https://www.jpj.gov.my/en/web/main-site/kenderaan11-en/-/knowledge_base/vehicle/vehicle-licensing-fee

Table 1.11. Road Taxes in Malaysia

Type	Fee	
Cars (private, sedan)		
Engine capacity		
1,000 cc and below	RM20.00	
1,001 cc–1,200 cc	RM55.00	
1,201 cc–1,400 cc	RM70.00	
1,401 cc–1,600 cc	RM90.00	
1,601 cc–1,800 cc	RM200.00	RM0.40/cc from 1,600 cc
1,801 cc–2,000 cc	RM280.00	RM0.50/cc from 1,800 cc
2,001 cc–2,500 cc	RM380.00	RM1.00/cc from 2,000 cc
2,501 cc–3,000 cc	RM880.00	RM2.50/cc from 2,500 cc
Above 3,000 cc	RM2,130	RM4.50/cc from 3,000 cc
Trucks (business use)		
Tonnage		
1,000 kg and below	RM0.00	RM0.06/kg from 0 kg
1,001 kg–1,500 kg	RM60.00	RM0.06/kg from 1,000 kg
1,501 kg–2,500 kg	RM90.00	RM0.06/kg from 1,500 kg
2,501 kg–5,000 kg	RM150.00	RM0.015/kg from 2,500 kg
5,001 kg–10,000 kg	RM187.50	RM0.011/kg from 5,000 kg
10,001 kg–20,000 kg	RM242.50	RM0.011/kg from 10,000 kg
20,001 kg–30,000 kg	RM352.50	RM0.011/kg from 20,000 kg
30,001 kg–40,000 kg	RM462.50	RM0.011/kg from 30,000 kg
40,001 kg–50,000 kg	RM572.50	RM0.011/kg from 40,000 kg
50,000 kg and above	RM682.50	RM0.011/kg from 50 000 kg
Motorcycles		
Engine capacity		
150 cc and below	RM2.00	
151 cc–200 cc	RM30.00	
201 cc–250 cc	RM50.00	
251 cc–500 cc	RM180.00	
501cc–800cc	RM250.00	
800 cc and above	RM350.00	

cc = cylinder capacity, kg =kilogramme.
Source: Malaysia Ministry of Transport, 'Road Taxes'. https://www.mot.gov.my/en/land/operators/road-taxes

Table 1.12. Import Duty and Local Taxes for Cars in Malaysia

	Import Duty				Local Taxes	
	CBU		CKD		CBU and CKD	
	MFN	ATIGA	MFN	ATIGA	Excise Duties	Sales Tax
Passenger Cars (including station wagons, sports cars, and racing cars)						
Engine capacity (cc)						
<1,800	30%	0%	10%	0%	75%	10%
1,800–1,999	30%	0%	10%	0%	80%	10%
2,000–2499	30%	0%	10%	0%	90%	10%
Above 2,500	30%	0%	10%	0%	105%	10%
Other Motor Cars						
Engine capacity (cc)						
<1,500	30%	0%	nil	0%	60%	10%
1,500–1,799	30%	0%	nil	0%	65%	10%
1,800–1,999	30%	0%	10%	0%	75%	10%
2,000–2,499	30%	0%	10%	0%	90%	10%
Above 2,500	30%	0%	10%	0%	105%	10%
Commercial Vehicles						
Class						
All	30%	0%	nil	0%	nil	10%

ATIGA = ASEAN Trade in Goods Agreement, CBU = complete built unit, CKD = complete knock down, MFN = most favoured nation.
Source: Malaysian Automotive Association (2019), 'Duties & Taxes on Motor Vehicles', 1 January. http://www.maa.org.my/pdf/malaysia_duties_taxes_on_motor_vehicles.pdf

1.2.6. Economic incentives for EV owners

According to Touchpoints Budget 2023[13] published by the Ministry of Finance, three types of incentives are being proposed:

- Full import duty exemption on components for locally assembled EVs until 31 December 2027
- Full excise duty and sales tax exemptions on locally assembled CKD EVs until 31 December 2027

[13] https://belanjawan.mof.gov.my/pdf/belanjawan2023/ucapan/touchpoint-budget-en.pdf

- Full import duty and excise duty exemption on imported CBU EVs until 31 December 2025

1.2.7. Economic incentives for charging infrastructure development

According to Touchpoints Budget 2023[13] published by the Ministry of Finance, an income tax exemption of 100% on the statutory income of EV charging equipment manufacturers from the year of assessment 2023 to the year of assessment 2032 and an investment tax allowance of 100% for a period of 5 years are being proposed.

1.2.8. Economic incentives for manufacturers

The National Low Carbon Mobility Blueprint 2021–2030 plans to implement the following actions:

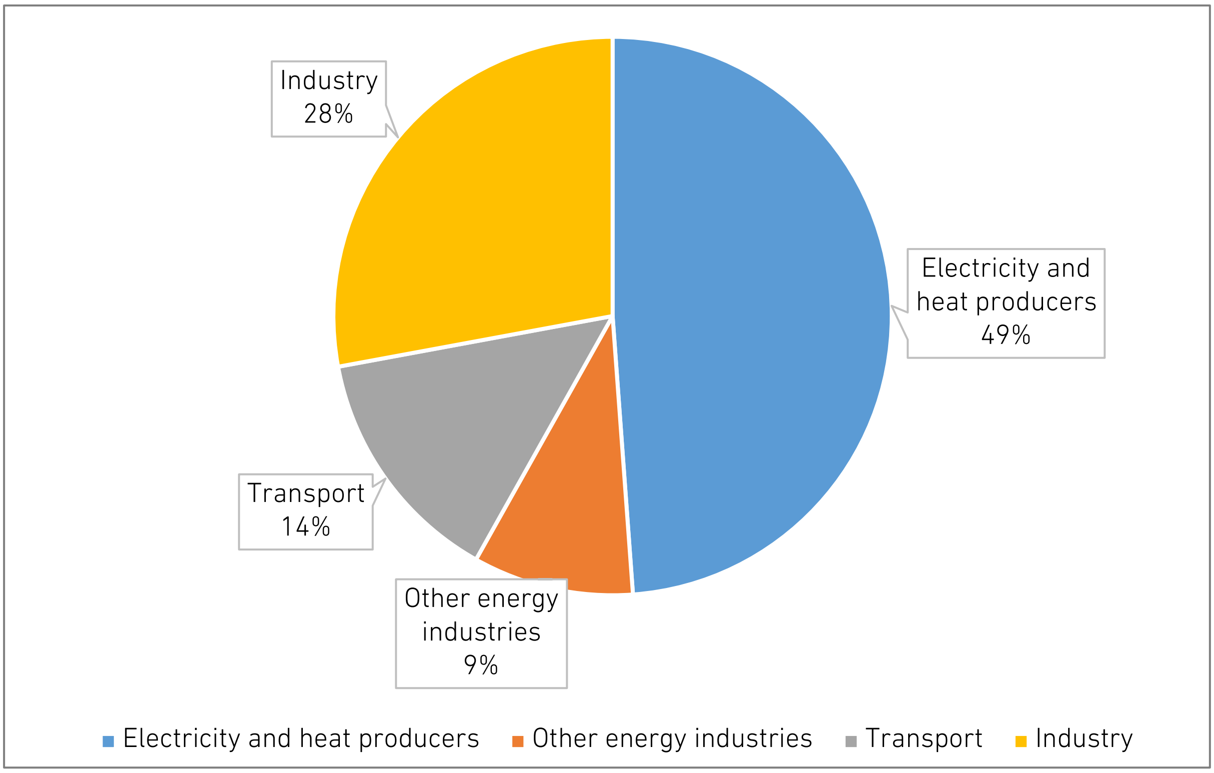
- Support research and development (R&D) activities of local EV makers and create business opportunities.
- Introduce a new tax incentive programme for 'green' industry, including companies engaged in production, logistics, and services related to low-carbon transport.

1.3. Singapore

1.3.1. Decarbonisation policy in the transport sector

Figure 1.5 shows Singapore's CO_2 emissions by sector in 2020. The transport sector accounts for 14% of the total and is the third largest source of CO_2 emissions.

Figure 1.5. Singapore CO_2 Emissions by Sector, 2020



Source: Compiled by IEEJ based on IEA data. https://www.iea.org/countries/singapore.

In February 2021, Singapore formulated the Singapore Green Plan 2030. This plan sets out the national policies and medium-to-long-term targets for the next 10 years with a view to achieving a sustainable society and is led by the Ministry of Sustainability and the Environment (MSE), the Ministry of Trade and Industry (MTI), the Ministry of Transport (MOT), the Ministry of National Development (MND), and the Ministry of Education (MOE). Being an island country, Singapore is particularly sensitive to rising sea levels and abnormal weather and aims to tackle climate change with a high priority due to its geographical environment. The plan consists of five key initiatives:

① City in Nature

② Energy Reset

③ Sustainable Living

④ Green Economy

⑤ Resilient Future

To decarbonise the transport sector, there is a government-led effort to promote EVs. The specific targets and actions are specified under the '② Energy Reset' initiative.

1.3.2. EV policies and targets

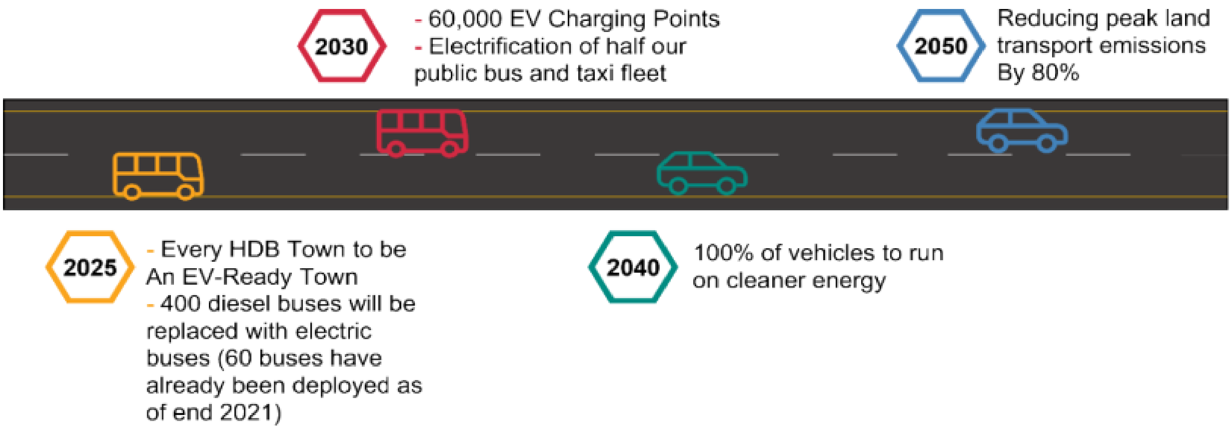
Singapore's EV policies and targets are based on Singapore Green Plan 2030 described earlier. As part of the effort, the Land Transport Authority (LTA) has created a roadmap, established a vision for the country's EV policies, and set the final goal of reducing CO_2 emissions arising from land transport by 80% from 2016 levels by 2050. In doing so, the LTA holds that switching from international combustion engine (ICE) vehicles to EVs will boost sustainability particularly for Singapore, whose domestic electricity is produced mostly from natural gas. In addition, since EVs generate only half as much CO_2 emissions compared to similar ICE vehicles, if all light cars become electricity-powered, the total domestic CO_2 emissions will decrease by 1.5 million–2 million tonnes, or roughly 4%.

Table 1.13. EV Policies and Targets by 2050 in Singapore

2025	Banning of new registration of diesel passenger vehicles and taxes
	All public housing to install more than 3 units of EV charging systems (EV Ready Town.
2030	After 2030, all passenger cars and taxis will be registered as clean energy vehicles (including electric, hybrid, or hydrogen fuel cell vehicles), and half of buses and taxis will be electrified.
	By 2030, there will be 60,000 charging points nationwide, including 40,000 in public parking lots and 20,000 in private facilities, including private apartment complexes.
2040	By 2040, all internal combustion engine vehicles will be banned and 100% clean energy vehicles will be used.
	By 2040, all public buses will be clean energy vehicles, such as hybrids or EVs.
2050	Reduce CO_2 emissions from land transport by 80% by 2050 from their peak in 2016.

Source: Created based on 'Our EV Vision', LTA website. https://www.lta.gov.sg/content/ltagov/en/industry_innovations/technologies/electric_vehicles/our_ev_vision.html

Figure 1.6. Overview of Singapore EV Roadmap



Source: LTA website.
https://www.lta.gov.sg/content/ltagov/en/industry_innovations/technologies/electric_vehicles/our_ev_vision.html (accessed 6 April 2023).

1.3.3. Status of EV introduction

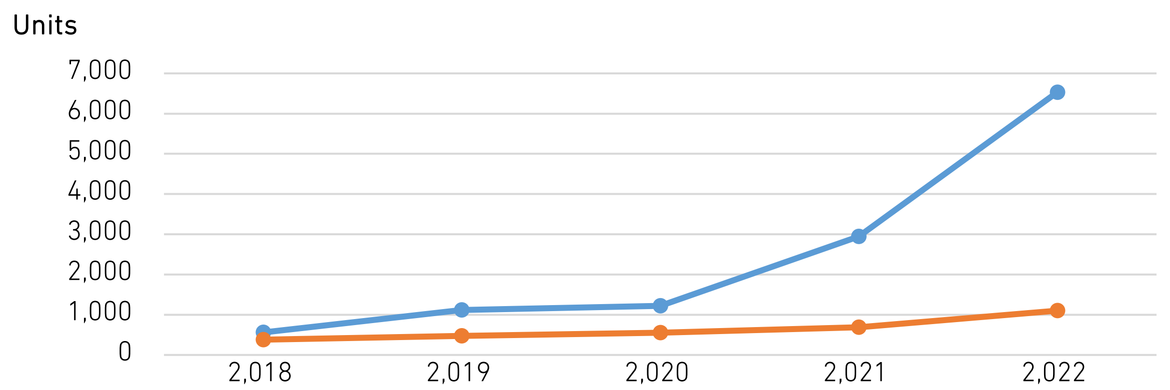
Table 1.14 shows the number of new EVs of each maker or brand registered between 2020 and 2022. In 2022, 3,634 new EVs were sold, which was more than double the figure in 2021 (and accounting for 11.7% of all new cars sold and registered). As a result, the number of registered EVs reached 6,531 as of the end of 2022. As there were 650,667 passenger vehicles in the country as of 2022, EVs accounted for 1% of the total. The increase has been led by United States EV maker Tesla, whilst BYD, Mercedes Benz, and BMW are also very popular.

Table 1.14. Newly Registered EVs by Maker/Brand, 2020–2022 (units)

Maker/Brand	2020	2021	2022
Tesla	20	924	875
BYD	3	89	786
BMW	4	121	492
Mercedes Benz	0	17	327
MG	34	129	228
Porsche	3	129	185
Pole Star	0	10	158
Hyundai	7	108	126
Blue Car	0	30	109
Audi	4	65	93
Opel	0	0	73
Volvo	0	0	63
Peugeot	0	0	34
Mini	6	39	33
Honda	0	19	12
Nissan	5	22	11
Smart	0	0	6
Toyota	0	10	6
Volkswagen	0	5	5
Mazda	0	0	4
Jaguar	10	8	3
Kia	1	13	3
Fiat	0	0	1
Ford	0	0	1
Renault	3	2	0
Total	100	1,740	3,634

Source: Created by IEEJ based on JETRO and LTA data.
https://www.jetro.go.jp/biz/areareports/special/2022/0302/eef67dd74d7fb734.html
https://www.lta.gov.sg/content/dam/ltagov/who_we_are/statistics_and_publications/statistics/pdf/MVP02-2_New_Cars_by_make.pdf

Figure 1.7. Number of Registered EVs and PHEVs, 2018–2022



	2,018	2,019	2,020	2,021	2,022
EV	560	1,120	1,217	2,942	6,531
PHEV	380	473	552	692	1,101

*Figures exclude tax exempted vehicles and vehicles for off-the-road use (RU plates).

Note: Figures exclude tax-exempted vehicles and vehicles for off-the-road use (RU plates).
Source: Created by IEEJ based on LTA data. https://www.lta.gov.sg/content/dam/ltagov/who_we_are/statistics_and_publications/statistics/pdf/MVP01-4_MVP_by_fuel.pdf

1.3.4. Current status of EV infrastructure

At a parliamentary session on 30 November 2022, Minister of Transport Subramaniam Iswaran said that there were over 3,600 charging points, which was more than double the number 2 years ago. He also said that the LTA recently awarded a tender to deploy an additional 12,000 charging points across all Housing Development Board (HDB; government-built apartment complexes) carparks.[14] The LTA has set a target of installing 60,000 charging points nationwide, namely 40,000 in public carparks and 20,000 in private sector facilities, including apartments, by 2030.

1.3.5. Vehicle registration fees

Certificate of entitlement (COE)

To own a car in Singapore, which is limited in area, it is necessary to obtain a car ownership certificate called a COE. The government controls the total national fleet by limiting the number of COEs issued.[15] A COE can be obtained by placing a bid at the biweekly COE auction held for each vehicle category, as described in Table 1.15. There are limits on the number of COEs issued in each auction, so their prices fluctuate depending on the supply

[14] https://www.mot.gov.sg/news/details/opening-speech-by-minister-for-transport-mr-s-iswaran-for-second-reading-of-electric-vehicles-charging-bill-2022

[15] Land Transport Authority (LTA), *Vehicle Tax Structure.* https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/tax-structure.html#CEVS_bandings_car

and demand at the time. The price for a Category A COE was S$93,503 at the auction that ended on 22 March 2023, surpassing the price recorded in 2013 of S$92,100 and marking a record high. Likewise, the price of a Category B COE was S$116,201, which also surpassed the record of S$115,501 marked two weeks ago, setting a new record.[16,17]

A COE is valid for 10 years, and when the term expires, the owner can either cancel the vehicle registration or renew the COE. A renewal does not require a fresh bid and can be done by paying the average price of a COE for the past three months, called a prevailing quota premium.

Table 1.15. Vehicle Categories in the COE

Category	
Category A	For COEs obtained before the May 2022 1st COE bidding exercise: Car with engine capacity up to 1,600 cc and Maximum Power Output up to 97 kW (130 bhp)
	For COEs obtained from the May 2022 1st COE bidding exercise onwards: Non-fully electric cars with engines up to 1,600 cc and Maximum Power Output up to 97 kW (130 bhp); and fully electric cars with Maximum Power Output up to 110 kW (147 bhp)
Category B	For COEs obtained before the May 2022 1st COE bidding exercise: Car with engine capacity above 1,600 cc or Maximum Power Output above 97 kW (130 bhp)
	For COEs obtained from the May 2022 1st COE bidding exercise onwards: Non-fully electric cars with engines above 1,600 cc or Maximum Power Output above 97 kW (130 bhp); and fully electric cars with Maximum Power Output above 110 kW (147 bhp)
Category C	Goods vehicle and bus
Category D	Motorcycle
Category E	Open – all except motorcycle

Source: LTA website.
https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/certificate-of-entitlement--coe-.html (accessed 6 April 2023).

Open market value (OMV)

The OMV is the price of a vehicle paid for when it is imported into Singapore. The OMV is determined by Singapore Customs and includes the purchase price, transportation costs, insurance, and any other costs associated with delivering the vehicle to Singapore and its

[16] https://www.aas.com.sg/motoring-info/coe/
[17] https://www.asiax.biz/news/62342/

sale. The price is published for each type of vehicle every month on the LTA website.

Registration fee (RF)

The registration fee is S350 for all types of vehicles, including passenger cars, taxis, motorcycles, commercial vehicles, and buses.

Additional registration fee (ARF)

The ARF is the additional registration fee that is charged based on the OMV price. The ARF has been subdivided into even smaller categories since February 2023, with rates increasing progressively with the amount of OMV. For instance, for a Honda FREED 1.5 E7 CVT model, of which the average OMV is S$18,774 as of 2023, the ARF is 100% of the OMV, which equals S$18,774.

Table 1.16. Additional Registration Fee (ARF) for Passenger Cars

Additional Registration Fee (ARF)		
	Vehicle Open Market Value (OMV)	ARF Rate (% of OMV to pay)
For cars registered with COEs obtained before the second COE bidding exercise in February 2023, or cars that do not need to bid for COEs registered before 15 February 2023	First S$20,000	100%
	Next S$30,000(i.e. S$20,001 to S$50,000)	140%
	Next S$30,000(i.e. S$50,001 to S$80,000)	180%
	Above S$80,000(i.e. S$80,001 and above)	220%
For cars registered with COEs obtained from the second COE bidding exercise in February 2023 onwards, or cars that do not need to bid for COEs registered on or after 15 February 2023	First S$20,000	100%
	Next S$20,000(i.e. S$20,001 to S$40,000)	140%
	Next S$20,000(i.e. S$40,001 to S$60,000)	190%
	Next S$20,000(i.e. S$60,001 to S$80,000)	250%
	Above S$80,000(i.e. S$80,001 and above)	320%

Source: LTA website. https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/tax-structure.html (accessed 6 April 2023).

Excise duty

Excise duty is a commodity tax, and its rate is set to 20% of the OMV.

Road tax

Tables 1.17 and 1.18 describe Singapore's road tax. The road tax is divided roughly into gasoline vehicles and EVs and must be paid every 6 or 12 months. As such, when buying a car, the buyer must check with the dealer whether the road tax for the car has been paid. When a car is sold, any remaining validity of the road tax that has been paid is transferred to the new owner with the car.

Furthermore, as shown in Table 1.18, the road tax was revised effective 1 January 2022. As a result, the road tax for vehicles within a rated power range of 90–230 kilowatts is lowered by up to 34%. Singapore's Ministry of Transport states that the purpose of this revision is to ensure that the road tax for EVs for general users is similar to that for comparable ICE vehicles.[18]

Table 1.17. Road Tax for Gasoline Vehicles

Road Tax (For Petrol, Petrol-Compressed Natural Gas (CNG), CNG or Diesel Cars)	
Engine Capacity (EC) in CC	6-Monthly Road Tax
EC ≤ 600	S$200 x 0.782
600 < EC ≤ 1,000	[S$200 + S$0.125(EC - 600)] x 0.782
1,000 < EC ≤ 1,600	[S$250 + S$0.375(EC - 1,000)] x 0.782
1,600 < EC ≤ 3,000	[S$475 + S$0.75(EC - 1,600)] x 0.782
EC > 3,000	[S$1,525 + S$1(EC - 3000)] x 0.782

Source: LTA website. https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/tax-structure.html (accessed 6 April 2023).

[18] https://www.mot.gov.sg/what-we-do/green-transport/electric-vehicles

Table 1.18. Road Tax for Electric Vehicles

Road Tax (For Electric Cars registered on or after 1 January 2021)	
Road tax, payable from 1 January to 31 December 2021, calculated based on the power rating of the car	
Power Rating (PR) in kW	6-Monthly Road Tax
PR ≤ 7.5	S$200 x 0.782
7.5 < PR ≤ 30	[S$200 + S$2(PR – 7.5)] x 0.782
30 < PR ≤ 90	[S$250 + S$3.75(PR – 30)] x 0.782
90 < PR ≤ 230	[S$475 + S$7.50(PR – 90)] x 0.782
PR > 230	[S$1,525 + S$10(PR – 230)] x 0.782
Road tax, payable from 1 January 2022, calculated based on the power rating of the car	
Power Rating (PR) in kW	6-Monthly Road Tax
PR ≤ 7.5	S$200 x 0.782
7.5 < PR ≤ 30	[S$200 + S$2(PR – 7.5)] x 0.782
30 < PR ≤ 230	[S$250 + S$3.75(PR – 30)] x 0.782
PR > 230	[S$1,525 + S$10(PR – 230)] x 0.782

Source: LTA website. https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/tax-structure.html (accessed 6 April 2023).

1.3.6. Incentives for EV owners

Electric Vehicle Early Adoption Incentive (EEAI)

Anyone who registers a new or imported second-hand full EV between 1 January 2021 and 31 December 2023 is eligible for an EEAI. This provides the owner with a refund of up to 45% or S$20,000 from the ARF.

Vehicle Emissions Scheme (VES)

The VES is a system that has been launched to promote the introduction of clean energy vehicles, mainly EVs, whilst limiting gasoline and other vehicles that emit greenhouse gases. Specifically, cars that are good for the environment are given cash refunds in the form of rebates, whilst those that are bad incur additional taxes. Environmental performance has five categories, namely A1, A2, B, C1, and C2 starting with the highest, and the ranking was determined initially based on the emission amounts of four pollutants (1 January 2018–30 June 2018: carbon dioxide (CO_2), hydrocarbon (HC), carbon monoxide (CO), and nitrogen oxides (NOX)). Further, particulate matter (PM) was added on 1 July 2018, resulting in a total of five pollutants.

Table 1.19 describes the emission regulations for vehicles registered between January 2021 and December 2023. Vehicles in the A1 category can receive a rebate of S$25,000, whilst ones in the C2 category must pay a surcharge of S$25,000. When combined with the EEAI described earlier, an owner is eligible for an incentive of up to S$45,000 in total, lightening the burden of the ARF payment.

Table 1.19. Vehicle Emission Scheme, January 2021–December 2023

Cars or Taxis Registered from 1 January 2021 to 31 December 2023									
Band	CO_2 (g/km)	HC (g/km)	CO (g/km)	NOx (g/km)	PM (mg/km)	Car		Taxi	
						Rebate	Surcharge	Rebate	Surcharge
A1	A1 ≤90	A1 ≤0.020	A1 ≤0.150	A1 ≤0.007	A1 = 0.0	S$25,000	N.A	S$37,500	N.A
A2	90<A2 ≤125	0.020<A2 ≤0.036	0.150<A2 ≤0.190	0.007<A2 ≤0.013	0.0<A2 ≤0.3	S$15,000	N.A	S$22,500	N.A
B	125< B ≤160	0.036< B ≤0.052	0.190< B ≤0.270	0.013< B ≤0.024	0.3< B ≤0.5	N.A	N.A	N.A	N.A
C1	160< C1 ≤185	0.052< C1 ≤0.075	0.270< C1 ≤0.350	0.024< C1 ≤0.030	0.5< C1 ≤2.0	N.A	S$15,000	N.A	S$22,500
C2	C2>185	C2>0.075	C2>0.350	C2>0.030	C2>2.0	N.A	S$25,000	N.A	S$37,500

Source: LTA website. https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/emissions-charges.html#VES_At_a_glance (accessed 6 April 2023).

Commercial Vehicle Emissions Scheme (CVES)

CVES is a VES but for commercial vehicles. Launched in 2021, the system was initially planned to end on 31 March 2023. However, it was decided to extend the term by two years with revised regulatory values and incentive amounts. The revised emission scheme has been effective from 1 April 2023 through 31 March 2025 as described in Table 1.20. The scheme is applied to small commercial vehicles (small freight cars with a maximum load weight of up to 3,500 kilogrammes, freight/passenger cars, and small buses) and the owner can receive a refund of up to S$15,000 at vehicle registration.[19] The incentive was capped at S$30,000 between April 2021 and March 2023 but was lowered with the revision to up to S$15,000. On the other hand, the surcharge was increased from S$10,000 to S$15,000 to encourage a switch to EVs by raising the amount.

[19]https://www.lta.gov.sg/content/ltagov/en/newsroom/2022/11/news-releases/extension_and_adjustments_to_CVES_and_ETS.html#:~:text=The%20CVES%20is%20an%20outcome,weight%20not%20exceeding%203%2C500kg.

Table 1.20. Commercial Vehicle Emissions Scheme for Small Commercial Vehicles, 1 April 2023–31 March 2025

CVES bandings, incentives, and surcharges							
Band	CO_2 (g/km)	HC (g/km)	CO (g/km)	NOx (g/km)	PM (g/km)	Incentive	Surcharge
A	A1 ≤123	A1 = 0	A1 = 0	A1 = 0	A1 = 0	S$15,000	-
B	150<B≤216	0.0 < B ≤ 0.025	0.0 < B ≤ 0.270	0.0 < B ≤ 0.015	0.0 < B ≤ 0.85	S$5,000	-
C	C>216	C > 0.025	C > 0.270	C > 0.015	C > 0.85	-	-S$15,000

Source: LTA website. https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/tax-structure.html

1.3.6. Economic incentives for the installation of charging infrastructure

The Electric Vehicle Common Charger Grant (ECCG) is in place as an incentive for installing charging systems. With this scheme, the government pays part of the costs in the form of a grant. The scheme began in July 2021 and was scheduled to end either at the end of December 2023 or when 2,000 units were reached, whichever came earlier, but on 3 March 2023, it was decided to extend the term by two years until the end of December 2025.[20]

The application procedure is as follows. The applicant files an application through the government's Business Grant Portal (BGP) (by preparing a cost estimate, etc.), and receives a Letter of Offer (LOF) if the application goes through. Then, the applicant installs an EV charger within six months after receiving the LOF, and when the work is completed, submits an electronic bill to the BGP. If the bill is approved, the applicant receives confirmation by the LTA and the grant.

The actual amounts of the grant are shown in Table 1.21. It is capped at S$4,000 in total per charger and consists of three cost components: (1) the charging system (50% of the total), (2) the fee for a licensed electrical worker (50% of the total), and (3) cabling and installation costs (50% of the total or up to S$1,000).

Table 1.21. Examples of the ECCG

Cost for Each Cost Component	50% Co-funding on Each Cost Component	Total Co-funding Amount
Example 1 Charging system = S$3,000 LEW fees = S$2,000 Cabling and installation cost = S$1,500	= S$1,500 = S$1,000 = S$750	=S$3,250
Example 2 Charging system = S$5,000 LEW fees = S$3,000 Cabling and installation cost = S$2,500	= S$2,500 = S$1,500 = S$1,000 (sub cap of S$1,000 on cabling and installation cost)	=S$4,000 (overall cap of S$4,000 per charger)

Source: LTA website.
https://www.lta.gov.sg/content/dam/ltagov/industry_innovations/Technologies/Electric_Vehicles/PDF/ECCG_Guidelines_and_FAQs.pdf

[20] https://www.lta.gov.sg/content/ltagov/en/newsroom/2023/3/newsreleases/sustaining_the_momentum_of_vehicle_electrification.html

1.3.7. Economic incentives for makers

In Singapore, there is an EV plant within the innovation centre newly established by the Republic of Korea's Hyundai Motor. When EV production begins in earnest, it will be the first time for automobiles to be produced in Singapore since the 1980s.

1.3.8. EV and battery production project

In November 2022, silica aerogel powder maker JIOS announced plans to operate a factory in its lab in Singapore through its innovation programme. This will be carried out with the support of the Economic Development Board (EDB), a statutory board under the Ministry of Trade and Industry. Behind this project is US$1.8 trillion in anticipated investment by automakers in EVs, batteries, and materials.[21] The company states that the purpose of the factory is to respond to the strong demand for its products.[22]

1.4. Thailand

1.4.1. Decarbonisation policy in the transport sector

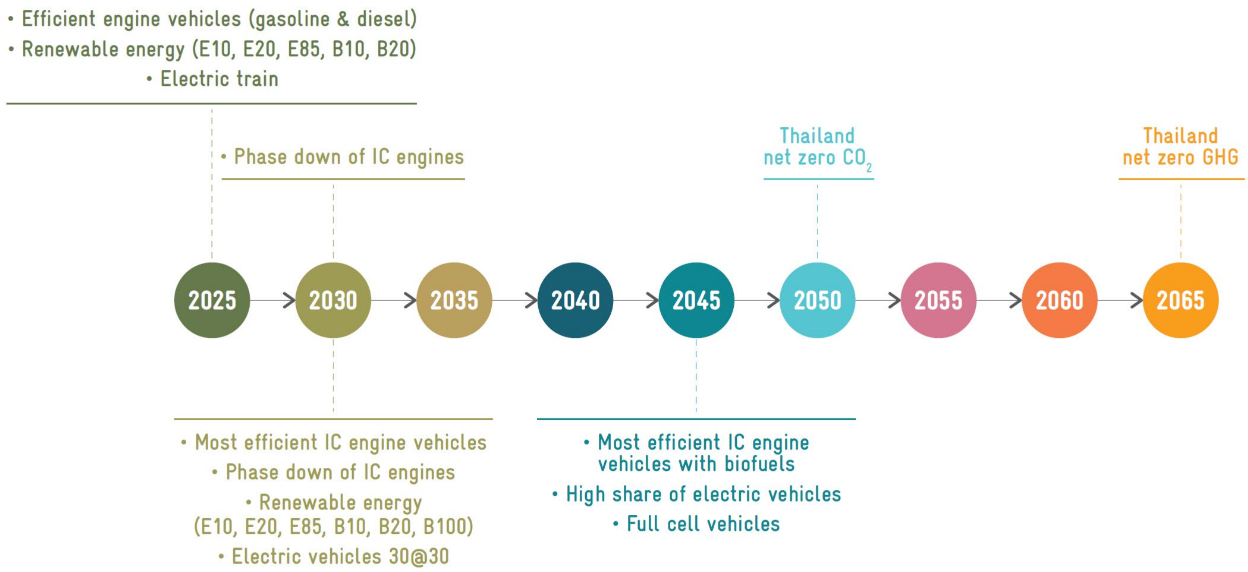
Thailand updated its Nationally Determined Contribution (NDC) in November 2022. The country intends to reduce its greenhouse gas emissions by 30% from the projected business-as-usual (BAU) level by 2030, and the level of contribution could increase up to 40%, subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity building support. Thailand's commitments also include a long-term objective to achieve carbon neutrality by 2050 and net-zero greenhouse gas emissions by 2065.

The transport sector contributed the largest share of final energy consumption in 2020, at around 38.40% of the final energy consumption by economic sectors. Total direct GHG emissions from the energy sector in 2018 was estimated at 257,340.89 $GgCO_2eq$, accounting for 69.06% of the country's total GHG emissions. GHG emissions from transport were 75,029.65 $GgCO_2eq$ (29.16%) by total direct GHG emissions from the energy sector in 2018.

Figure 1.8 shows the path towards net-zero emissions in the transportation sector as outlined by the Thai government. Decarbonisation policy in the transport sector consists of the electrification of transport; cleaner and more efficient technologies, such as hybrid, plug-in hybrid, electric, and fuel cell electric vehicles (FCEVs), with fuel-cell technology as a more effective option for long-haul truck segments; and energy efficiency improvement.

[21] https://www.reuters.com/graphics/AUTOS-INVESTMENT/ELECTRIC/akpeqgzqypr/index.html
[22] ttps://jiosaerogel.com/jios-aerogel-commissions-new-factory-in-singapore-for-electric-vehicle-battery-components/

Figure 1.8. Net Zero GHG Emission Timeline for the Transport Sector



Source: Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment, Thailand (2022), Long-term Low Greenhouse Gas Emission Development Strategy (November 2022).

1.4.2. EV policy and targets

Thailand aims to be a major global production base for EVs and parts. Under this vision, with the launch of the National Electric Vehicle Policy Committee (NEVPC) in 2020, the Thai government set the goal of having at least 30% of domestic vehicle production be EVs by 2030 (EV 30@30 Policy). The Thai government has been steadily working to promote EVs through subsidies, reductions in import duties and tax relief, and other methods.

The EV 30@30 Policy is a three-phase development plan for the EV industry.

Phase 1 (2021–2022): the government will promote electric motorcycles and support infrastructure nationwide.

Phase 2 (2023–2025): the EV industry will be developed to produce 225,000 cars and pick-up trucks, 360,000 motorcycles, and 18,000 buses and trucks by 2025, including the production of batteries. This first milestone is designed to deliver cost advantages via economies of scale.

Phase 3 (2026–2030): to produce 725,000 EV cars and pick-ups plus 675,000 EV motorcycles (Table 1.22) and to install 12,000 DC charging stations (Table 1.23).

Table 1.22. Targets of EV Production and Usage in Thailand

Target		2025	2030	2035
Passenger Cars/Pickups				
Annual Production	(million cars)	0.225	0.725	1.35
Usage	(million cars)	0.225	0.44	1.154
Buses/Trucks				
Annual Production	(million cars)	0.018	0.034	0.084
Usage	(million cars)	0.018	0.033	0.083
Motorcycles				
Annual Production	(million cars)	0.36	0.675	1.85
Usage	(million cars)	0.36	0.65	1.80

Source: Electric Vehicle Association of Thailand (EVAT).

Table 1.23. Targets of EV Charging Stations in Thailand

Target	2025	2030
Passenger Cars/Pickups		
DC first charging stations	4,400	12,000
Motorcycles		
Charging stations	260	1,450

Source: National Electric Vehicle Policy Committee.

1.4.3. Fuel economy regulation

As of September 2023, passenger cars and pickup trucks manufactured in Thailand (domestically produced) are compliant with Euro 4, and mandatory compliance with Euro 5 has been postponed until January 2025.

Twenty-seven types of domestically produced eco-cars (those falling under Phase 2 of the government-led eco-car project) are Euro 5 compliant.

1.4.4. Current status of the introduction of EVs

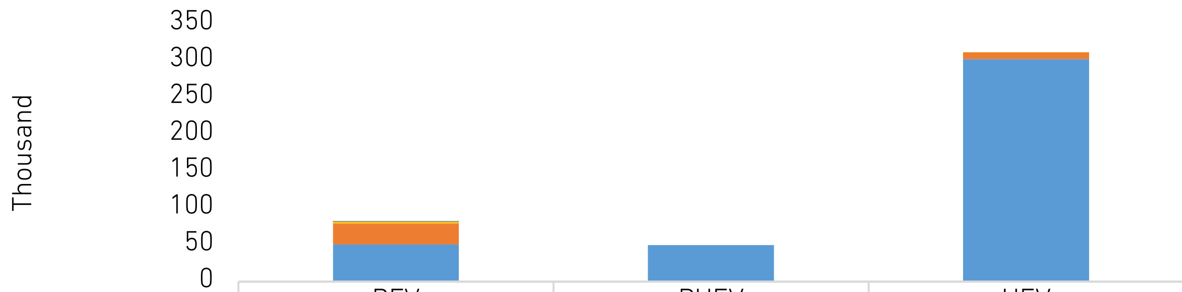
Since the launch of the EV policies, the number of EV registrations has steadily increased. Table 1.24 shows the number of HEV and PHEV, and BEV registrations in Thailand. The number of HEV and PHEV registrations increased steadily between 2018 and 2021 (20,344 units in 2018, 30,676 units in 2019, 32,264 units in 2020, and 42,800 units in 2021). However, in 2022, the number of HEV and PHEV registrations reached 75,366, showing rapid growth. The growth of BEVs has been even more rapid, the number of registered BEVs greatly increased from 5,781 units in 2021 to 20,816 units in 2022 and reached 49,952 by July 2023.

Table 1.24. New HEV/PHEV and BEV Registrations in Thailand, 2019–2022

Year	2019	2020	2021	2022
Total EVs	32,248	35,270	48,581	96,182
HEVs/PHEVs	30,676	24,464/7,807	35,740/7,060	64,035/11,331
BEVs	1,572	2,999	5,781	20,816
ICE Vehicles	2,976,432	2,577,016	2,620,113	2,996,735

Note: Motorcycles, buses, trucks, and motor-tricycles are also included.
BEV = battery electric vehicle, EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Thailand Department of Land Transport, Electric Vehicle Association in Thailand.

Figure 1.9. Accumulated Number of xEV Registrations
(as of 31 July 2023)



	BEV	PHEV	HEV
Truck	232	0	0
Bus	2338	0	2
Motor-tricycles	699	0	0
Motorcycle	28042	0	9106
Car	50557	49587	302042

BEV = battery electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Electric Vehicle Association in Thailand.

1.4.5. Current status of EV charging infrastructure

Table 1.24 shows the number of DC and AC chargers in Thailand as of 22 May 2023. Thailand has set a goal of installing 4,400 DC charger units by 2025, but as of May 2023, only 1,795 units had been installed. On the other hand, the number of AC chargers has rapidly increased, more than doubling in 8 months (Table 1.25).

Table 1.25. EV Charging Infrastructure in Thailand

Year	As of 20 Sep 2022	As of 22 May 2023
Total	2,572	4,628
DC CSS2	942	1,471
DC CHAdeMO	246	324
AC	1,384	2,833

Source: Thailand Department of Land Transport, Electric Vehicle Association in Thailand.

1.4.6. Costs associated with vehicle purchase (excise tax, registration fee)

The Thai government has implemented some taxes and levies associated with the purchase of vehicles. These are an excise tax and vehicle registration fee.

Excise tax

Excise tax rates on xEVs have been reduced from 2022 to 2025. The normal tax rates and reduced rates are shown in Table 1.27 as one of the economic incentives for manufacturers.

Vehicle registration fee

New vehicle registration requires (i) a new vehicle registration fee, (ii) vehicle tax (Thai Department of Land Transport), and (iii) a compulsory vehicle insurance premium, in addition to an optional vehicle insurance premium and parking fees. Vehicle inspection is required for motorcycles older than 5 years old and passenger cars, trucks, and buses older than 7 years old.

In Thailand, the certification of vehicle storage space is not mandatory.

(i) New vehicle registration fee

The cost for new car registration consists of a new car registration fee, car registration manual, licence plate, and vehicle inspection fee. For passenger cars, the total cost to register a new car is B565.

(ii) Vehicle tax

The vehicle tax is an annual expense that is paid to the Department of Land Transport. Each car model has different vehicle tax rates depending on the type, size, engine power, and the service life of the car.

The tax for personal cars up to seven seats with general use, such as four-door sedans, four-door pickup trucks, etc. is calculated based on the rate determined by the actual engine capacity (cc). For example, the vehicle tax of a new sedan with four seats and an engine capacity of 1,799 cc is B2,098.5.

Taxes for passenger cars for more than seven people, car hire, personal trucks, and land transport are calculated based on the rate determined by vehicle weight and type of vehicle.

(iii) Compulsory vehicle insurance

The compulsory vehicle insurance is for all types of vehicles. It is a regulation under the Car Accident Protection Act 1992. If violated, there will be a fine of not more than B10,000.

Table 1.26. Total Fees for New Vehicle Registration Fees and Taxes, Compulsory Vehicle Insurance Premiums

Type of Vehicle	Total Fee for New Vehicle Registration Fees and Taxes[a] (baht, average in 2021)	Compulsory Vehicle Insurance Premiums[b] (baht)
Passenger Vehicles	2,750	Personal, hiring/renting/public 600, 1,900
Buses	1,901	Personal, hiring/renting/public 600, 1,900 (no more than 7 passengers) 1,100, 2,320 (no more than 15 seats) 2,050, 3,480 (15–no more than 20 seats) 3,200, 6,660 (20–no more than 40 seats) 3,740, 7,520 (over 40 seats) Driving between the districts within the province (hiring/renting/public only): 1,580 (no more than 15 seats) 2,260 (15–20 seats) 3,810 (20–40 seats) 4,630 (more than 40 seats)
Trucks	3,448	Personal, hiring/renting/public 900, 1,760 (no more than 3 tonnes) 1,220, 1,830 (3–6 tonnes) 1,310, 1,980 (6–12 tonnes) 1,700, 2,530 (more than 12 tonnes)
Motorcycles	100	EV: 300, 350 (personal, hiring/renting/public) ICE: 150 (no more than 75 cc) 300, 350 (75–125 cc, individual, hiring/renting/public) 400 (125–150 cc) 600 (more than 150 cc)
Three-wheelers	325	EV: 500,1,440 (personal, hiring/renting/public) ICE: personal, hiring/renting/public 720, 1,440 (Bangkok) 400, 400 (outside Bangkok)

Sources: [a] Ministry of Transport, Department of Land Transport, 'Registration Fee and Tax'.
[b] Office of Insurance Commission, 'Compulsory Vehicle Insurance'.
https://www.oic.or.th/th/consumer/อัตราเบี้ยประกันภัย-พรบ

1.4.7. Economic incentives for xEV owners

The Thai government approved a framework for a new EV promotion programme at a cabinet meeting on 15 February 2022 (Royal Thai Government, 2022). The promotion programme includes subsidies for the purchase of EVs. The subsidies are scheduled to be provided from 2022 to 2025 to manufacturers and distributors, not consumers. Thus, the subsidies are indirect incentives for xEV owners (Table 1.27).

BEVs have a 5–6-year tax exemption period, whilst PHEVs and HEVs receive a 5%–12.5% tax reduction depending on fuel economy.

Compulsory automobile insurance for EVs (passenger cars, motorcycles, and three-wheeled vehicles) is imposed as a fixed insurance rate regardless of engine capacity.

1.4.8. Economic incentives for charging infrastructure development

In April 2022, the Board of Investment of Thailand (BOI) approved revised incentives and conditions for investment in the EV charging station sector. In addition to the 5-year corporate tax exemption applicable to investments in charging stations with 40 or more chargers (25% of which are DC), the revised measures now provide a 3-year tax incentive for smaller charging stations.

The revised measure also eliminates two conditions that prohibit investors from receiving additional benefits from other institutions and the ISO certification requirement.

It is required for investors in charging stations to comply with relevant safety regulations and submit a plan to either implement EV smart charging systems or connect to the EV Charging Network Operator Platform (Thai BOI, 2022).

1.4.9. Economic incentives for manufacturers

As of April 2023, the BOI granted investment incentives to 26 EV manufacturing projects, including seven HEV projects, eight PHEV projects, 15 BEV projects, and 2 electric bus projects, with a total investment of B86.8 billion (investment value excluding the cost of land and working capital). And annual manufacturing capacity of BEV is 270,000 units. For EV components and batteries, the BOI also granted investment incentives to 16 projects for components and 28 projects for battery and energy storage components production, of which the total investment was B23.82 billion (investment value excluding cost of land and working capital) (Thai BOI, 2023).

In March 2021, the BOI announced a tax incentive for next-generation automobiles in Decree 3/2564 (Thai BOI, 2021). Manufacturing only HEVs or PHEVs should not be eligible for the benefit, and manufacturing of BEVs must also be conducted. New tax incentives consist of a corporate tax incentive, which is 3–8-year corporate tax exemption on EVs and EV parts production depending on the investment value (Table 1.27). Other incentives are R&D grants, human resource development grants, investment support for the establishment of new EV battery pilot plants, and so on.

Table 1.27. Tax Incentives for Manufacturers

Products		
Battery electric four-wheelers	Total investment capital of not less than B5 billion	BEVs: 8-year CIT exemption PHEVs: 3-year CIT exemption HEVs: no tax incentives + 1–3-year exemption in case of R&D
	Total investment capital of less than B5 billion	BEVs: 3-year CIT exemption PHEVs: 3-year CIT exemption HEVs: no tax incentives Maximum total of 11-year tax exemption available if all requirements are met
Battery electric motorcycles,		3-year CIT exemption Maximum total of 11-year tax exemption available if all requirements are met
Battery electric three-wheelers Buses and trucks		3-year CIT exemption Maximum total of 10-year tax exemption available if all requirements are met
Batteries		Pack assembly: 5-year CIT exemption Module production: 8-year CIT exemption Cell production: 8-year CIT exemption (no cap)
17 key parts of EVs		8-year CIT exemption

BEV = battery electric vehicle, CIT = corporate income tax, EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Thailand BOI (2022), *Electric Vehicle Industry*. https://www.boi.go.th/upload/content/Smart_EV.pdf

The Cabinet meeting on 22 February 2022 also decided on a draft proposal for EV import tariff reductions and exemptions. The draft applies to both imports under general tariffs and imports through free trade agreements (FTAs) and is in effect from 2022 to 2023. BEVs with a retail value not exceeding B2 million are exempt from duty if the tariff does not exceed 40% after using the FTA. If the tariff exceeds 40% under the same conditions, 40% of the tariff is reduced. In the case of imports with a general tariff of 80%, the tariff is reduced to 40%. BEVs with a retail value of B2 million–B7 million are duty free if tariffs do not exceed 20% after using the FTA. If the tariff exceeds 20% under the same conditions, 20% of the tariff will be reduced. For imports under general tariffs, the rate is reduced to 60% (Table 1.27).

The Thai government approved the general framework of regulations on excise tax rates at a Cabinet meeting on 15 February 2022 (Thai Government, 2022). PHEVs (passenger cars and pickup trucks), EVs (passenger cars and pickup trucks), low-emissions eco-cars, and fuel cell (FC) pickup trucks are subject to different new excise tax rates until 31 December 2025. The rate for EV pickup trucks is 0% until 31 December 2025, and 2% from 1 January 2026 to 31 December 2035. For 21 other types of vehicles, the new tax rates will apply from 2026 to 2035. For example, for passenger cars up to 3,000 cc, the rate will be raised in stages, starting at 13% and increasing to 30% after 1 January 2030. The excise tax rate for passenger cars over 3,000 cc will be 50% from 1 January 2026 (Table 1.28).

Table 1.28. Economic Incentives for Manufacturers

Type of Battery Electric Vehicle	Incentive			Condition*
	Subsidy	Tariff (period 2022–2023)	Excise tax (period 2022–2025)	
Passenger vehicle retail price not exceeding B2 million	B70,000 for less than 30 kWh B150,000 for more than 30 kWh	Exemption from tariff rates less than 40% with FTA, 40% reduction from tariff rates exceed 40% with FTA, 40% tariff rates from tariff rates 80% without FTA	Exemption of excise tax from 8% to 2%	If production is to begin in Thailand in 2024, its scale shall be at least the same as the number of finished vehicles imported from 2022 to 2023, and in 2025, it shall be at least 1.5 times the number of finished vehicles imported from 2022 to 2023.
Passenger vehicle retail price more than B2 million but less than B7 million	None	Exemption from tariff rates less than 20% with FTA, 20% reduction from tariff rates exceed 20% with FTA, 60% tariff rates for 80% tariff rates without FTA	Exemption of excise tax from 8% to 2%	Production of EV components can be divided into one of the following three categories: (i) battery cells, (ii) battery module assembly and one other electronic component, and (iii) battery pack assembly and two other electronic components.
Pick-up retail price not	B150,000 for more than 30 kWh	None	Exemption of excise tax from 10% to 0%	Production of EV components can be divided into one of the following three categories: (i) battery cells, (ii) battery module

Type of Battery Electric Vehicle	Incentive			Condition*
	Subsidy	Tariff (period 2022–2023)	Excise tax (period 2022–2025)	
exceeding B2 million				assembly and one other electronic component, and (iii) battery pack assembly and two other electronic components.
Motorcycle retail price not exceeding B0.15 million	B18,000	Exemption of tariff to 0%	Exemption of excise tax from 1% to 0%	EV components are expected to be produced domestically.

* Vehicles manufactured in Thailand are eligible for the incentive.
EV = electric vehicle, FTA = free trade agreement, kWh = kilowatt hour.
Sources:
Government of Thailand Official Gazette (2022), 30 May. https://www.ratchakitcha.soc.go.th/DATA/PDF/2565/E/120/T_0015.PDF
News from Government of Thailand (2022) 22 February. https://www.thaigov.go.th/news/contents/details/51817

1.4.10. EV and battery production plan

The national electric vehicle policy committee set the targets of EV battery production of 1 million (20 gigawatt hours, GWh) in 2025 and 5.4 million (40 GWh) in 2030.

As of April 2023, three manufactures (First One Minutes Mobility, Mercedes Benz, and Takano Cars) have started manufacturing EVs in Thailand. In Thailand, manufacturers are accelerating the construction of EV and EV battery plants in recent years.

The BOI announced that China's giant EV manufacturer, GAC Aion New Energy Automobile, will invest more than B6 billion to build a manufacturing plant in Thailand.[23] GAC Aion said the new plant would begin the assembly of EVs by June 2024.[24] The GAC Group plan to invest B6 billion over the next 3–5 years to build EV and battery plants to supply East Asia.

[23] The Nation (2023), 8 July. https://www.nationthailand.com/thailand/economy/40029179
[24] Just Auto.
https://www.just-auto.com/news/gac-aion-to-build-evs-in-thailand/

China's new EV manufacturer, BYD Auto, began the construction of a new plant in Thailand in March 2023. The plant will produce EVs and HEVs and will start operations in 2024 with an annual capacity of 150,000 units.[25]

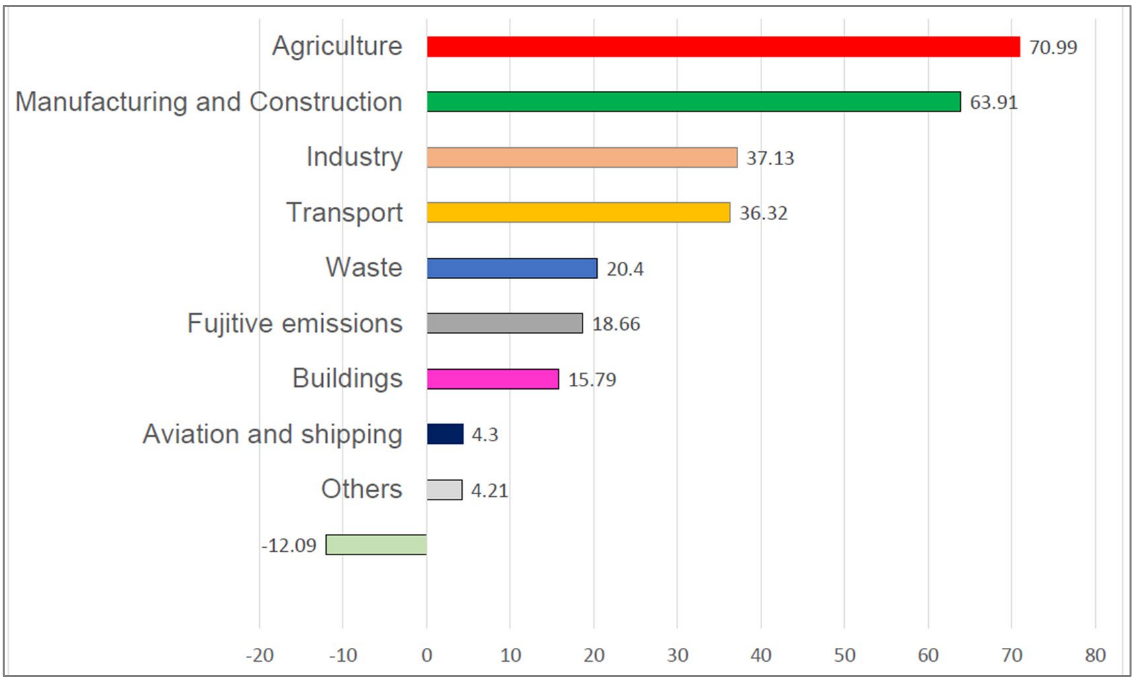
1.5. Viet Nam

1.5.1. Decarbonisation policy in the transport sector

Under the Paris Agreement, Viet Nam has committed in its updated Nationally Determined Contribution (NDC) to cut GHG emissions by 9% by 2030, compared to the business-as-usual (BAU) scenario using domestic resources, with the increasing ambition to 27% against the BAU contingent upon receiving international support. To meet these GHG emissions reduction targets, road transport will have to reduce emissions substantially.

According to the Report for NDC Transport Initiative for Asia (Study of Electric Mobility Development in Viet Nam 2021/8), by the German research institute GIZ (2021), the transport volume is continuing to increase, with an annual average growth rate of above 10% for passenger transport and above 5% for freight transport. With such a high increase, GHG emissions reduction in the transport sector is challenging. The CO_2 emissions data organisation, OurWorld in Data, shows that Viet Nam's transport sector is the third biggest contributor of about 14.5% to the country's GHG emissions in 2018 (Figure 1.10).

Figure 1.10. Greenhouse Gas Emissions by Sector, Viet Nam, 2018 (million tonnes)

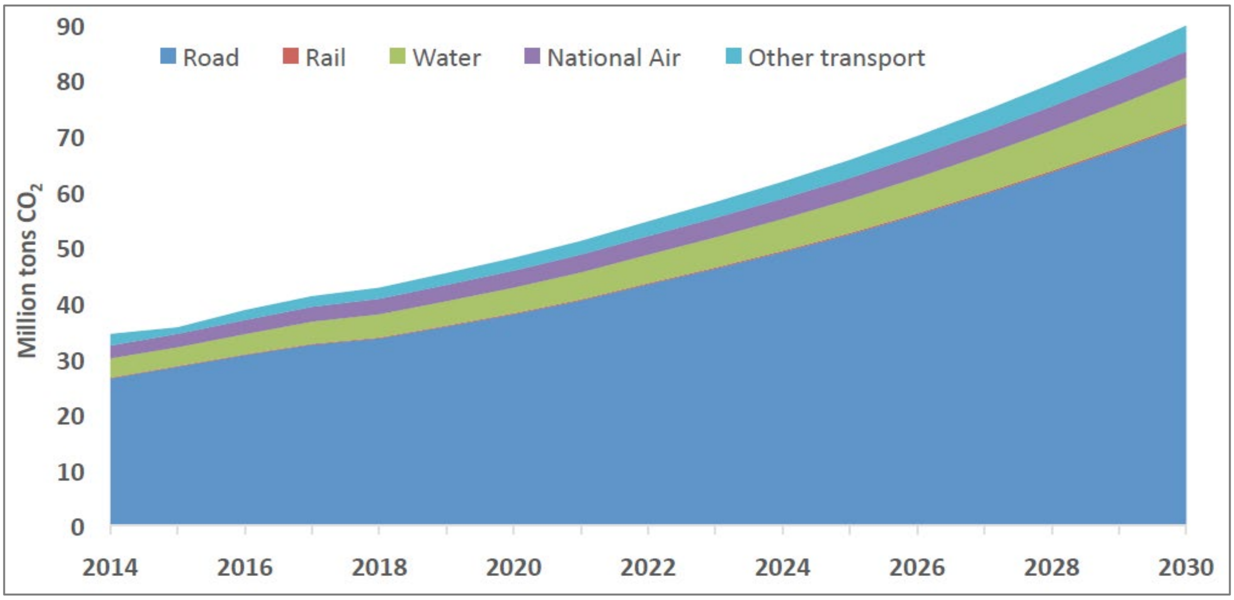


Source: Our World in Data. Viet Nam CO_2 Country Profile. https://ourworldindata.org/co2/country/vietnam

[25] Just Auto. https://www.just-auto.com/news/byd-begins-construction-of-ev-plant-in-thailand/

A World Bank report on climate change in transport stated that Viet Nam's transport sector's CO_2 emissions will increase from 33.2 million tonnes of CO_2 in 2014 to 89.1 million tonnes in 2030 under the BAU scenario (Oh et al., 2019). Within such forecast, road transport, the largest emitter at 26.4 million tonnes of CO_2 in 2014, will see an increase in emissions to 71.7 million tonnes in 2030 (Figure 1.11).

Figure 1.11. CO_2 Emissions Projection by Transport Subsectors Under the BAU Scenario



BAU = business as usual.
Source: Oh et al. (2019).

As for transportation policy at the national level, Resolution No. 55-NQ/TW on Orientation of National Energy Development Strategy to 2020 with a Vision to 2045 (2020/02) orients policies to promote clean and renewable energy, especially in the industry and transport sector. Under Decision No.2707/QD-BGTVT in 2018, the Ministry of Transport (MOT) is responsible for developing an action plan for sustainable transport development. The MOT needs to develop different types of policies towards road transport, waterways, and aviation, and in particular in road transport. It needs to adopt energy-efficient vehicles and mass public transport to tackle GHG emissions reductions as well as air pollution in big cities.

Motorbikes (motorised two-wheelers) are the predominant form of transportation in Viet Nam. More than 90% of vehicles in Viet Nam are motorbikes, which ranks Viet Nam as the fourth-largest country for motorbike use in the world. This massive motorbike market is starting to saturate, and with the increase in the middle-class wealth population, Viet Nam is starting to observe a steady market growth of automobiles (four-wheelers). However, for big cities, such as Ho Chi Minh City and Ha Noi, the deployment of energy-efficient and cleaner motorbikes and public transportation development are the main challenges.

1.5.2. EV policy and targets

There is no specific policy framework dedicated to EV deployment or EV charging station development in Viet Nam. Resolution 55/NQ/TW (2020), National Energy Development Strategy, is the first and only official national document that requires the promotion of e-mobility.

The GIZ report (GIZ, 2021) shows a summary of the central and local policies related to EV deployment.

The National Energy Development Strategy expects local governments to develop targets, policies, and programmes. Until now, two cities have developed EV promotion targets, with the number of e-motorcycles reaching 5% of total motorcycles in Ha Noi by 2030, and the goal of 200 e-buses by 2025 in Nha Trang.

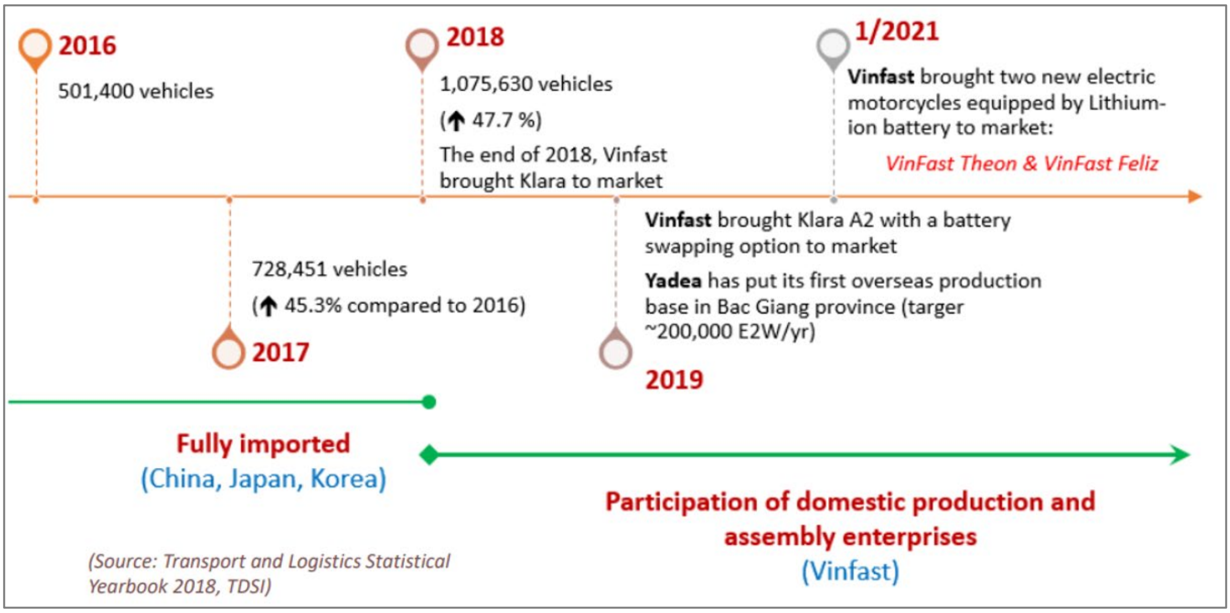
Da Nang City adopted Decision 124/QD-UBND to promote EV charging stations with policy encouragement of EV adoption. Da Nang City has a target for the number of charging stations of 150 Level 1–2 stations and 15 Level 3 stations by 2025, followed by 250 Level 1–2 stations and 50 Level 3 stations by 2030. With these exceptions, most cities are yet to set specific targets, incentives, or roadmaps for EV deployment.

There are also programmes run by cities to potentially promote clean transportation. Ha Noi and Ho Chi Minh City are trying to regulate the access of ICE two-wheelers to city centres with Decision 5953/QD-UBND: Restriction/Prohibition of Internal Combustion Engines (ICEs) Access to City Centres (GIZ, 2021).

1.5.3. Current status of the introduction of EVs

The EV four-wheeler and electric two-wheeler market in Viet Nam is in its very early stages, although e-bikes and e-motorcycles have been widely adopted in the market. By 2018, electric two-wheeler adoption had exceeded 1 million, up from 500,000 in 2016. E-motorcycles are in an uptrend with a 46% increase in 2020. The number of domestically manufactured and assembled vehicles is rapidly increasing, whilst e-bikes are in a downtrend with a 15% decrease in 2020 (Figure 1.12).

Figure 1.12. Penetration of E2W into the Vietnamese Market



E2W = electric two-wheelers.

A negligible number of HEVs, PHEVs, and BEVs have been imported and sold in the domestic market – 140 vehicles in 2019 and 900 vehicles in 2020, mainly HEVs.

VinFast, a subsidiary of the domestic conglomerate Vingroup, entered the auto industry in 2017 with ICE cars then released its first EV model in 2021. VinFast reportedly sold 24,000 cars domestically in 2021, which put the company in fourth place amongst automobile companies in Viet Nam. VinFast continued to increase EV models in 2022 to challenge the US. During the Consumer Electronics Show in the US in 2022, VinFast said the company would cease production of engine cars by the end of 2022 (Nikkei Asia, 2022).

1.5.4. Current status of EV charging infrastructure

Despite the absence of a national policy target for EV charging infrastructure development, VinFast is steadily increasing the number of charging stations. It is reported that over 8,000 charging ports at nearly 500 charging stations had been installed by the end of July 2021. VinFast's Phase 1 deployment plan was 40,000 charging ports at 2,000 charging stations nationwide.

Vinfast is also tying up with Petrolimix to set up a network of charging networks, especially electric two-wheeler battery swapping/renting stations. In addition, VinFast has also announced that it will operate Vinbus services in five large cities with e-buses produced by VinFast (Vietnamnet, 2021; Ucarshop, 2021).

1.5.5. Costs associated with vehicle purchase (value-added tax, excise fee, registration fee)

The Vietnamese government has implemented some taxes and levies associated with the purchase of vehicles. They are value-added tax (VAT), excise tax (special consumption tax), and a car registration fee.

Value-added tax

Vehicles are subject to a standard VAT rate of 10%.

Excise tax

Since the introduction of the excise tax law in 1998, there have been some changes in the applicable excise tax rates. The 2014 law introduced differentiation by engine cylinder capacity and power source (Table 1.29).

Table 1.29. 2014 Excise Tax Rates

Source Type	Class	Excise Tax Rate
Combustion Engine (<9 seats)	<2 L	45%
	2 L–3 L	50%
	>3 L	60%
Hybrid	(fuel consumption of no more than 70%)	70% of the above applicable rates
Bio-diesel		50% of the above applicable rates
Electric Vehicle		25%

L = litre.
Source: Nguen Anh Duong (2022).

The 2016 law reduced the tax rates with a smaller capacity of the engine, with higher tax rates for bigger capacity engines (Table 1.30).

Table 1.30. 2016 Excise Tax Rates

Source Type	Class	Excise Tax Rate
Combustion Engine (<9 seats)	<1.5 L	35%
	1.5 L–2.0 L	40%
	2.0 L–2.5 L	50%
	2.5 L–3.0 L	60%
Hybrid	(Fuel consumption of no more than 70%)	70% of the above applicable rates
Bio-diesel		50% of the above applicable rates
Electric Vehicle	Passenger cars	15%
	Passengers and goods	10%

L = litre.
Source: Nguen Anh Duong (2022).

The Excise Tax 2022 Law lowered the tax rates on battery-powered EVs, especially from March 2022 to February 2027 (Table 1.31).

Table 1.31. 2022 Excise Tax Rates

Source Type	Seats	Excise Tax Rate
Electric Vehicle	<9 seats	3% (Mar 2027: 11%)
	10–16 seats	2% (Mar 2027: 7%)
	16–24 seats	1% (Mar 2027: 4%)
	Passengers and goods	2% (Mar 2027: 7%)

Source: Nguen Anh Duong (2022).

Registration fee

Vehicle registration fees are applicable by local municipals, and they may vary by region (Table 1.32).

Table 1.32. Registration Fees

Municipal	Fee	EV
Ha Noi	12%	0%: Mar 2022–Feb 2025
Ha Tinh	11%	50% of applicable fee: Mar 2025–
Others	10%	

Source: Nguen Anh Duong (2022).

1.5.6. Economic incentives for xEV owners

The Vietnamese government has not introduced economic incentives for individual owners, but there is an incentive for public bus operators to invest in clean energy buses and depots, which is applicable to general clean energy buses and depots including bio-fuel buses and compressed natural gas buses.

Bus operators can be exempted from import duty on domestically unavailable parts and components for the manufacture and assembly of vehicles. Registration fees are also exempted for clean-energy buses. Public bus authorities are set a lower excise tax. Bus operators may receive the support of the provincial or central government for loan interest rates. Depending on local resources, the provincial government will promulgate specific regulations for the procurement of new vehicles. According to Resolution No. 07/2019/NQ-HDND of Ha Noi, 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.

1.5.7. Economic incentives for charging infrastructure development

There are no dedicated incentives for the development of charging infrastructure. There are a few economic incentives for public bus operators' infrastructure investment, not limited to EV charging stations but including refuelling stations for engine-powered buses. Bus operators may be eligible to access preferred loans, including official development assistance loans and preferred credit loans. Some local governments may provide loan interest subsidies. For example, Ha Noi City subsidises 50% of the loan interest for the first 5 years of investment.

1.5.8. Economic incentives for manufacturers

By Decree 57/2020/ND-CP, a preferential import tax rate of 0% will be levied on raw materials and accessories that have not been domestically produced before manufacturers' domestic assembly. Note that this decree applies to general automobile materials and accessories and is not limited to EVs.

Manufacturers may need to sign up for this tax incentive programme. From the third year, at least 125 vehicles are required to be produced. However, there is no specific target in terms of the ratio of EVs out of total new car sales.

1.5.9. User/driver management

Since the early 2010s, there has been growth in electric two-wheelers in Viet Nam, especially e-bikes. Many students choose e-bikes with a preference for flexibility, convenience, and cheaper costs.

Road Traffic Law (No.23/2008/QH12) does not require a driving test or a driving licence for riding e-bikes. This allows large numbers of riders using e-bikes for daily travel, especially the younger generations. The Viet Nam government amended the Road Traffic Law to classify driving licences for motorised two- and three-wheelers into three categories: A1, A2, and A3, which were subsequently regrouped into four categories: A0, A2, A, and B1.

1.5.10. EV battery production plan, EV criteria

The Vietnamese government has not enacted a manufacturing plan for EV batteries or EV standards.

1.5.11. Battery reuse plan

The Vietnamese government has not enacted an EV battery reuse plan.

1.5.12. Variable renewable energy introduction plan

According to the Vietnamese government's 8th Power Development Plan, renewable energy will account for 29% of the capacity of power generation facilities by 2030.

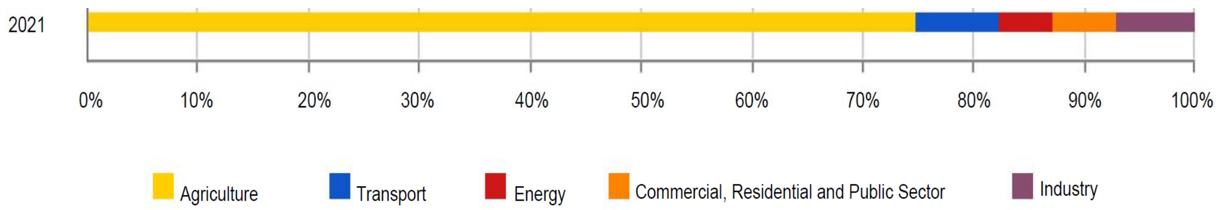
1.6. Brazil

1.6.1. Decarbonisation policy in the transport sector

According to its Nationally Determined Contribution (NDC), Brazil confirms its commitment to reduce its greenhouse gas emissions in 2025 by 37% and in 2030 by 50%, compared with 2005. Brazil's commitments also include a long-term objective to achieve climate neutrality by 2050.

Figure 1.13. shows the estimated CO_2 emissions profile of Brazil by sector as of 2021.

Figure 1.13. Estimated Emissions Profile by Sector, 2021 ($MtCO_2e$)



Source: Sistema de Estimativas de Emissões e Remoções de Gases de Efeito Estufa (SEEG) (2023), Análise Das Emissões De E Suas Implicações Para As Metas Climáticas Do Brasil 1970–2021. https://www.oc.eco.br/wp-content/uploads/2023/03/SEEG-10-anos-v4.pdf, accessed 1 September 2023.

As the transport sector accounts for about 10% of the total, of which 87% is attributed to automobile transport, the decarbonisation of road transport is an urgent issue. Brazil's main policies for decarbonising its transport sector include the decarbonisation of fuels under the Renovabio programme and infrastructure improvements for more efficient road transport.

(1) Renovabio

The use of biofuel is given a central role in reducing greenhouse gas (GHG) emissions, not only in the transport sector, and Renovabio[26] has been implemented since 2019.

Renovabio is a national programme that aims to reduce greenhouse gas emissions by increasing the percentage of biofuels, including ethanol, in fuel consumption from 16.4% in 2014 to 18.3% in 2030.

Biofuel producers can receive certificates, called CBios, in exchange for reporting the amount of GHG they reduced in the production process to the Ministry of Mines and Energy and obtaining approval. At the same time, fuel distributors (posts) are obligated to purchase CBios for the amount of fossil fuels they sell.

[26] Ministry of Mineral and Energy. RenovaBio. https://www.gov.br/anp/pt-br/assuntos/producao-e-fornecimento-de-biocombustiveis/renovabio

Renovabio incentivises ethanol producers who want to obtain commercially valuable CBios to reduce GHG emissions in the ethanol production process. The programme can reduce emissions not with subsidies and regulations but by leveraging the market mechanism.

In 2021, out of the 25,222,723 CBios credits made available for purchase to 142 fuel distributors, 24,405,193 credits, or 97% of the target, were purchased, with 102 distributors achieving 100% of the required amount.[27] One CBios credit is worth a reduction of 1 tonne of CO_2e.

(2) Road infrastructure construction

According to a World Economic Forum[28] report, Brazil ranks 116th out of 141 countries in road infrastructure quality and 85th for overall transport infrastructure, making the construction of transport infrastructure a challenge that needs to be tackled. Meanwhile, the federal government's planned public investment budget (2020–2023) for infrastructure upgrades was BRL488.82 billion, of which only 5%, or BRL25.97 billion, was allocated to land transport. With only around 17%[29] of the budget allocated to transport even when including the BRL 39.51 billion for water transport and BRL 18.26 billion for sea transport, funding for infrastructure construction must be sought from non-government sources as well. The main infrastructure projects by the federal government are switching to Private Participation in Infrastructure (PPI) investment, a public-private joint investment programme that focuses on private sector funding.

1.6.2. EV policy and targets

Having abundant hydropower resources, the ratio of low-carbon electricity has been over 80% since the 1980s in Brazil and was 79% in 2021. Accordingly, the country has relatively high potential to reduce emissions through automobile electrification. Furthermore, flexible-fuel vehicles that run on bioethanol derived from sugar cane, which are known to have a superior CO_2 reduction effect compared with gasoline vehicles, are in widespread use in the country.

As part of its Rota2030 automotive programme, which aims to enhance the safety and energy efficiency of cars and the technologies mounted in them, Brazil has indicated plans to grant reductions in its industrialised products tax (IPI) for hybrid cars, EVs, and flex

---

[27] Ministry of Mineral and Energy. Comprovação da meta individual de 2021 por distribuidor de combustíveis.
https://www.gov.br/anp/pt-br/assuntos/renovabio/comprovacao-da-meta-individual-de-2021-por-distribuidor-de-combustiveis

[28] World Economic Forum (2019), *The Global Competitiveness Report 2019*.
https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

[29] Ministry of Economy. Plano Plurianual (PPA).
https://www.gov.br/economia/pt-br/assuntos/planejamento-e-orcamento/plano-plurianual-ppa

hybrid cars (specific figures will be discussed later) to promote their use. However, no specific targets have been set for the introduction of EVs.

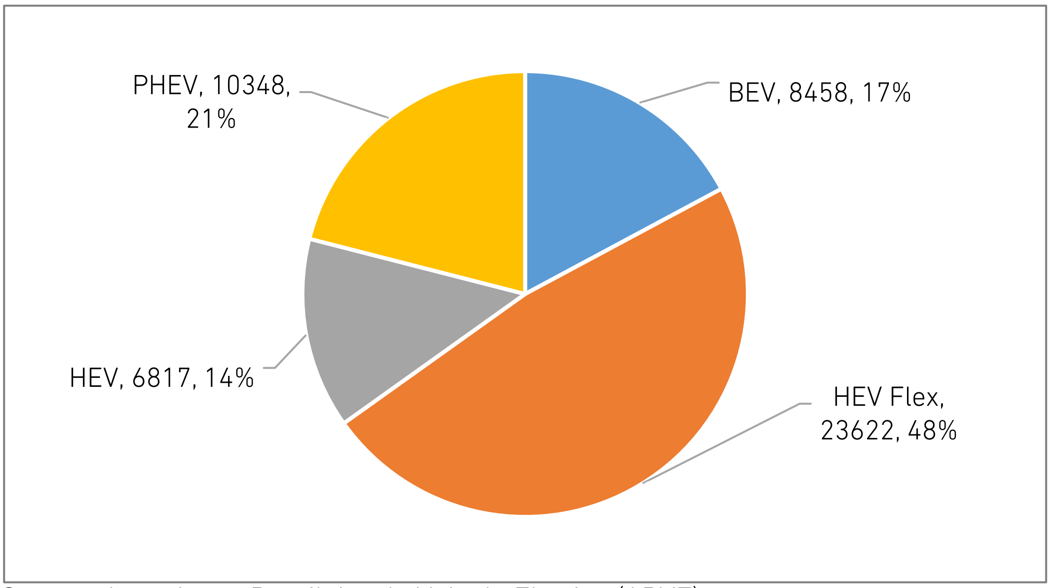
1.6.3. Fuel economy regulation

Regarding fuel efficiency, Rota 2030 Mobility and Logistics sets out mandatory requirements regarding fuel efficiency, structural performance, and drive support equipment. It sets detailed formulas for calculating the fuel efficiency requirements to be met by 1 October 2022 based on the weight and type of vehicle, such as whether the car is a passenger vehicle, commercial vehicle, or sports utility vehicle (SUV) and whether it is small, a four-wheel drive, and so on. It requires owners to affix appropriate labels on their cars. A 1% reduction in the IPI is granted to vehicles that meet these requirements, and a 2% reduction is given for those that meet even higher requirements. The actual formulas are described in Exhibit III, Federal Decree 9.557/2018.

1.6.4. Current status of introduction of EVs and charging infrastructure

Flex HEVs account for the highest percentage amongst all xEVs registered as small cars (passenger vehicles and light commercial vehicles) in 2022, with BEVs accounting for 17.2%, Flex HEVs for 48%, HEVs for 13.8%, and PHEVs for 21%. BEVs posted the largest growth rate from the previous year, growing from 2,851 units in 2021 to 8,458.

Figure 1.14. Share of New xEV Cars and Light Commercial Vehicles, 2022

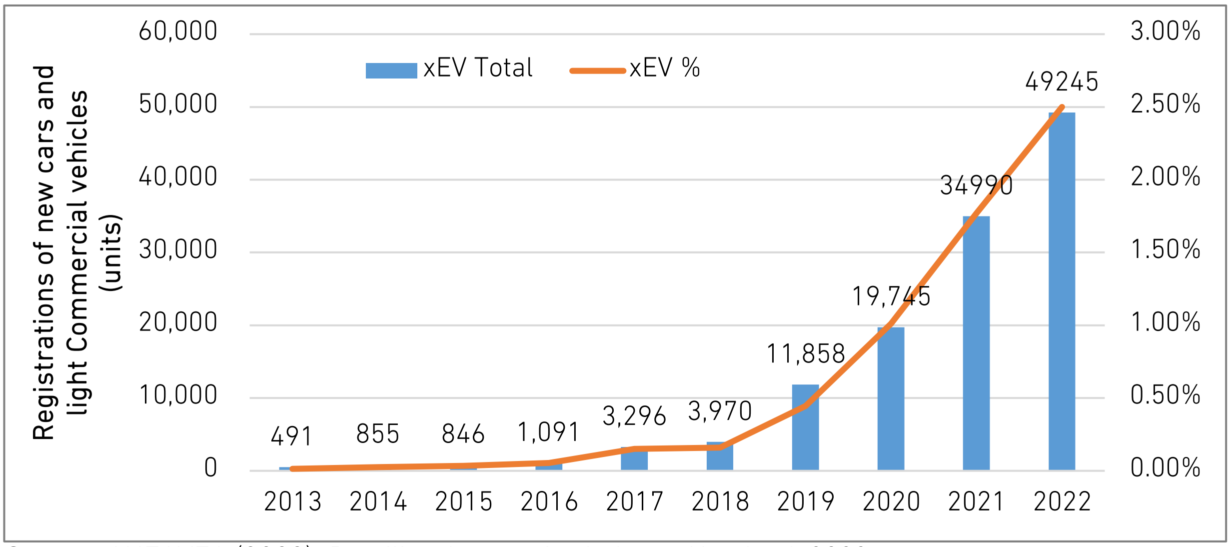


Source: Associacao Brasileira do Veiculo Eletrico (ABVE).

The number of xEVs registered amongst all small cars (passenger vehicles and light commercial vehicles) in 2022 was 42,945 units, accounting for 2.5% of all four-wheeled vehicles.

Figure 1.15. Number of Units and Share of xEV Registrations, 2013–2022

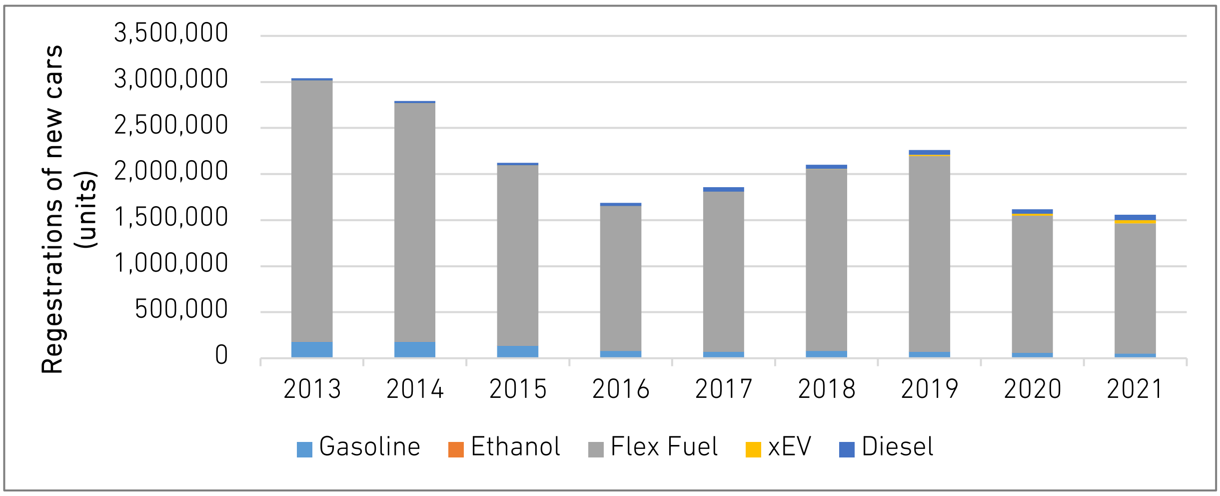
(Total of Car and Light Commercial Vehicles)



Source: ANFAVEA (2022), *Brazilian Automotive Industry Yearbook 2022*.

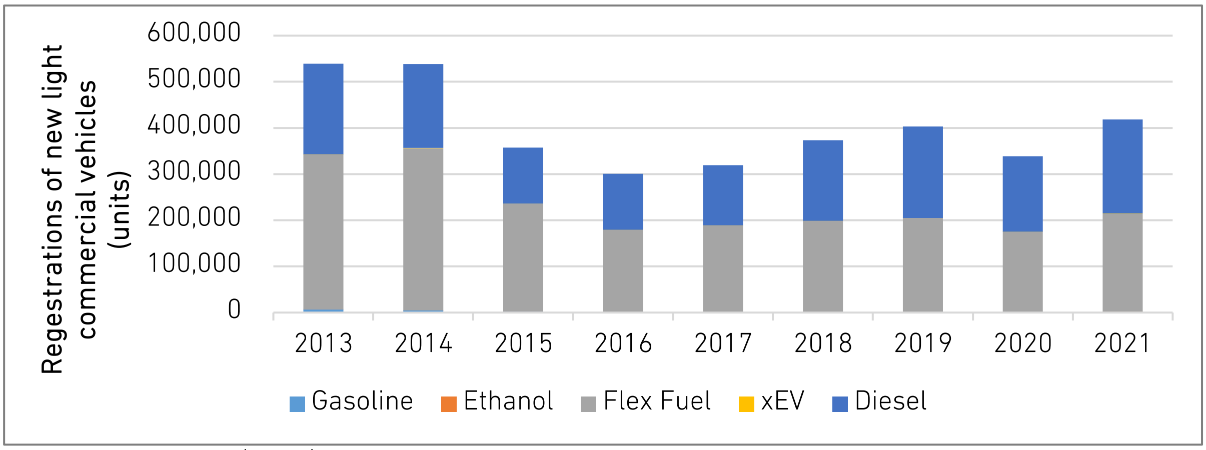
The share of fuels for new cars registered in 2021 was, for passenger cars, 90.58% flex fuel, 3.84% diesel, 3.34% gasoline, and 2.24% xEVs, and for light commercial cars, 50.8% flex fuel, 48.8% diesel, 0.36% gasoline, and 0.04% xEVs.

Figure 1.16. Number of Car Registrations by Fuel Type, 2013–2021



Source: ANFAVEA (2022), Brazilian Automotive Industry Yearbook 2022.

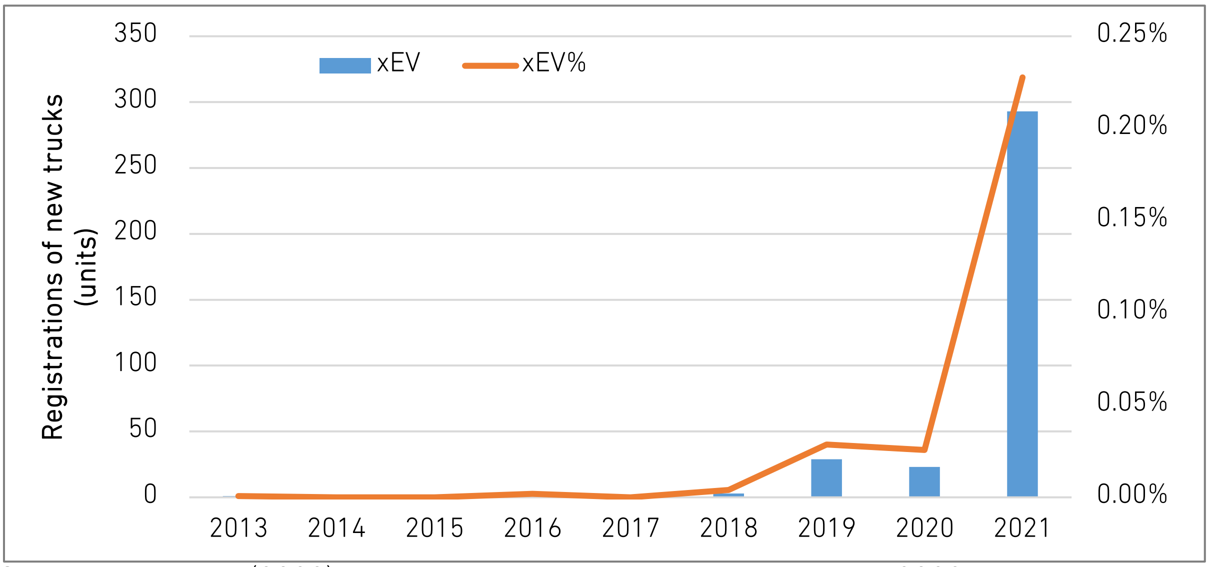
Figure 1.17. Number of Light Commercial Vehicle Registrations by Fuel Type, 2013–2021



Source: ANFAVEA (2022), Brazilian Automotive Industry Yearbook 2022.

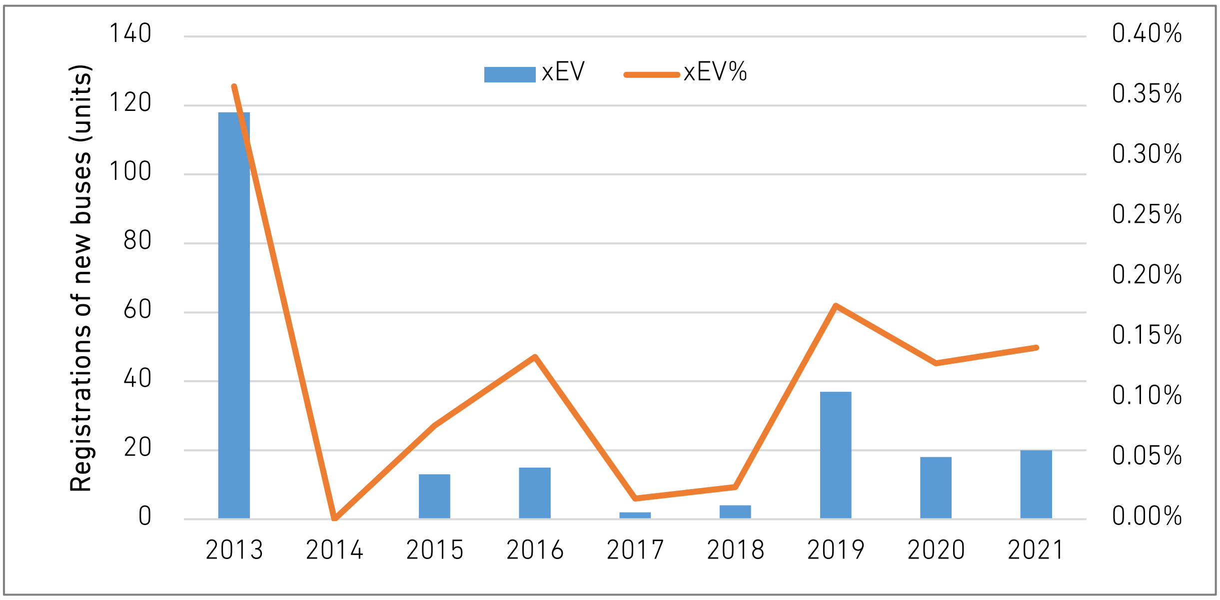
The share of fuels for trucks and buses newly registered in 2021 was 99% diesel for both vehicle types, and the share of xEVs was 0.23% for trucks and 0.14% for buses.

Figure 1.18. Number and Share of xEV Truck Registrations, 2013–2021



Source: ANFAVEA (2022), Brazilian Automotive Industry Yearbook 2022.

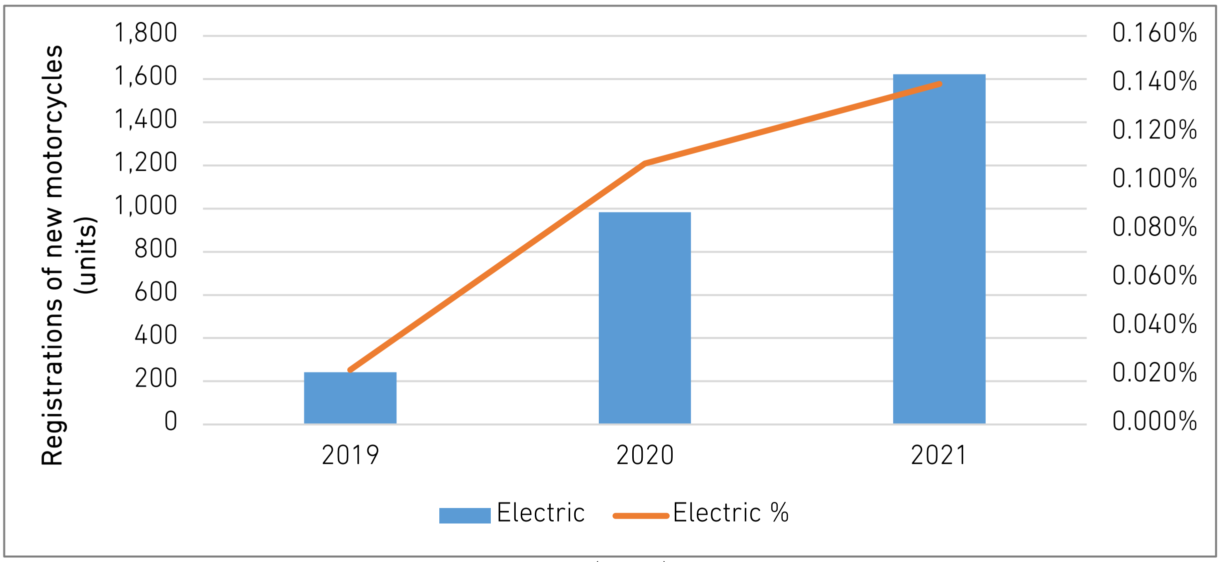
Figure 1.19. Number and Share of xEV Bus Registrations, 2013–2021



Source: ANFAVEA (2022), Brazilian Automotive Industry Yearbook 2022.

The share of fuels for newly registered motorcycles in 2021 was over 61% flex fuel, with gasoline accounting for 38% and electricity 0.14%.

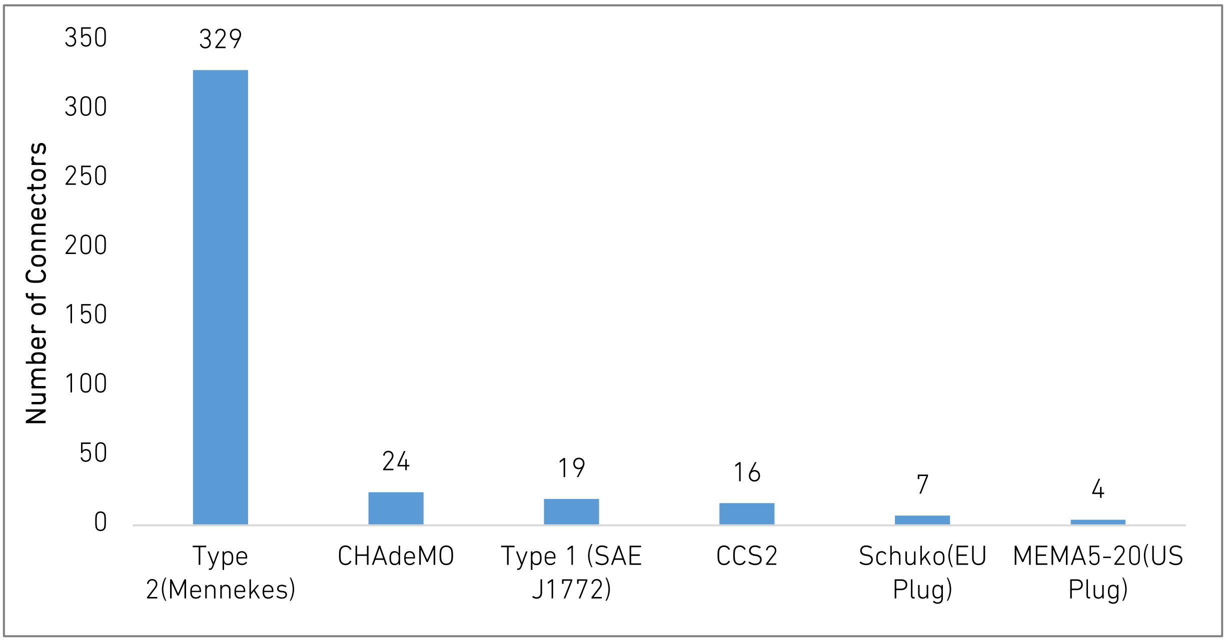
Figure 1.20. Number and Share of xEV Motorcycle Registrations, 2019–2021



Sources: Abracio Dados do Setor (2020), https://www.abraciclo.com.br/site/wp-content/uploads/2022/08/20200710-Dados-do-Setor-2020.pdf; Abracio Dados do Setor (2021), https://www.abraciclo.com.br/site/wp-content/uploads/2022/08/Abraciclo-Dados-do-Setor-2022-1.pdf; Abracio Dados do Setor (2022), https://www.abraciclo.com.br/site/wp-content/uploads/2022/08/Abraciclo-Dados-do-Setor-2022-1.pdf

Figure 1.21 shows the number of different connectors at EV charging stations. There are 100 charging stations in São Paulo, 46 in Rio de Janeiro, and 13–14 in major cities such as Florianópolis, Curitiba, and Brasília, but there are smaller cities with just a couple of stations.

Figure 1.21. Number of Connectors at Electric Vehicle Charging Stations by Type (as of October 2021)



Sources: Statista. Number of Connectors at Electric Vehicle Charging Stations in Brazil as of October 2021, by Type. https://www.statista.com/statistics/1174573/types-electric-vehicle-charging-station-connectors-brazil/; Electromaps. Charging Stations in Brazil. https://www.electromaps.com/en/charging-stations/brazil

1.6.5. Vehicle registration fees

(1) Taxes at the time of purchase

The taxes imposed when purchasing a car are: an industrialised products tax called IPI (Imposto sobre Produtos Industrializados), a tax on the circulation of goods and services called ICMS (Imposto sobre Circulação de Mercadorias e Serviços), and social integration tax/social security financing called PIS/COFINS (PIS: Programa de Integração Social) (COFINS: Contribuição Social para Financiamento da Seguridade Social). A 35% customs duty is also imposed on imported cars.

The IPI is a federal tax imposed on imported industrial products that go through customs clearance and on industrialised goods when they are shipped out from their actual or deemed production facilities. IPI rates are set in fine increments between 0% and 20% based on fuel type, vehicle weight, and fuel efficiency. The latest tax rates are indicated in Exhibit IV, Federal Decree 11,158/2022.

The tax on the circulation of goods and services, ICMS, is a state tax that varies by state. In São Paulo, for example, the ICMS is 12% across-the-board for passenger vehicles, small commercial vehicles, trucks, and buses.

The social integration tax, PIS, like the social security financing contribution (COFINS), is a quasi-federal tax that arises when services and goods are imported and is based on the sales of corporations stipulated by tax laws. The rate of PIS/COFINS is 11.6% for passenger and small commercial vehicles, 8.1% for trucks, and 6.02% for buses.

(2) Automobile ownership tax (IPVA, Imposto sobre a Propriedade de Veiculos Automotores)

The automobile ownership tax is imposed annually on automobile owners. Since the IPVA is a state tax, the tax rate imposed varies by state. Currently, the rates are highest for São Paulo and Minas Gerais at a maximum of 4% of the sales price. The IPVA is calculated based on the market price, and the amount varies depending on characteristics such as the vehicle type, displacement, place of manufacture (in or outside Brazil), and the fuel used.[30]

Table 1.33. IPVA in São Paulo

Type	Tax Rate (%)
Trucks	1.5
Buses and minibuses	2.0
Commercial	2.0
Motorcycles, tricycles	2.0
Vehicles	4.0
Vehicles owned by lease company	1.0

Source: Governo do estado de sao Paulo.

[30] Governo do estado de sao Paulo.
https://portal.fazenda.sp.gov.br/servicos/ipva/Paginas/mi-aliquota.aspx
IPVA: o que é Imposto Sobre a Propriedade de Veículos Automotores.
https://www.suno.com.br/artigos/ipva/

1.6.6. Economic incentives for EV owners

(1) IPVA discount

The IPVA is a state tax, and the level of preferential treatment varies by state.[31]

Scope: EVs and hybrids

States/regions eligible: Rio Grande do Norte, Pernambuco, Piauí, Maranhão, Ceará, Rio Grande do Sul, Paraná, and the Federal District

States given a 50% discount: Mato Grosso do Sul, Rio de Janeiro, and São Paulo

[Source : Saiba quais estados têm isenção de IPVA para carros elétricos. https://canalve.com.br/saiba-quais-estados-tem-isencao-de-ipva-para-carros-eletricos/]

(2) IPTU discount

The urban building and property ownership tax (IPTU: Imposto sobre a Propriedade Predial e Territorial Urbana) is a municipal tax imposed on real estate owners in urban areas. In September 2022, the mayor of São Paulo announced plans to give a discount on the IPTU. However, the actual discount rates and other details have not been revealed.[32]

[Source: Prefeito assina lei que apoia carro elétrico em SP http://www.abve.org.br/prefeito-de-sp-assina-lei-que-beneficia-veiculo-eletrico/]

1.6.7. Economic incentives for charging infrastructure development

So far, no incentives for the installation of charging infrastructure have been confirmed.

In a recent move, a law requiring the installation of charging infrastructure in gas stations on federal highways was proposed by Senator Eliziane Gama in February 2023. Accordingly, a proposed loan limit to help reach the installation target is also being considered.[33]

1.6.8. Economic incentives for manufacturers

(1) Import tax exemption

Import taxes for xEVs have been reduced. Most have been reduced from 35% to 0%, with some taxed at 2% or 4%.

---

[31] Rubens Morelli/Canal VE (2022), 'Saiba quais estados têm isenção de IPVA para carros elétricos', 24 December.
https://canalve.com.br/saiba-quais-estados-tem-isencao-de-ipva-para-carros-eletricos/

[32] Associação Brasileira do Veículo Elétrico (ABVE) (2021), 'Prefeito assina lei que apoia carro elétrico em SP', 21 September.
http://www.abve.org.br/prefeito-de-sp-assina-lei-que-beneficia-veiculo-eletrico/

[33] Projeto de Lei n° 392, de 2023.
https://www25.senado.leg.br/web/atividade/materias/-/materia/155819

Electric vehicles were added to the Brazilian List of Exceptions to the MERCOSUR Common External Tariff by Resolution 97/2018 of CAMEX (Executive Secretariat of the Foreign Chamber of Commerce).[34]

An extension of this exemption until December 2025 is being considered.[35]

(2) IPI exemption

An IPI tax relief for hybrid and electric vehicles has been in place since November 2018, and the latest tax rates are between 5.27% and 15.05%, depending on the weight and fuel efficiency of vehicles, as shown in Table 1.34 (the tax rates are stipulated in Exhibit IV, Federal Decree 11,158/2022).

Table 1.34. IPI Tax Rates

Type (Code in IPI Rate Table)	Fuel Efficiency Index	IPI Tax Rate by Vehicle Weight		
		1,400 kg or less	1,401–1,700 kg	1,701 kg or more
Hybrid cars (8703.40.00 and 8703.60.00)	1.10 MJ/km or less	6.77	7.53	8.28
	1.11–1.68 MJ/km	9.03	9.78	11.29
	More than 1.68 MJ/km	12.79	14.3	15.05
Electric cars (8703.80.00)	0.66 MJ/km or less	5.27	6.02	6.77
	0.67–1.35 MJ/km	7.53	9.03	10.54
	More than 1.35 MJ/km	10.54	12.04	13.55

Source: Exhibit IV, Federal Decree 11,158/2022 (https://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2022/Decreto/Anexo/d11158-anexo4.pdf).

[34] IEA Import tax for EVs (Resolution 97/2018).
https://www.iea.org/policies/8716-import-tax-for-evs-resolution-972018
http://www.camex.gov.br/resolucoes-camex-e-outros-normativos/58-resolucoes-da-camex/1402-resolucao-n-86-de-18-de-setembro-de-2014

[35] Portal movilidad.
https://portalmovilidad.com/brazil-close-to-new-incentives-for-electric-vehicles-what-projects-did-the-senate-approve/

Further, flex hybrid vehicles, which can run on bioethanol fuel as well as gasoline, receive an IPI rate reduction of at least 3% compared to vehicles with engines of an equivalent class and category.

1.7. India

1.7.1. Decarbonisation policy in the transport sector

At COP26, India announced its target to achieve net zero by 2070, to source 50% of its total electricity from renewable energy sources by 2030, and to reduce carbon emissions by 2030 compared to 2005. It was also announced that[36] carbon Intensity (CO_2 emissions divided by gross domestic product) would be reduced by 45%.

1.7.2. EV policy and targets

The Indian government has set a goal of increasing the penetration rate of EVs to 30% by 2030. This is expected to reduce GHG emissions by 4% compared to the BAU scenario. In addition, think tanks NITI Aayog and RMI India estimate that the EV sales self-sufficiency rate by 2030 will be 80% for two- and three-wheelers, 50% for four-wheelers, and 40% for buses.[37]

The Amendment of the Energy Conservation Bill passed by the Diet in August 2022 stipulates a minimum consumption rate when using non-fossil energy sources, and its scope has been expanded to include automobiles.[38] [39]

Additionally, a subsidy scheme called Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) is operated by the central government. The first phase (FAME I) was implemented for four years starting in April 2015, and the second phase (FAME II) started in April 2019. The second phase was scheduled to be implemented for three years, but it has been decided to extend the period until March 2024. The scheme is a supporting project to encourage the progressive introduction of[40] reliable, available, and effective electric and hybrid vehicles (xEVs).

FAME I has a budget of INR8.59 billion and has provided subsidies of INR3.59 billion for 280,000 vehicles over four years. The subsidy amount by vehicle type is shown in Table 1.35.

[36]https://pib.gov.in/PressReleasePage.aspx?PRID=1795071
[37] https://www.niti.gov.in/sites/default/files/2021-04/FullReport_Status_quo_analysis_of_various_segments_of_electric_mobility-compressed.pdf , p.15 and p.31
[38]https://corporate.cyrilamarchandblogs.com/2023/01/the-energy-conservation-amendment-act-2022-key-highlights/#_ftn11
[39] https://prsindia.org/billtrack/the-energy-conservation-amendment-bill-2022
[40] https://fame2.heavyindustries.gov.in/content/english/15_1_FAMEI.aspx

Table 1.34. Range of Demand Incentives Available Across Vehicle Segments and Technologies Under the FAME Scheme

Vehicle Segment	Mild Hybrid INR (US$)	Strong Hybrid INR (US$)	Plug-in Hybrid INR (US$)	Battery-operated Electric INR(US$)
Two-wheelers	1,800–6,200 (27–93)	-	13,000–18,000 (195–270)	7,500–29,000 (112.5–435)
Three-wheelers	3,300–7,800 (49.5–117)	-	25,000–46,000 (375–690)	11,000–61,000 (165–915)
Passenger cars	11,000–24,000 (165–360)	59,000–71,000 (885–1,065)	98,000–1,18,000 (1,470–1,770)	76,000–1,38,000 (1,140–2,070)
Light commercial vehicles	17,000–23,000 (255–345)	52,000–62,000 (780–930)	73,000–1,25,000 (1,095–1,875)	1,02,000–1,87,000 (1,530–2,805)
Buses	30,00,000–41,00,000 (45,000–61,500)	51,00,000–66,00,000 (76,500–99,000)	-	-

Note: Demand incentives are also available for retrofit kits across all vehicle segments and technologies for up to 15%–30% of the kit price, depending on the amount of fuel consumption reduced, as well as price of the kit.
Source: Ministry of Heavy Industry & Public Enterprises (2015), 'Scheme for Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India – FAME India: Scheme Guidelines'. https://heavyindustries.gov.in/sites/default/files/2023-09/OM_FAME_India.PDF

FAME II[41] has a budget of INR100 billion for the first three years, of which approximately 86% will be used to increase EV demand, and 10% will be used to develop charging infrastructure (Table 1.36). The target vehicle types for demand stimulation measures are buses (EV), four-wheeled vehicles (EV, PHEV, and SHEV), three-wheeled vehicles (EV) including rickshaws, and two-wheeled vehicles (EV), of which public transportation and commercial vehicles will be targeted. Although the subsidy is mainly provided for public transport and commercial vehicles, personally owned motorcycles are also eligible for the

[41] Ministry of Heavy Industries and Public Enterprises, Department of Heavy Industry (2019), Notification. 8 March, New Delhi (Original text of FAME II).

subsidy. They are also required to be equipped with advanced batteries that meet certain performance standards. The maximum number of subsidies and the amount of subsidies by vehicle type as of 2019 are shown in Table 1.37. Furthermore, regarding support for the development of public charging infrastructure, it is stated that flexible funding can be provided depending on the project. It also proposes to provide one slow charger for every electric bus and one fast charger for every 10 electric buses.

Table 1.36. Fund Breakdown for FAME II

Sr. No.	Component	2019–20 (INR10 million)	2020–21 (INR10 million)	2021–22 (INR10 million)	Total Fund Requirement (INR10 million)
1	Demand incentives	822	4,587	3,187	8,596
2	Charging infrastructure	300	400	300	1,000
3	Administrative expenditure including publicity, ICE activities	12	13	13	38
Total for FAME II		1,134	5,000	3,500	9,634
4	Committed expenditure of Phase I	366	0	0	366
Total		1,500	5,000	3,500	10,000

Source: Ministry of Heavy Industries, Government of India. 'National Automotive Board (NAB): OEM and Dealers'. https://fame2.heavyindustries.gov.in/ModelUnderFame.aspx (accessed 22 March 2023).

Table 1.37. Type of Vehicle and Subsidies Under FAME II

	Upper Limit of Price at Factory (INR10,000)	Upper Limit (number of units)	Vehicle Battery Capacity (kWh)	Subsidy per Unit (INR)	Total Subsidy (INR10 million)
Registered e-2-wheelers	15	1,000,000	2	20,000–	2,000
Registered e-3-wheelers (including rikshaws)	50	500,000	5	500,00–	2,500
e-4-wheelers	150	35,000	15	150,000–	525
4W strong hybrid vehicles	150	20,000	1.3	13,000	26
e-bus	2,000	7,090	250	5,000,000–	3,545
Total					8,596

Source: Ministry of Heavy Industries, Government of India. 'National Automotive Board (NAB): OEM and Dealers'. https://fame2.heavyindustries.gov.in/ModelUnderFame.aspx (accessed 22 March 2023).

In FAME II, a total of 67 types of xEV vehicle models are currently certified (excluding similar model numbers). The breakdown is shown in Table 1.38.

Table 1.38. Registered Number of xEV Models

	Active	Expired
Three-wheelers (e-3W)	38	34
Four-wheelers (e-4W)	5	4
Two-wheelers (e-2W)	24	1
Total	67	39

Source: Ministry of Heavy Industries, Government of India. 'National Automotive Board (NAB): OEM and Dealers'. https://fame2.heavyindustries.gov.in/ModelUnderFame.aspx (accessed 22 March 2023).

Table 1.39. Registered Number of OEM

	Registered Number of OEMs (Active Ones)
Three-wheelers (e-3W)	39
Four-wheelers (e-4W)	1
Two-wheelers (e-2W)	20

Source: Ministry of Heavy Industries, Government of India. 'National Automotive Board (NAB): OEM and Dealers'. https://fame2.heavyindustries.gov.in/ModelUnderFame.aspx (accessed 22 March 2023).

FAME II has been extended for two years, and the total budget remains unchanged from before and after the extension. As shown in Figure 1.22, the budget for 2019–2020 was INR5 billion. For fiscal year (FY) 2020–2021, INR6.93 billion were allocated, but the budget was subsequently revised, and only about 46% (INR3.18 billion) of the original budget was actually used. For FY2021–2022 and FY2022–2023, INR8 billion and INR289.8 billion were allocated, respectively, and almost all was used. For FY2023–2024, INR51.72 billion (the remaining amount from the original budget of INR100 billion) has been allocated, and it is planned that more than half of the FAME II budget will be used in FY2023.[42]

India has introduced corporate average fuel economy (CAFE) regulations to reduce CO_2 emissions.

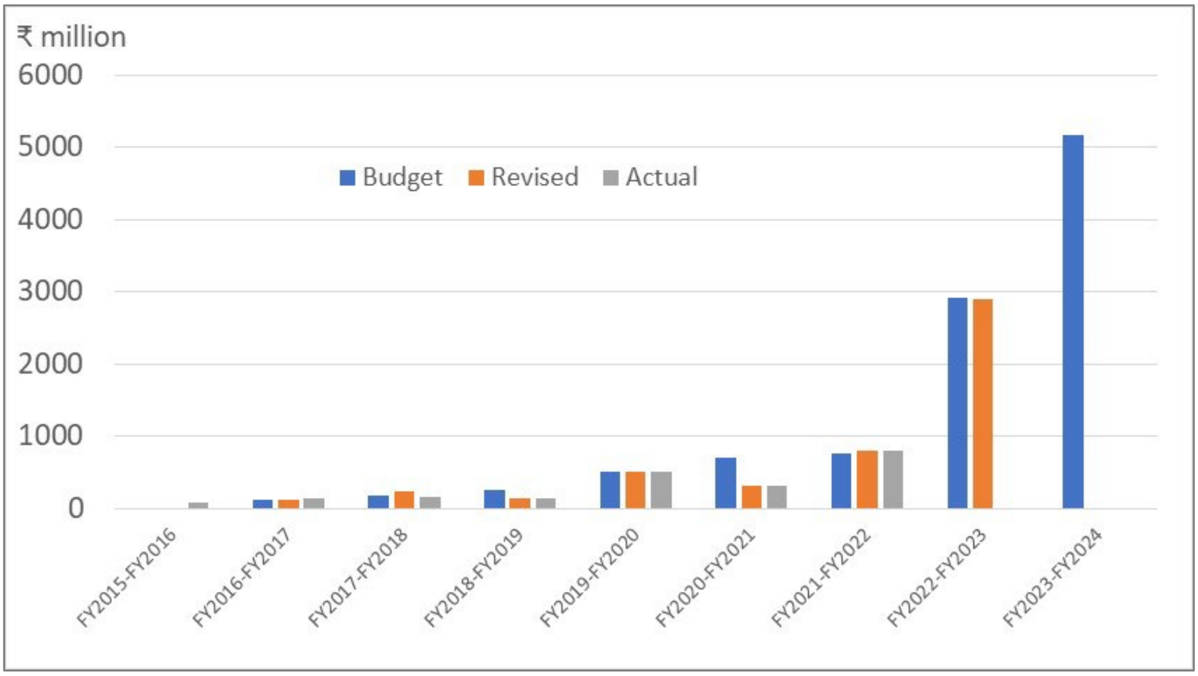
In April 2015, fuel economy regulations were announced for vehicles with nine seats or less and a gross vehicle weight of less than 3.5 tonnes. The first stage was applied from 2017–2018 onwards, and the second stage from 2022–2023 onwards. In the first stage, assuming an average vehicle weight of 1,037 kg, the average fuel efficiency standard value was 5.49 L/100 km, and in the second stage, assuming an average vehicle weight of 1,082 kg, the average fuel efficiency standard value is 4.89 L/100 km (note that the second stage fuel economy standard is the value revised on 6 January 2021). These fuel efficiency regulations are expected to reduce fuel consumption by 22.97 million tonnes by 2025.

The introduction of fuel efficiency standards for other vehicles was also considered. In August 2017, fuel efficiency regulations for commercial vehicles (HDVs: heavy-duty vehicles) with a gross vehicle weight of 12 tonnes or more were decided, and fuel efficiency standards and correction factors were set in September 2021 and March 2022. In July 2019, fuel efficiency regulations for commercial vehicles (light and commercial vehicles) with a gross vehicle weight of 3.5–12 tonnes were decided, and the correction coefficient was revised in March 2022. These fuel economy regulations will be applied to[43]

[42] https://www.indiabudget.gov.in/doc/eb/sbe48.pdf
[43] https://beeindia.gov.in/en/programmesenergy-efficiency-in-transport-sector/fuel-efficiency

BS-VI (Phase 6 Exhaust Gas Control) compliant vehicles, and from April 2022, it will be mandatory to sell and register only BS-VI compliant cars and motorcycles.[44] Furthermore, the implementation of these fuel efficiency standards was announced in June 2022 and came into effect in April 2023. As a result, fuel consumption standards will be applied to all vehicles manufactured or imported in India, including light, medium-sized, and large-sized vehicles, and it is expected that more fuel-efficient vehicles will be introduced.[45]

Figure 1.22. Budget and Expenses



Source: https://www.indiabudget.gov.in/doc/eb/sbe48.pdf

The following is an introduction to state-by-state initiatives, rather than national ones. To establish itself as the electric vehicle capital of India and accelerate the pace of electric vehicle adoption, Delhi Territory announced the Delhi Electric Policy[46] in 2020. The aim is to make 25% of all new car registrations BEVs by 2024, thereby improving the environment in Delhi. The policy will be in effect for three years after its implementation and will include financial incentives (purchase incentives, disposal incentives, loan interest reductions, and exemptions), road tax and registration fee exemptions, and the creation of a wide network of charging stations and replaceable auto parts. Initiatives include bringing the vehicle and its database into public ownership, establishing skill centres and creating jobs, building a battery recycling ecosystem, and establishing a

[44] https://www.icicilombard.com/blogs/car-insurance/car/bs6-norms-and-their-impact-on-the-two-wheeler-industry
[45] https://pib.gov.in/PressReleasePage.aspx?PRID=1839570
[46] https://www.smev.in/govt-notification.php

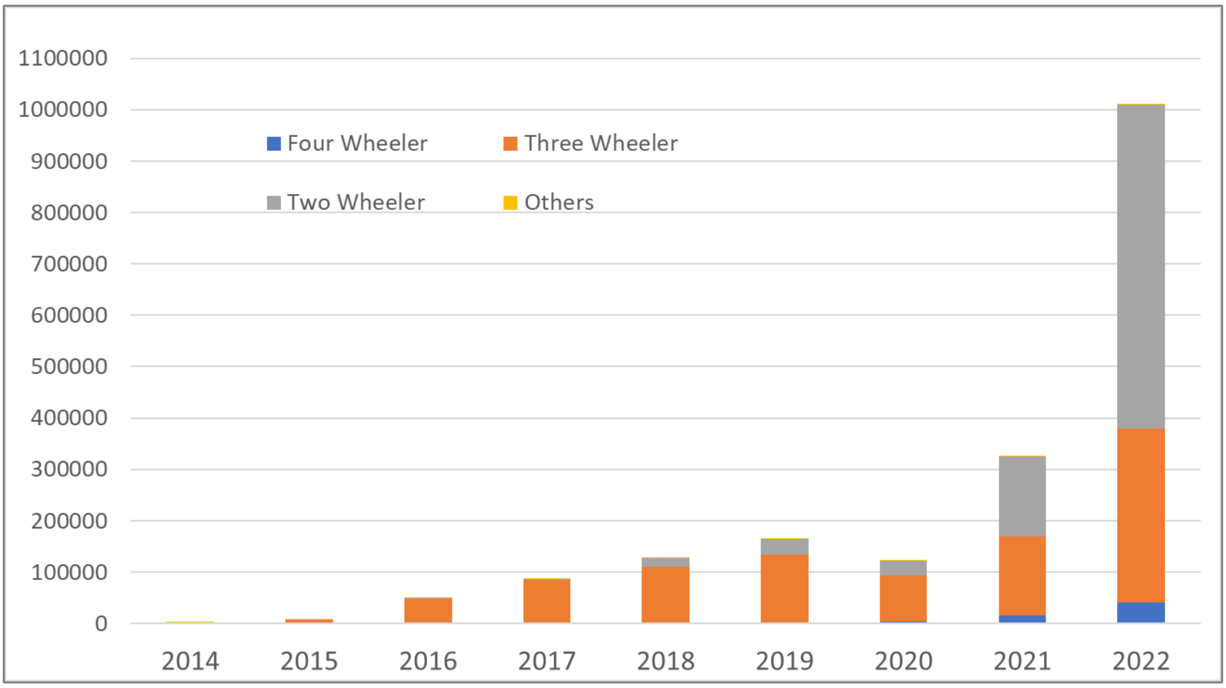
national EV fund.

1.7.3. Current status of EV introduction

On 23 February 2022, the PIB announced that 766,478 EVs had received demand incentives under FAME II, and 6,315 electric buses had been approved in 26 states.[47] According to India's Ministry of Heavy Industries, as of 15 March 2023, a total of INR41.66 billion in subsidies had been injected and 937,508 electric vehicles had been sold.[48] According to the database of [49] India's domestic vehicle registration software, VAHAN, approximately 1.9 million EVs were registered between 2014 and 2022. As shown in Figure 1.23, although the number of registered EVs temporarily decreased in 2020, the number of new EV registrations increased significantly from 2021 to 2022. By vehicle type, from 2014 to 2020, the introduction of electric three-wheeled vehicles was the main source, but from 2021 to 2022, the introduction of electric two-wheeled vehicles also increased rapidly. The electrification ratio of new vehicle registrations in 2022 was 4.7% (0.8% for four-wheeled vehicles, 52.4% for three-wheeled vehicles, and 2.6% for two-wheeled vehicles).

[47] https://pib.gov.in/PressReleasePage.aspx?PRID=1886007
[48] https://fame2.heavyindustries.gov.in/dashboard.aspx
[49] https://vahan.parivahan.gov.in/vahan4dashboard/vahan/vahan/view/reportview.xhtml

Figure 1.23. Number of New EV Registrations



Source: Ministry of Road Transport & Highways, Government of India, 'Vahan Dashboard'. https://vahan.parivahan.gov.in/vahan4dashboard/vahan/vahan/view/reportview.xhtml (accessed 9 March 2023).

1.7.4. Current status of EV charging infrastructure

According to the PIB's announcement, as of 23 January 2022, FAME II had approved 2,877 EV charging stations[50] in 68 cities in 25 states.

As of 25 March 2022, there were[51] 1,576 EV charging stations installed on 16 expressways, and as of 1 January 2022, there were[52] 1,536 EV charging stations installed at retail stores in 32 states/municipalities.

1.7.5. Vehicle registration fee

FAME I reduced or exempted taxes on hybrid and electric vehicles. Nationwide, excise taxes were reduced (30% for conventional cars, 6%–12.5 % for hybrid and electric vehicles) and infrastructure-related taxes were exempted (1%–4% for conventional cars). Additionally, the state of Delhi reduced the state value-added tax (VAT) from 2016 to 2017 (12.5% for conventional cars and 5% for hybrid and electric cars).[53]

From the beginning, FAME II stated that states should be encouraged to expand non-fiscal

---

50 https://www.pib.gov.in/PressReleasePage.aspx?PRID=1842699
51 https://data.gov.in/search?title=EV
52 https://data.gov.in/search?title=EV
53 https://theicct.org/wp-content/uploads/2021/06/India-hybrid-and-EV-incentives_working-paper_ICCT_27122016.pdf

incentives, such as exemptions and discounts on road taxes, toll taxes, parking fees, and discounts on registration fees.

Previously, the central government and state governments had each imposed complex indirect taxes, but in July 2017, a unified indirect tax, the Goods and Services Tax (GST), was introduced. The tax rate varies depending on the goods and services and is divided into five tax rates: 0%,[54] 5%, 12%, 18%, and 28%. As per the decision of the 36th GST Committee Meeting, from 1 August 2019, all EVs received a tax reduction from 12% to 5% , and EV chargers and charging stations received a tax reduction from 18% to 5%.[55] Additionally, electric buses owned by local authorities that can carry more than 12 passengers are exempted from GST.[56]

1.7.6. Economic incentives for xEV owners

FAME II offers discounts on vehicle purchase fees to purchasers and end users of electric and hybrid vehicles. The maximum subsidy amount per vehicle will be reviewed annually by the Project Implementation and Sanctioning Committee (PISC), but in the first year it will be 40% of the vehicle cost for buses and 20% of the vehicle cost for other vehicles at the maximum. There is an upper limit on the factory price of vehicles eligible for the subsidy; for example, a four-wheeled electric vehicle will be excluded from the subsidy if it exceeds INR1.5 million.

1.7.7. Economic incentives for charging infrastructure development

With FAME II, the aim is to install 2,700 charging stations divided into 3 km x 3 km sections in metros, smart cities, hilly areas, and cities with more than 1 million people across the country. The company also aims to install charging stations every 25 km[57] on both sides of expressways.

1.7.8. Economic incentives for manufacturers

To invite large-scale investment and promote the domestic manufacturing industry, India has introduced production-linked incentives (PLI) in some sectors. In the second round, which started on 1 April 2021, the scope of subsidies was expanded to a total of 10 sectors, including automobiles, and will be provided by the increased sales of products manufactured in India (base year: 2019–2020). A subsidy of 3%–5% will be paid to eligible companies for four years.[58] The main objectives of PLI in the automotive industry are to

[54] https://g-japan.in/faq/tax-e-26/
[55] 36th GST Committee Meeting Materials, p.8.
https://gstcouncil.gov.in/sites/default/files/Minutes/Signed%20Minutes%20-%2036th%20GST%20Council%20Meeting.pdf
[56] Ministry of Finance Press Release. https://pib.gov.in/newsite/PrintRelease.aspx?relid=192337
[57] https://www.godigit.com/guides/government-schemes/fame-india-scheme
[58] https://www.meity.gov.in/esdm/pli

overcome cost disabilities, create economies of scale, and build a strong supply chain in the field of advanced automotive technology products. The amount of domestic investment that must be achieved is determined as shown in Table 1.40.[59]

Table 1.40. Target of New Investment

Cumulative New Domestic Investment to Be Achieved	Champion OEM (Except 2W and 3W)	Champion OEM 2W and 3W	Component Champion	New Non-automotive Investor (OEM) Company or Its Group Company (ies)	New Non-Automotive Investor (Component) Company or Its Group Company (ies)
Up to or before 31 March 2023	300	150	40	300	80
Up to or before 31 March 2024	800	400	100	800	200
Up to or before 31 March 2025	1,400	700	175	1,400	350
Up to or before 31 March 2026	1,750	875	220	1,750	440
Up to or before 31 March 2027	2,000	1,000	250	2,000	500

Source: Ministry of Heavy Industries (2021), 'Notification: Production Linked Incentives (PLI) Scheme for Automobile and Auto Component Industry', 23 September.

The PLI system for the automotive industry can enable India's vehicle transport system to leapfrog from traditional fossil fuels to a green, sustainable, advanced, and efficient electric vehicle system. The specific initiatives include granted incentives of up to 18 % (see Table 1.41). According to a press release, as of 15 March 2022, the five-year investment target of INR425 billion has been exceeded, reaching over INR748.5 billion (including 20 businesses with a total of INR450.16 billion). The Champion OEM Incentive

[59] Ministry of Heavy Industries (2021), 'Notification: Production Linked Incentives (PLI) Scheme for Automobile and Auto Component Industry', 23 September.

Scheme has succeeded in attracting investment proposals [60] from 75 businesses, totalling INR298.34 billion.

Table 1.41. Incentives for Champion OEM and New Non-automotive (OEM) Investor Companies

Determined Sales Value (in INR10 million)	Incentive (% of determined sales value)
≦ 2,000	13%
> 2,000 to 3,000	14%
> 3,000 to 4,000	15%
> 4,000	16%
Cumulative determined sales value of INR100 billion over 5 years	Additional 2%

Source: Ministry of Heavy Industries (2021), 'Notification: Production Linked Incentives (PLI) Scheme for Automobile and Auto Component Industry', 23 September.

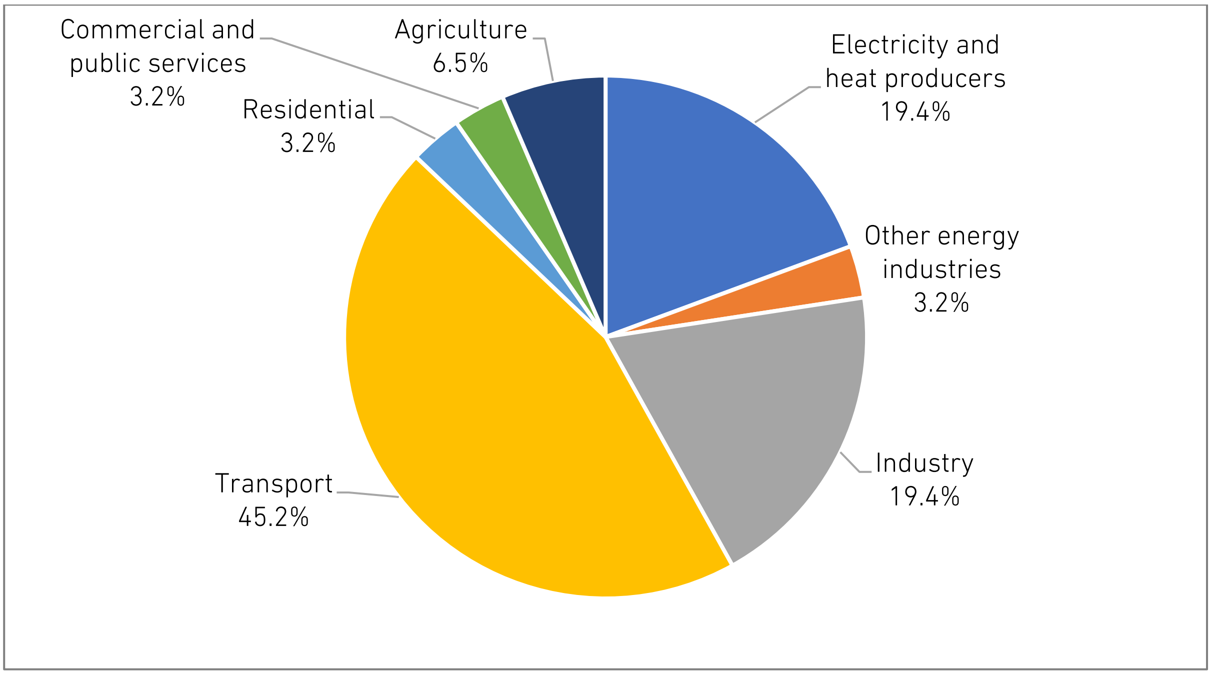
[60] https://heavyindustries.gov.in/UserView/index?mid=2482

1.8. New Zealand

1.8.1. Decarbonisation policy in the transport sector

The transport sector accounts for about 45% of the total CO_2 emissions, making it the single largest emission source in New Zealand. In May 2022, the New Zealand government released an Emissions Reduction Plan (ERP). The ERP consists of over 300 initiatives across various sectors. For the transport sector, a goal of reducing emissions from transport by 41% from 2019 levels by 2035 and to zero by 2050 was established.[61]

Figure 1.24. New Zealand CO_2 Emissions by Sector, 2020



Source: Compiled by the IEEJ based on IEA data (https://www.iea.org/countries/new-zealand).

1.8.2. EV policy and targets

To achieve a functional and low-emission transport system with a high degree of liberty like the current one, the 'Decarbonising Transport Action Plan 2022–25' [62] was formulated. According to the plan, the following measures will be implemented to increase the ratio of zero-emission vehicles amongst all light vehicles to 30% by 2035:

- Encourage the wider use of low-emission vehicles and remove barriers to provide access to more New Zealanders.

[61] https://www.transport.govt.nz//assets/Uploads/MOT4716_Emissions-Reduction-Plan-Action-Plan-P04-V02.pdf

[62] https://www.transport.govt.nz//assets/Uploads/MOT4716_Emissions-Reduction-Plan-Action-Plan-P04-V02.pdf

- Improve the supply of electric vehicle (EV) charging infrastructure so that all EV users can access chargers when necessary.
- Implement further measures to facilitate a shift from internal combustion engine (ICE) vehicles, particularly old, high-emission ones.

To guide the market to increase both the amount and types of low- and zero-emission vehicles between now and 2034, a clean car standard was formulated and a CO_2 target to be applied to car importers was established. This target will be lowered each year to reach 0 grammes in 2035. The CO_2 target is scheduled for a review in 2024 by law.

1.8.3. Fuel economy regulation

In New Zealand, there is a government initiative called the Clean Car Standard (CCS) in place to promote the import of low-emission vehicles and reduce CO_2 emissions to certain target values. From 1 January 2023, the CCS CO_2 values of a vehicle will be used to determine whether the vehicle will incur a charge or be awarded credits. There are two payment schemes: Pay as You Go and Fleet Average. With Pay as You Go, vehicles are assessed on a per vehicle basis, and must either pay for any charges that arise or use existing CO_2 differences from the target or credits to offset the fees. With Fleet Average, imported vehicles are assessed on an annual basis. If the average CO_2 emissions for imported vehicles exceed the target at the end of the year, a fee will be charged.

Table 1.42. Payment Schemes of the Clean Car Standard

Payment scheme	Pay as You Go	Fleet Average
Description	Importers operating on Pay as You Go will comply with targets on a per vehicle basis.	Importers operating on Fleet Average will comply with targets on an annual basis.
CO_2 credits	Per vehicle A CO_2 credit is applied if the vehicle CO_2 emissions are less than the individual vehicle target for that vehicle.	Annual A CO_2 credit is applied if the actual average vehicle CO_2 emissions across the importer's total fleet, during an obligation year, are less than the target for the year.

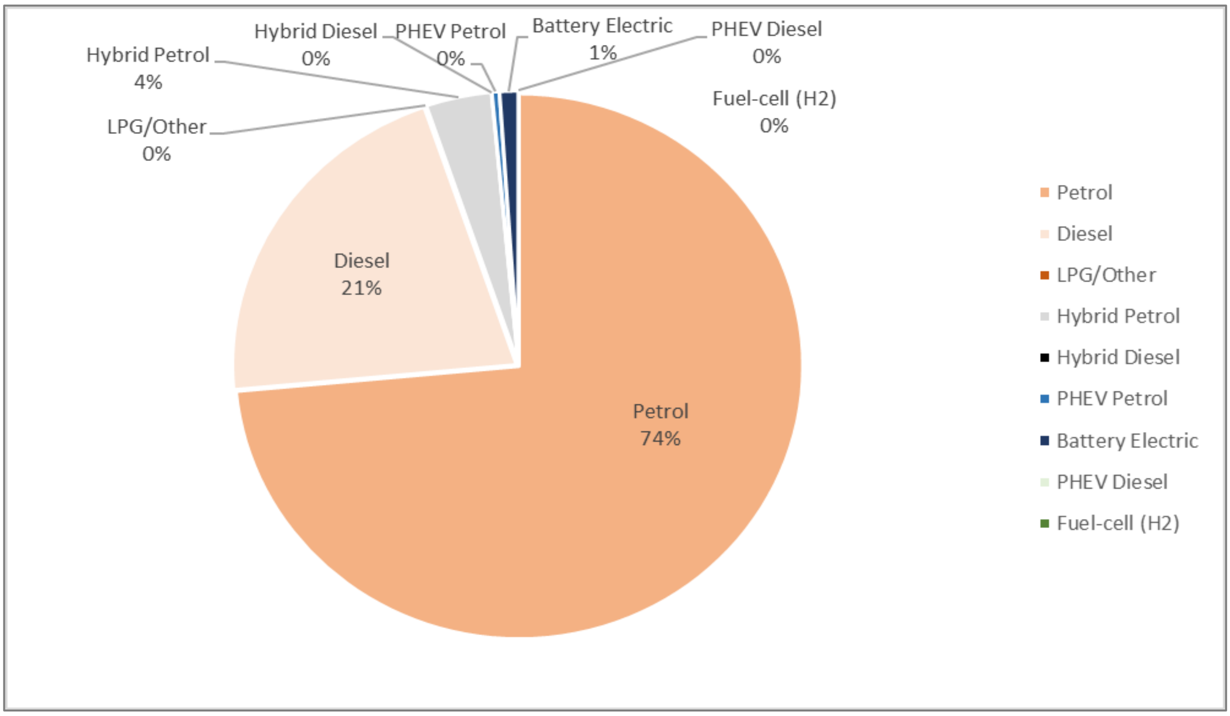
Payment scheme	Pay as You Go	Fleet Average
	Credits can be banked or transferred	Credits can be saved or transferred
Charges	Per vehicle – based on the annual rate If a vehicle's CO_2 emissions are greater than the target, a charge will be due at the time of accepting the vehicle in the CCS System unless credits are used to offset. Rates for 2023: • New vehicles: \$36.00 per gramme of CO_2 in excess • Used vehicles: \$18.00 per gramme of CO_2 in excess	Annual – based on the annual rate If the total vehicle CO_2 emissions are greater than the total targets across the obligation year a charge will be due unless credits are used to offset. Rates for 2023: • New vehicles: \$45.00 per gramme of CO_2 in excess • Used vehicles: \$22.50 per gramme of CO_2 in excess
Process for joining	Automatic acceptance	By application

Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-standard/overview/).

1.8.4. Current status of introduction of EVs and charging infrastructure

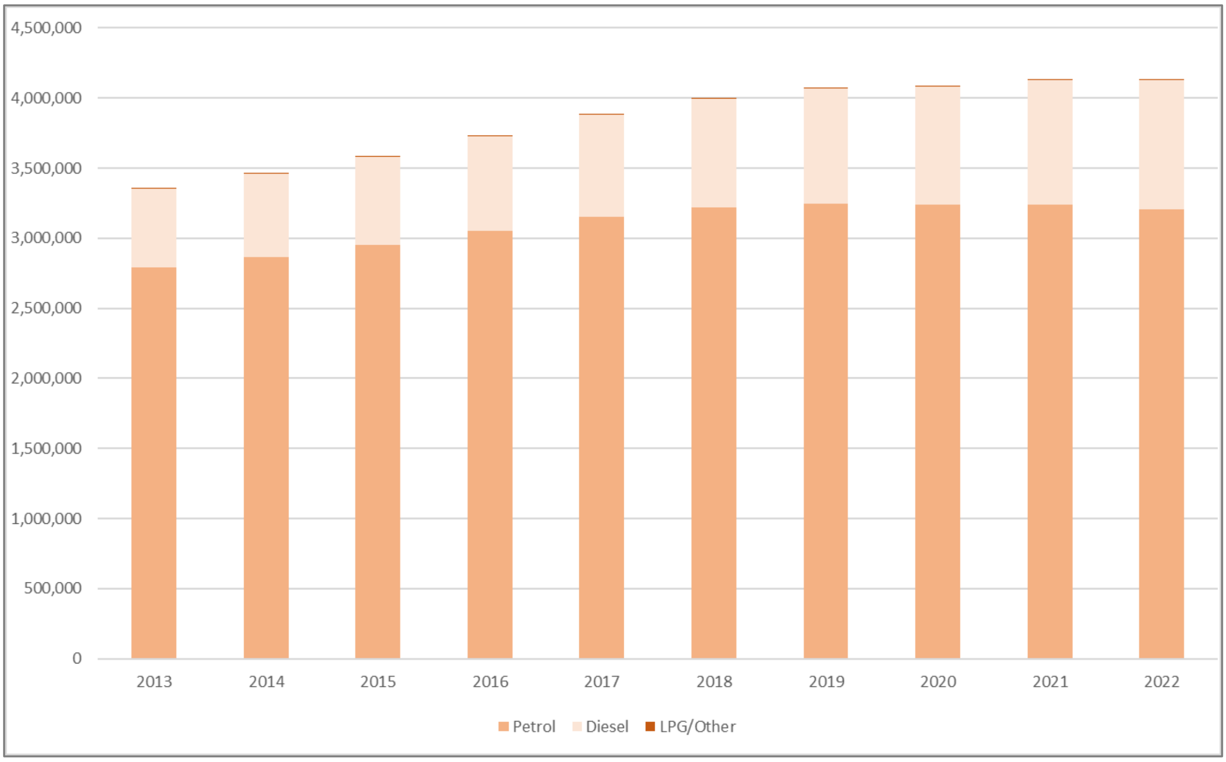
As of the end of 2022, gasoline and diesel vehicles together accounted for about 95% of all registered small cars, and the share of xEVs including hybrids was still small.

Figure 1.25. Share of Registered Small Cars, 2022



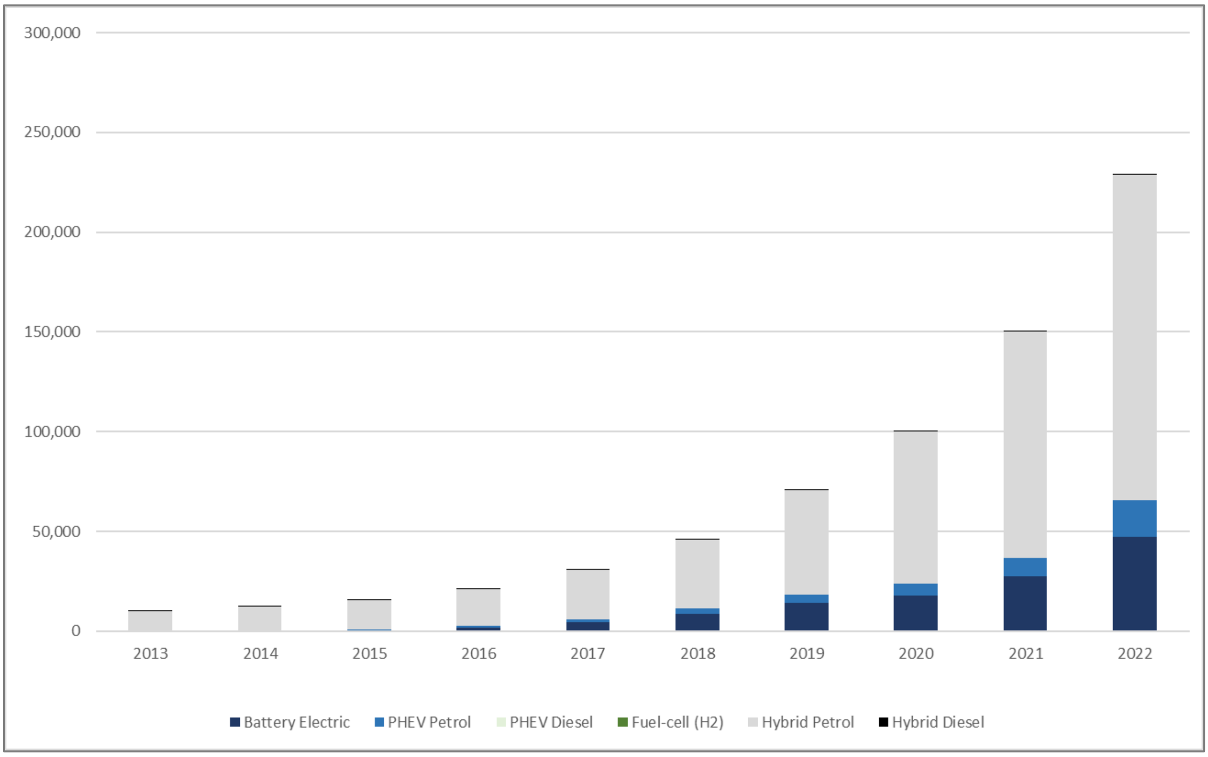
Source: Ministry of Transport (https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/2021-annual-fleet-statistics).

Figure 1.26. Number of Registered Small Cars (Gasoline, Diesel, and LPG)



LPG = liquefied petroleum gas.
Source: Ministry of Transport (https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/light-motor-vehicle-registrations/).

Figure 1.27. Number of Registered Small Cars (EV, Hybrid, and FC)



Source: Ministry of Transport (https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/2021-annual-fleet-statistics/).

In recent years, the number of registered gasoline vehicles has been declining, whilst those of BEVs and other xEVs, as well as hybrids, have been rising.

New Zealand's public EV charger network covers more than 96% of the state road network and has grown to a level where there is a high-speed/rapid direct current (DC) charger at least every 75 kilometres. The government has helped strengthen the EV charger network by co-funding the installation of more than 600 public and 400 private sector EV chargers through the Low Emissions Vehicle Contestable Fund (LEVCF) of the Energy Efficiency & Conservation Authority (EECA).[63]

According to EVRoam, the live database for New Zealand's EV charger infrastructure, 363 EV charging stations were registered as of July 2023.

[63] https://www.transport.govt.nz/assets/Uploads/Redacted-OC210328-Update-on-the-development-of-a-national-electric-vehicle-charging-infrastructre-plan-SIGNED-21.5.2021-Min-Wood-1.pdf

1.8.5. Vehicle registration fees

The following taxes are required to register a vehicle, and the total is shown in Table 1.40:

- a registration fee
- a license fee
- an Accident Compensation Corporation (ACC) levy
- applicable standards levy
- a number plate fee
- a label fee
- a registration administration fee
- Goods and Services Tax (GST)

Table 1.40. Vehicle Registration Fees in New Zealand

Registration of Motor Vehicle (Issued with Standard Plates)		6 months	12 months
Private passenger - petrol driven	0–1,300 cc	$166.48	$215.22
	1,301–2,600 cc	$210.18	$258.92
	2,601–4,000 cc	$241.23	$289.97
	Over 4,001 cc	$348.18	$396.92
Private passenger - diesel driven	0–1,300cc	$200.89	$284.04
	1,301–2,600cc	$244.59	$327.74
	2,601–4,000cc	$275.64	$358.79
	Over 4,001 cc	$382.59	$465.74
Private passenger - electric driven		$166.48	$215.22

Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/licensing-rego/vehicle-fees/registration-fees/).

Further, fees for high-emission vehicles must be paid for such vehicles when they are first registered in New Zealand. In addition, Road User Charges (RUC)[64] are also required.

Table 1.44. Fees for High-emission Vehicles in New Zealand

Vehicle Carbon Emissions (grammes per kilometre)	Used Vehicle Fees (Excluding GST)	New Vehicle Fees (Excluding GST)
192 or more	(emissions* - 186) x $37.50 Capped at $2,500	(emissions* - 186) x $50 Capped at $4,500.

* The CO_2 emissions of the vehicle must be calculated in accordance with the Land Transport Rule: Vehicle Efficiency and Emissions Data 2022.
Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/overview/).

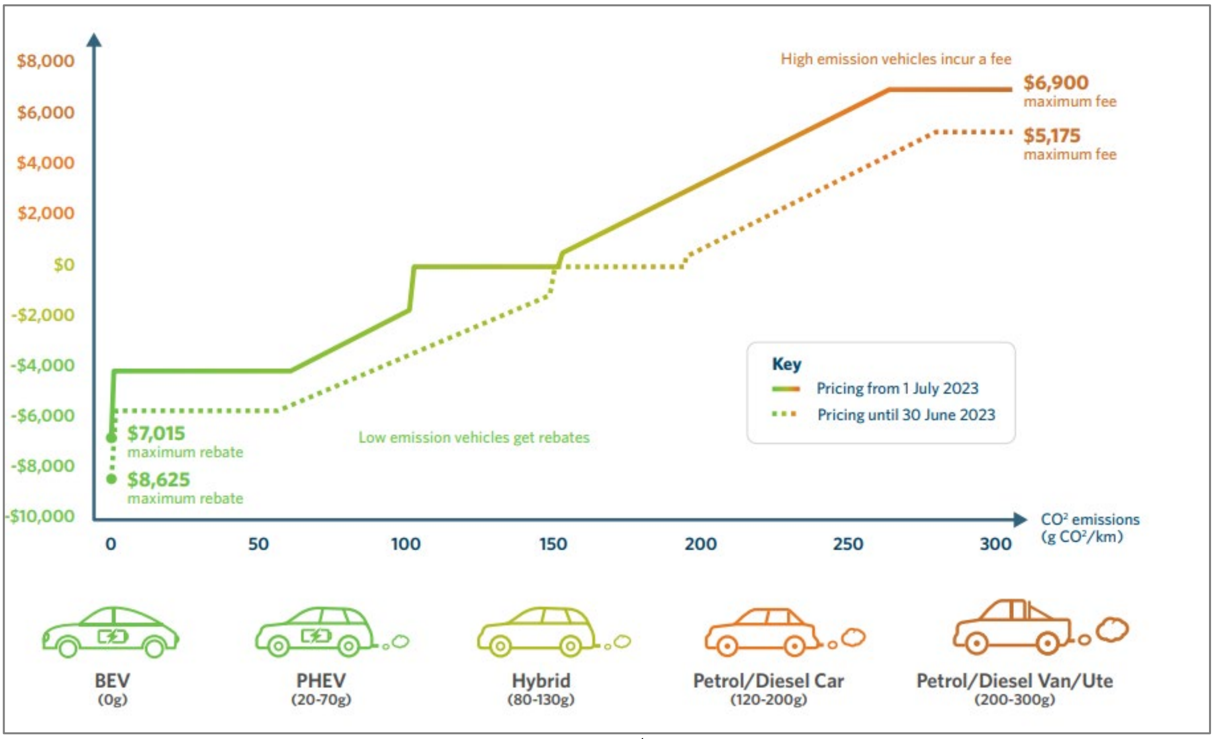
1.8.6. Economic incentives for EV owners

To contribute to New Zealand's goal of becoming carbon neutral by 2050, a clean car discount has been introduced to lower the purchase price of low-emission vehicles.

Depending on the CO_2 emissions of each car, newly registered or second-hand imported cars are either given a cash refund or charged a fee. As shown in Tables 1.45 and 1.46, the monetary amount changed from 1 July 2023.

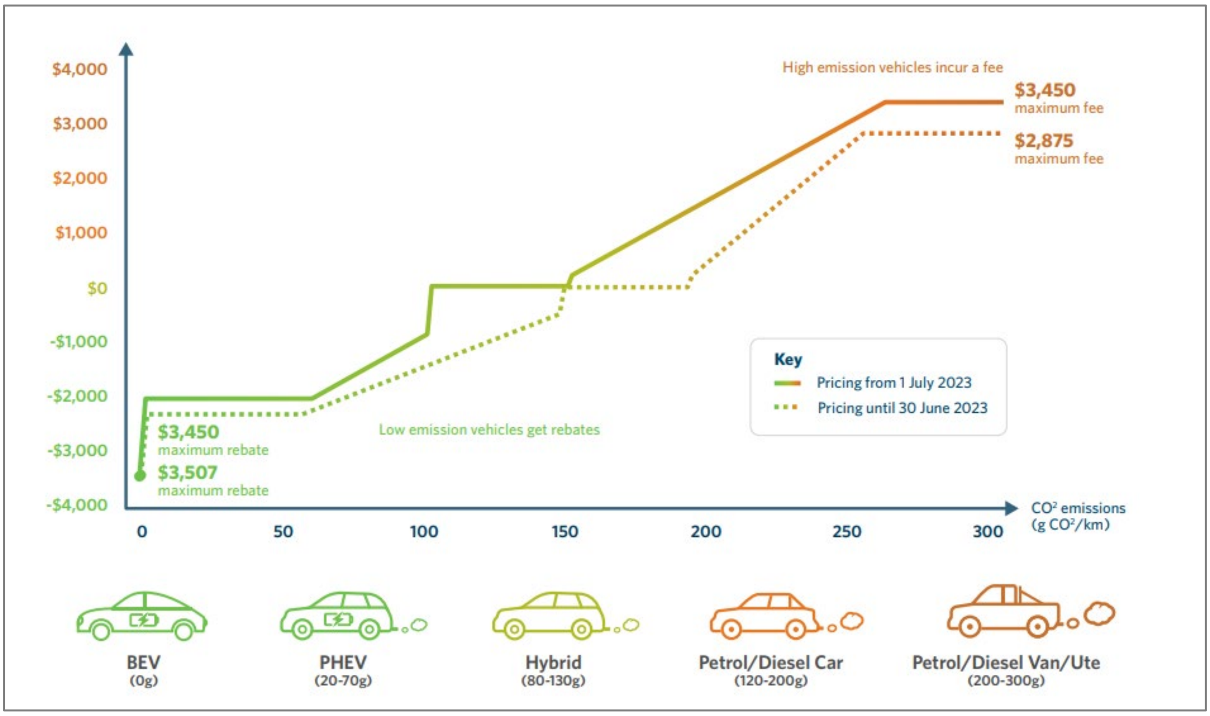
[64] https://www.nzta.govt.nz/vehicles/road-user-charges/ruc-rates-and-transaction-fees/

Figure 1.28. Clean Car Discount Rebates and Fees for New Vehicles



Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/clean-car-discount-1-july-2023-changes/).

Figure 1.29. Clean Car Discount Rebates and Fees for Used Vehicles



Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/clean-car-discount-1-july-2023-changes/).

Table 1.45. Summary of 1 July Changes to Rebates

Vehicle Type/Description	What Is Changing
Zero-emission vehicles (EVs)	For new models, the rebate will reduce from $8,625 to $7,015. For used imports, the rebate will increase from $3,450 to $3,507.50.
Low-emission vehicles	The threshold at which low-emission vehicles will be eligible for a rebate will change from 146 g CO_2/km to 100 g CO_2/km.
Zero band range vehicles	Some vehicles won't be eligible for a rebate or incur a fee. The zero-band range will be 101–149 g CO_2/km, down from 147–191 g CO_2/km.
Rebates rates for new vehicles	The rebate rate per gramme of CO_2 in the range of 60–100 will be $57.50. The current rate is $51.55. The maximum rebate will decrease from $5,750 to $4,025.
Rebates rates for used vehicles	The rebate rate per gramme of CO_2 in the range of 60–100 will be $28.75. The current rate is $20.62. The maximum rebate will decrease from $2,300 to $2,012.50.
Disability vehicles*	A special rebate for new and used low-emission disability vehicles will be introduced: $11,500 for a battery electric vehicle, and $5750 for hybrids. * Disability vehicles are vehicles modified to carry people seated in wheelchairs or which have swivel seats for easier entry/exit. These vehicles must be certified as disability vehicles and be first registered in New Zealand.

Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/clean-car-discount-1-july-2023-changes/).

Table 1.46. Summary of 1 July Changes to Fees

Carbon Emissions (g CO_2/km)	New Vehicles	Used Vehicles
150–259	The fee rate per gramme will change from $58.00 to $57.50.	The fee rate per gramme will change from $43.00 to $28.75.
260 or more	The maximum fee will increase from $5,175 to $6,900.	The maximum fee will increase from $2,875 to $3,450.

Source: Waka Kotahi NZ Transport Agency (https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/clean-car-discount-1-july-2023-changes/).

Further, light electric vehicles (with a weight load of up to 3,500 kg) are exempt from RUC through 31 March 2024. Large electric vehicles (with a weight load of over 3,500 kg) are exempt from RUC through 31 December 2025.[65]

1.8.7. Economic incentives for charging infrastructure development

The Low Emission Transport Fund is providing support for the public EV charger installation project, and the sixth round of applications was being received as of February 2023.[66]

1.8.8. Economic incentives for manufacturers

Since cars are not assembled in New Zealand, there are no economic incentives offered for EV production.

1.8.9. Implications

New Zealand's domestic electricity supply consists mostly of renewable energy, namely hydropower, geothermal power, and wind power. Meanwhile, the country's main industry is primary industry products, in which they are productive and internationally competitive. As such, whilst the country is treating EVs preferentially, it is also pursuing a multi-faceted and phased approach to decarbonise the transport industry, including promoting the use of hydrogen and biofuel.

[65] https://www.nzta.govt.nz/vehicles/road-user-charges/ruc-exemptions/

[66] https://www.eeca.govt.nz/co-funding/transport-emission-reduction/low-emission-transport-fund/round-6-adoption-of-public-charging-infrastructure/

The number of EVs registered in New Zealand is still small compared to its entire fleet but has been rising steadily in recent years. EV purchase subsidies and CO_2 emission vehicle taxes are producing a certain level of results towards the wider adoption of EVs.

References

Bangkok Post (2021), 'EA Serving Up Greener Energy Production', 14 December. https://www.bangkokpost.com/business/2231403/ea-serving-up-greener-battery-production

Bureau of Energy Efficiency, Ministry of Power, 'Government of India, 'Fuel Efficiency''. https://beeindia.gov.in/en/programmesenergy-efficiency-in-transport-sector/fuel-efficiency (accessed 22 March 2023).

Christopher & Lee Ong (2020), 'National Automotive Policy 2020'. https://www.christopherleeong.com/media/3773/clo_nap_2020.pdf

Cyril Amarchand Mangaldas (2023), 'The Energy Conservation (Amendment) Act, 2022: Key Highlights'. https://corporate.cyrilamarchandblogs.com/2023/01/the-energy-conservation-amendment-act-2022-key-highlights/#_ftn11 (accessed 22 March 2023).

DDTC News (2021), 'PPnBM Mobil Listrik, Sri Mulyani Sebut Ada Pengawasan dari DJP', 15 March. https://news.ddtc.co.id/ppnbm-mobil-listrik-sri-mulyani-sebut-ada-pengawasan-dari-djp-28434

Electric Vehicle Association of Thailand (EVAT) (n.d.), 'Number of Electric Vehicle Charging Stations in Thailand'. http://www.evat.or.th/15708256/current-status

Electricity Generating Authority of Queensland (EGAT, (n.d.), 'EGAT's EV Charging Station 'EleX by EGAT''. https://www.egat.co.th/en/business-operation/egat-service-business/ev-business-solution/elex-by-egat

Energy Absolute PCL (2021), 'Opportunity Day 3Q/2021'. https://www.energyabsolute.co.th/calendar/presentation/20211122172822.pdf

GIZ (2021), *Study of Electric Mobility Development in Viet Nam*. https://changing-transport.org/wp-content/uploads/Electric-mobility-assessment_Final-report_EN_210813-1.pdf

Global Japan Consulting, 'E-26：India's new GST' (in Japanese). https://g-japan.in/faq/tax-e-26/ (accessed 22 March 2023).

Goods and Services Tax Council (2019), 'Minutes of 36th GST Council Meeting Held on 27th July, 2019'. https://gstcouncil.gov.in/sites/default/files/Minutes/Signed%20Minutes%20-%2036th%20GST%20Council%20Meeting.pdf

Government of India (2022), 'Expressways/Highways-wise Electric Vehicle (EV) in the Country in Various Segment'. https://data.gov.in/search?title=EV (accessed 9 March 2023).

Government of India (2022), 'State/UTs-wise No. of Retail Outlets (Ros) where Electric Vehicle (EV) Charging Facility as on 01.01.2022'. https://data.gov.in/search?title=EV (accessed 9 March 2023).

Government of India, Ministry of Heavy Industries & Public Enterprises, Department of Heavy Industry (2019), 'Notification: Scheme for Faster Adoption and Manufacturing of Electric Vehicles in India Phase II (FAME India Phase II)'. https://fame2.heavyindustries.gov.in/content/english/32_1_FAMEDepository.aspx (accessed 22 March 2023).

Government of National Capital Territory of Delhi (Transport Department) (2022), 'Delhi Electric Policy, 2020'. https://www.smev.in/govt-notification.php

ICICI Lombard (2021), 'BS6 Norms and Their Impact on the Two-Wheeler Industry'. https://www.icicilombard.com/blogs/car-insurance/car/bs6-norms-and-their-impact-on-the-two-wheeler-industry (accessed 22 March 2023).

Indonesian Ministry of Energy and Mineral Resources (2022), 'PLN Engages Private Sector to Install More Charging Stations', 4 January. https://www.esdm.go.id/en/media-center/news-archives/pln-engages-private-sector-to-install-more-charging-stations

JETRO (2023), 'India and Potential for Four Wheel EVs', (in Japanese). https://www.jetro.go.jp/biz/areareports/2023/282e51364b047c16.html (accessed 9 March 2023).

Kasikorn Research Center (2022), 'Sales of Chinese BEVs Set to Exceed 10,000 Units in 2022 Amid Gloomy Domestic Car Market', 1 April. https://www.kasikornresearch.com/en/analysis/k-econ/business/Pages/BEV-z3319.aspx

Kompass (2022), 'Sampai Februari 2022, Jumlah SPKLU Nasional Diklaim Mencapai 267 Unit' [Until February 2022 the Number of National SPKLU Claimed Reaches 267 Units], 28 March. https://otomotif.kompas.com/read/2022/03/28/110200915/sampai-februari-2022-jumlah-spklu-nasional-diklaim-mencapai-267-unit

Ministry of Electronics & Information Technology, Government of India, 'Production Linked Incentive Scheme (PLI) for Large Scale Electronics Manufacturing'. https://www.meity.gov.in/esdm/pli (accessed 22 March 2023).

Ministry of Environment, Forest and Climate Change (2022), 'India's Stand at COP-26'. https://pib.gov.in/PressReleasePage.aspx?PRID=1795071 (accessed 22 March 2023).

Ministry of Heavy Industries (2021), 'Notification: Production Linked Incentives (PLI) Scheme for Automobile and Auto Component Industry'. https://heavyindustries.gov.in/UserView?mid=2482

Ministry of Heavy Industries (2022), 'Press Release: 7,66,478 Electric Vehicles Supported Under Phase-II of FAME India Scheme, till 19th December, 2022'. https://pib.gov.in/PressReleasePage.aspx?PRID=1886007 (accessed 22 March 2023).

Ministry of Heavy Industries (2022), 'Press Release: 2,877 Electric Vehicle Charging Stations Sanctioned Under FAME–II in 68 Cities Across 25 States/UTs'. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1842699 (accessed 9 March 2023).

Ministry of Heavy Industries (2022), 'Press Release on PLI Scheme for Automobile and Auto Component Industry by MHI'. https://heavyindustries.gov.in/UserView?mid=2482

Ministry of Heavy Industries (2023), 'Demand No. 48'. https://www.indiabudget.gov.in/doc/eb/sbe48.pdf

Ministry of Heavy Industries, 'National Automotive Board (NAB): Dashboard'. https://fame2.heavyindustries.gov.in/dashboard.aspx (accessed 22 March 2023).

Ministry of Heavy Industries, Government of India, 'National Automotive Board (NAB): FAME I'. https://fame2.heavyindustries.gov.in/content/english/15_1_FAMEI.aspx (accessed 22 March 2023).

Ministry of Heavy Industries, Government of India, 'National Automotive Board (NAB): OEM and Dealers'. https://fame2.heavyindustries.gov.in/ModelUnderFame.aspx (accessed 22 March 2023).

Ministry of Road Transport & Highways (2022), 'Notification Issued to Include Compliance with Fuel Consumption Standards (FCS), for Light, Medium and Heavy Duty Motor Vehicles of Various Categories, Manufactured in, or Imported by, India'. https://pib.gov.in/PressReleasePage.aspx?PRID=1839570 (accessed 22 March 2023).

Ministry of Road Transport & Highways, Government of India, 'Vahan Dashboard'. https://vahan.parivahan.gov.in/vahan4dashboard/vahan/vahan/view/reportview.xhtml (accessed 9 March 2023).

Nguen Anh Duong (2022), 'Policies to Promote EV Development in Viet Nam', presentation at the Central Institute for Economic Management, Viet Nam, at the 1st Meeting of ERIA Research Project in FY2021, Working Group on 'Policies and Infrastructure Development for the Wider Penetration of xEVs in ASEAN Countries', 28 February.

Nikkei Asia (2022), 'Vietnam's VinFast Takes the EV Battle to Tesla with U.S. Push', 25 April. https://asia.nikkei.com/Business/Automobiles/Vietnam-s-VinFast-takes-the-EV-battle-to-Tesla-with-U.S.-push2

NITI Aeyog (2021), 'Status Quo Analysis of Various Segments of Electric Mobility and Low Carbon Passenger Road Transport in India'. https://www.niti.gov.in/sites/default/files/2021-04/FullReport_Status_quo_analysis_of_various_segments_of_electric_mobility-compressed.pdf

Oh, J.E., et al. (2019), *Addressing Climate Change in Transport: Volume 1: Pathway to Low-Carbon Transport.* Washington, DC: World Bank and GIZ. https://documents1.worldbank.org/curated/en/581131568121810607/pdf/Volume-1-Pathway-to-Low-Carbon-Transport.pdf

PLN (2022), 'Pembalap: Layanan Home Charging Dongkrak Minat Masyarakat Punya Electric Vehicle (EV)' [Drivers: Home Charging Service Boosts Public Interest in Having an Electric Vehicle (EV)], press release, 17 April.

Press Information Bureau, Government of India, Ministry of Finance (2019), 'GST Rate on All Electric Vehicles Reduced from 12% to 5% and of Charger or Charging Stations for EVs from 18% to 5%', https://pib.gov.in/newsite/PrintRelease.aspx?relid=192337 (accessed 22 March 2023).

Prime Minister's Office of Malaysia (2019), 'The National Transport Policy 2019-2030'. https://www.malaysia.gov.my/portal/content/30900

PRS Legislative Research (2022), 'The Energy Conservation (Amendment) Bill, 2022' https://prsindia.org/billtrack/the-energy-conservation-amendment-bill-2022 (accessed 22 March 2023).

PWC (2019), 'Upcoming Luxury-Goods Sales Tax Rules on Motor Vehicles', *Tax Indonesia* No 19. https://www.pwc.com/id/en/taxflash/assets/english/2019/taxflash-2019-17.pdf

Rokadiya, S. and A. Bandivadelar (2016), 'Hybrid and Electric Vehicles in India -Current Scenario and Market Incentives'. https://theicct.org/wp-content/uploads/2021/06/India-hybrid-and-EV-incentives_working-paper_ICCT_27122016.pdf

Royal Thai Government (2022), 'Cabinet Approves Guidelines to Promote Electric Vehicles', 15 February. https://www.thaigov.go.th/news/contents/details/51601

Thai Board of Investment (Thai BOI) (2021), 'Policy for Promoting Manufacturing EV and Parts of EV', March. https://www.boi.go.th/upload/content/3_2564_600501f3ceba5.pdf

Thai Board of Investment (Thai BOI) (2023), 'BOI Reveals EV Promotion Total of Over 100 Billion Accelerate Investment Stimulus Supports Rising Domestic Demand', 5 April. https://www.boi.go.th/index.php?page=press_releases_detail&topic_id=133884

Thai Board of Investment (Thai BOI) (2022), 'Thailand BOI Approves Enhanced Measure to Boost EV Sector; Reports 110.7 Billion Baht in Investment Applications in Q1', press release. https://www.boi.go.th/index.php?page=press_releases_detail&topic_id=132250

Thai Ministry of Natural Resources and Environment (2021), 'Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy Thailand'. https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf

Thananusak, T., P. Punnakitikashem, S. Tanthasith, and B. Kongarchapatara, (2021), 'The Development of Electric Vehicle Charging Stations in Thailand: Policies, Players, and Key Issues (2015–2020)', *World Electric Vehicle Journal*, 12(1). https://www.mdpi.com/2032-6653/12/1/2/htm

Ucarshop (2021), 'VinFast Already Installs over 8,100 EV Charging Ports at Around 500 Charging Stations in Vietnam', 29 July. https://www.ucarshop.com/information/298744

Vietnamnet (2021), 'Investment in Charging Stations is Needed for the Electric Car Industry', 25 September. https://vietnamnet.vn/en/investment-in-charging-stations-needed-for-electric-car-industry-777407.html

Chapter 2

Estimation of GHG Emissions from PLDVs in the Fuel Cycle (WtW) and Vehicle Cycle (LCA)

1. Introduction

In ASEAN and India, automobiles are rapidly spreading, resulting in various adverse effects, such as deteriorating air pollution, increasing oil imports, and increasing GHG emissions. Automobile electrification is effective in reducing oil consumption and air pollution in the road sector. However, energy consumption and GHG emissions for not only 'Tank to Wheel' but also 'Well to Tank' should be considered. Furthermore, GHGs are emitted when automobiles are manufactured or disposed of. It is said that manufacturing batteries for electric vehicles consumes a large amount of energy. Therefore, we should consider not only the emissions during the use of automobiles but also the total amount of emissions, including those during production and disposal. Namely, Life Cycle Assessment (LCA) is needed. The amount of these emissions varies greatly depending on the powertrain type, and the overall amount of emissions will change depending on the powertrain type that penetrates in the future.

This study estimates the total GHG emissions related to passenger light-duty vehicles (PLDVs) on a Well-to-Wheel (WtW) and LCA basis to contribute to the policy planning of ASEAN countries and India in the field of automobiles and energy. The study covers Indonesia, Thailand, Malaysia, Viet Nam, Singapore, and India.

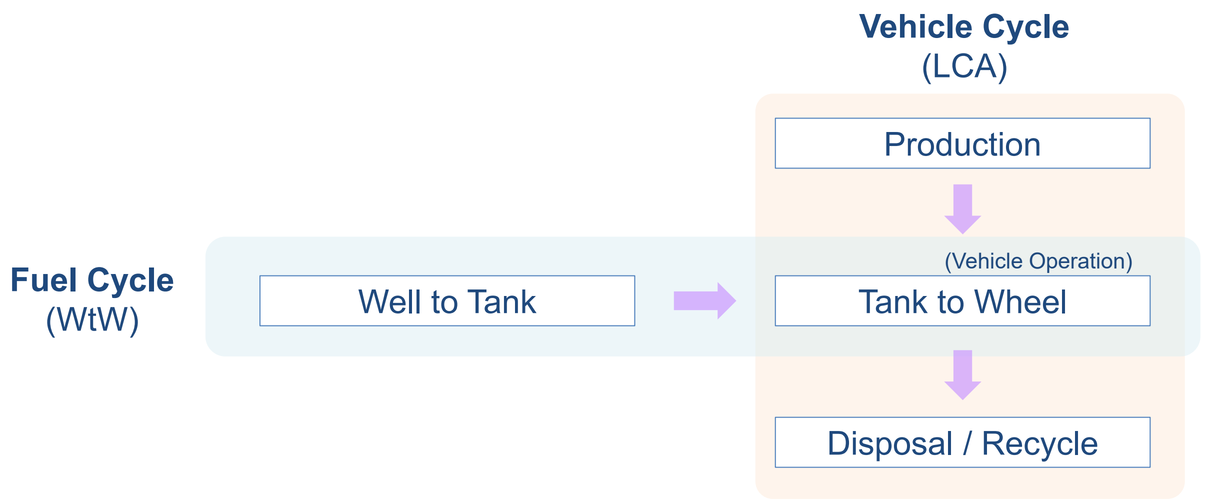
2. Estimation Method

2.1. Fuel Cycle (WtW) and Vehicle Cycle (LCA)

When driving automobiles, GHGs are emitted from the combustion of fuel. When manufacturing or disposing of automobiles, GHGs are also emitted from factories. So, it is important to consider a comprehensive analysis from two angles. One is the fuel cycle from well to wheels for fuels. The other is the vehicle cycle from raw material mining to the manufacturing of parts and the assembling, driving, and disposing of automobiles (LCA).

This study attempts to estimate the total GHG emissions related PLDVs by combining both assessments. First, we estimate the WtW intensity per mileage and the LCA intensity per vehicle for each vehicle type. This study covers internal combustion engine vehicle (ICE), hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), and battery electric vehicle (BEV) powertrain types. Next, we estimate the number of vehicles (production volume, operating volume, and disposal volume) by powertrain. Then, by multiplying each intensity by the number of vehicles, we estimate the GHG emissions of the entire country related to PLDVs up to 2040.

Figure 2.1. Fuel Cycle (WtW) and Vehicle Cycle (LCA)



WtW = Well to Wheel, LCA = Life Cycle Assessment.
Source: Authors.

2.2. GHG emissions in the fuel cycle (WtW)

Fuel cycle or WtW analysis considers GHG emissions in automotive fuels throughout the process from fuel mining to transformation, transport, and final consumption. In particular, when comparing the amount of GHG emissions by automobiles that use different energies (gasoline, electricity, biofuels, etc.), it is necessary to consider the entire energy supply process, not only at the time of final consumption of using the automobiles. To make a comparison amongst the powertrain types, we estimate the GHG emissions per 1 km of travel distance.

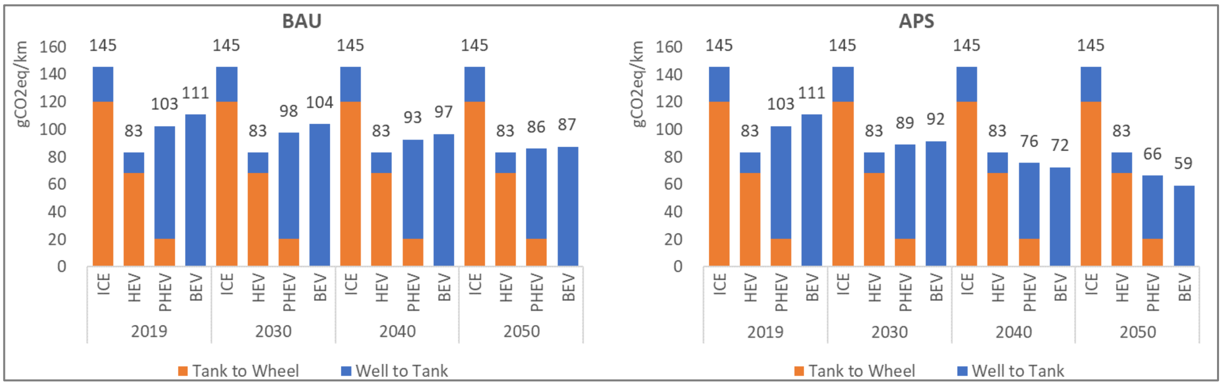
2.2.1. WtW intensities for the four countries

The WtW analysis was already conducted in an ERIA project.[67] For Indonesia, Thailand, Malaysia, and Viet Nam, which were analysed in the project, the estimation results for WtW are applied in this study. The intensities in the four countries are shown in Figures 2.2–2.5, where the BAU assumes Business as Usual, and the APS shows the Advanced Policy Scenario, which assumes more aggressive energy efficiency and a higher penetration of non-fossil fuels.

[67] Economic Research Institute for ASEAN and East Asia (2022), *Policies and Infrastructure Development for the Wider Penetration of Electric Vehicles (EVs) in ASEAN Countries*.

The tank-to-wheel emissions are in the following order of magnitude: ICE > HEV > PHEV > BEV, whilst the well-to-tank emissions depend on the degree of decarbonisation of the power supply. In Thailand, which has a cleaner power generation mix, BEVs are the lowest emitter on a WtW basis today. Even in other countries, if their power mix were to become as clean as the APS, BEVs would be the lowest emitters on a WtW basis.

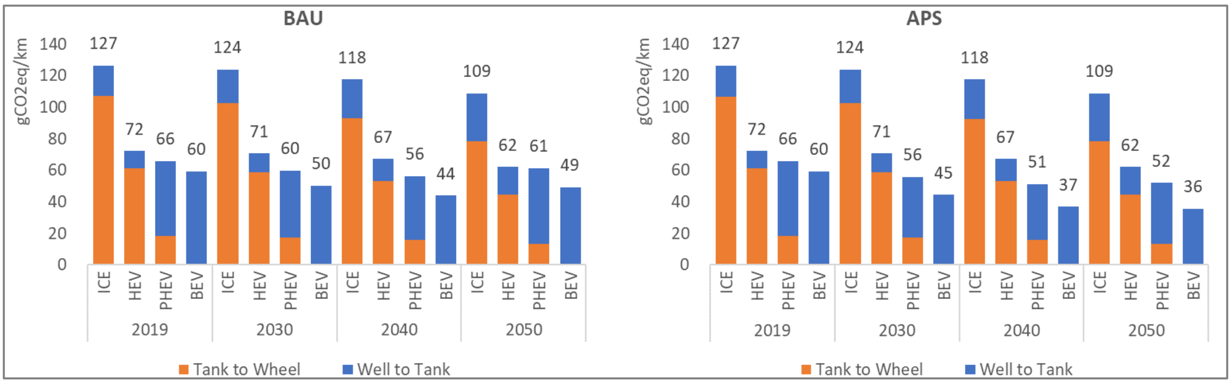
Figure 2.2. GHG Intensities Based on Well to Wheel (Indonesia)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.

Source: ERIA (2022).

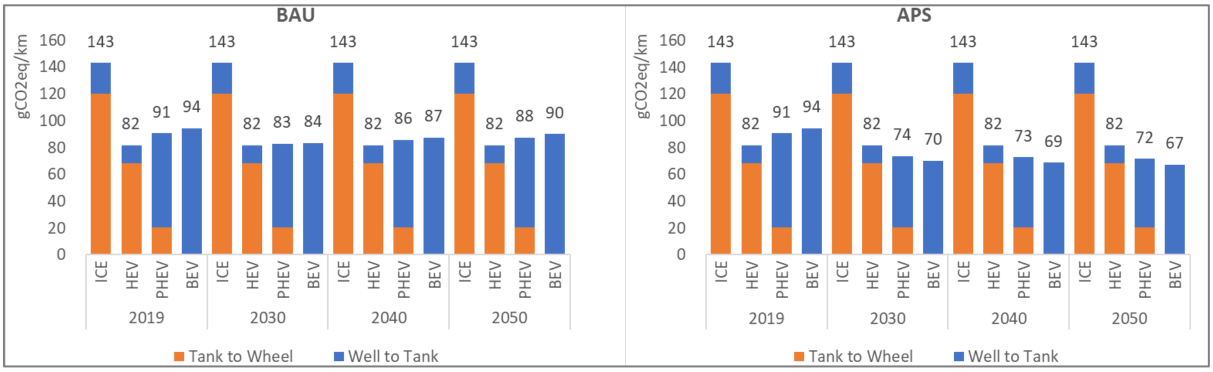
Figure 2.3. GHG Intensities Based on Well to Wheel (Thailand)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.

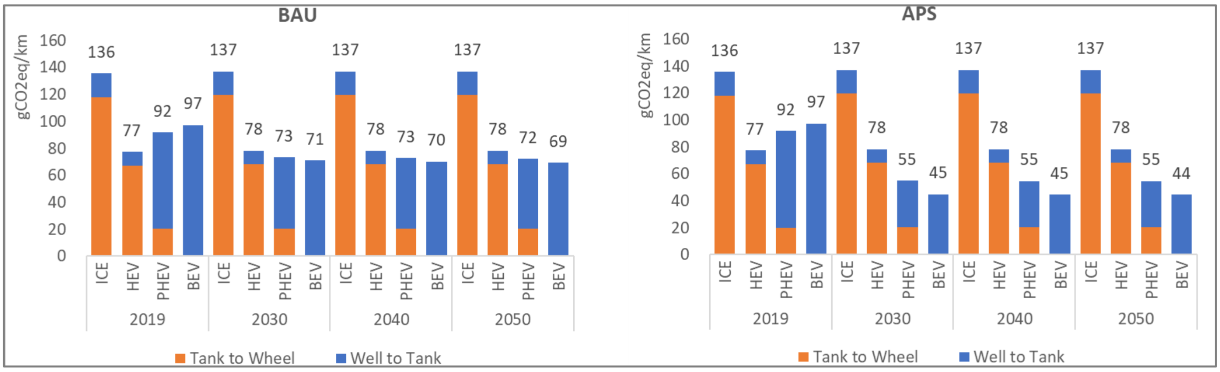
Source: ERIA (2022).

Figure 2.4. GHG Intensities Based on Well to Wheel (Malaysia)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.
Source: ERIA (2022).

Figure 2.5. GHG Intensities Based on Well to Wheel (Viet Nam)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.
Source: ERIA (2022).

2.2.2. WtW intensities for Singapore and India

WtW analysis for Singapore and India was not done in the previous ERIA project. Therefore, this study estimates WtW intensities for the two countries using the same method as the other four countries. For the detailed estimation procedure, see ERIA (2022).

A) Assumptions for Tank to Wheel

Tank to Wheel calculates the GHG emissions when driving a car. Here, the main factors are gas/electric mileage, as shown in Table 2.1. We assume the efficiencies are identical amongst the countries and without any improvement in the future.

Table 2.1. Fuel Efficiency by Powertrain

	Fuel Efficiency	Engine/Battery Driving Ratio
ICE	20 km/L	100%/0%
HEV	35 km/L	100%/0%
PHEV	35 km/L, 8 km/kWh	30%/70%
BEV	8 km/kWh	0%/100%

BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.
Source: ERIA (2022).

B) Assumptions for Well to Tank

Well to Tank calculates GHG emissions during the fuel supply process. We describe in detail separately for liquid fuels (gasoline and biofuel) and electricity. Tables 2.2 and 2.3 show the assumptions for well to tank for liquid fuels, including the GHG intensities from extraction, refinery, import, and biofuel production. The GHG intensities of imported crude oil and gasoline are estimated considering the composition of the import sources.

Table 2.2. Assumptions for Well to Tank for Liquid fuels (Singapore)

	Domestic Crude Oil	Imported Crude Oil	Imported Gasoline	Biofuels
Import ratio	-	100%[a]	66%[a]	-
GHG from extraction (gCO_2eq/L)	-	214[b]	553[c]	-
CO2 from refinery (gCO_2eq/L)	58[a]			1,200[d]
Biofuel blending ratio (in 2050)	-	-	-	0%[e]

Sources:
[a] Estimated based on IEA (2021), *World Energy Statistics and Balances.*
[b] Authors.
[c] Authors, including GHG emissions at refinery and extraction.
[d] ERIA (2020), *Evaluation of CO_2 Emissions Reduction by Mobility Electrification and Alternative Biofuel Introduction in East Asia Summit Countries*.
[e] IEEJ (2021), *IEEJ Outlook 2022*.

Table 2.3. Assumptions for Well to Tank for Liquid fuels (India)

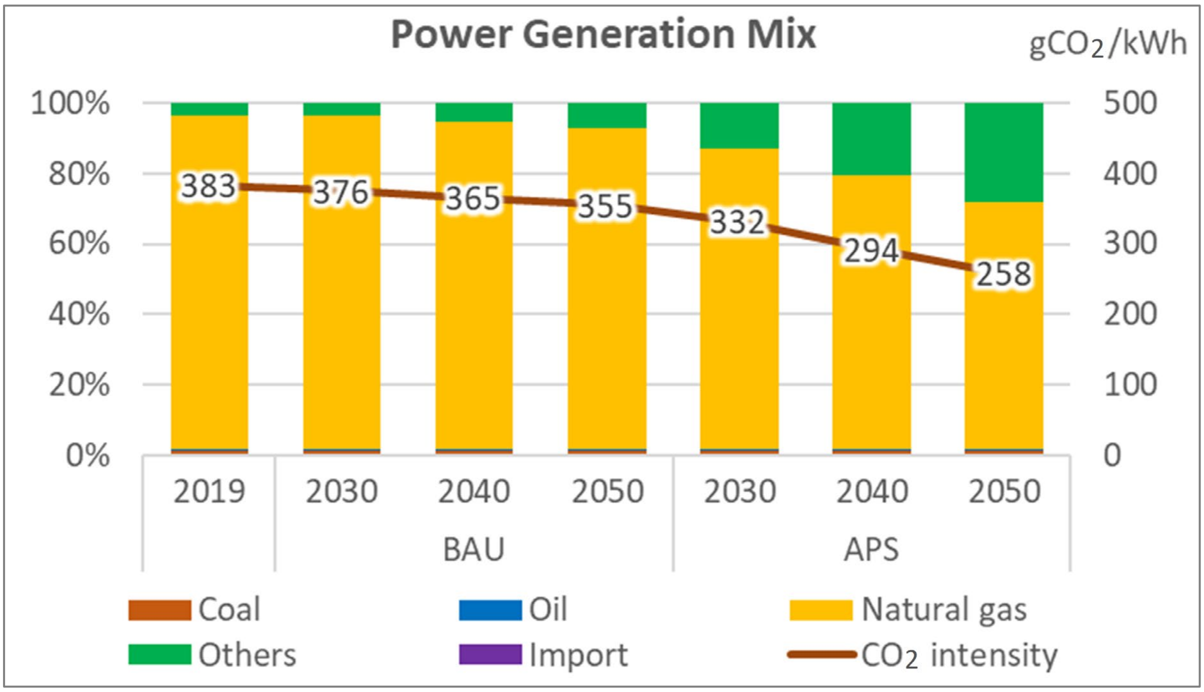
<table>
<tr><th></th><th>Domestic Crude Oil</th><th>Imported Crude Oil</th><th>Imported Gasoline</th><th>Biofuels</th></tr>
<tr><td>Import ratio</td><td>-</td><td>86%[a]</td><td>5%[a]</td><td>-</td></tr>
<tr><td>GHG from extraction (gCO_2eq/L)</td><td>275[b]</td><td>337[c]</td><td rowspan="2">309[d]</td><td>-</td></tr>
<tr><td>CO2 from refinery (gCO_2eq/L)</td><td colspan="2">130[a]</td><td>1,200[e]</td></tr>
<tr><td>Biofuel blending ratio (in 2050)</td><td>-</td><td>-</td><td>-</td><td>5%[f]</td></tr>
</table>

Sources:
[a] Estimated based on IEA (2021), *World Energy Statistics and Balances.*
[b] Masnadi et al. (2018), 'Global Carbon Intensity of Crude Oil Production'.
[c] Authors.
[d] Authors, including GHG emissions at refinery and extraction.
[e] ERIA (2020), *Evaluation of CO_2 Emissions Reduction by Mobility Electrification and Alternative Biofuel Introduction in East Asia Summit Countries*.
[f] IEEJ (2021), *IEEJ Outlook 2022*.

The GHG emissions (per kWh) during power generation are estimated based on the power generation mix in ERIA's outlook.[68] The outlook has two scenarios, Business as Usual (BAU) and the Advanced Policy Scenario (APS). The APS assumes more aggressive energy efficiency and a higher penetration of non-fossil fuels. The power generation mix and GHG emissions in Singapore and India are set as shown in Figures 2.6. and 2.7.

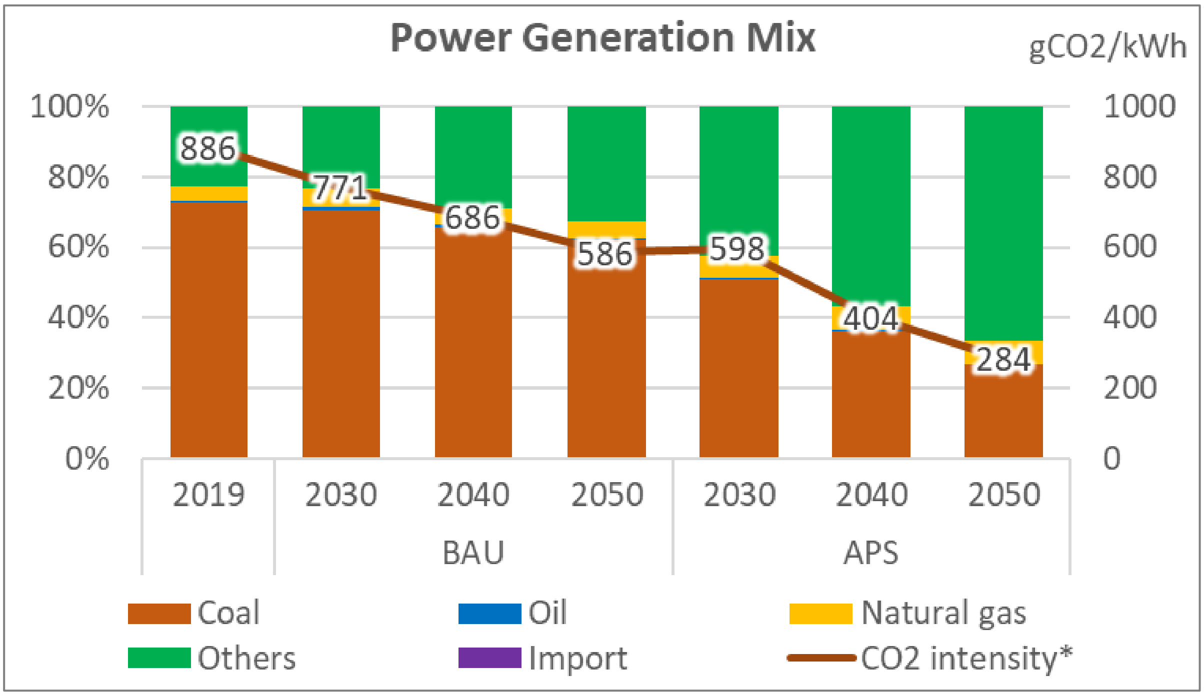
[68] ERIA (2021), *Energy Outlook and Energy Saving Potential in East Asia 2020*.

Figure 2.6. Power Generation Mix and CO_2 Intensity (Singapore)



APS = Advanced Policy Scenario, BAU=Business as Usual.
Note: CO_2 intensity is based on the receiving end.
Source: Estimated based on ERIA (2021), *Energy Outlook and Energy Saving Potential in East Asia 2020.*

Figure 2.7. Power Generation Mix and CO_2 Intensity (India)

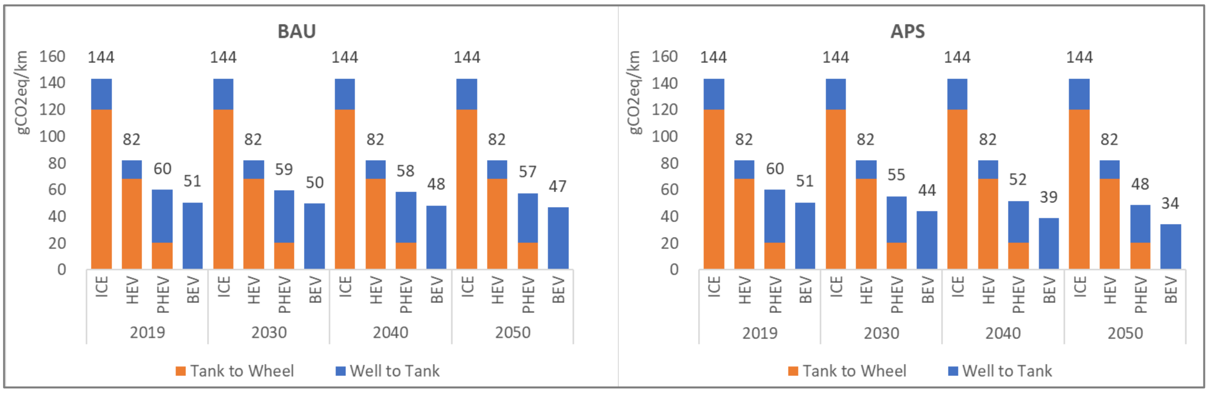


APS = Advanced Policy Scenario, BAU=Business as Usual.
Note: CO_2 intensity is based on the receiving end.
Source: Estimated based on ERIA (2021), *Energy Outlook and Energy Saving Potential in East Asia 2020.*

C) Results of Well-to-Wheel intensities

Figures 2.8. and 2.9. show the well-to-wheel base emissions in Singapore and India respectively, estimated from the above assumptions. Singapore has a clean power generation mix and BEVs are the lowest emitters at the time of writing this report in 2023. On the other hand, India's power mix is dominated by coal-fired power, and BEVs emit more GHGs than other electric vehicles. However, due to the decarbonisation of power sources, emissions from BEVs will decrease.

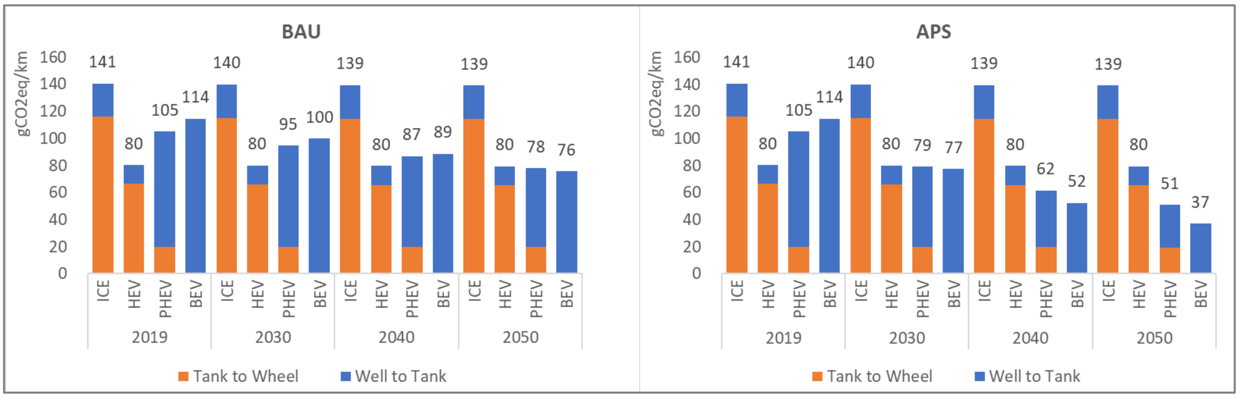
Figure 2.8. GHG Intensities Based on Well to Wheel (Singapore)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.

Source: Authors.

Figure 2.9. GHG Intensities Based on Well to Wheel (India)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.

Source: Authors.

2.3. GHG Emissions in the Vehicle Cycle (LCA)

Vehicle-cycle or LCA analysis considers GHG emissions from mining raw materials to the manufacturing of parts, assembling, driving, and disposing of automobiles. When comparing the amount of GHG emissions by automobiles with different powertrains (ICE, BEV, etc.), it is necessary to consider the entire life cycle process, not only during operation but also during the manufacturing and disposal stages. To make comparisons amongst the powertrain types, we estimate the GHG emissions per vehicle, excluding the operation stage, which is dealt with in the Tank to Wheel analysis.

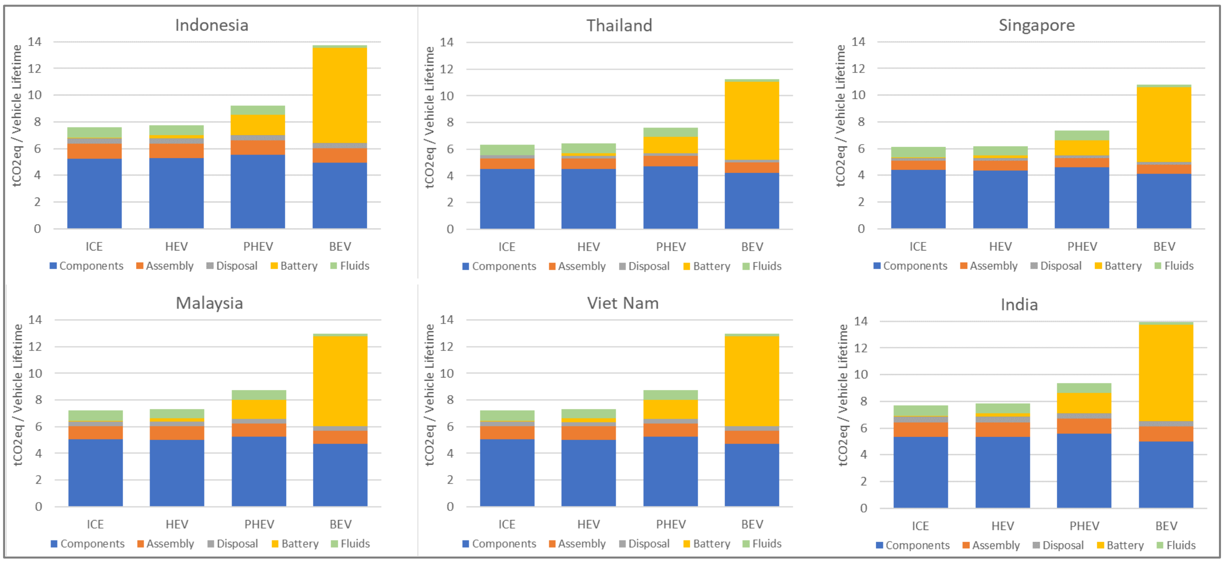
The GHG emissions per vehicle are referred to in the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) Model 2021 version, developed by Argonne National Laboratory. The intensities in the model are adapted for the US. However, it is believed that there is not much difference in energy consumption and emissions regardless of which country produces if the state-of-the-art technology is used in automobile manufacturing. Only for electricity consumption, the CO_2 intensity in the power generation of each country is applied, instead of the one for US.

This study assumes that these intensities remain unchanged in the future, except the CO_2 intensity in the power generation, which improves based on ERIA's outlook.[69] To simplify the calculations, this study assumes that all vehicles are manufactured in each country. Namely, imports of vehicles and parts are not considered. This assumption is probably far from the actual situation, so it should be recognised as an issue for more sophisticated analysis in the future.

Figure 2.10 shows GHG emissions per vehicle in the vehicle cycle. For ICEs, HEVs, and PHEVs, the largest portion is 'components', which includes GHG emissions when making each material, such as the body and engine, and includes emissions during mining the raw materials. More than half of the emissions come from sectors related to iron manufacturing. GHG emissions from battery production account for a considerable weight for BEVs. This is because the production of batteries consumes a large amount of electricity. Therefore, emissions in Thailand and Singapore, which have cleaner power mixes, are relatively small.

[69] ERIA (2021), *Energy Outlook and Energy Saving Potential in East Asia 2020*.

Figure 2.10. GHG Emissions in the Vehicle Cycle in 2019 (Excluding Vehicle Operation)



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.

Source: Authors.

Figure 2.11 shows the vehicle cycle intensities in 2040 in the BAU and APS cases. The intensities in 2040 are lower than in 2019 due to improvements in the CO_2 intensity in the power generation sector. Also, the APS case, which has a cleaner power mix, has lower intensities than the BAU case.

Figure 2.11. GHG Emissions in the Vehicle Cycle by Scenario (Excluding Vehicle Operation)

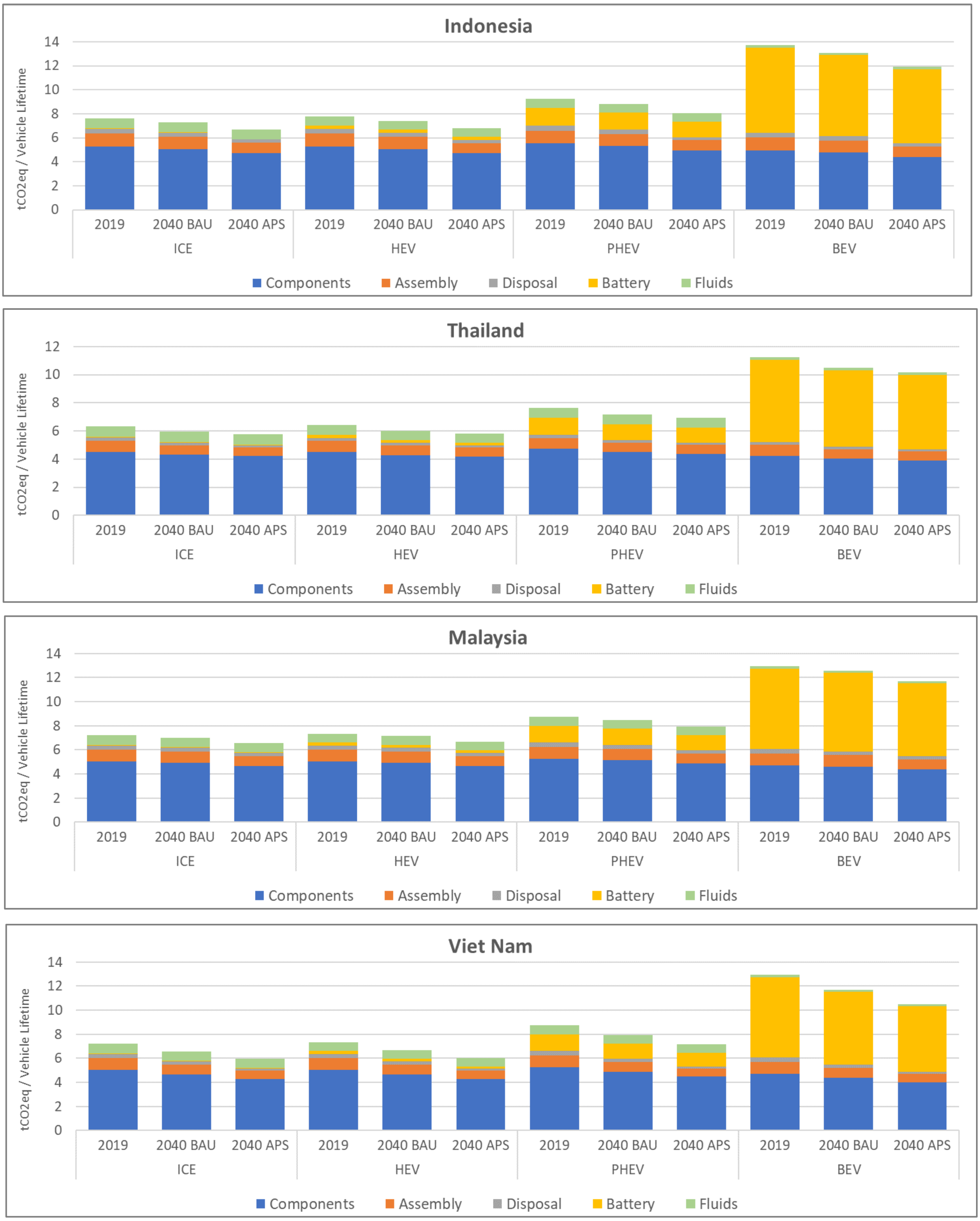
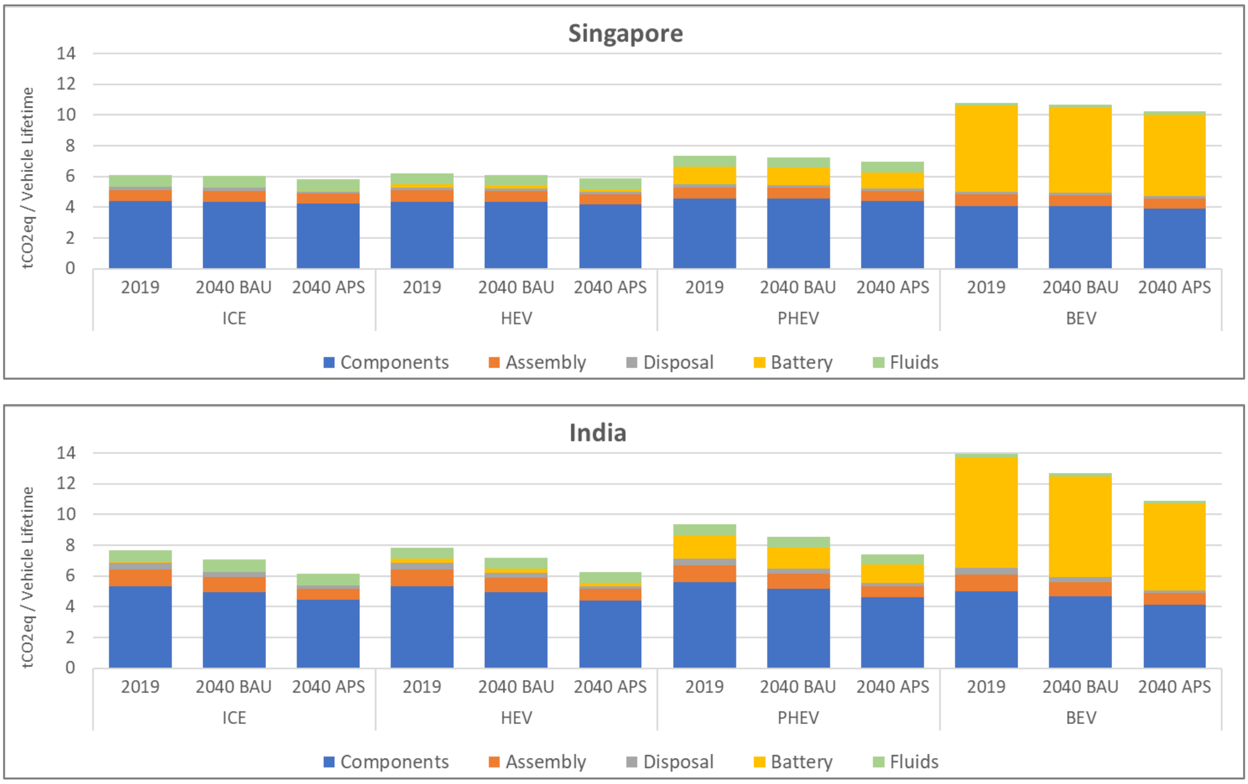


Figure 2.11. *Continued*



APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

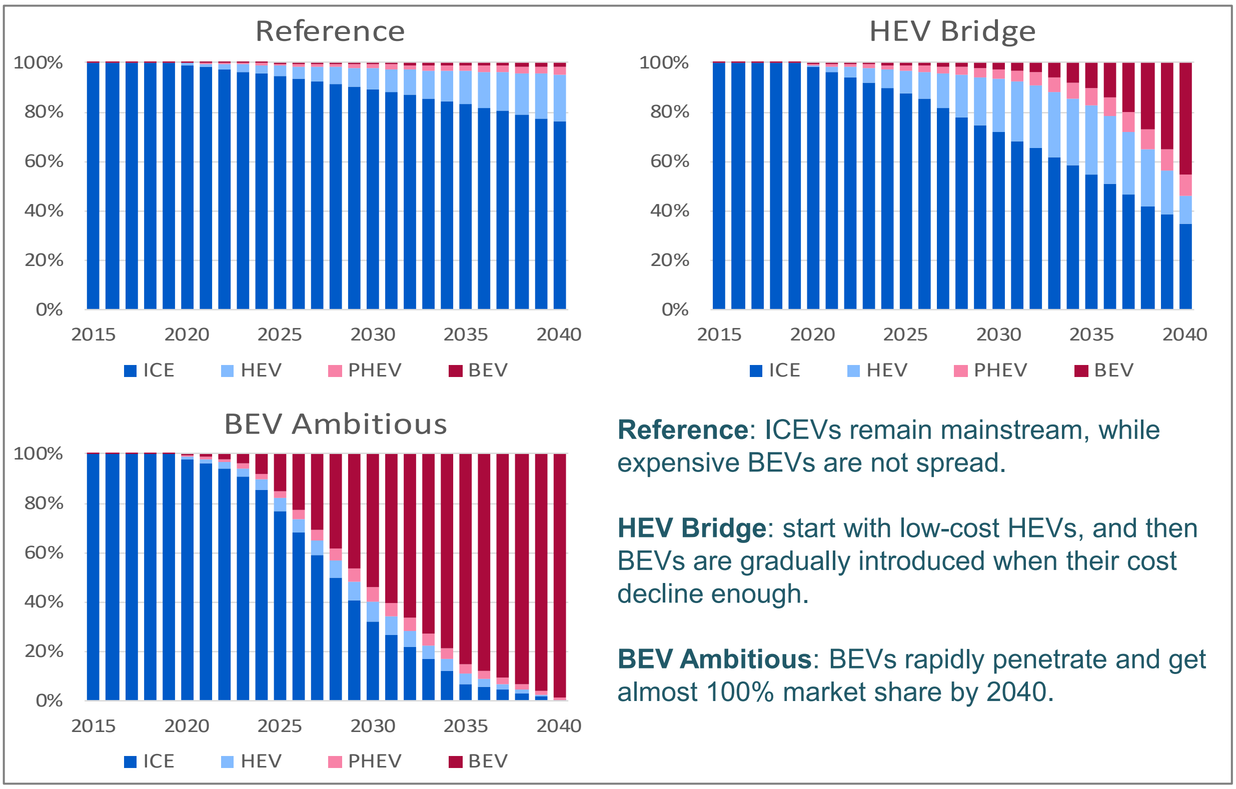
2.3.1. xEV Penetration by Powertrain

Sections 2.2 and 2.3 mentioned the emission intensities of each powertrain vehicle. However, the whole country-based emissions depend on how each powertrain penetrates. This section sets the scenarios for the penetration of each powertrain. We refer to the scenario analysis conducted in previous ERIA projects.[70]

Figure 2.12 shows the sales mix by the scenarios for PLDVs analysed in the previous ERIA projects. In the Reference scenario, ICEs remain mainstream, whilst expensive BEVs are not widespread. The HEV Bridge scenario assumes starting with low-cost HEVs, and then BEVs are gradually introduced when their cost declines enough. In the BEV Ambitious scenario, BEVs rapidly penetrate and reach an almost 100% market share by 2040.

[70] ERIA (2019), *Study on Electric Vehicle Penetrations' Influence on 3Es in ASEAN*. ERIA (2020), The *Influence on Energy and the Economy of Electrified Vehicle Penetration in ASEAN*. This study newly estimates xEV penetration by the same method for Singapore and India.

Figure 2.12. Scenarios for PLDV Sales by Powertrain



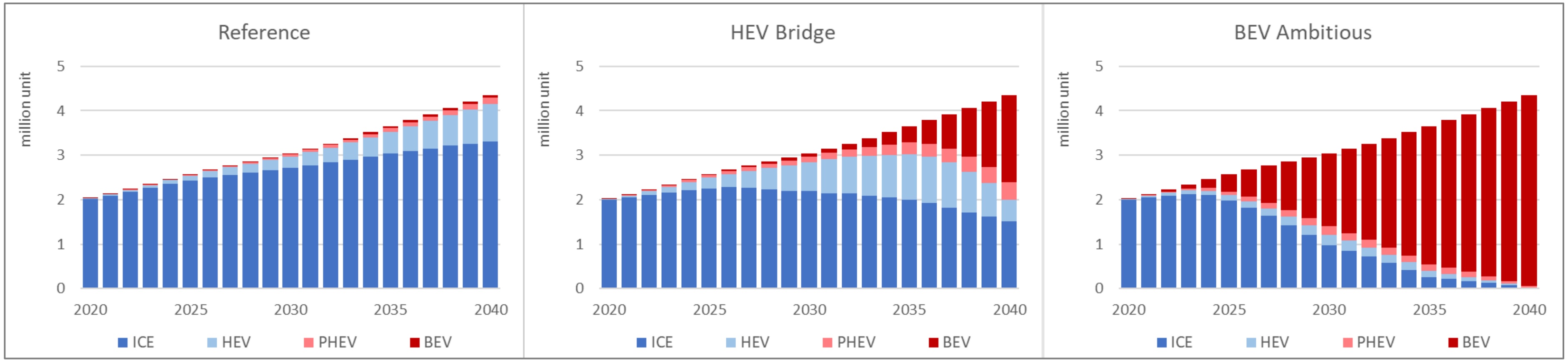
Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: ERIA (2019, 2020b).

In Indonesia, Viet Nam, and India (Figures 2.13, 2.16, and 2.18), car ownership rates are still low today, and as income levels rise, the number of vehicles owned will rapidly increase by 2040 (double in Indonesia and quadruple in Viet Nam and India), and car sales will also rapidly increase.[71] In Thailand, Malaysia, and Singapore (Figures 2.14, 2.15, and 2.17), the car ownership rates are higher than those in the previous three countries, growth in the number of vehicles owned is moderate (1.2–1.4 times by 2040), and car sales will also grow relatively gradually.

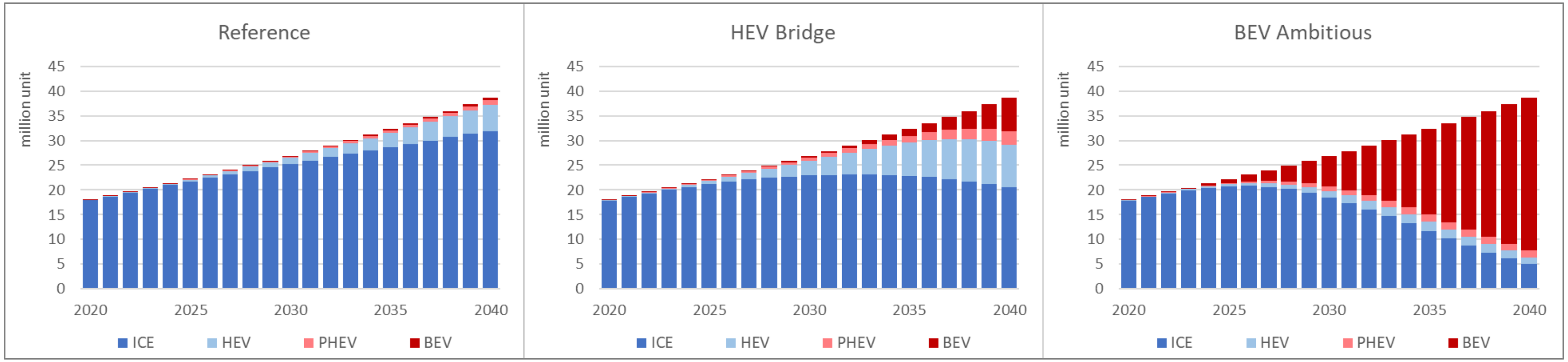
[71] The effects of carsharing are outside the scope of this study.

Figure 2.13. PLDV Sales and PLDVs on the Road by Powertrain (Indonesia)

PLDV Sales



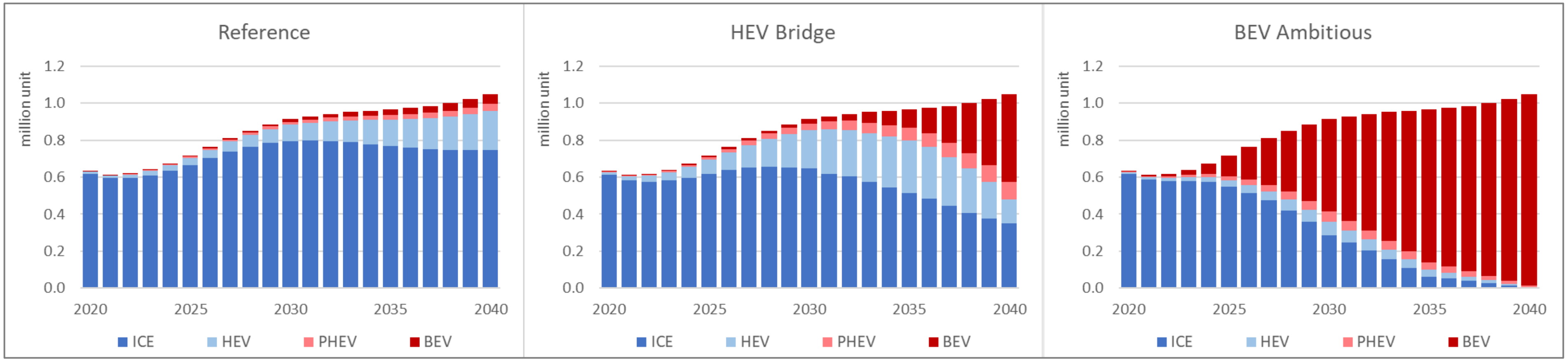
PLDVs on the Road



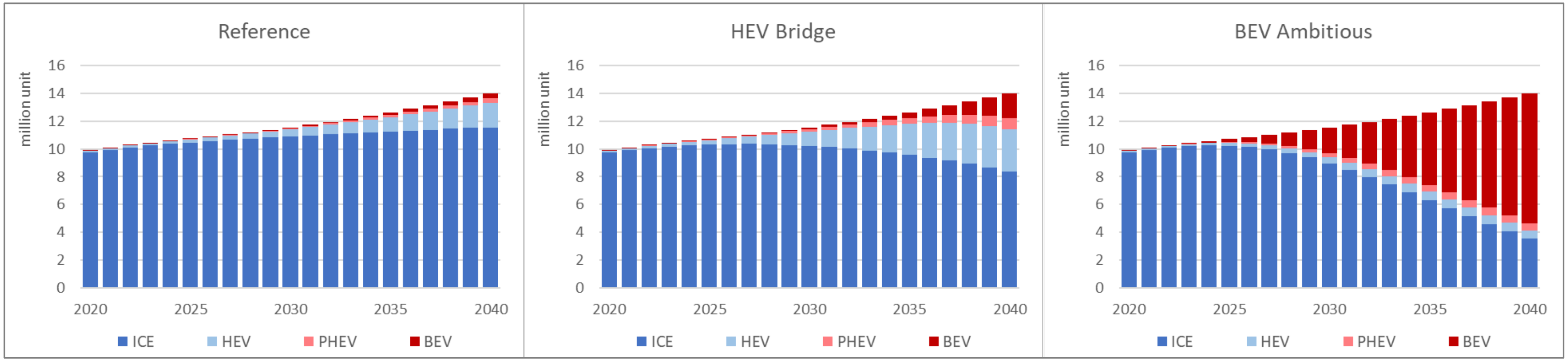
Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: ERIA (2019, 2020b).

Figure 2.14. PLDV Sales and PLDVs on the Road by Powertrain (Thailand)

PLDV Sales



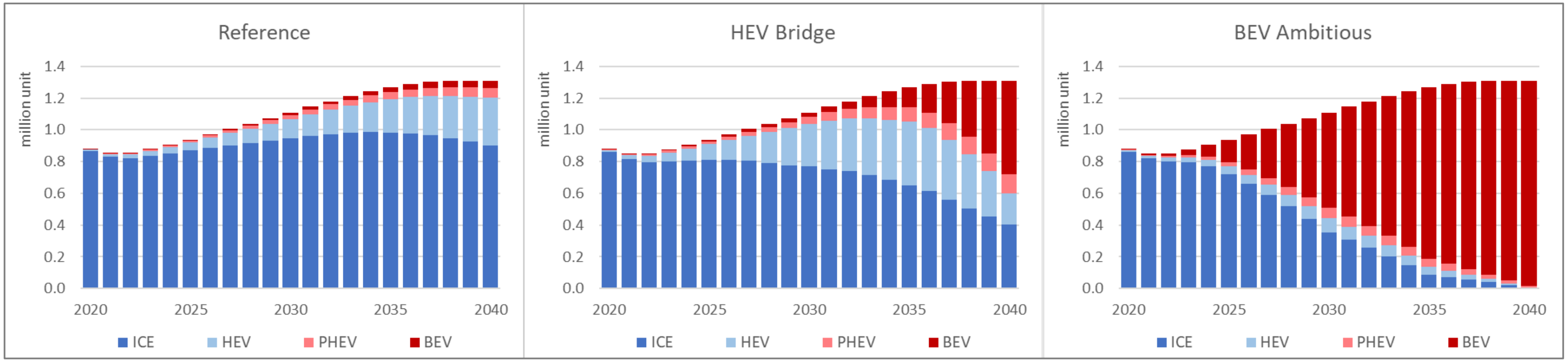
PLDVs on the Road



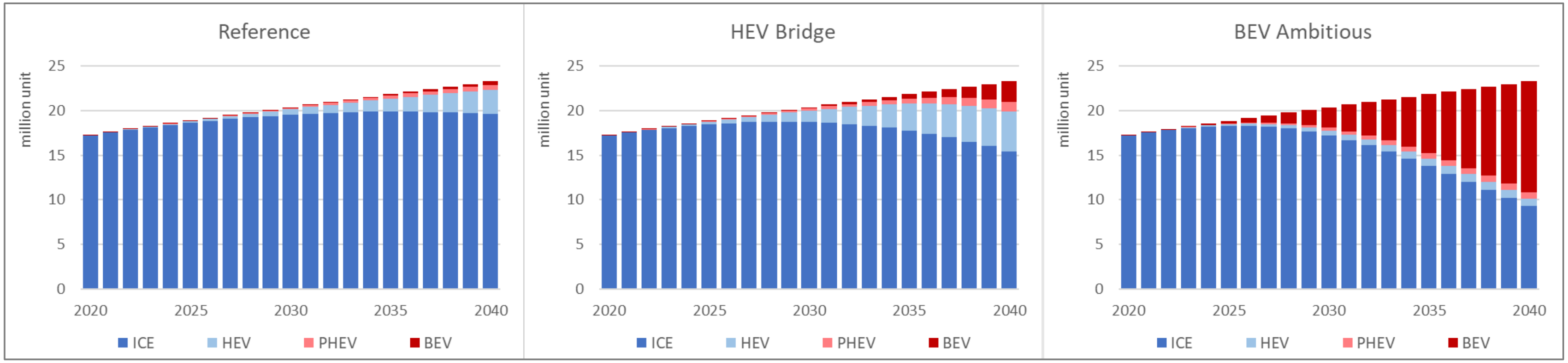
Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: ERIA (2019, 2020b).

Figure 2.15. PLDV Sales and PLDVs on the Road by Powertrain (Malaysia)

PLDV Sales



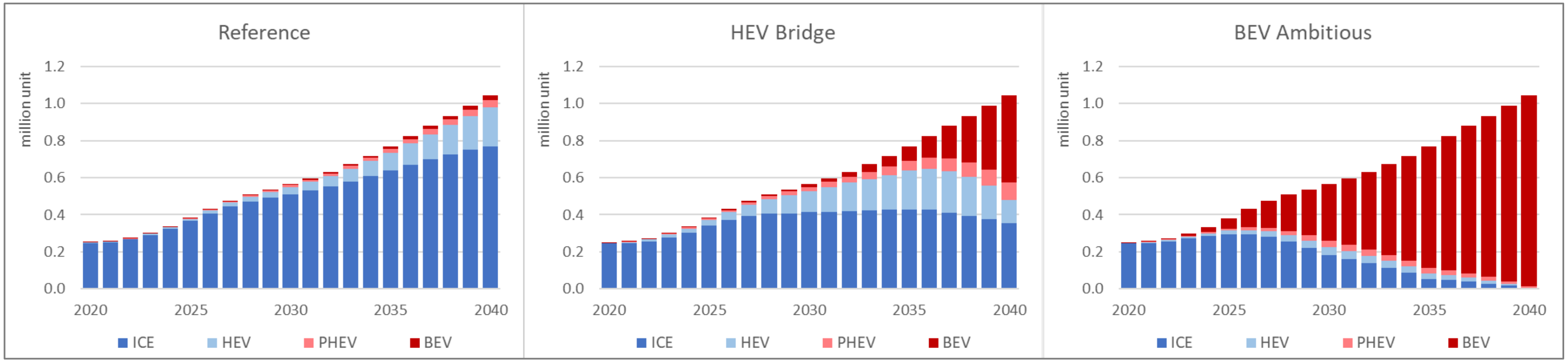
PLDVs on the Road



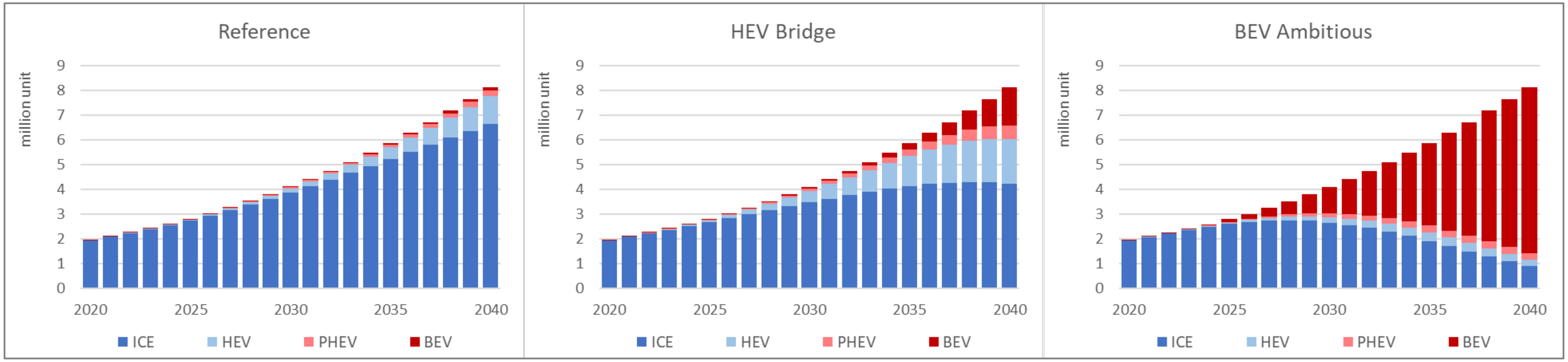
Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: ERIA (2019, 2020b).

Figure 2.16. PLDV Sales and PLDVs on the Road by Powertrain (Viet Nam)

PLDV Sales



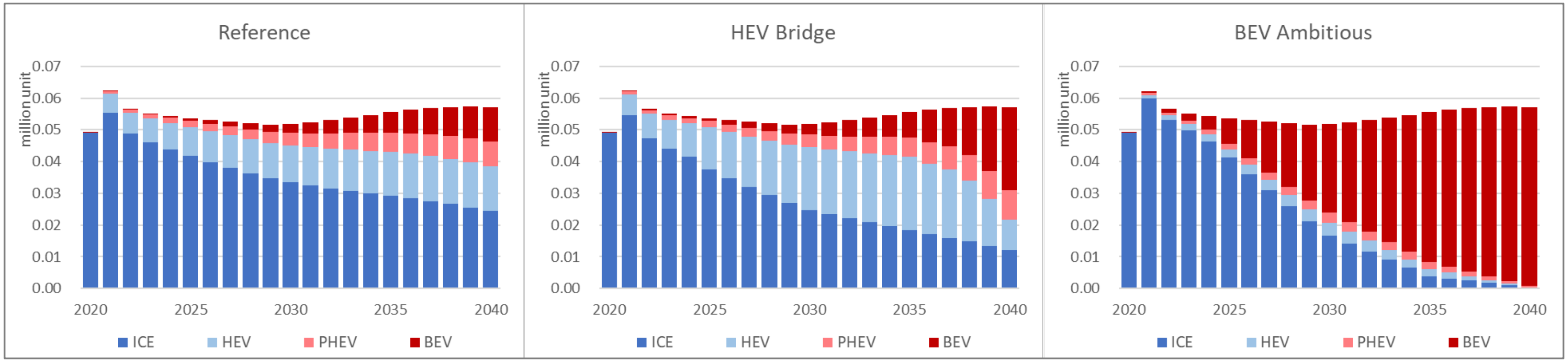
PLDVs on the Road



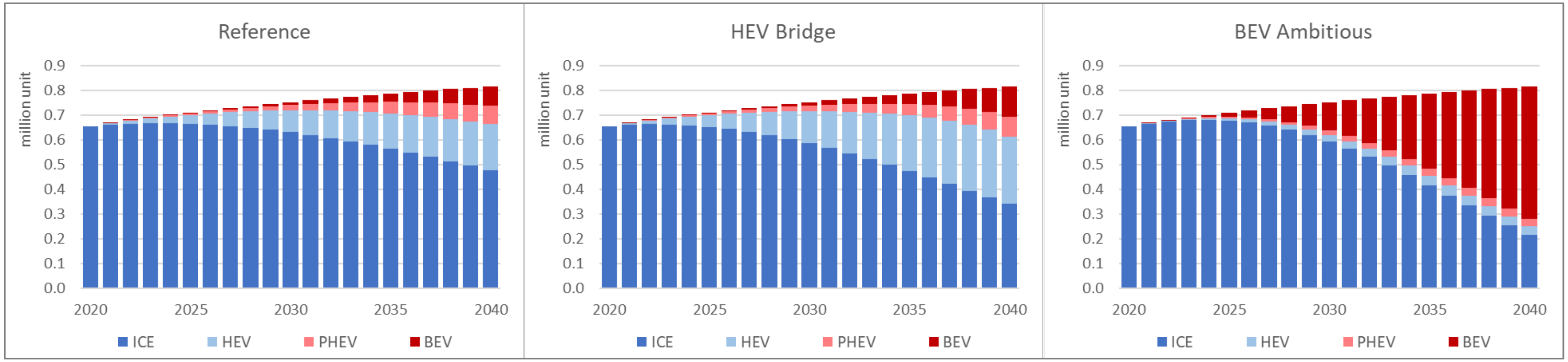
Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: ERIA (2019, 2020b).

Figure 2.17. PLDV Sales and PLDVs on the Road by Powertrain (Singapore)

PLDV Sales



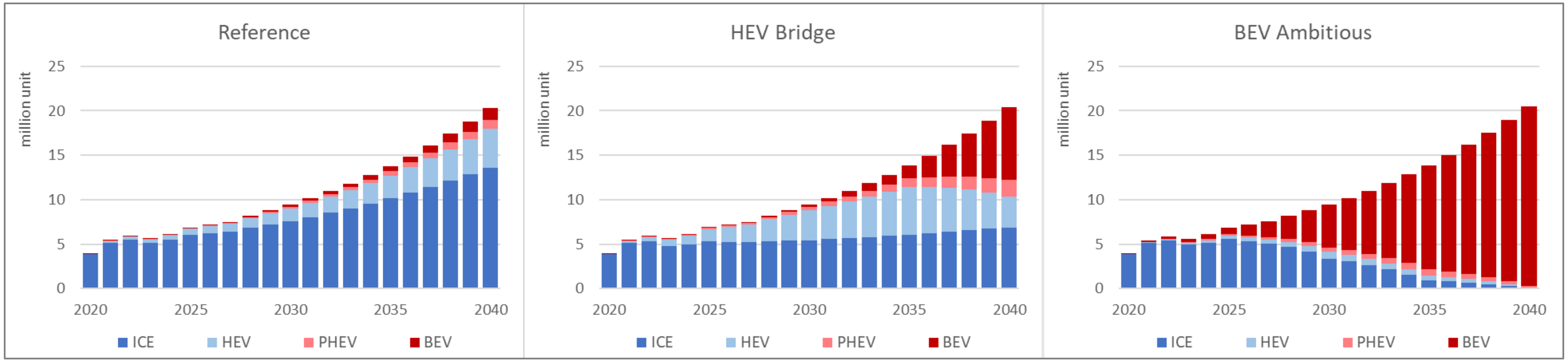
PLDVs on the Road



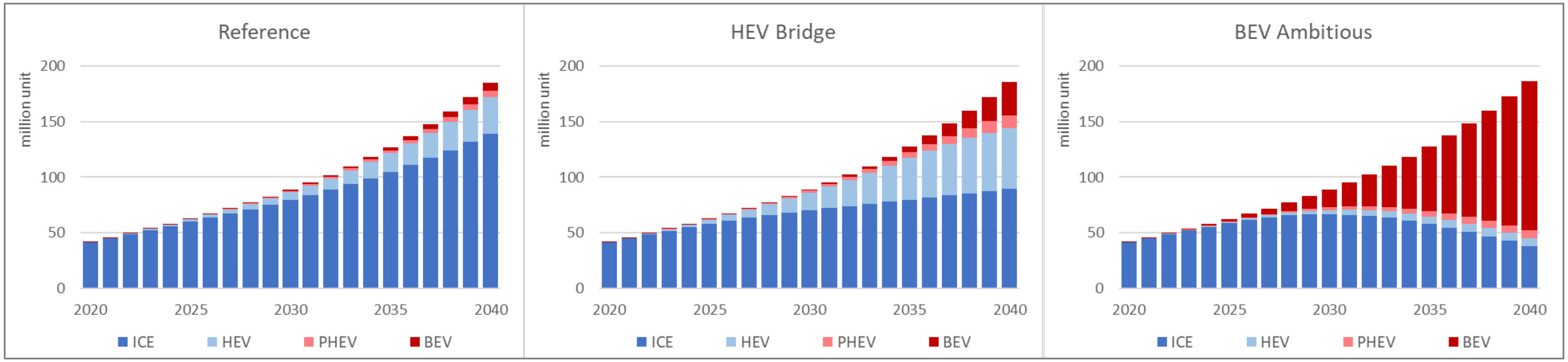
Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: Authors.

Figure 2.18. PLDV Sales and PLDVs on the Road by Powertrain (India)

PLDV Sales



PLDVs on the Road



Note: BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: Authors.

2.4. Total GHG Emissions in the Fuel Cycle (WtW) and Vehicle Cycle (LCA)

2.4.1. Estimation Method

This study estimated the total GHG emissions in the fuel cycle (WtW) and vehicle cycle (LCA) by multiplying the emission intensities (mentioned in sections 2.2 and 2.3) by the number of vehicles (mentioned in section 2.3.1) as shown in Figure 2.19.

Figure 2.19. Calculating Formula

Production =

$$\Sigma\,(\text{Number of Vehicles in Production}_{PT} * \text{LCA Production Intensity}_{PT})$$

Operation (= fuel cycle) =

$$\Sigma\,(\text{Number of Vehicles on Road}_{PT} * \text{Annual Mileage} * \text{WtW Intensity}_{PT})$$

Disposal =

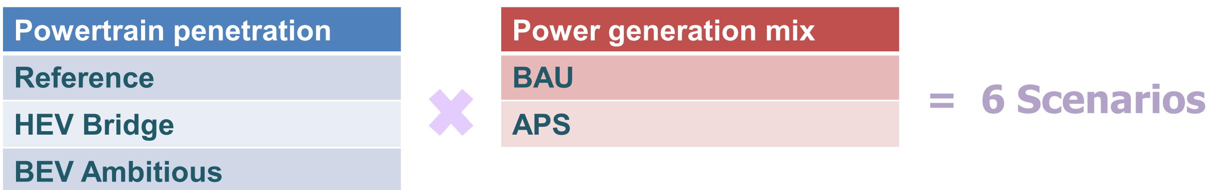
$$\Sigma\,(\text{Number of Vehicles for Disposal}_{PT} * \text{LCA Disposal Intensity}_{PT})$$

LCA = Life Cycle Assessment, PT = powertrain, WtW = well to wheel.
Source: Authors.

Emissions during production are estimated by multiplying the number of vehicles in production by the LCA intensity for each powertrain. However, to simplify the calculations, we assume that the production number is the same as the number of domestic sales. Emissions when driving are estimated by multiplying the number of vehicles on the road, the distance travelled, and the WtW intensity. We assume that the annual mileage is set at 10,000 km per year for all countries. Emissions at disposal are estimated by multiplying the number of vehicles for disposal by the LCA intensity. The number of vehicles for disposal can be calculated by the difference between the number of vehicle sales and the increment in the number of vehicles on the road.

This study calculated the GHG emissions for six scenarios as shown in Figure 2.20. There are three powertrain penetration scenarios and two power generation mix scenarios, so all combinations make six scenarios.

Figure 2.20. Scenarios for Estimation



Source: Authors.

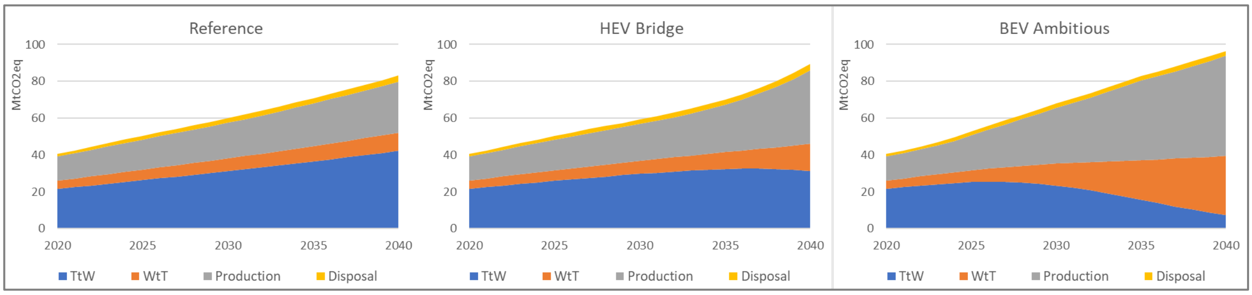
3. Results

3.1. Indonesia

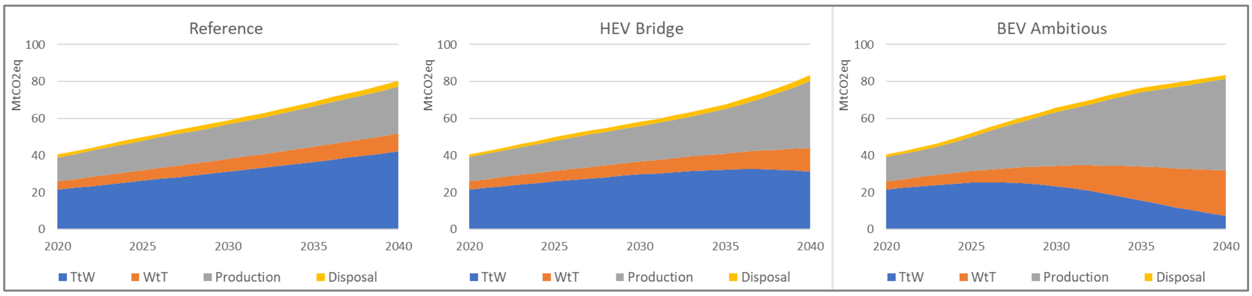
Figure 2.21 shows the estimation results for the fuel and vehicle cycle basis emissions in Indonesia. The country has a large share of coal-fired power in its generation mix. Therefore, in the BAU power mix, the BEV Ambitious scenario emits the most. The well-to-wheel emissions are small, whilst the emissions during production are large. This is because of the rapid spread of BEVs, namely the rapid increase in production. If a clean power mix can be realized, the total emissions for all the scenarios will be almost the same at around 80 Mt in 2040.

Figure 2.21. Total GHG Emissions in the Fuel Cycle and Vehicle Cycle (Indonesia)

BAU Power Mix



APS Power Mix



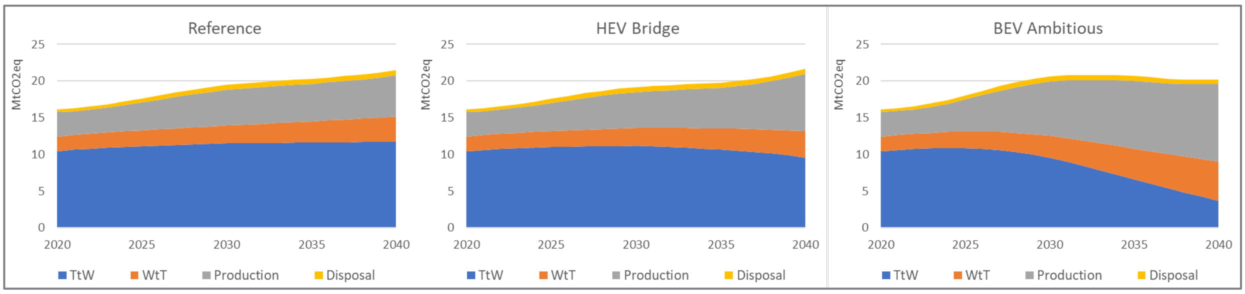
Note: APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, TtW = tank to wheel, WtT = well to tank.
Source: Authors.

3.2. Thailand

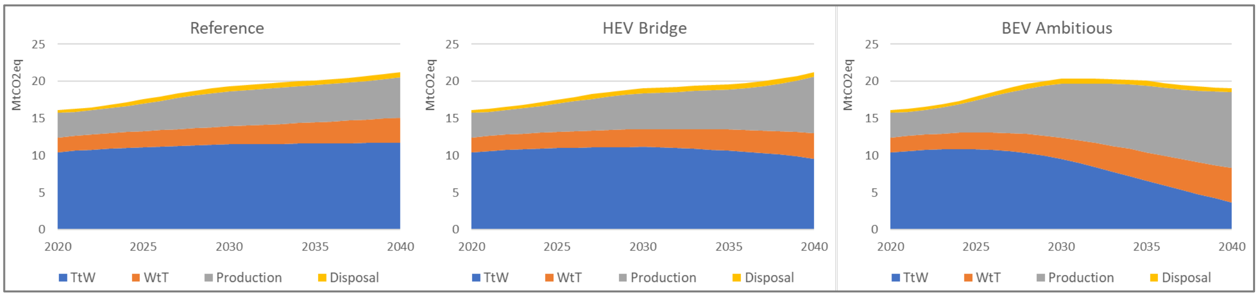
Figure 2.22 shows the estimation results for the fuel and vehicle cycle basis emissions in Thailand. The country has relatively clean power with a high proportion of gas-fired power and imported electricity from the Lao PDR, which has mainly hydro power. Even with the BAU power mix, the BEV Ambitious scenario has the lowest GHG emissions, peaking in the mid-2030s. For the APS power mix, the BEV Ambitious scenario is even more favourable.

Figure 2.22. Total GHG Emissions in the Fuel Cycle and Vehicle Cycle (Thailand)

BAU Power Mix



APS Power Mix



Note: APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, TtW = tank to wheel, WtT = well to tank.
Source: Authors.

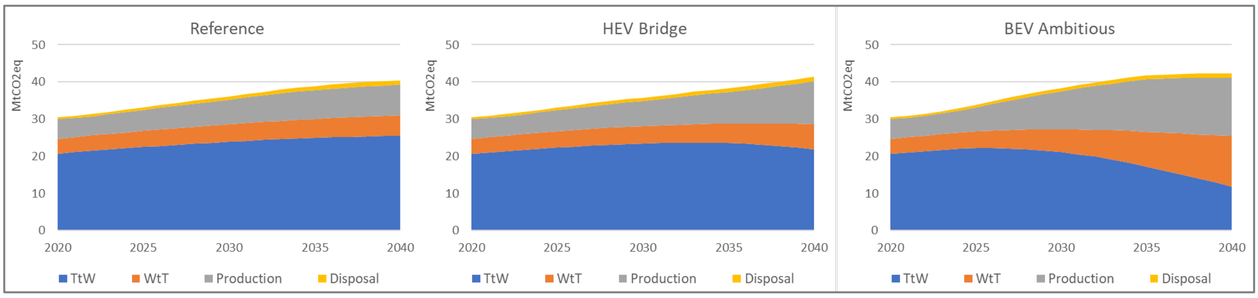
3.3. Malaysia

Figure 2.23 shows the estimation results for the fuel and vehicle cycle basis emissions in Malaysia.

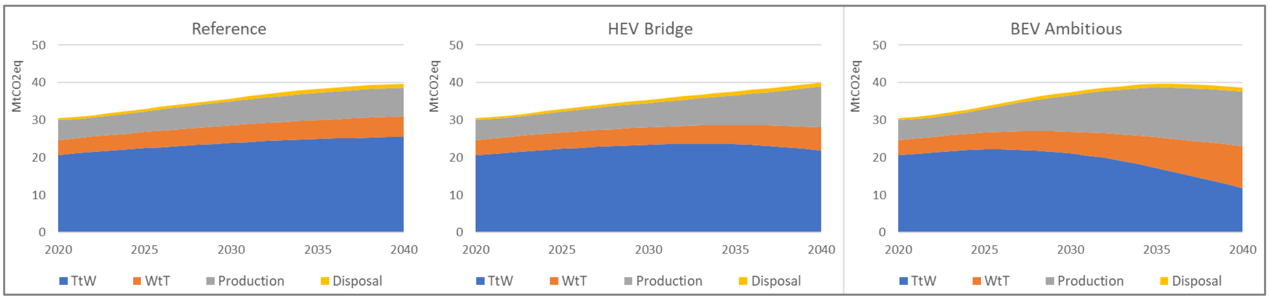
The proportion of coal-fired power is relatively high in the generation mix today. In the BAU power mix, GHG emissions are the largest in the BEV Ambitious scenario, but they will peak in the late-2030s. If the APS power mix can be realised, the peak point will be earlier, and the BEV Ambitious scenario will have the lowest emissions.

Figure 2.23. Total GHG Emissions in the Fuel Cycle and Vehicle Cycle (Malaysia)

BAU Power Mix



APS Power Mix



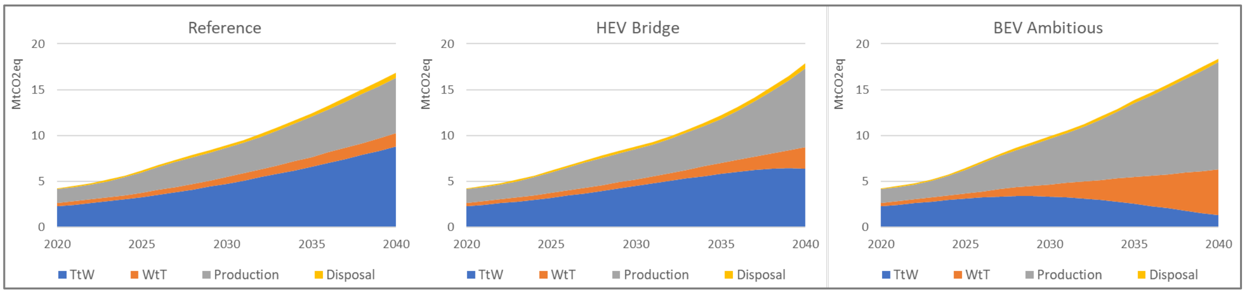
Note: APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, TtW = tank to wheel, WtT = well to tank.
Source: Authors.

3.4. Viet Nam

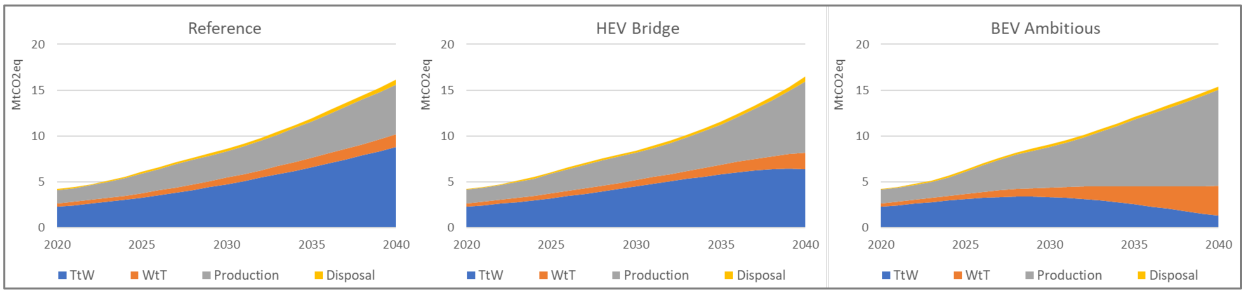
Figure 2.24 shows the estimation results of the fuel and vehicle cycle basis emissions in Viet Nam. The proportion of coal-fired power is relatively high. Therefore, the BEV Ambitious scenario emits the most in the BAU power mix. The well-to-wheel emissions are small, whilst the emissions during production are large. This is because of the rapid spread of BEVs, namely the rapid increase in production. If the APS power mix can be realised, the BEV Ambitious scenario will have the lowest GHG emissions.

Figure 2.24. Total GHG Emissions in the Fuel Cycle and Vehicle Cycle (Viet Nam)

BAU Power Mix



APS Power Mix



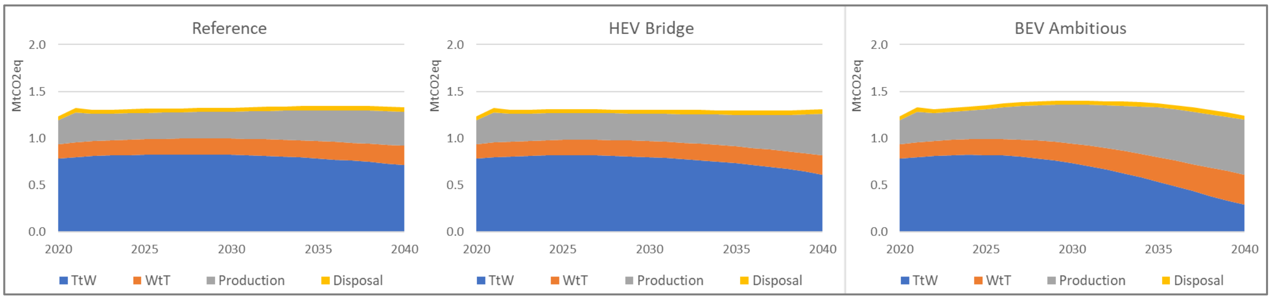
Note: APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, TtW = tank to wheel, WtT = well to tank.
Source: Authors.

3.5. Singapore

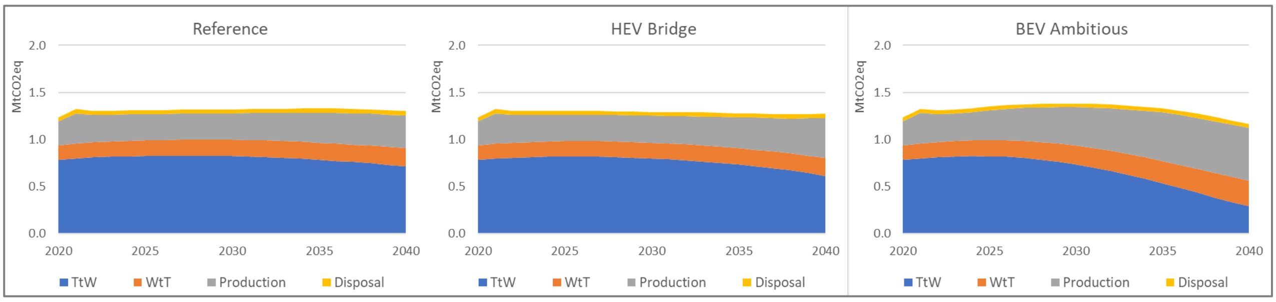
Figure 2.25 shows the estimation results for the fuel and vehicle cycle basis emissions in Singapore. The country has relatively clean power with a high proportion of gas-fired power. Even with the BAU power mix, the BEV Ambitious scenario has the lowest GHG emissions, peaking at around 2030. For the APS power mix, the BEV Ambitious scenario is even more favourable.

Figure 2.25. Total GHG Emissions in the Fuel Cycle and Vehicle Cycle (Singapore)

BAU Power Mix



APS Power Mix



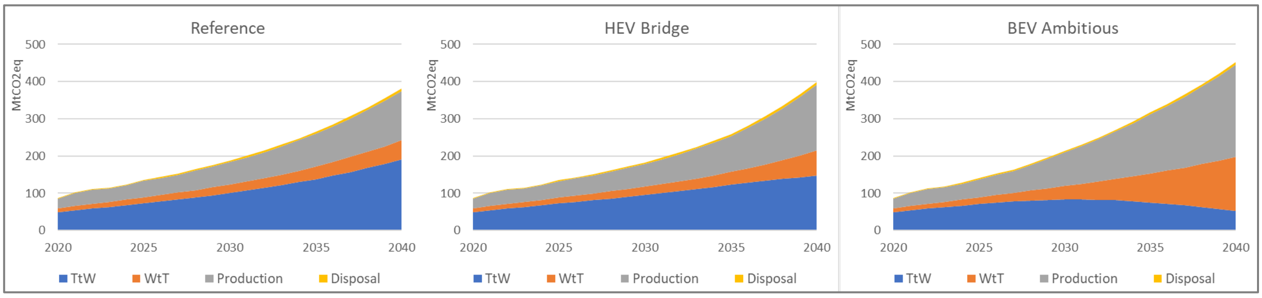
Note: APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, TtW = tank to wheel, WtT = well to tank.
Source: Authors.

3.6. India

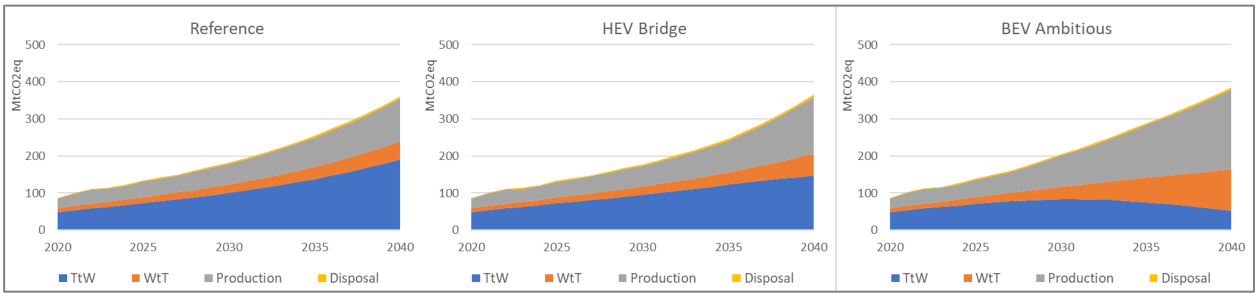
Figure 2.26 shows the estimation results for the fuel and vehicle cycle basis emissions in India. The country has a large share of coal-fired power in its generation mix. Therefore, the BEV Ambitious scenario emits the most in the BAU power mix. Emissions during production are quite large. This is because of the rapid spread of BEVs, namely the rapid increase in production. If the clean power mix can be realised, the total emissions in the BEV Ambitious scenario will be reduced to approximately the same level as the other two scenarios, at around 350 Mt in 2040.

Figure 2.26. Total GHG Emissions in the Fuel Cycle and Vehicle Cycle (India)

BAU Power Mix



APS Power Mix



Note: APS = Advanced Policy Scenario, BAU = Business as Usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, TtW = tank to wheel, WtT = well to tank.
Source: Authors.

7. Conclusion

GHG emission sources related to automobiles are diverse. We should consider not only emissions when driving automobiles but also emissions during the production and disposal of vehicles, including the mining of raw materials and manufacturing of parts. Furthermore, the amount of these emissions varies greatly depending on the powertrain type, and the overall amount of emissions will change depending on the type of powertrain that penetrates in the future.

This study conducted a comprehensive scenario analysis for vehicle electrification from the views of the fuel cycle (WtW) and vehicle cycle (LCA), and found:

- The emissions related to BEVs are small on the WtW basis but large in the production process.
- Countries with fast-growing car penetration have a higher proportion of emissions from the production process.
- The decarbonisation of the power generation mix affects the emissions in both the fuel cycle and vehicle cycle.

This study is a trial analysis based on certain assumptions. Some assumptions, especially for vehicle cycle energy intensities, are probably far from the real situation (this report utilizes the vehicle cycle energy intensities that are included in the Argonne National Laboratory's GREET Model, which applies US domestic passenger vehicle production volume, sales, and respective energy consumption in the value chain of manufacturing processes). However, such a comprehensive view is important. It is necessary that a more precise analysis will be conducted considering the real situation of each country.

References

Economic Research Institute for ASEAN and East Asia (ERIA) (2019), *Study on Electric Vehicle Penetrations' Influence on 3Es in ASEAN*. Jakarta: ERIA. https://www.eria.org/publications/study-on-electric-vehicle-penetrations-influence-on-3es-in-asean/

Economic Research Institute for ASEAN and East Asia (ERIA) (2020a), *Evaluation of CO2 Emissions Reduction by Mobility Electrification and Alternative Biofuel Introduction in East Asia Summit Countries.* Jakarta: ERIA. https://www.eria.org/publications/evaluation-of-co2-emissions-reduction-by-mobility-electrification-and-alternative-biofuel-introduction-in-east-asia-summit-countries/

Economic Research Institute for ASEAN and East Asia (ERIA) (2020b), *The Influence on Energy and the Economy of Electrified Vehicle Penetration in ASEAN*. Jakarta: ERIA. https://www.eria.org/publications/the-influence-on-energy-and-the-economy-of-electrified-vehicle-penetration-in-asean/

Economic Research Institute for ASEAN and East Asia (ERIA) (2021), *Energy Outlook and Energy Saving Potential 2020*. Jakarta: ERIA. https://www.eria.org/publications/energy-outlook-and-energy-saving-potential-in-east-asia-2020/

Economic Research Institute for ASEAN and East Asia (2022), *Policies and Infrastructure Development for the Wider Penetration of Electric Vehicles (EVs) in ASEAN Countries*. Jakarta: ERIA. https://www.eria.org/publications/study-on-policies-and-infrastructure-development-for-the-wider-penetration-of-electrified-vehicles-in-asean-countries/

Institute of Energy Economic, Japan (2021), *IEEJ Outlook 2022*. https://eneken.ieej.or.jp/en/whatsnew/439.html. Paris: IEA.

International Energy Agency (2021), *World Energy Statistics and Balances.* Paris: IEA.

Masnadi et al. (2018), 'Global Carbon Intensity of Crude Oil Production', *Science*, 361(6405).

https://www.science.org/doi/10.1126/science.aar6859

Chapter 3
EV Charging Systems

1. Introduction

As there are more affordable EV choices on the market, consumers' primary concern will become charging opportunities. McKinsey's 2020 ACES Consumer Survey[72] explains that a lack of charging infrastructure is the top reason to hesitate for EV adoption. Governments should acknowledge the barrier and need planned policy to support developing charging infrastructure. This sub-chapter reports insights and lessons from early EV market experiences.

There are three charging types:[73]

(1) Public charging en route

(2) Public charging at the destination

(3) Home/workplace charging

The first two types are typically called DC fast charging. DC fast charging converts AC electricity to DC, delivering power to EVs at higher rates. DC fast charging usually takes from 30 minutes to less than 60 minutes for a 120–160 km range.[74]

Some public charging at destinations and the majority of home/workplace charging is called Level 2 AC charging. Level 2 AC charging is typically mounted on a wall, a pedestal, or an electric pole using 220–240-volt AC power. Public Level 2 AC chargers usually require 2–3 hours for the 30–50 km range. Home/workplace AC chargers can charge for a 120–150 km range in 8 hours.

---

[72] McKinsey (2020), 'Can Established Auto Manufacturers Meet Customer Expectations for ACES?' 5 February. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/aces-2019-survey-can-established-auto-manufacturers-meet-customer-expectations-for-aces#/

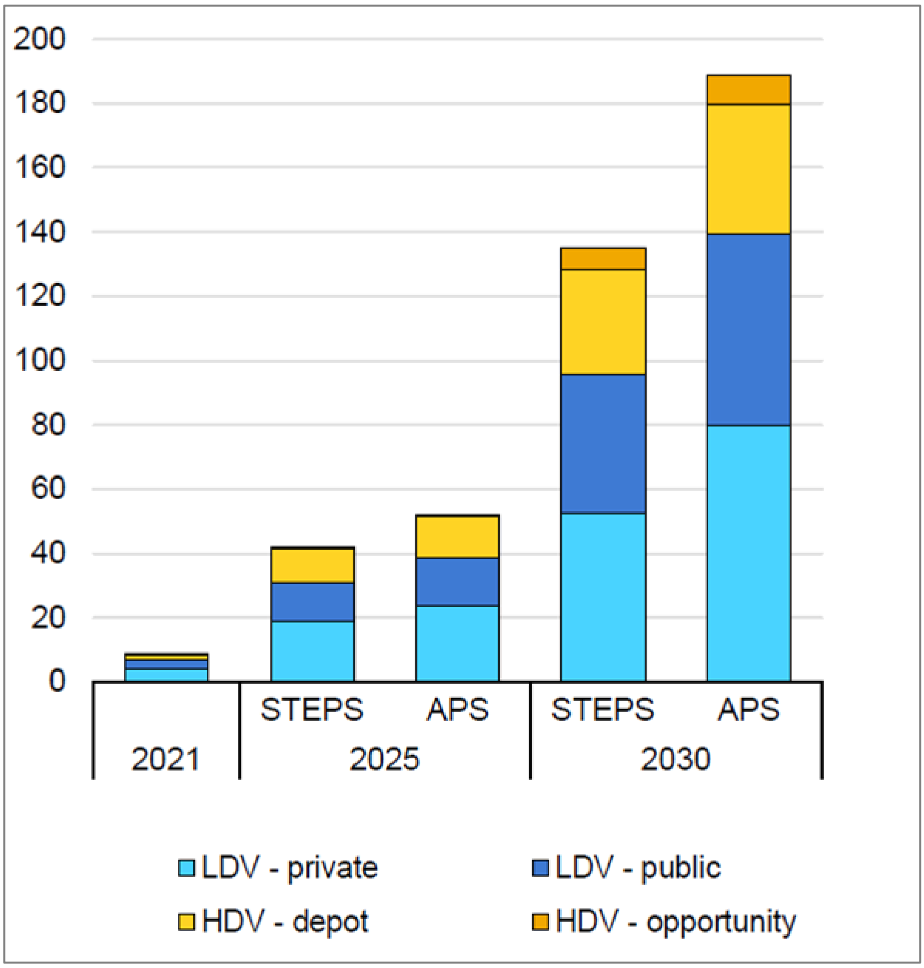
[73] Ministry of Economy, Trade and Industry, Automobile Division, 24th Task Force for Comprehensive Review of Regulations, etc. Concerning Renewable Energy, etc. Meeting Materials (2022), *Efforts to Promote Charging Infrastructure.* https://www8.cao.go.jp/kisei-kaikaku/kisei/conference/energy/20221111/221111energy13.pdf

[74] Edison Foundation (2018), *Electric Vehicle Sales Forecast and the Charging Infrastructure Required through 2030*. https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_EEI-EV-Forecast-Report_Nov2018.ashx

2. Level 2 AC Charging: Government Support

Many EV reports, including the well-known International Energy Agency (IEA) Global *Electric Vehicles Outlook 2022*, indicate that home/workplace charging has a significant role in the early EV market (Figure 3.1).

Figure 3.1. Charging Market Size by Type of Charger (US$ billion)



STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; LDV = light-duty vehicle (includes passenger LDVs and LCVs); HDV = heavy-duty vehicle (includes buses, medium-duty trucks and heavy-duty trucks).
Source: IEA (2022), *Global EV Outlook 2022*. https://www.iea.org/reports/global-ev-outlook-2022

Mounting a Level 2 AC charger at a detached single-family home or a detached office building has fewer barriers. There are many choices of Level 2 AC chargers in the market, and the installation is easy.

EV adoption usually takes place in cities. China, the top EV market, and many early EV market countries are experiencing challenges in mounting Level 2 AC chargers at muti-dwelling apartments and multi-storey office buildings in cities. Those apartments and buildings have dedicated parking spaces or floors, and allocating EV charging spaces and power supply can be challenging. Unless there are enough dedicated EV charging spaces, residents and workers feel reluctant to adopt EV use. Adding EV charging spaces and power supply capacity is not easy, so it is crucial to design adequate charging plans at the home/building design stage. Policies must support planning for charging design by addressing requirements in the building codes.

Increasingly, European countries and many cities in North America are adopting charging space and power capacities in their building codes as shown in Table 3.1.[75]

Table 3.1. Charging Spaces Requirements in Building Codes in Europe and North America

Europe	Residential	Non-residential
United Kingdom (June 2022–)[76]	Homes with parking must have their own charging point. For residential buildings with parking in a covered car park, each dwelling's parking space must have a charging point.	For more than 10 parking spaces, must have a minimum of 1 charging point and cable routes for at least 20% of the remaining spaces.
European Union (Revised Energy Performance of Buildings Directive)[77]	All new and thoroughly renovated residential buildings with more than 10 parking spaces must have pre-wiring for charging in each parking space.	For commercial buildings, 20% of spaces have to be pre-wired. States need to have regulations to require minimum charging points for all non-residential buildings with more than 20 parking spaces by 1 January 2025.
North America	**Residential**	**Non-residential**
Washington, DC	Multi-dwelling: 20% EV-ready (3+ spaces)	20% EV-ready (3+ spaces)
Denver, CO	Single: 1 EV-ready space per unit	5% EV-installed, 10% EV-ready, 10% EV-capable

[75] Pacific Northwest National Laboratory, Department of Energy (2021). https://www.energycodes.gov/sites/default/files/2021-07/TechBrief_EV_Charging_July2021.pdf

[76] Department for Levelling Up, Housing and Communities (2021), Building Regulation in England for the Installation of Electric Vehicle Charge Points or Cable Routes. https://assets.publishing.service.gov.uk/media/6218c5d38fa8f54911e22263/AD_S.pdf

[77] European Commission (2023), Report from the Commission to the European Parliament and the Council Promotion of E-Mobility through Buildings Policy. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023DC0076&pk_campaign=preparatory&pk_source=EURLEX&pk_medium=TW&pk_keyword=EUGreendeal&pk_content=Report&pk_cid=EURLEX_news

	Multi: 5% EV-installed, 15% EV-ready, 80% EV-capable	
Seattle, WA	Single: 1 EV-ready space per unit Multi: EV-ready 100% (<7 spaces), 20% (7+ spaces)	10% EV-ready
San Jose, CA	Single: 1 EV-ready space per unit Multi: 10% EV-installed, 20% EV-ready, 70% EV-capable	10% EV-installed, 40% EV-capable
Vancouver, BC	Single: 1 EV-ready space per unit Multi: 100% EV-ready	10% EV-ready

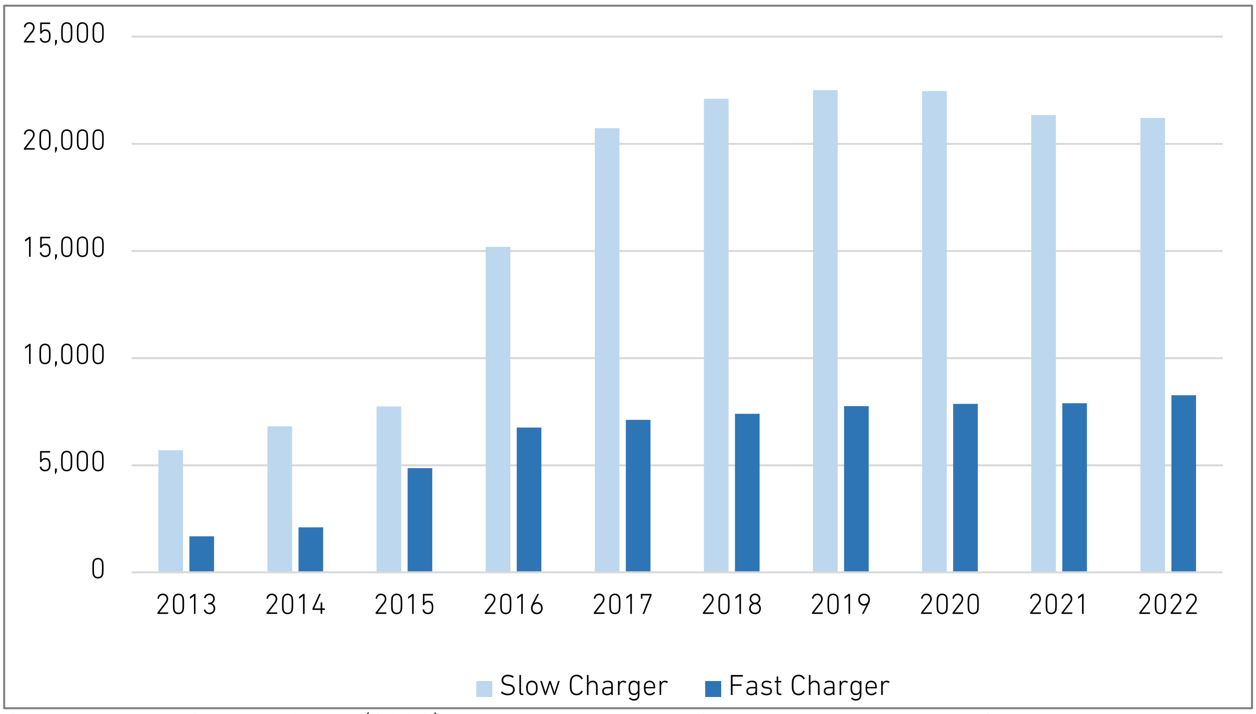
Source: International Code Council. (https://codes.iccsafe.org/content/ICCEVBCSGGR2021P1/current-approaches-to-ev-integrated-codes).

3. Public Charging: Government Support

Level 2 AC charger deployment is vital in the early stage of the EV market, but governments should have a careful plan for public charging infrastructure. More residents in apartments and workers in city buildings will consider adopting EVs, and public charging access will become their first concern.

Japan is one of the earliest EV deployment countries, and the government and the industry experienced challenges with public chargers. Public chargers en route are the most focused area of investment and government support. Many fast chargers are installed at highway service areas, road rest areas, and car dealers.

Figure 3.2. Number of Public Chargers in Japan



Source: Japan Cabinet Office (2022), *The Development of Charging Infrastructure Status*, 11 November. https://www8.cao.go.jp/kisei-kaikaku/kisei/conference/energy/20221111/221111energy13.pdf

En route chargers increased in the 2010s with significant government subsidies and engineering code amendments. Still, Figure 3. 2 shows that the number of public chargers in Japan has not increased, and even decreased, in recent years.

While early charging facilities are approaching the point of replacement and need to be replaced, an increasing number of stations are abandoning these charging facilities for profitability reasons. Standalone EV charging is not profitable or sustainable, and this lack of profitability has been expected:

- Fewer EVs are visiting the stations.
- An EV charging station can only expect a few customers compared with a petrol station because charging customers stay longer than those who need gas refuelling.
- The revenue of an EV charging station is less than a gas station because the electric price is less than the petrol price.

We can learn a different lesson on public charging at the destination from the experience of the United States.

Tesla, the leader of the EV market in the United States and Europe, started the EV business including the fast charger network development. Tesla typically targets prestige shopping malls, restaurants, and resorts for EV users. People spend hours at these destinations, and charging spaces are usually priority spots with easier access to a building. Because Tesla started targeting high-income customers, the strategy was very successful. Retailers welcome Tesla Superchargers because they can expect high-income customers. There are service providers with a similar approach, proposing fast chargers at malls and restaurants to attract relatively rich customers who can afford to choose expensive EV models and are expected to spend extra cash whilst they charge.

Such a business model may not be applicable when we see more affordable EV models and EV adoption expands to middle-income classes.

Governments need to support public chargers for this class. When more affordable EV models become available, middle-income classes will adopt EVs. Many middle-income classes live in affordable homes and apartments in cities, and there will be fewer charging capacities in such affordable apartments. Fast chargers at shopping malls and restaurants are not daily visiting destinations for those middle-income classes. They usually visit less costly places, such as public parks, public libraries, and public parking for other destinations. Municipal governments should understand the need for public charging for middle-income classes.

3.1. Japan's Experience

Asian countries can learn from the Japanese experience of charging infrastructure development in an early EV market. As seen in Figure 3.2, the number of public charging stations are not increasing in the recent Japanese market. Nissan and Mitsubishi Motors have been trying to propose a different EV use style with a very compact EV, Kei car standard model in 2022.

As a pioneer of EVs with its Leaf model, Nissan has many fast chargers at thousands of Nissan dealers. Leaf users can visit any Nissan dealer to use a fast charger. This model is good for Leaf users but does not help dealers' businesses.

With Sakura, Nissan proposes a home-charging use style because Sakura users typically do not drive many miles in a day, and the car has a smaller battery with a limited range; home/workplace charging matches the practical daily Sakura use.

4. Commercial Fleet Charging

As the IEA's 2023 EV outlook pointed out, more models are available, and the market is starting to pick up pace.

Many experts suggest commercial fleets are ideal for EVs in an early EV market.[78]

- Commercial fleets usually have scheduled routes, or a limited drive range from depots. Operators can plan the routes and EV use in daily planning so that drivers have less range anxiety.

[78] McKinsey (2020), 'Charging Electric-vehicle Fleets: How to Seize the Emerging Opportunity', 10 March. https://www.mckinsey.com/capabilities/sustainability/our-insights/charging-electric-vehicle-fleets-how-to-seize-the-emerging-opportunity

- They can charge vehicles during non-business hours at the depot.
- Commercial fleets drive much more than private cars, and the cheaper fuel cost and the lower maintenance cost allow financial advantages with the EV fleet. McKinsey's 2020 report suggests that fleet EVs can have a total cost of ownership of 15%–25% less than ICE vehicles by 2030.

Many commercial fleets operators are adopting fleet electrification:

- Post office/delivery business fleets

  In 2022, Japan Post announced that they intend to switch all fleets to electrification, covering over 110,000 vehicles. By 2025, they plan to deploy 13,000 small EV trucks and 28,000 EV bikes.

- Public buses/school buses

  Many public transit authorities and cities are moving towards bus electrification. In the United States, Denver plans 100% public transit by 2050, Los Angeles plans 100% electric public transit by 2030, and Washington, DC plans 100% electric buses by 2042.

  Utilities and energy suppliers are also addressing public school bus electrification. School buses are usually operated in the morning and afternoon only, and energy suppliers plan to use school bus EV batteries as distributed power resources during the day and school vacation periods.

  Colorado's Boulder City and California's Sacramento City are early adopters of school bus electrification, and Dominion Energy is offering the Electric School Bus Initiative in their service territory.

- Rental cars/car sharing/ride hailing

  Cities can also support other forms of ride service business electrification. Major rental car companies Hertz and Avis are converting their fleets through electrification. Ride-hailing company Uber offers rebate initiatives to EV drivers in selected cities. Rental car and car sharing services usually have depots at their major pick-up depots, which are ideal for public charging opportunities.

Some companies are also now operating what they call 'Charging-as-a-service' businesses. The service is not limited to charging but includes everything related to EV charging, investment in charger and battery storage, operation scheduling, and vehicle maintenance. The service providers charge a monthly fee to collect everything and for investment, operation, electricity, and maintenance. The business fleet operators, like public bus authorities, schools, and rental companies, do not need to invest in the chargers or even vehicles.

5. Two-/three-wheel EV Bike Charging

In Asia's market, two- and three-wheelers are the most electrified market segment today, and Asia is leading the world's two- and three-wheeler electric market development. With the recent high oil prices, electric bikes have become economically competitive in their life cycle cost. Two-/three-wheel electric bike models are more affordable compared with the price difference in the light-duty vehicle model. The electric bike market will grow faster than the light-duty EV market in developing countries.

One of the unique programmes for electric two-/three-wheelers is the development of 'battery swapping' and the associated 'battery-as-a-service'.

Battery swapping is a measure to mitigate long charging times by switching drained batteries with fully charged batteries at swapping stations. Compared with a fixed-mounted battery model, the battery-swapping bike cost is significantly cheaper without a battery and cost competitive enough with a conventional engine model. Battery-swapping EV bike users use battery-swapping services and pay monthly swap fees, usually equivalent to or less than the petrol refuelling cost.

There are many battery-swapping service providers in the Asian market, and Gogoro, a start-up company from Chinese Taipei, is the leading company. Gogoro is dominant not only in the Chinese Taipei market but has expanded its services to other Asia countries, including India. Gogoro now has more than 12,000 swapping stations across nine countries.[79]

The battery-as-a-service business started with start-ups, and the market is growing fast. We see new clean energy players in the market. China's battery giant CATL's subsidiary, Contemporary Amperex Energy Service Technology, Ltd., offers a swapping and battery management solution, EVOGO. Japanese energy supplier Eneos has started a battery swapping management service, Gachaco, with Japanese bike manufacturers at Eneos gas stations.

For battery-as-a-service providers, the business has a few major challenges. Service providers need more than one battery per bike, demanding more initial investment and charging equipment. The other major challenge is the need for battery standards. There are roughly 10 different battery standards with different bike manufacturers and battery manufacturers. Swapping battery standardisation has been discussed since 2021; major bike manufacturers from Japan and Italy announced a consortium agreement in Spring 2021, but we have not seen much progress. Eneos' Gachaco currently offers service to only one battery standard from Honda. Regarding EV battery standardisation, incumbent car manufacturers struggle to secure their position when battery manufacturers dominate the battery supply chain, including the battery's precious minerals and metals. The EV battery

[79] Japan Times (2023), 'One-minute Battery Swaps Are Spurring EV Adoption in Asia', 10 April. https://www.japantimes.co.jp/news/2023/04/10/business/tech/ev-battery-swap-asia-adoption/

design, management, and procurement are all essential in EV model development, and car manufacturers need more control in the present market.

Battery-as-a-service business players are also interested in battery management/degradation assessment/recycling in life cycle management. They are interested in improvement of the charging business by offering stationary battery use and minimising the electricity capacity charge. Battery manufacturers and energy service providers are also planning the aggregated use of EV batteries for grid balancing.

5.1. Battery Swapping in a Four-wheel Commercial Fleet Application

Battery swapping fleets and services are predominantly found in the two-/three-wheel sector, but application to the four-wheel sector is not a new idea. Tesla demonstrated battery swapping as an alternative to the Supercharger service in 2013, allowing the Model S to swap battery in 90 seconds rather than waiting half an hour with a Tesla Supercharger.

With the battery-swapping robot, the technology was considered a breakthrough for battery swapping, but Tesla abandoned the swapping idea in 2015 due to a lack of customer interest. China's premium EV manufacturer, NIO, offers a battery-swapping model with a battery-leasing service. NIO purchased a bankrupt battery lease company for this service, and they offer a battery-less choice in a selected model. Customers with a battery-less model can visit NIO's dedicated service shops, where NIO offers premium services in dining, shopping, and entertainment whilst customers wait for a battery swap.[80]

Battery swapping for four-wheelers will best fit commercial EV fleets, an evolution model of charging-as-a-service, with battery standardisation the primary key factor.

6. Long-haul Heavy-duty Vehicle Charging

In the heavy-duty segment of long-haul trucks, improvements are being made for practical use as battery costs continue to decline. The total cost of ownership of EV heavy-duty vehicles (HDVs) is cheaper than that for conventional diesel trucks, but the economics of heavy-duty long-haul truck electrification can be a big cost challenge for fast charging within a driver's off-duty time. If a driver's daily range is 300–400 km, EV HDV charging is similar to LDV commercial fleets; night/off-time destination or depot charging will work. Many countries' regulations require a mandated rest when a truck drives more than 400 km. The European Union requires a 45-minute break after every 4.5 hours of driving, and the United States mandates 30 minutes after 8 hours of driving. Drivers refuel diesel during this break time, and EV HDVs should be charged during this break time.

---

[80] Sino-German Cooperation on Low Carbon Transport (CLCT) (2022), *Overview on Battery Swapping and Battery-as-a-Service (BaaS) in China*, 1 August. https://changing-transport.org/publications/overview-on-battery-swapping-and-battery-as-a-service-baas-in-china/

Such fast charging for a big battery capacity requires a power range of 250–350 kW.

Many highway rest areas are located in suburban areas en route, with fewer power transmission lines. Fast chargers in suburban rest areas will require an additional high voltage transmission line, and the investment cost is significantly bigger than a depot charging spot in cities.

Such high costs will become a significant barrier for private truck operators, and for public support, more than one municipal government must be involved.

Central governments should lead discussions to prepare long-haul EV truck charging infrastructure. Such discussions should involve many stakeholders, truck operators, delivery companies, highway managers, rest area managers, municipals, and power transmission operators.

Governments also need careful consideration before starting long-haul charging infrastructure initiatives, with comparison of the alternatives. Railway and waterway transport are usually less CO_2-intense, and they can also serve as a passenger transportation.

Chapter 4
Policy Implications

The deployment of electric vehicles (EVs) is considered an important option to move away from oil dependence, improve local air quality, and mitigate climate change. Some countries, such as Indonesia and Thailand, consider EVs an important option for developing manufacturing. Incentives are provided to both owners and investors for manufacturing companies, of which examples include Indonesia's differentiated luxury tax rate, Malaysia's excise tax exemption, and Thailand's tax exemption for battery electric vehicles (BEVs). India's FAME scheme has been spurring the growth of two-wheelers, and three-wheelers. How to secure funding will be an important point for the continuation of the provision of incentives for BEVs. In this regard, New Zealand offers an interesting case of a rebate system introduced for BEVs, where the funding is sourced from those owners who purchase inefficient vehicles and have to pay a higher fee.

The analysis of the BEV fuel cycle (WtW) and vehicle cycle (LCA) offers these important implications:

- The emissions related to BEVs are small on the WtW basis but large in the production process.
- Countries with fast-growing car penetration have a higher proportion of emissions from the production process.
- The decarbonisation of the power generation mix affects the emissions in both the fuel cycle and vehicle cycle.

Policy has an important role to play in the layout of a holistic approach in which both the demand side and supply side of the roadmap is established towards achieving the carbon neutrality of the transport sector, and important emphasis needs to be placed on the necessary energy requirements for battery production.

The development of charging infrastructure requires careful planning as well. As it is increasing in European countries and many cities in the United States, integration with building code and charging system development are important options for four-wheelers. For two-/three-wheelers, the development of 'battery-swapping' and the associated 'battery-as-a-service' can be an important business option for meeting the growing demand. Meanwhile, the 'battery-as-a-service' business requires high initial investment for batteries for swapping purposes, and financing will be a challenge. Perhaps there should be ways where those battery-as-a-service providers can enjoy similar tax breaks as those for installing charging systems to help develop this type of business in the early stages.