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Study on Policies and Infrastructure Development for the Wider Penetration of Electrified Vehicles in ASEAN Countries

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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.

The findings, interpretations, conclusions, and views expressed in their respective chapters are entirely those of the author/s and do not reflect the views and policies of the Economic Research Institute for ASEAN and East Asia, its Governing Board, Academic Advisory Council, or the institutions and governments they represent. Any error in content or citation in the respective chapters is the sole responsibility of the author/s.

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Foreword

In East Asia Summit (EAS) countries, progress has been made in recent years towards electrifying the transport sector. Electric vehicles (EVs) are considered as the important technological options for those EAS countries towards air quality improvement in the urban area, 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 would have to prepare necessary policies, programmes and plans, economic incentives, focused areas of services, and accelerate the decarbonisation of the power sector.

This report has provided the well-to-wheel CO_2 emissions from the electrification of the transport sector, and identified the strengths, weaknesses, opportunities, and threats for the selected Association of Southeast Asian Nations (ASEAN) countries' electrification of the transport sector. The report also analysed passenger vehicles' total cost of ownership for internal combustion engine vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and battery electric vehicles. The report has explored the tipping point for battery electric vehicles to become cost competitive against internal combustion engine vehicles, in those cases for passenger vehicles, buses/trucks, and motorcycles.

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

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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.

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List of Abbreviations and Acronyms

AEDP = Alternative Energy Development Plan

APS = advanced policy scenario

ASEAN = Association of Southeast Asian Nations

BOI = Board of Investment (Thailand)

BEV = battery electric vehicle

cc = cylinder capacity

CO_2 = carbon dioxide

COE = Center of Excellence

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

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

SWOT = strengths, weaknesses, opportunities, and threats

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

Amongst the Association of Southeast Asian Nations (ASEAN) countries, 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 the 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:

- **Brunei Darussalam** plans to set EV sales at 65% of vehicle sales by 2035.
- No incentives are provided to EV owners yet.
- **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. 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.
- **Thailand** has announced a new roadmap to lead the country to become a hub of EVs in ASEAN countries in 5 years. Under the roadmap, it is 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.
- EV owners can enjoy lower excise tax at 2% in contrast to that of ICE vehicles at 30%. The excise tax rate for hybrid electric vehicles (HEVs) is 10.5%.
- **Viet Nam** does not have a policy or goal relating to the introduction of EVs. The excise tax rate is differentiated by powertrain (EVs at 3% and ICE vehicles at 70%).

Chapter 2

The tank-to-wheel emissions are almost the same level amongst the countries since the fuel efficiencies of automobiles are identical. Emissions are relatively lower in Thailand, where biofuels are introduced. On the other hand, the differences in the well-to-tank emissions amongst the countries are large. The emissions by using liquid fuels do not differ much, meanwhile the emissions from using electricity vary greatly not only amongst countries, but also in terms of the time axis and the scenarios (based on climate change measures).

The differences in the power generation mix affect the amount of well-to-wheel emissions. HEVs are the lowest emitters when the generation mix depends on fossil fuels, whilst battery electric vehicles (BEVs) are the lowest emitters when it is clean. In the advanced policy scenario where power is cleaner, BEVs become the best option in terms of the well-to-wheel basis emissions by 2040 at the latest in all the five countries. It is essential that automobile electrification progress along with the decarbonisation of the power generation mix.

Chapter 3

The five analysed ASEAN countries offer different incentives for the wider diffusion of EVs. The methods are mainly focused on passenger vehicle ownership, in a form of differentiated luxury tax (Indonesia), exemption of excise tax (Malaysia), and lower excise tax (Thailand and Viet Nam). Discounts on electricity price as provided by Indonesia can benefit EV owners as well. No countries have yet provided subsidies for EV owners.

As the tipping point analysis indicates, the analysed countries may require continue providing economic incentives up to 2025 when the benefit of owning an EV would outweigh that of ICE vehicles.

Aside from the initial cost of vehicle purchase, operational costs – particularly energy prices – should continue to be the important factor for an owner's decision on vehicle purchase. Time of use pricing for electricity may encourage the purchase of EVs under the maintained high international crude oil price.

In countries – such as Indonesia and Viet Nam – where fuel economy for buses and trucks is relatively low, the benefits of shifting to EVs can be felt earlier than other analysed countries. The respective countries' relative electricity price (more than 40% lower than that of diesel in tons of oil equivalent terms) also adds value to the use of EVs.

To realise the potential benefits of the use of EVs, investing in infrastructure for charging stations would be important, particularly for those countries of which tipping point (buses and trucks) would be sometime before 2025.

The benefits of driving e-motorcycles have already outweighed those of conventional motorcycles (excluding the case in Brunei Darussalam).

Charging infrastructure development as well as business development should be ready for the expected rise in e-motorcycles.

Chapter 4

With the strengths, weaknesses, opportunities, and threats (SWOT) analysis, the five analysed ASEAN countries share common issues that are required to overcome.

- The five ASEAN countries need to accelerate the decarbonisation of the power sector.
- It is also important to invest in the power grid capacity and reliability improvement so that the electricity demand increase from the expected rise in EV charging will be sufficiently met.
- The five ASEAN countries should accumulate knowledge and experiences on EV charging, for which implementation needs to be carefully considered with financial and technical support from the respective government that may be in cooperation with the donor agencies.

Depending on the different levels of progress in the electrification of the transport sector, implications can be drawn as below.

- **Indonesia and Viet Nam**: For the transport sector electrification, these countries are better positioned to start from motorcycle electrification in view of the current consumers' heavy dependence on motorcycles.
- **Brunei Darussalam, Malaysia, and Viet Nam:** At the initial stage of electrifying the transport sector, these countries may need to focus on public bus electrification.
- **Indonesia and Thailand:** As these countries aspire to become the BEV production hub, they may need to develop the rules for regulations and standards for BEV battery reuse and recycling.

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 those EAS countries towards improving air quality in urban areas, enhancing energy security for shifting away from oil dependence, and mitigating climate change – if these are coupled with low-carbon power generation sources.

Amongst the Association of Southeast Asian Nations (ASEAN) countries, Indonesia, Malaysia, and Thailand have formulated EV production plans, and their plans include battery production. Indonesia has issued a Presidential Decree for the diffusion of EVs, and the country has also formulated EV production plans that include battery production. Indonesia aims to establish integrated production systems from the extraction of cobalt (required for cathodes) to battery production. Vehicle manufacturers in Thailand have formulated a plan to assemble batteries produced in other countries.

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 company members (such as manufacturing companies of automobiles, batteries, and electrical engineering).

Study Method

The study conducted both quantitative and qualitative analyses as follows.

First, the study analysed policies and regulations as well as economic incentives for the wider diffusion of EVs in the five ASEAN countries analysed.

Second, the study considered enablers (such as policies, regulations, production basis, financing, and human resources) for the diffusion of EVs in relation to ownership, manufacturing, and development of charging infrastructure. With the SWOT analysis framework, the study identified strengths, weaknesses, opportunities, and threats for the electrification of the transport system in the analysed countries.

Third, the study estimated the impact of EV deployment on energy savings and CO_2 emissions reduction by 2040. Different mix of electricity generation will differently affect the CO2 emissions from EV. Therefore, ERIA's Energy Outlook's electricity generation mix by 2040 was utilised as the basis for estimating the impacts derived from EVs on CO_2 emissions reduction (ERIA, 2021). As the countries analysed in this study either consider or establish plans for carbon neutrality beyond 2050, the assessment on the impact of EVs on CO_2 emissions reduction and its coordination with the supply-side decarbonisation is critically important. 2040 marks the transition timing in this process, and various supply-side transition options (biomass blending, ammonia blending, and carbon capture, utilisation, and storage) will be considered as well.

Fourth, the study analysed the total cost of ownership for passenger vehicles, from the use of EVs, and compared it with that of ICE vehicles, hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs). The analysis was conducted in consideration of the respective countries' differences on tax incentives, electricity prices, and other relevant costs. The study also presented the tipping point when EVs would become more cost competitive compared with ICE vehicles.

Fifth, the study formulated recommendations for ASEAN countries to formulate necessary policies for wider diffusion of EVs, and to develop infrastructure.

Report Structure

This report is structured to analyse the potential and economic benefits and/or costs of a shift towards EVs in Indonesia as follows.

Chapter 1 presents the EV policies in ASEAN countries, including policies, targets, the current status of the introduction of EVs, and economic incentives for the diffusion of EVs.

Chapter 2 presents the well-to-wheel (WTW) analysis that considers greenhouse gas emissions (and energy consumption) in automotive fuels throughout the process from fuel mining to transformation, transport, and final consumption.

Chapter 3 presents the analysis of total cost of ownership of EVs and compares it with ICE vehicles, HEVs, and PHEVs for the five countries in ASEAN: Brunei Darussalam, Indonesia, Malaysia, Thailand, and Viet Nam. The chapter presents the analysis results of the tipping point of EVs – when the benefits of owing electrified vehicles (xEVs) would surpass that of ICE vehicles and HEVs.

Chapter 4 presents the SWOT analysis regarding EV deployment strategies for the five ASEAN countries.

Finally, Chapter 5 draws policy implications from the above analysis.

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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/

Chapter 1

EV Policies in ASEAN Countries

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

1. Country Policies

1.1. Brunei Darussalam

- **Decarbonisation Policy in the Transport Sector**

Brunei Darussalam's Land Transport Master Plan sets forth the standards, regulations, processes, and systems to be defined and implemented for transport infrastructure and operations across Brunei to minimise the overall impact on the natural and built environment, minimise the carbon footprint, and maintain local air and noise quality. The plan includes the following specific policies.

- Develop an environmental impact assessment for all major transport initiatives before implementation.
- Promote energy efficiency and a reduction in carbon emissions through a carbon reduction blueprint.
- Progressively tighten emissions standards for new, imported, and existing vehicles.
- Fully recognise and support the Heart of Borneo initiative working in collaboration with the governments of Malaysia and Indonesia.
- Develop and apply appropriate planning standards, including promoting the concept of liveable neighbourhoods where local trip-making by walking and cycling is encouraged.

- **EV Policy and Target**

The Government of Brunei Darussalam believes that EVs are a powerful means of transportation, as they focus on short-range transportation that can be recharged relatively inexpensively with electricity. Furthermore, Brunei's National Climate Change Policy plans to set EV sales at 65% of vehicle sales by 2035. To achieve this goal, the government will make policy decisions by controlling EV prices and expanding the number of charging stations, including through excise tax incentives and the like, as well as paying attention to electricity and vehicle licence fees. The Electric Vehicle Joint Task Force composed of relevant stakeholders was established in 2019 to ensure the implementation of EV promotion policies. In addition, pilot projects such as the development of charging stations are currently being implemented through government initiatives.

- **Current Status of Introduction of EVs and Charging Infrastructure**

There is no statistically reliable information on the number of EVs introduced or the number of charging stations in Brunei.

- **Vehicle Registration Fees**

According to Brunei's Land Transport Department, a vehicle licence costs B$2.25 per privately-owned car per 100 cylinder capacity (cc) (Table 1.1). Registration fees and road taxes are also charged. Brunei publishes the road price for each car, which includes the showroom price or vehicle price, registration fee, vehicle insurance, and so on (Table 1.2).

Table 1.1. Vehicle Licence Fees in Brunei Darussalam

Types	Fees (per 100 cc)	Frequency of Renewal
Motorcycles and Private Cars	B$2.25	7 years of age and above – renewal every year
Taxis	B$4.5	After first year of registration – renewal every 6 months
Commercial	B$4.5	After first year of registration – renewal every 6 months (except for company registered cars, inspection is done annually once reaching 7 years of age and above)
Motor Omnibus	B$6.0	After first year of registration – renewal every 6 months
Trailers	B$10	After first year of registration – renewal every 6 months
Dealer's General Licence	B$100	Every year

cc = cylinder capacity.
Source: Brunei Darussalam Department of Economic Planning and Statistics.

Table 1.2. Example of 'On the Road Price' in Brunei Darussalam

Car: 2,500 cc or 2.5 litre	
Showroom price	B$49,900
+Registration fee	B$25
+ Licence plate	B$40
+ Road tax	B$57
+ Vehicle insurance	B$1,832
On the road price	B$51,854

cc = cylinder capacity.
Source: Brunei Darussalam Department of Economic Planning and Statistics.

- **Economic Incentives for EV Owners**

Brunei launched a 2-year pilot project on EVs on 25 March 2021. Until the licence fee for EVs is decided through this pilot project and put into effect, both participants and nonparticipants of the project are exempt from paying vehicle licence fees.

- **Economic Incentives for Charging Infrastructure Development**

According to the Brunei Darussalam National Climate Change Policy, the Electric Vehicle Joint Task Force is set to collaborate with key relevant government agencies, main industry players, and other private sector parties to increase access to charging facilities and other supporting infrastructure. No specific information has been released.

- **Economic Incentives for Manufacturers**

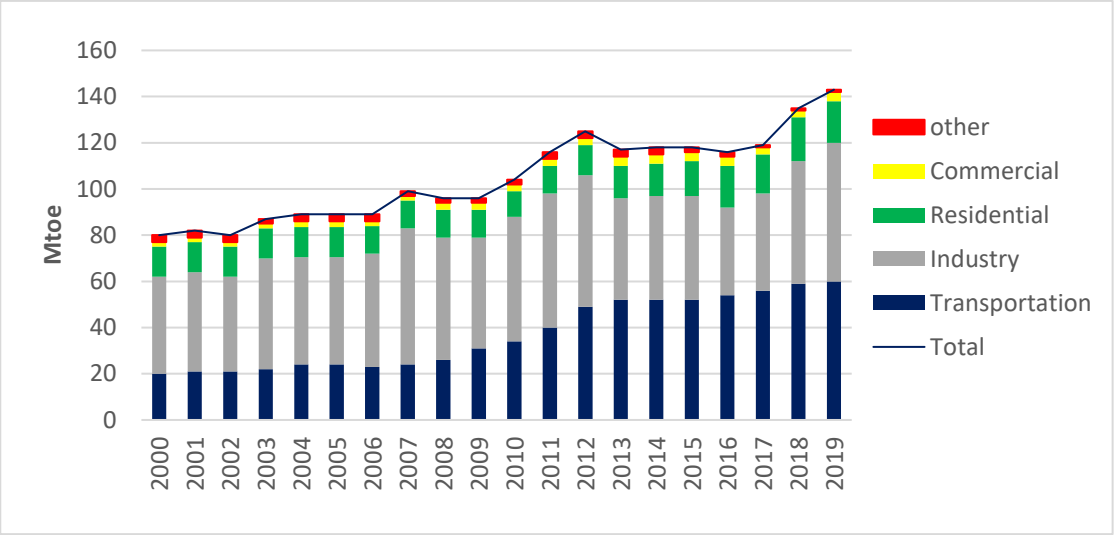
No specific information has been released.

1.2. Indonesia

- **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 tons of oil equivalent.
Source: Indonesia Long-term Strategy 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 substitute

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. The country plans to utilise fatty acid methyl-ester and bio-hydrocarbon or green diesel for biofuels, and bioethanol and crude palm oil-based gasoline for 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).

- **EV Policy and Target**

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.[1] Indonesia also intends for alternative-powered vehicles to account for 20% of total vehicle production by 2025.[2]

As Table 1.3 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.

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 purpose, 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.

[1] 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

[2] 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

Table 1.3. Indonesia's EV Target

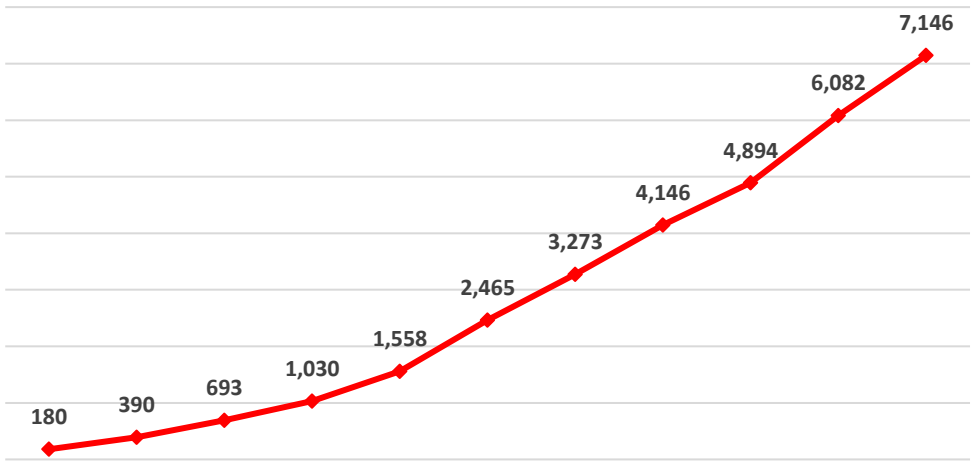
Item			2020	2025	2030	2035
Motor Vehicles	Production	Total (Unit)	1,500,000	2,000,000	3,000,000	4,000,000
		LCEV (%)	10	20	25	30
		LCGC (%)	25	20	20	20
	Sales	Total (Unit)	1,250,000	1,690,000	2,100,000	2,500,000
	Export	Total (Unit)	250,000	310,000	900,000	1,500,000
Motorcycles	Production	Total (Unit)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

Note: LCEV = low carbon emissions vehicle, LCGC = low cost green car.

Source: Indonesia's Strategy on Low Carbon Emission Vehicle and Automotive Standard (2018). http://www.catarc.org.cn/Instandard//UploadFile/2019/12/16/3-Indonesia-Mr.%20Putu%20Juli%20Ardika%20-%20CATARC%20221018.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[3] 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).

Figure 1.2. Roadmap of Charging Stations Infrastructure in Indonesia



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Investment (Rp million)	309	669	1,188	1,766	2,672	4,227	5,613	7,110	8,393	10,431	12,255
Labour	216	468	832	1,236	1,870	2,958	3,928	4,975	5,873	7,928	8,575

SPKLU locations include:

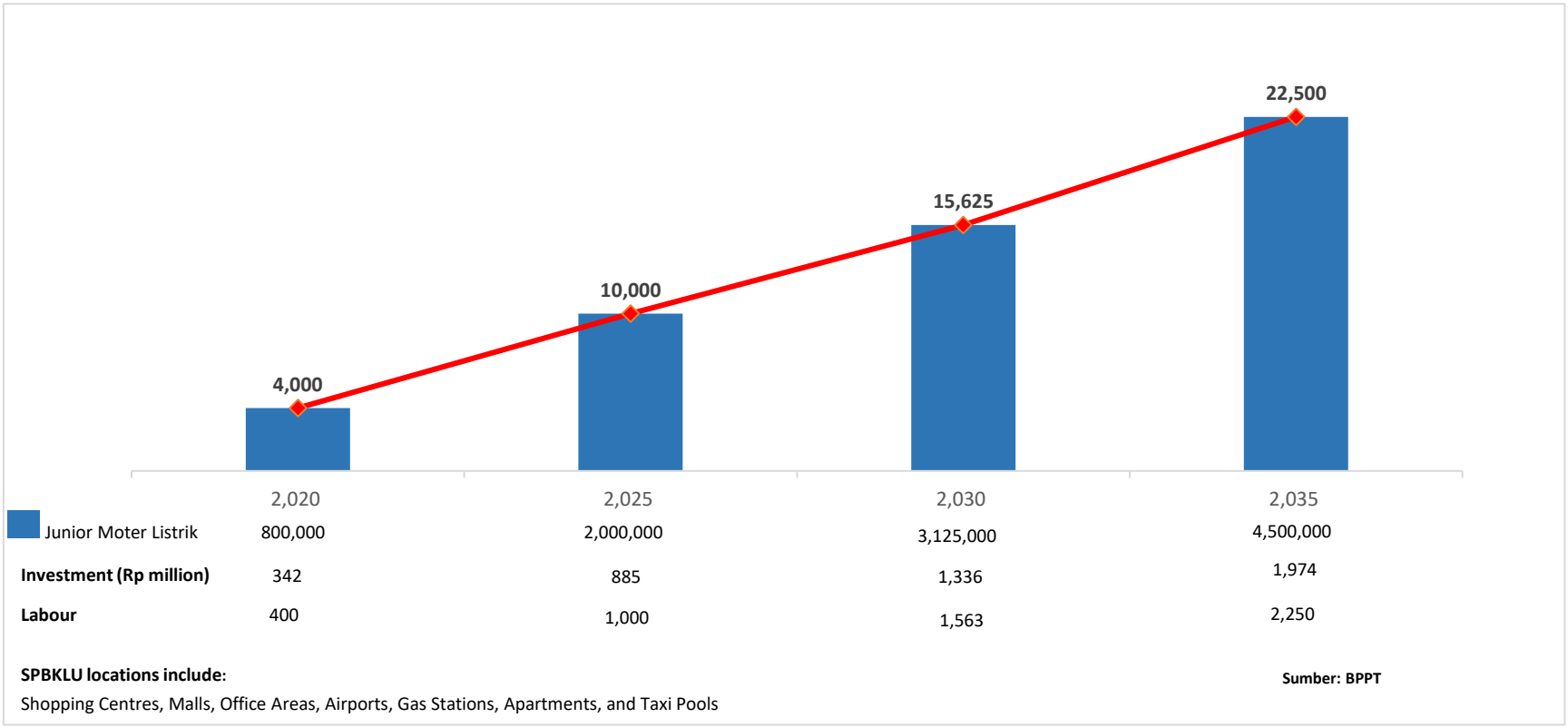
Shopping Centres, Malls, Office Areas, Airports, Gas Stations, Apartments, and Taxi Pools

Sumber: PT PLN (persero)

SPKLU = *Stasiun Pengisian Kendaraan Listrik Umum* (Public Electric Vehicle Charging Station).
Source: Provision of Electricity Charging Infrastructure and Electricity Rate for Battery-based Electric Motor Vehicles (2020). https://gatrik.esdm.go.id/assets/uploads/download_index/files/683a2-bahan-presentasi-pak-hendra-1-.pdf

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

Figure 1.3. Roadmap of Swap Battery Stations in Indonesia



SPBKLU = *Stasiun Penukaran Baterai Kendaraan Listrik Umum* (Public Electric Battery Exchange Station).
Source: Provision of Electricity Charging Infrastructure and Electricity Rate for Battery-based Electric Motor Vehicles (2020).
https://gatrik.esdm.go.id/assets/uploads/download_index/files/683a2-bahan-presentasi-pak-hendra-1-.pdf

- **Current Status of Introduction of EVs**

Indonesia's HEV/PHEV sales number in 2021 was 2,508, and BEVs accounted for 685 units in the same year. This represents 0.36% of total sales of vehicles. The total passenger vehicle sales in 2021 was 887,202, which was 1.67 times higher than the previous year but still below pre-pandemic levels (Table 1.4).

Table 1.4. Number of HEV/PHEV and BEV Registrations, 2019, 2020, and 2021 in Indonesia

Year	HEVs/PHEVs	BEVs	Total of EVs	Total Passenger Vehicle Sales
2019	351	0	351	1,030,126
2020	1,114	120	1,234	532,027
2021	2,508	685	3,193	887,202

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/

EV sales are still extremely small but are growing. xEV sales have grown by nearly nine times compared to 2019, although there is still a considerable gap with the target EV production share of 10% in 2020 or 20% in 2025. Whilst the production targets in the EV roadmap include exports, more widespread adoption of EVs within the country is essential for meeting the target.

- **Current Status of EV Charging Infrastructure**

As of February 2022, there were 267 electric vehicle charging station (EVCS) units across 224 sites. Of those EVCSs, the state power company PLN owns 120 units installed across 92 sites (Kompass, 2022). For reference, there were more than 5,500 conventional petroleum fuel stations in Indonesia as of the end of 2020.

The Indonesian Ministry of Energy and Mineral Resources has a target to install EV charging stations at 695 locations in fiscal year (FY) 2022. PLN also has a target to build 580 SPKLUs (EVCS for four-wheelers) in FY2022 and 4,900 swap battery stations for two-wheelers (SPBKLUs) (Thai Ministry of Energy and Mineral Resources, 2022).

- **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 ($16)
- four-wheelers: Rp375,000 ($26)

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

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

- **Economic Incentives for Owners of xEVs**

There are two types of economic incentives for xEV owners: lower luxury tax rates and an electricity tariff discount.

- 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 1.5, 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.

Table 1.5. 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, PHEV = plug-in hybrid electric vehicle, km = kilometre, l = litre.
Source: Government issued Regulation Number 74 of 2021 (PP-74). https://peraturan.bpk.go.id/Home/Details/171112/pp-no-74-tahun-2021

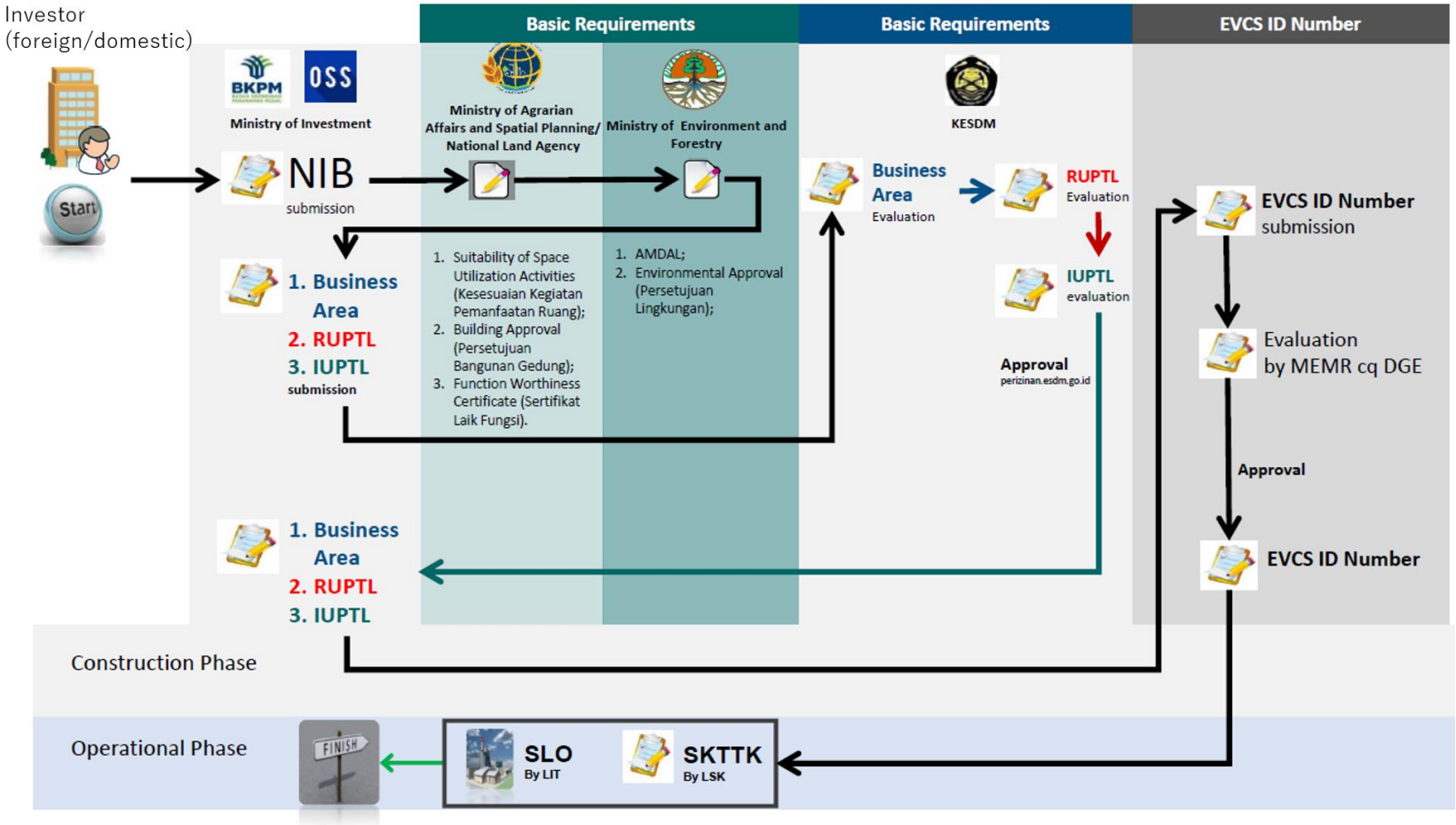
・ Electricity Tariff Discount

As an economic incentive for using EVs, Indonesia's state power company PLN offers a 30% electricity tariff discount between 10:00 p.m. to 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.

- **Provisions for Charging Infrastructure Development**

A business permit must be obtained for operating a SPKLU business. Power companies applying for a permit must fulfil the requirements related to 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: EV Regulation in Indonesia. Presentation Slide at 1st Online Meeting (28 February 2022).

- **Economic Incentives for Manufacturers**

There are three major economic incentives in place for manufacturers.

・ 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 1.6).

Table 1.6. Conditions for Corporate Tax Reduction

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

Investment (Rp)	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 (The rate in Indonesia is 22%.)
(https://taxsummaries.pwc.com/indonesia/corporate/taxes-on-corporate-income).
Source: BDO Indonesia (2018), 'Tax Holiday Revamped', Newsletter, 19 December.

The EV businesses eligible for the tax reduction are shown in Table 1.7.

Table 1.7. 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: Regulation Number 130/PMK.010/2020 (PMK-130).
https://peraturan.bpk.go.id/Home/Details/148016/pmk-no-130pmk0102020

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

・ Income Tax Incentives

Table 1.8 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 1.8. Eligible Auto Manufacturing Businesses

Eligible to			
1	Four or more wheeled vehicle industry	29100	Public transportation for >42 passengers and/or trucks
2	Carosery industry for four or more wheeled vehicle industry and trailer and semi-trailer industry	29200	Manufacturing of parts of car or vehicle carosery
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 component and equipment for two- or three-wheeled motorcycles	30912	Engines and engine parts, die casting components, brake systems, transmission systems

Source: Law of the Republic of Indonesia Number 9 of 2016.
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 APM in the form of free charger units for the purchase of electric vehicles and free insurance for 1 year

1.3. Malaysia

- **Decarbonisation Policy in the Transport Sector**

Malaysia has 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, to 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 journey
- Advance towards green transport ecosystem
- Expand the global footprint and promote the internationalisation of Malaysia's transportation services

- **EV Policy and Target**

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 system.

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 1.9).

Table 1.9. Target Sales Share of EVs in Malaysia

Year	Current Status	Targets (2030)
Passenger vehicles	30,414 (BEV: 700)	15%
Motorcycles	2071	15%
Buses	35	10,000

Source: Country Report of Malaysia (1st Meeting of ERIA Research Project in FY2021).

To facilitate the sales increase, Malaysia plans to expand the charging systems to install 10,000 units (AC: 9,000 units, and DC: 1000 units) in 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 is targeted to account for 10%, and it is targeted to increase to 50% (2023–2025). From 2025 to 2030, Malaysia's government will establish local product qualification for tender participation.

The blueprint includes the plan for economic incentives for BEVs and PHEVs summarised in Table 1.10.

Table 1.10. 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 the sales of maximum 10,000 units	50% exemption	
PHEVs	100% import and excise duty exemption for complete built units – for the 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).

On 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 the leader in automotive manufacturing industry. The NAP 2020 focuses on next-generation vehicles (NxGV), Industrial Revolution (IR 4.0), and mobility-as-a-service (MaaS) (Christopher & Lee Ong, 2020).

- **Current Status of Introduction of EVs**

In 2021, the number of EVs in passenger vehicle stocks was 30,415 (Table 1.11).

Table 1.11. Current Status of EVs in Malaysia

	Current Status
Passenger vehicles	30,415 (BEV:700)
Motorcycles	2071
Buses	35

BEV = battery electric vehicle.
Source: Country Report of Malaysia (1st Meeting of ERIA Research Project in FY2021).

- **Current Status of EV Charging Infrastructure**

According to the Malaysia Green Technology and Climate Change Corporation, around 400 units have been installed across Peninsular Malaysia (November 2021). According to technical information on the web (TECHWIRE ASIA), approximately 500 units have been installed in Malaysia as a whole (August 2021).

- **Vehicle Registration Fees**

According to the Road Transport Department, 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 1.12).

There is a road tax of RM20 for private sedans 1,000 cc and below (Table 1.13). A payment of excise duties and sales tax will also be required (Table 1.14).

Table 1.12. 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.

Table 1.13. Road Taxes in Malaysia

Cars (private, sedan)

Engine Capacity	Fee	
1,000cc 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	
1,601–1,800 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	Fee	
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
1501 kg–2,500 kg	RM90.00	RM0.06/kg from 1,500 kg
2,501kg–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

Table 1.13. *Continued*

Motorcycles

Tonnage	Fee
150 cc and below	RM 2.00
151 cc–200 cc	RM 30.00
201 cc–250 cc	RM 50.00
251 cc–500 cc	RM 180.00
501cc–800cc	RM 250.00
800 cc and above	RM 350.00

cc = cylinder capacity, kg =kilogramme.
Source: Malaysia Ministry of Transport.

Table 1.14. Import Duty and Local Taxes for Cars in Malaysia

A. Passenger Cars (including station wagons, sports cars, and racing cars)

	Import Duty				Local Taxes	
	CBU		CKD		CBU & CKD	
Engine Capacity (cc)	MFN	ATIGA	MFN	ATIGA	Excise Duties	Sales Tax
<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%

B. Other Motor Cars

	Import Duty				Local Taxes	
	CBU		CKD		CBU & CKD	
Engine Capacity (cc)	MFN	ATIGA	MFN	ATIGA	Excise Duties	Sales Tax
<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%

C. Commercial Vehicles

	Import Duty				Local Taxes	
	CBU		CKD		CBU and CKD	
Class	MFN	ATIGA	MFN	ATIGA	Excise Duties	Sales Tax
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. 1 January 2019.

- **Economic Incentives for xEV Owners**

According to the National Low Carbon Mobility Blueprint 2021–2030, BEV-specific incentives are being planned.

Provide tax incentives (reducing) to bridge the price gap and build market trust

- BEV complete built unit excise duty and import tax exemption (for maximum 10,000 units in total) (2021–2022)

- 50% import duty and excise duty exemption (2023–2025)

Incentives specific to PHEVs are:

Provide tax exemption for qualified complete knock down PHEVs

- 100% exemption (2021–2022)

- 75% exemption (2023–2025)

- 50% exemption (2026–2030)

Further, the Ministry of Finance plans to propose the exemption of consumption tax on EVs and up to 100% exemption of the road tax for vehicle owners in FY2022. In addition, a personal income tax cut of up to RM2,500 is scheduled to be applied to the purchase and installation, leasing, and lease-purchase of EV chargers and payment of EV charger usage fees.

- **Economic Incentives for Charging Infrastructure Development**

Further, the National Low Carbon Mobility Blueprint 2021–2030 indicates that the following amounts will be provided as charger infrastructure installation funds to support PHEVs.

- RM5,000 per PHEV (2021–2025)

- RM3,000 per PHEV (2026–2030)

Tax incentives will be provided to private-sector charger businesses up to 2030 via the Green Income Tax Exemption (70% exemption on income tax).

- **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.

- **EV and Battery Production Plan**

The blueprint includes the action plan for EV production as summarised in Table 1.15.

Table 1.15. Action Plan of EV Increases Specified in 'Low Carbon Mobility Blueprint 2021–2030' in Malaysia

Year	Electric Cars	Buses	Motorcycles
Action Plan	・ Government lead by example ・ Adopt EV cars for taxi fleet as part of taxi service modernisation and rebranding ・ Provide EV incentives for the market ・ Ensure EV charging infrastructure sufficient for private EV penetration ・ Provide R&D grants and support to manufacturers of local EV cars ・ Build a holistic EV ecosystem	・ Establish e-bus central procurement agency ・ Subsidise public transport electricity tariff and electricity Provide support to manufacturers of local EV buses	・ Procure electric motorcycles for government enforcement fleet ・ Use electric motorcycles for delivery service ・ Develop battery swapping standard for electric motorcycles in Malaysia ・ Provide support to manufacturers of local electric motorcycles

Source: Ministry of Environment and Water (2021).

- **Battery Reuse Plan**

The policy for reuse of EV battery is under formulation.

- **Variable Renewable Energy (VRE) Introduction Plan**

Currently, Malaysia's share in renewable electricity generation accounts for 2%, whilst the government plans to expand the share to 20% in 2025. Photovoltaics (PV) are expected to play an important role for meeting the target. Net metering is implemented in Malaysia, with the rooftop PV system playing an important role. Also, for facilitating large-scale PV introduction, Malaysia has implemented a large-scale solar bidding system of which first bidding took place in 2016, followed by those implemented in 2017 and 2019.

1.4. Thailand

- **Decarbonisation Policy in the Transport Sector**

The transport sector contributed the largest share of final energy consumption, at around 38.40% of the final energy consumption by economic sectors 2020. GHG emissions from transport, were 68,260.17 $GgCO_2eq$ (27.21%) by total direct GHG emissions from the energy sector in 2016 (Ministry of Natural Resources and Environment, 2021).

The Cabinet endorsed the Nationally Determined Contribution (NDC) Roadmap (2021–2030) in 2017 as a guidance to achieve its NDC targets. In the roadmap, the mitigation measures for the transport sector are (i) avoid and/or /reduce traveling, (ii) shift and /or maintain travel modes, and (iii) improve energy efficiency in transport with the mitigation target of 41.0 $MtCO_2eq$ in 2030. Thailand's roadmap for 2030 estimates that the transport sector will contribute about 36.3% of GHG emissions reduction.

The NDC Action Plan 2021–2030 was developed to support the implementation of the NDC Roadmap (2021-2030) and was prepared by the Office of Transport and Traffic Policy and Planning, Ministry of Transport. The NDC Action Plan 2021–2030 clarifies mitigation measures from related plans such as travel demand management, transit-oriented development,, expansion of railway network, and bus fleet upgrades to the GHG emissions reduction of 35.42 $MtCO_2eq$ in 2030.

The Energy Efficiency Plan 2018–2037 (EEP2018) was prepared by the Department of Alternative Energy Development and Efficiency, Ministry of Energy. EEP2018 has a goal of reducing energy intensity by 30% from 2010 levels by 2037. A total of 54,371 kilotons per oil equivalent (ktoe) of energy savings is expected by the end of the plan, with the focus areas of transport, industry, commercial and government buildings, residential and agriculture, with energy savings targets by 2037 of 17,682 ktoe, 21,137 ktoe, 6,418 ktoe, 3,300 ktoe, and 527 ktoe, respectively. The Master Plan for Sustainable Transport Development and Climate Change Mitigation and the transport system development was prepared by the Office of Transport and Traffic Policy and Planning, Ministry of Transport. This master plan includes (i) integrated transport systems, (ii) improved transport services, (iii) regulations and institutions, (iv) human resource development, and (v) innovation and technology strategies.

- **EV Policy and Target**

Thailand aims to be a major global production base for electric vehicles and parts. Under this vision, in February 2020, The National Electric Vehicle Policy Committee (NEVPC) was launched and in March 2020, the NEVPC announced a new EV roadmap to lead the country to become an EV hub in 5 years and to increase EV production to 30% of total annual automotive production or about 750,000 units out of 2.5 million units in Thailand by 2030 (EV 30@30 Policy).

In May 2021, the NEVPC established Thailand's EV policy direction and each committee, which consist of (i) promoting of the manufacturing industry electric vehicles and parts, (ii) infrastructure and battery development to support electric vehicles, (iii) assessing the impact of fuel and GHGs from the promotion of electric vehicles, and (iv) promoting the electric vehicle adoption.

The EV policy direction is made up of a three-phase development plan. Under Phase 1 (2021–2022), the government will promote electric motorcycles and support infrastructure nationwide. Under 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) is driven by the '30/30 Policy' to produce 725,000 EV cars, pick-ups plus 675,000 EV motorcycles (Table 1.16) and to install 12,000 DC charging stations (Table 1.17). This will account for 30% of all auto production in 2030 and includes domestic manufacture of batteries. The NEVPC also sets financial and tax incentives, as well as safety standards, for EV and battery manufacturers.

Table 1.16. Targets of EV Production and Usage in Thailand

Year	Passenger Cars/Pickups		Buses/Trucks	
Target	Annual Production (million cars)	Usage (million cars)	Annual Production (million cars)	Usage (million cars)
2025	0.225	0.225	0.018	0.018
2030	0.725	0.44	0.034	0.033

Year	Motorcycles	
Target	Annual Production (million cars)	Usage (million cars)
2025	0.36	0.36
2030	0.675	0.65

Source: National Electric Vehicle Policy Committee.

Table 1.17. Targets of EV Charging Stations in Thailand

Year	Passenger Cars/Pickups	Motorcycles
Target	Target of DC charge	Total target station
2025	2,200–4,400	260
2030	12,000	1,450

Source: National Electric Vehicle Policy Committee.

- **Current Status of Introduction of EVs**

After the launch of the EV policies, the number of EV registrations has steadily increased. Table 1.18 shows the number of HEV and PHEV, and BEV registrations in Thailand. Between 2018 and 2021, the number of HEV and PHEV registrations has increased steadily (20,334 units in 2018 and 30,676 units in 2019, 32,264 units in 2020, and 42,800 in 2021). Similarly, the number of registered BEVs has greatly increased from 325 units in 2018 to 5,781 units in 2021. Meanwhile, it also shows that the number of HEVs and PHEVs outnumber that of BEVs, and the share of EVs in total automotive market has remained sluggish.

The Kasikorn Research Center indicated that the Thai BEV market has been stimulated by new government support measures, and that Chinese automakers are rapidly expanding their share of the BEV market on the strength of their low prices, capturing 80% of the total BEV market and expected to sell over 10,000 BEVs by 2022 (K-Research, 2022).

Table 1.18. New HEV/PHEV, and BEV Registrations from 2018 to 2021 in Thailand

Year	HEVs/PHEVs	BEVs	Total EVs	ICE Vehicles
2018	20,344	325	20,699	2,919,669
2019	30,676	1,572	32,248	2,952,140
2020	24,464/7,807	2,999	35,263	2,545,420
2021	35,740/7,060	5,781	48,581	2,584,088

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

- **Current Status of EV Charging Infrastructure**

Since 2015, the number of charging stations in Thailand has gradually increased to 1,511 (normal chargers) and 774 (fast chargers) as of September 2021 (EVAT, n.d.).

In recent years, with the support of the Thai government, many start-ups (GridWhiz, Chosen Energy, EVF, The Fifth Element, Evolt, Future charge, Sharge management) and existing companies in Thailand, the oil and gas industry (PTT public company, Bangchak, Susco, Shell, Caltex Chevron), electricity sector (MEA, PEA, EGAT), green energy industry (Energy Ablolute, GLT), and the automotive industry have entered the EV charging business (Thananusak, et al., 2021). For example, EGAT has indicated plans to increase the number of EV stations to 48 by 2021 and 90 by 2022, which would allow charging every 200–250 kilometres (EGAT, n.d.).

- **Vehicle Registration Fee**

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

Excise Tax

The Thai government approved the general framework of regulations on excise tax rates at a Cabinet meeting on 15 February 2022 (Thai Government, 2022). This decision is based on the Electric Vehicle Promotion Policy approved by the Cabinet on 15 February 2022. PHEVs (passenger cars and pickup trucks), EVs (passenger cars and pickup trucks), low-emissions eco-cars, and fuel cell (FC) pickup trucks will be subject to different new excise tax rates, e.g. 2% for EV passenger cars and 0% for EV pickup trucks until 31 December 2025, and 0% for FC pickup trucks until 31 December 2025, respectively, 0% until 31 December 2025, and from 1 January 2026 to 31 December 2035. The rate for EV pickup trucks is 0% until 31 December 2025, and 2% from 1 January 2026, up 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 1.21).

Vehicle Registration Fee

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

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

(1) New vehicle registration fee

The cost for new car registration consists of 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.

(2) Vehicle Tax

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 for actual engine capacity (cc). For example, the vehicle tax of a new sedan with four seats and engine capacity of 1799 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 for vehicle weight and type of vehicle.

(3) Compulsory Vehicle Insurance

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 1.19. Total Fee of New Vehicle Registration Fees and Taxes, Compulsory Vehicle Insurance Premiums

Type of Vehicle	Total Fee of New Vehicle Registration Fees and Taxes* (baht, average in 2021)	Compulsory Vehicle Insurance Premiums** (baht)
Passenger Vehicles	2750	Personal, hiring/renting/public 600, 1,900
Buses	1901	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) Runs between the distinct and the distinct in 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	3448	Personal, hiring/renting/public

Type of Vehicle	Total Fee of New Vehicle Registration Fees and Taxes* (baht, average in 2021)	Compulsory Vehicle Insurance Premiums** (baht)
		900, 1,760 (no more than 3 tons) 1,220, 1,830 (3–6 tons) 1,310, 1,980 (6–12 tons) 1,700, 2,530 (more than 12 tons)
Motor cycles	100	EV: 300, 350 (personal, hiring/renting/public) ICE: 150 (no more than 75 cc) 300, 350 (75–125cc, individual, hiring/renting/public) 400 (125–150cc) 600(more than 150cc)
Three-wheeler	325	EV: 500,1,440 (personal, hiring/renting/public) ICE: personal, hiring/renting/public 720, 1,440 (Bangkok) 400, 400 (outside Bangkok)

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

- **Economic Incentives for xEV Owners**

The Thai government approved a framework for a new electric vehicle promotion programme at a cabinet meeting on 15 February 2022 (Royal Thai Government, 2022). The promotion programme includes subsidies for the purchase of EVs, with B70,000 or B150,000 per vehicle for passenger cars depending on battery capacity, B150,000 per vehicle for pickup trucks, and B18,000 per vehicle for motorcycles. However, vehicles exceeding B2 million and motorcycles exceeding B150,000 are not eligible for the subsidy. The subsidy is scheduled to be provided from 2022 to 2025. The subsidy is provided to manufacturers and distributors, not consumers. Thus, subsidies are indirect incentives for xEV owners (Table.1.21).

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 a fixed insurance rate regardless of engine capacity.

- **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 either plan to install EV smart charging systems or plan to connect to the 'EV Charging Network Operator Platform The connection to the 'EV Charging Network Operator Platform' is required (Thai BOI, 2022).

- **Economic Incentives for Manufacturers**

As of 30 April 2022, the BOI granted investment incentives to 31 EV manufacturing projects, including seven HEV projects, seven PHEV projects, 14 BEV projects, and three electric bus projects, with a total investment of B57.87 billion (investment value excluding cost of land and working capital) and annual manufacturing capacity of 666,855 units. For EV components and batteries, the BOI also granted investment incentives to 11 projects for components and 18 projects for battery production, of which a total investment was B15.32 billion(investment value excluding cost of land and working capital) (Thai BOI, 2022).

In March 2021, the BOI announced a new 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 to 8-year corporate tax exemption on EVs and EV parts production depending on investment value (Table 1.20). Other incentives are R&D grants, human resource development grants, investment support for the establishment of a new EV battery pilot plants, and so on.

Table 1.20. 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 to 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

CIT = corporate income tax, EV = electric vehicle, BEV = battery electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Thailand BOI. 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 will be 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 to 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 1.21).

Table 1.21. 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 duty to 2%	If production is to begin in Thailand in 2024, its scale shall be at least the same 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 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, (iii) battery pack assembly and two other electronic components
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 duty to 2%	
Pick Up Retail price not exceeding B2 million	B150,000 for more than 30 kWh	None	Exemption of excise duty to 0%	Production of EV components can be divided into one of the following three categories: (i) battery cells, (ii) battery module assembly and one other

Type of Battery Electric Vehicle	Incentive			Condition**
	Subsidy	Tariff (Period 2022–2023)	Excise Tax (Period 2022–2025)	
				electronic component, (iii) battery pack assembly and two other electronic components
Motorcycle Retail price not exceeding B0.15 million	B18,000	Exemption of tariff to 0%	None	EV components are expected to be produced domestically

Note: ** 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 dated 30 May 2022. (https://www.ratchakitcha.soc.go.th/DATA/PDF/2565/E/120/T_0015.PDF), News from Government of Thailand dated 22 February 2022 (https://www.thaigov.go.th/news/contents/details/51817).

- **EV and Battery Production Plan**

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

According to Kasikorn Research Center (K-Research), EVs market share in the next 5 years will increase to one-quarter, or 240,000 units, of the total car sales nationwide. When EV production is approaching its full capacity in 2023, it is expected that at least 260,000 units of EV batteries will be rolled out to serve the demands in Thailand.

In December 2021, Energy Absolute (EA), which is one of the largest renewable power producers in Thailand, opened a B6 billion ($178 million) lithium-ion battery factory in Chachoengsao, a central Thai province home to many automotive companies. The plant is the first in Southeast Asia with an annual output capacity of 1 gigawatt hour, can produce batteries for 4,160 buses or 30,000 saloon cars in the first phase. EA plans to first produce batteries for 400 electric buses. EA's subsidiary Amita Technology (Thailand) Co, which operates the factory, uses pouch cell technology to make batteries with a lighter weight and a high-power storage (EA, 2021). At EAs battery production facility, EA also makes solvents for use in a battery recycling process, and has set up an electrolyte production unit for battery performance testing (Bangkok Post, 2021).

- **Battery Reuse Plan**

The application of battery energy storage systems in Thailand is in its infancy, and there is no official plan and target by the government with regard to battery reuse at present.

- **VRE Introduction Plan**

On the move to reinforce electricity security, the Ministry of Energy has amended its Alternative Energy Development Plan (AEDP) 2018, which covers operations from 2018 to 2037, to comply with the national electricity generating capacity development, increasing the ratio of renewable energy sources to 29.4 gigawatts (GW) or 34% of the national electricity generating capacity by 2037. The goal of the AEDP is to increase the share of renewable and alternative energy in electricity, heat, and biofuels to reach 30% of final energy consumption in 2037.

According to the latest amendment of the AEDP 2018, electricity generated from renewable energy sources will be introduced into the national power grid, with solar power 15.6 GW, biomass 5.8 GW, wind power 3.0 GW, and hydropower from domestic sources and Lao People's Democratic Republic 3.0 GW, and waste to energy 0.9 GW, respectively. And according to the latest amendment of the AEDP 2018, the target proportion of biofuel use to fuel demand in transportation in 2037 is 9.99%.

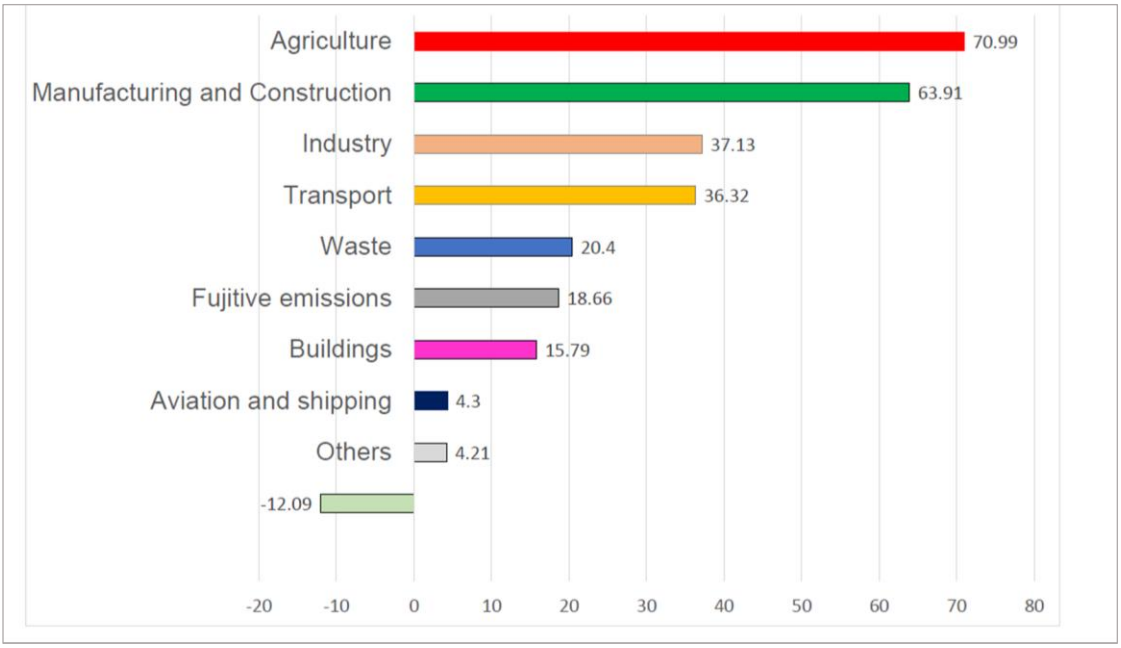
1.5. Viet Nam

- **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% in 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, 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, the 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, about 14.5%, to the country's GHG emissions in 2018 (Figure 1.5).

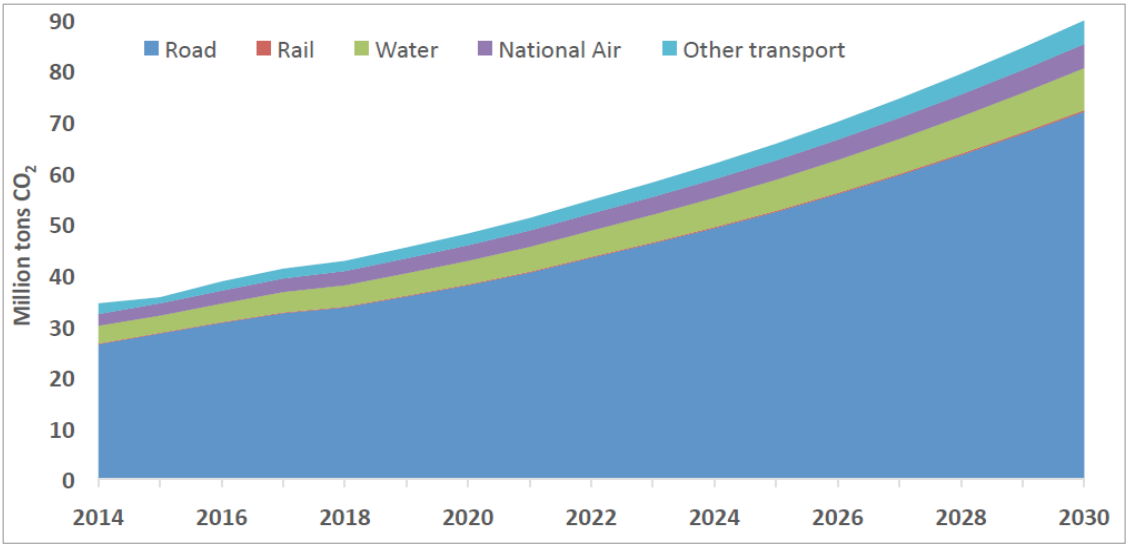
Figure 1.5. Greenhouse Gas Emissions by Sector, Viet Nam, 2018



Note: Greenhouse gas emissions are measured in tonnes of carbon dioxide-equivalent (million tons).
Source: Our World in Data. Viet Nam CO_2 Country Profile.
https://ourworldindata.org/co2/country/vietnam

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 tons of CO_2 in 2014 to 89.1 million tons in 2030 under the BAU scenario. Within such forecast, road transport, the largest emitter at 26.4 million tons of CO_2 in 2014, with emissions to increase to 71.7 million tons in 2030 (Figure 1.6) (Oh et al., 2019).

Figure 1.6. CO_2 Emissions Projection by Transport Subsectors under BAU Scenario



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

As for the 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), does orient 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 to develop 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, the MOT needs to adopt energy-efficient vehicles and mass public transport to tackle GHG emissions reduction 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 motorbike use country 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.

- **EV Policy and Target**

There is no specific policy framework dedicated to EV deployment or EV charging station development. 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 the summary of 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 of 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 ICE two-wheelers access to city centres with Decision 5953/QD-UBND: Restriction/Prohibition of Internal Combustion Engines (ICEs) access to city centres (GIZ, 2021).

- **Current Status of Introduction of EVs**

The EV four-wheeler and electric two-wheeler market in Viet Nam is in a very early stage, although e-bikes and e-motorcycles have been widely adopted in the market. By 2018, electric two-wheeler adoption 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 (Table 1.22).

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.

The domestic conglomerate Vingroup's subsidiary, VinFast entered the auto industry in 2017 with internal combustion engine cars, then released the 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 continues to increase EV models in 2022, to challenge the American market. During Consumer Electric Show in the U.S. earlier in 2022, VinFast said the company will cease production of engine cars by the end of 2022 (Nikkei Asia, 2022).

Table 1.22. Penetration of E2W into Viet Nam's Market

	2016	2017	2018	2019	2020	2021
E2W numbers of vehicles	**501,400**	**728,451** (+45.3%)	**1,075,630** (+47.7%)			
			Vinfast brought "Klara" to market			
				Vinfast brought "Klara A2" with a battery swapping option.		
				Yadea put the first oervseas production in Bac Giang province (target - 200,000 Eww/year)		
						Vinfast brought two new E2W Li-Ion battery.
	Imported from China, Japan, and Republic of Korea.			Domestic Production and Assembly (VinFast)		

E2W = electric two-wheelers.

Source: Le Anh, T. (2021), 'Promoting E-Mobility in Viet Nam', Presentation at ASEAN Energy & Utilities Digital Week, 7 July. https://asew-expo.com/AEUDW2021/download/ASEAN-Electric-Vehicle-Outlook/Session2/Dr_LE_ANH_Tuan.pdf

- **Current Status of EV Charging Infrastructure**

Despite the absence of a national policy target for EV charging infrastructure development, VinFast is steadily increasing the 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-wheelers 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).

- **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 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 the differentiation by engine cylinder capacity and power source (Table 1.23).

Table 1.23. 2014 Excise Tax

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

L = litre.

Source: Policies to Promote EV Development in Viet Nam. (A presentation slide at the study meeting on 28 February 2022, Central Institute for Economic Management).

The 2016 law reduced the tax rates with a smaller capacity of the engine, with higher tax rates for bigger capacity engines (Table 1.24).

Table 1.24. 2016 Excise Tax

Source Type	Class	Excise Tax Rate
Combustion Engine (<9 seats)	<1.5L	35%
	1.5L–2.0L	40%
	2.0L–2.5L	50%
	2.5L–3.0L	60%
Hybrids	(fuel consumption 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: Policies to Promote EV Development in Viet Nam. (A presentation slide at the study meeting on 28 February 2022, Central Institute for Economic Management).

In Excise Tax 2022 Law, tax rates on battery-powered EVs were lowered, especially from March 2022 to February 2027 (Table 1.25).

Table 1.25. 2022 Excise Tax

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

Source: Policies to Promote EV Development in Viet Nam (A presentation slide at the study meeting on 28 February 2022, Central Institute for Economic Management).

Registration Fee

Vehicle registration fees are applicable by local municipals, and they may vary by region (Table 1.26).

Table 1.26. Registration Fee

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

Source: Policies to Promote EV Development in Viet Nam. (A presentation slide at the study meeting on 28 February 2022, Central Institute for Economic Management)

- **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 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.

- **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 loan interest for the first 5 years of investment.

- **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, not limited to electric vehicles.

Manufacturers may need to sign up for this tax incentive programme. From the 3rd 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.

- **User/Driver Management**

Since the early 2010s, there has been growth in electric two-wheels in Viet Nam, especially e-bikes. Many students chose 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 Road Traffic Law to classify driving licences for motorised two- and three-wheelers into three categories: A1, A2, and A3, which was subsequently regrouped into four categories: A0, A2, A, and B1.

- **EV Battery Production Plan, EV Criteria**

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

- **Battery Reuse Plan**

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

- **VRE 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.

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Chapter 2

Well-to-Wheel Analysis of EVs in ASEAN Countries

1. Introduction

In the Association of Southeast Asian Nations (ASEAN), the use of automobiles is rapidly spreading, resulting in various adverse effects such as deteriorating air pollution, increasing oil imports, and increasing greenhouse gas (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.

This study estimates GHG emissions from passenger light duty vehicles (PLDV) on a well-to-wheel basis for 2030, 2040, and 2050 to contribute policy planning of ASEAN countries in the field of automobile and energy. The study scopes Indonesia, Thailand, Malaysia, Viet Nam, and Brunei Darussalam.

2. Estimation Method

2.1. Scope of the Well-to-Wheel Analysis

The well-to-wheel (WTW) analysis is to consider GHG emissions (and energy consumption) in automotive fuels throughout the process from fuel mining to transformation, transport, and final consumption. 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 using automobiles.

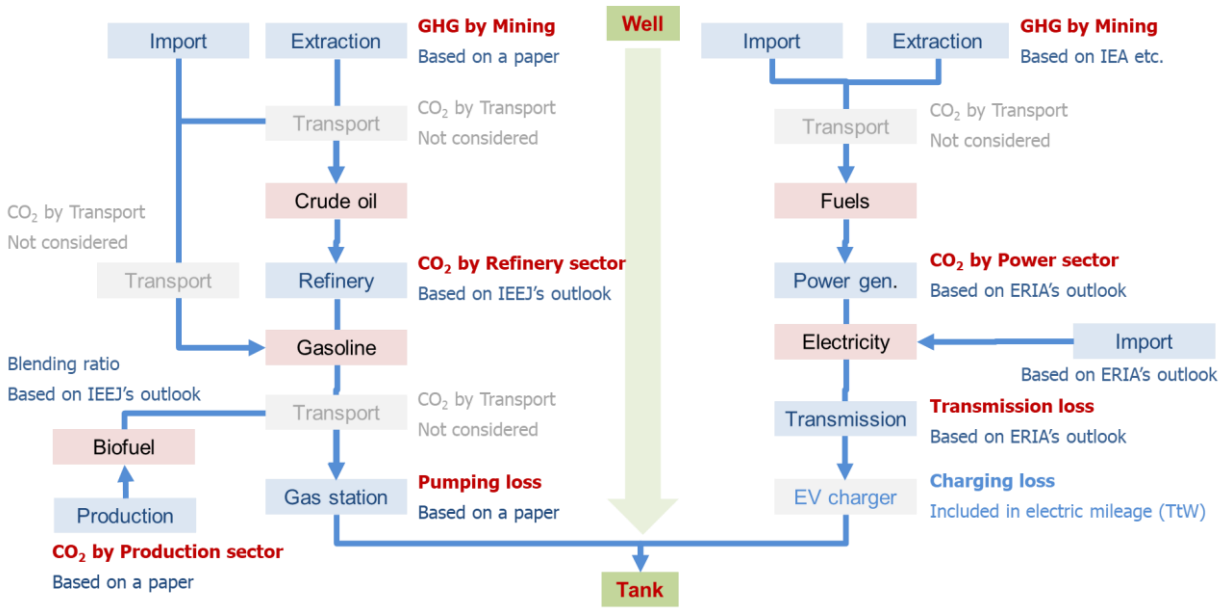
Tank-to-wheel (TTW) is the final consumption stage and refers to the time when using an automobile. Fossil fuels (gasoline, etc.) emit CO_2 when burned at the final consumption stage, whilst electricity and biofuels do not.

Well-to-tank (WTT), on the other hand, refers to the energy supply process, from fuel mining to transformation, transport, and filling to automobiles (Figure 2.1). For gasoline, it covers GHG emissions in each process of mining of crude oil, which is the raw material of gasoline, transport to a refinery plant, refining into gasoline in the plant, transport to a gas station, and refuelling an automobile. Viewing in terms of a country, crude oil may be mined and refined into gasoline in the home country, crude oil may be imported and then refined in the home country, or gasoline itself may be imported. In the case of imports, GHG emissions at the mining, transport, and refining stages in the export country should be tracked. Gasoline might be mixed with biofuels and supplied, in which case GHG emissions during the production of the biofuels is also covered.

In the case of electricity, it covers GHG emissions during mining of fossil fuels, which are raw materials, transport to a power generation plant, generation at the plant, transmission to

charge station, and recharging to an electric vehicle. For imported fossil fuels or electricity, emissions from mining, transport, and generation must be covered in the export country, as like gasoline.

Figure 2.1. Energy Flow of Well-to-Tank



Note: Transport is out of scope in this study. This is because the form of transport (ships, pipelines, railroads, trucks, etc.) of each country are complicated, and it is not easy to obtain information such as the transportation mix and transportation distance of each mode.
ERIA = Economic Research Institute for ASEAN and East Asia, GHG = greenhouse gas, IEA = International Energy Agency, IIEJ = Institute of Energy Economics, Japan.
Source: Authors.

2.2. Assumptions

This WTW analysis scopes vehicle types such as internal combustion engine (ICE) vehicles, hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs).[4] To make a comparison amongst the powertrain types, we estimate GHG emissions per 1 kilometre of travel distance. The target fuels are gasoline, biofuel, and electricity.

[4] Fuel-cell electric vehicles are out of scope in this study. This is because the hydrogen supply process is complicated and it is unclear what kind of supply system each country plans.

Table 2.1. CO_2 Factor of Energy for Automobiles

	Well-to-Tank	Tank-to-Wheel
Gasoline	varies by country	2,400 gCO_2/L^*
Biofuel (ethanol)	1,200 gCO_2/L^*	0 gCO_2/L^*
Electricity	varies by country	0 gCO_2/kWh

Note: * litre of gasoline equivalent.
G = gram, kWh = kilowatt hour, L = litre.
Source: Authors.

2.2.1. Assumptions for Tank-to-Wheel

TTW calculates GHG emissions when driving a car. Here, the main factors are distance travelled (gas/electric) and CO_2 factors of energy. They are set as shown in Table 2.1 and Table 2.2. We assume the efficiencies are identical amongst the countries and without any improvement in the future.

Table 2.2. 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%

ICE = internal combustion engine, HEV = hybrid electric vehicle, km = kilometre, kWh = kilowatt hour, L = litre, PHEV = plug-in hybrid electric vehicle, BEV = battery electric vehicle.
Source: Authors.

2.2.2. Assumptions for Well-to-Tank

WTT calculates GHG emissions during the fuel supply process. We describe in detail separately for liquid fuels (gasoline, biofuel) and electricity.

Liquid Fuels

GHG Intensity During Mining

The GHG emissions (per litre of gasoline) during mining crude oil, which is the raw material of gasoline, are set as shown in Table 2.3. For the GHG intensity when mining in domestic oil field, we refer to a paper by Masnadi et al. (2018). Regarding the GHG intensity of imported crude oil, we specify the import source in the trade data in the ASEAN Stats Data Portal (https://data.aseanstats.org/trade-annually), and then estimate average of the intensities of each export country weighted by import value of the top five countries (excluding countries

with less than 3%). We set to fix that the intensity at the mining, the import ratio of crude oil and import source mix at the current level.

Table 2.3. GHG Emissions During Crude Oil Mining

	Domestic Crude Oil[1] gCO_2eq/L^{*4}	Imported Crude Oil[2] gCO_2eq/L^{*}	Import Ratio[3]
Indonesia	489	287	29%
Thailand	163	242	66%
Malaysia	412	258	24%
Viet Nam	283	220	43%
Brunei	182	301	0%

Note: *litre of gasoline equivalent.
GHG = greenhouse gas.
Sources: [1]Masnadi et al. (2018), [2]Authors, [3]Estimated based on IEA (2021), World Energy Statistics and Balances.

GHG Intensity at Refinery

The GHG emissions (per litre of gasoline) during refining crude oil into gasoline are set as shown in Figure 2.5. For the GHG intensity in domestic refinery plant, we estimate based on the International Energy Agency's energy balance statistics. Regarding the intensity of imported gasoline, we specify the import source in the trade data in the ASEAN Stats Data Portal, and then estimate the average of the intensities of each export country weighted by import value of the top five countries (excluding countries with less than 3%). Regarding emissions during crude oil mining for imported gasoline, the intensity of their own country is set in the case of oil-producing countries, whilst in the case of non-producing countries intensity is adopted as the world average assuming importing crude oil. We set to fix that the intensity at the refinery, the import ratio of gasoline and import source mix at the current level.

Table 2.4. GHG Emissions at Refinery

	Domestic Gasoline *1 gCO_2eq/L	Imported Gasoline *2 gCO_2eq/L^{*}	Import Ratio *3
Indonesia	173	405	54%
Thailand	43	377	20%
Malaysia	112	418	56%
Viet Nam	16	494	26%
Brunei	867	463	50%

Note: *litre of gasoline equivalent.
Sources: *1 Estimated based on IEA (2021), *2 Authors. Including GHG emissions at refinery and extraction.

GHG Intensity During Biofuel Production

The GHG emissions (per litre of gasoline) during producing biofuels are set as shown in Table 2.5. We refer to a paper by ERIA (2020) for the intensity and set biofuel blending ratio based on IEEJ's outlook.

Table 2.5. GHG Emissions from Biofuel Production

	Biofuel Production [*1] gCO_2eq/L^*	**Blending Ratio in 2050 [*2]**
Indonesia	1,200	0%
Thailand	1,200	35%
Malaysia	1,200	0%
Viet Nam	1,200	0%
Brunei	1,200	0%

Note: * litre of gasoline equivalent.
Sources: *[1] ERIA (2020),*[2] IEEJ (2021).

GHG Intensity at Refuelling

The pumping loss rate at the gas station is tiny but assumed to be 0.5%, referring to a paper by the Japan Automobile Research Institute (JARI, 2011).

Electricity

GHG Intensity During Mining

The GHG emissions (per ton of oil equivalent) during mining fossil fuels, which is the input or power generation, are set as shown in Table 2.6. The GHG emissions during mining of fuels (coal, oil, natural gas) are calculated based on the IEA's GHG statistics. They include emissions through flare and venting. Regarding the intensity of imported fossil fuels, we specify the import source in the trade data in the ASEAN Stats Data Portal, and then estimate average of the intensities of each export country weighted by import value of the top five countries (excluding countries with less than 3%). We set to fix that the intensity at the mining, the import ratio of fuels and import source mix at the current level.

Table 2.6. GHG Emissions During Fuel Mining

	Domestic Fuels * tCO_2eq/toe			**Imported Fuels ** tCO_2eq/toe**		
	Coal	Oil	Gas	Coal	Oil	Gas
Indonesia	0.10	0.27	0.13	0.20	0.24	0.19
Thailand	0.27 *	0.13	0.09	0.14	0.37	0.16
Malaysia	0.27 *	0.29	0.07	0.15	0.36	0.08
Viet Nam	0.33	0.32	0.10	0.20	0.12	0.19
Brunei	0.27 *	0.16	0.07	0.10	0.41	0.13

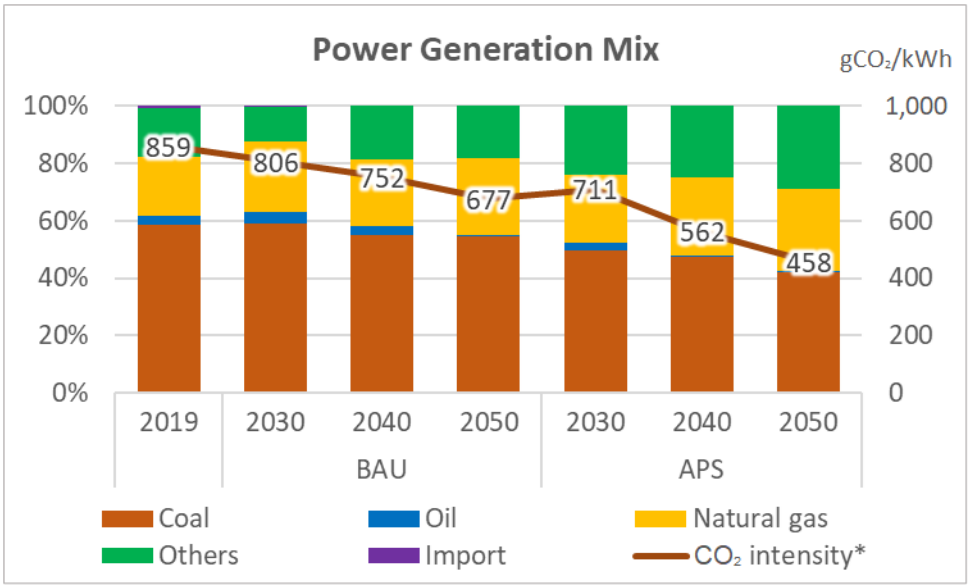
Note: *Global average is applied because data are not available.
Sources: *Estimated based on IEA (2021a, 2021b), ** Authors.

GHG Intensity at Power Generation

The GHG emissions (per kWh) during power generation are estimated based on the power generation mix in ERIA's outlook. The outlook has two scenarios, business-as-usual (BAU) and advanced policy scenario (APS). APS is assumed more aggressive energy efficiency and higher penetration of non-fossil fuels. The power generation mix and GHG emissions are set as shown in Figures 2.2 to 2.6.

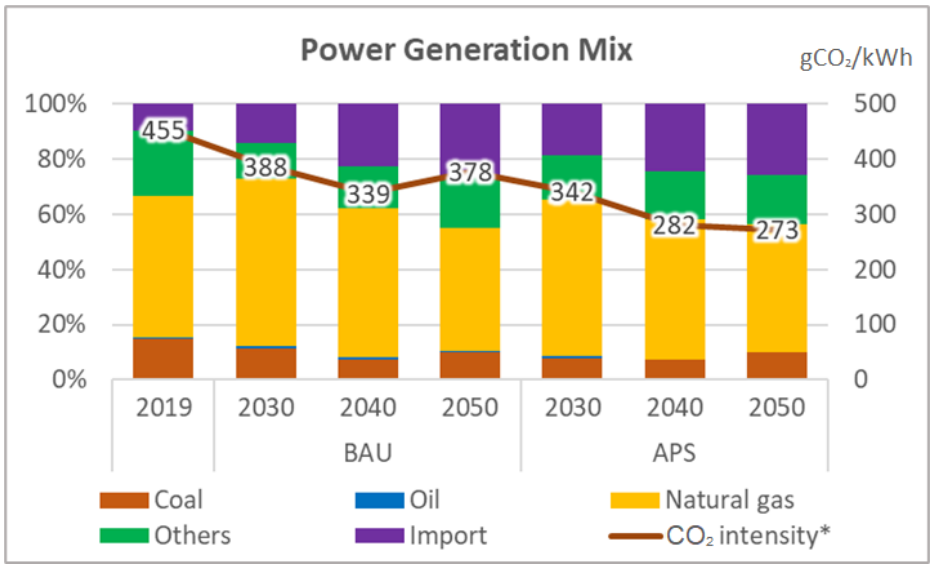
The import of electricity is also included in the power generation mix. The GHG intensities are changing as the generation mix and the import ratio of electricity. Regarding the GHG intensity of imported electricity, we specify the import source in the trade data in the ASEAN Stats Data Portal, and then estimate average of the intensities of each export country weighted by import value of the top five countries (excluding countries with less than 3%). However, it does not cover emissions from mining of imported input fuels in the electricity exporting countries.

Figure 2.2. Power Generation Mix and CO_2 Intensity (Indonesia)



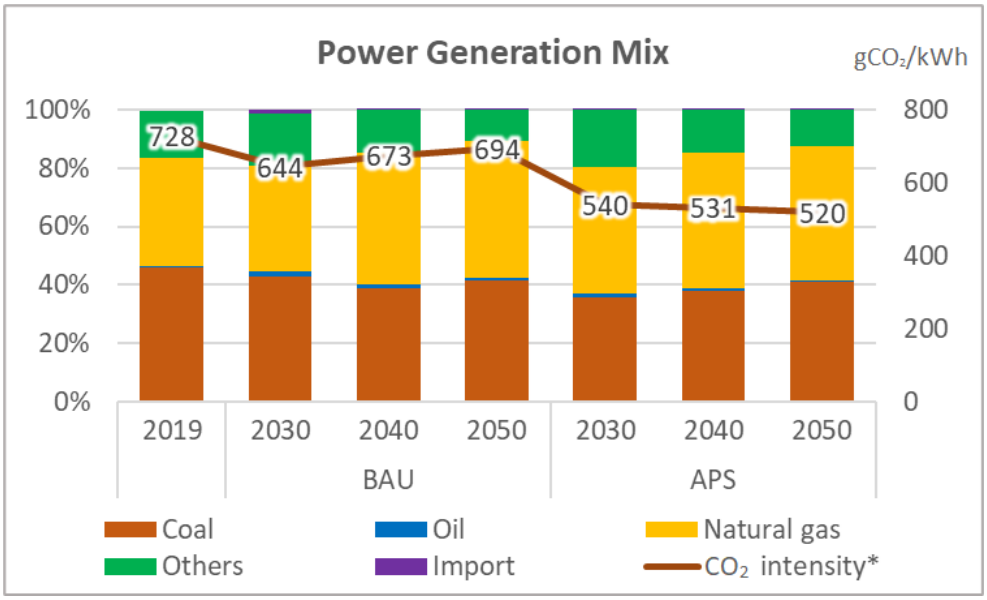
Note: CO_2 intensity is based on receiving end.
BAU = business-as-usual, APS = advanced policy scenario.
Source: Estimated based on ERIA (2021).

Figure 2.3. Power Generation Mix and CO_2 Intensity (Thailand)



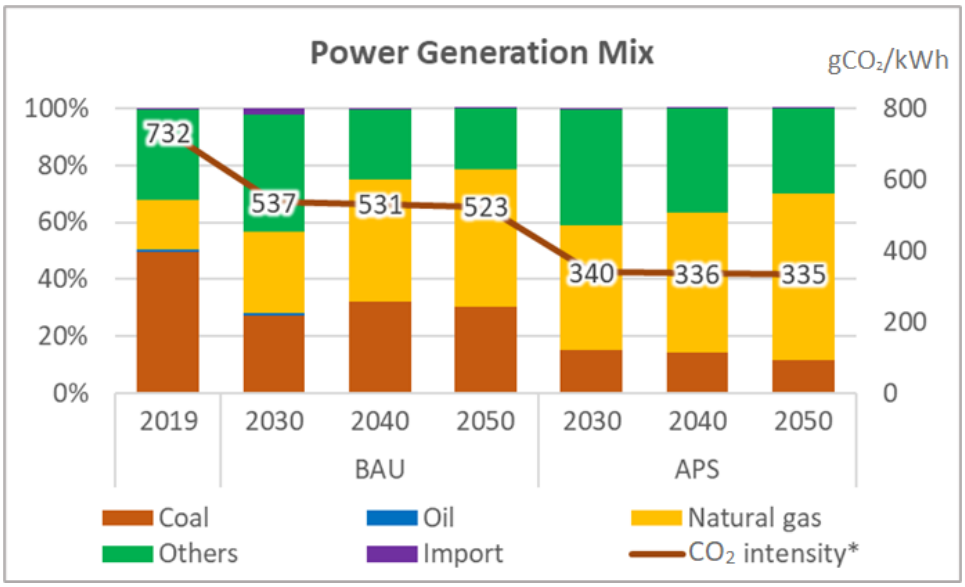
Note: CO_2 intensity is based on receiving end.
BAU = business-as-usual, APS = advanced policy scenario.
Source: Estimated based on ERIA (2021).

Figure 2.4. Power Generation Mix and CO_2 Intensity (Malaysia)



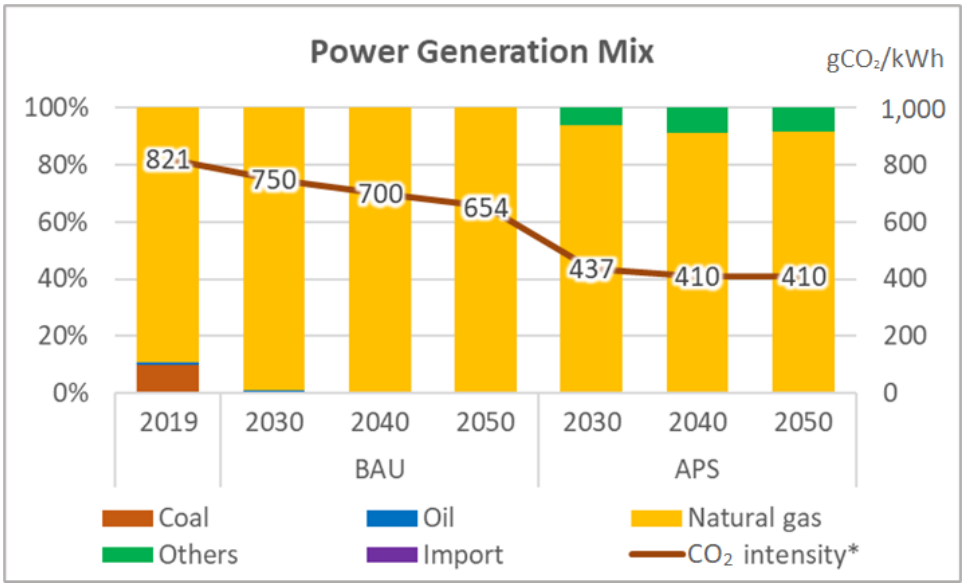
Note: CO_2 intensity is based on receiving end.
BAU = business-as-usual, APS = advanced policy scenario.
Source: Estimated based on ERIA (2021).

Figure 2.5. Power Generation Mix and CO_2 Intensity (Viet Nam)



Note: CO_2 intensity is based on receiving end.
BAU = business-as-usual, APS = advanced policy scenario.
Source: Estimated based on ERIA (2021).

Figure 2.6. Power Generation Mix and CO_2 Intensity (Brunei Darussalam)



Note: CO_2 intensity is based on receiving end.
BAU = business-as-usual, APS = advanced policy scenario.
Source: Estimated based on ERIA (2021).

GHG Intensity at Recharging

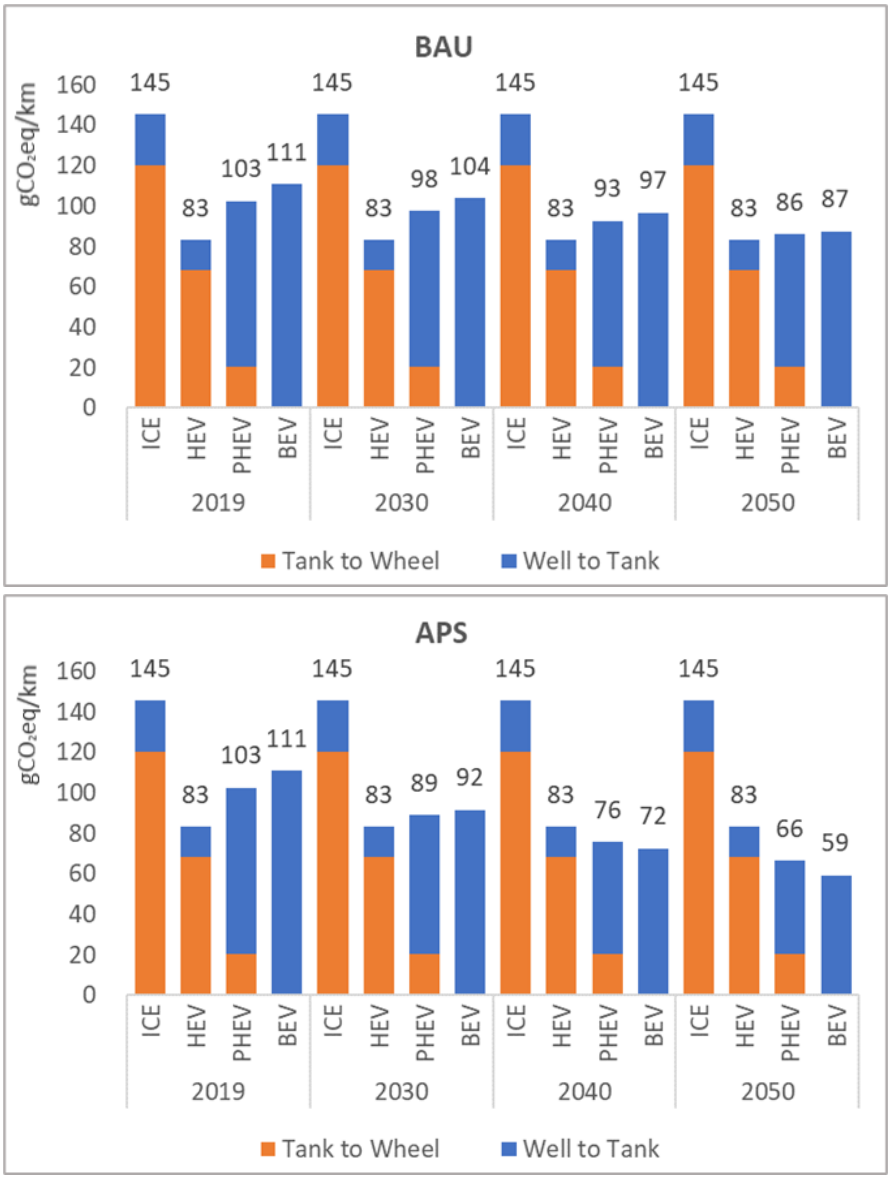
The charging loss is incorporated in the electric mileage of electric vehicles, therefore it is included in TTW but not in WTT.

3. Results

3.1. Indonesia

Figure 2.7 shows the estimation results of the well-to-wheel (WTW) basis emissions based on the BAU scenario and APS generation mix in Indonesia. The country has a large portion of coal-fired power in the generation mix. Therefore, WTW emissions from BEVs are relatively high and emissions from HEVs is the lowest today. In the BAU scenario, HEVs, PHEVs, and BEVs will be at almost the same level, and slightly lower for HEVs, in 2050. Meanwhile, in the APS, where generation efficiency and renewable power are advancing, BEVs will become the lowest emitter from 2040.

Figure 2.7. GHG Emissions based on Well-to-Wheel by Powertrain (Indonesia)

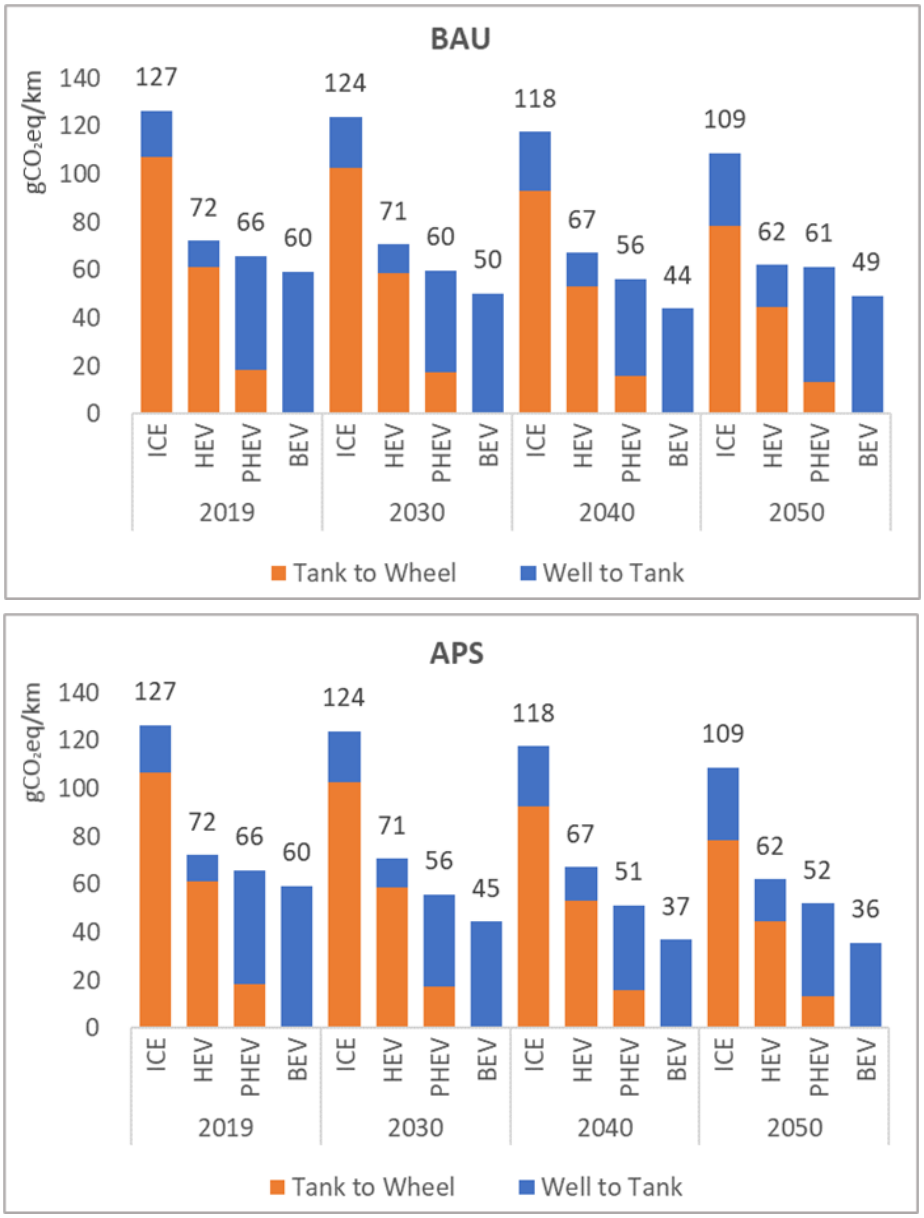


APS = advanced policy scenario, BAU = business-as-usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

3.2. Thailand

Figure 2.8 shows the estimation results of the well-to-wheel basis emissions based on the BAU and APS generation mix in Thailand. The country has relatively clean power with a high proportion of gas-fired power and imported electricity from the Lao People's Democratic Republic, mainly from hydropower. Even at present, BEVs are the lowest emitter, even though TTW emissions are relatively lower due to blending biofuels (E10, E20, E85, etc.). Towards 2050, BEVs will become cleaner relative to other powertrain models.

Figure 2.8. GHG Emissions based on Well-to-Wheel by Powertrain (Thailand)

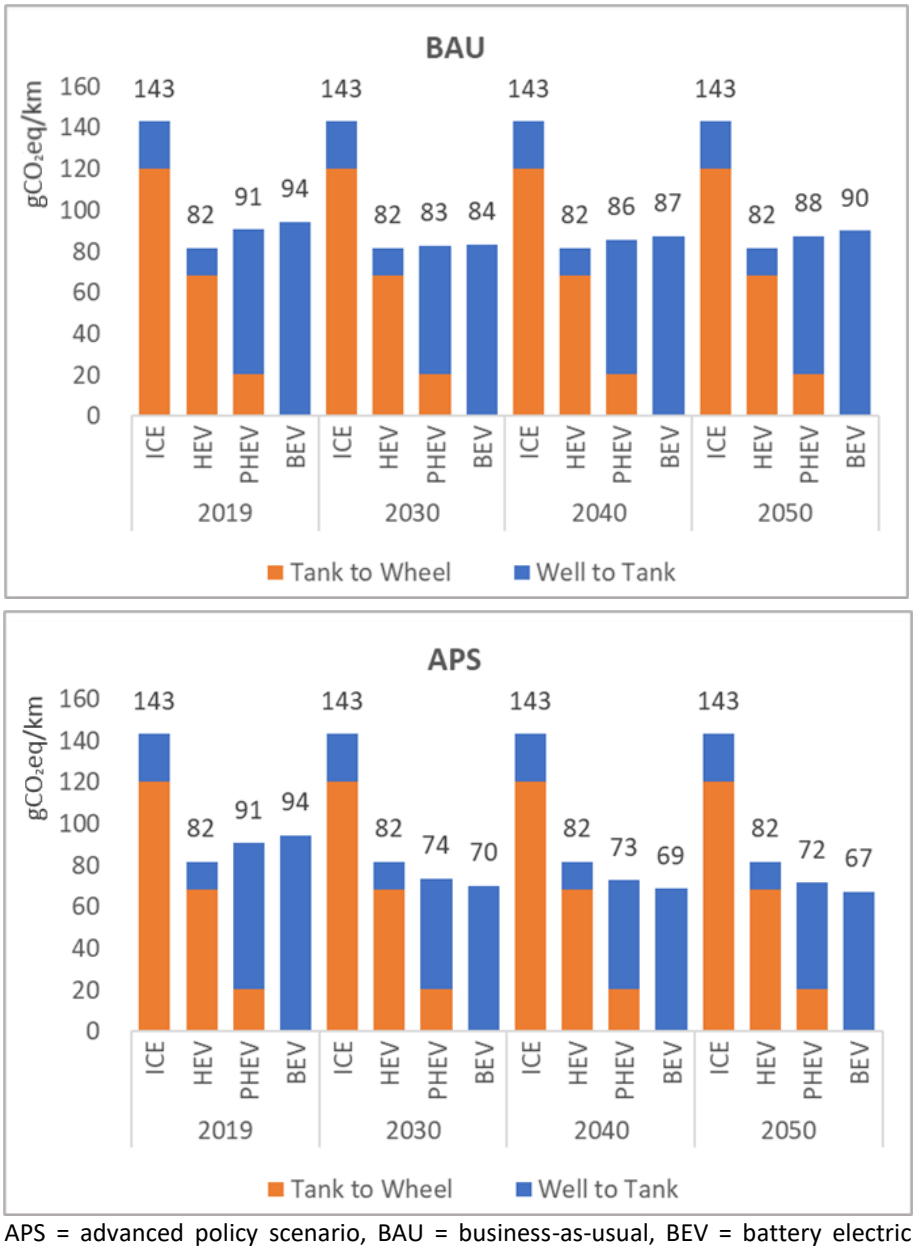


APS = advanced policy scenario, BAU = business-as-usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

3.3. Malaysia

Figure 2.9 shows the estimation results of the well-to-wheel basis emissions based on BAU and APS generation mix in Malaysia. The proportion of coal-fired power is relatively high in the generation mix today. Emissions from HEVs are the lowest today and even in 2050 in the BAU. In the APS, on the other hand, BEVs will become the lowest emitter from 2030.

Figure 2.9. GHG Emissions based on Well-to-Wheel by Powertrain (Malaysia)

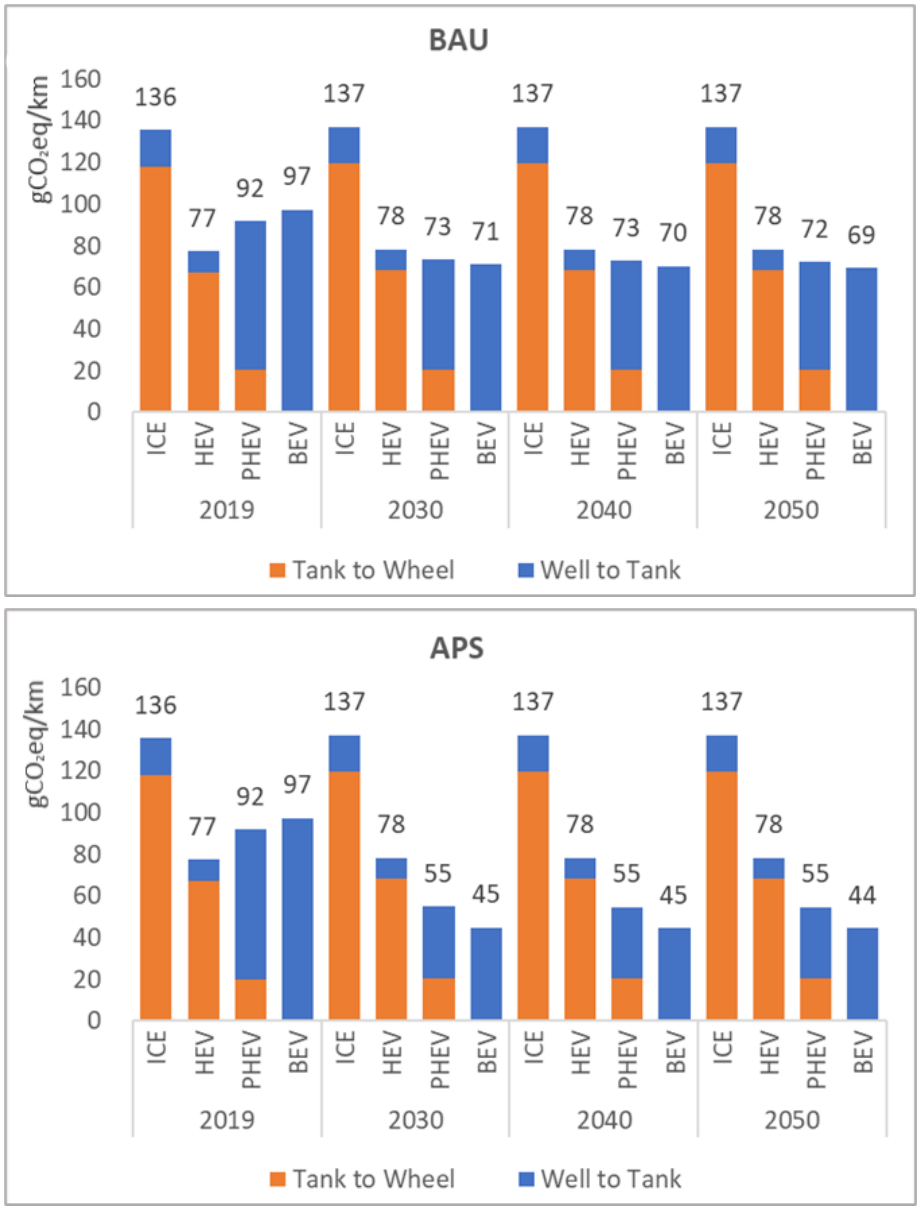


APS = advanced policy scenario, BAU = business-as-usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

3.4. Viet Nam

Figure 2.10 shows the estimation results of the well-to-wheel basis emissions based on BAU and APS generation mix in Viet Nam. The proportion of coal-fired power is relatively high, therefore HEVs is the lowest emitter today. With the introduction of gas-fired power, BEVs will become the lowest emitter after 2030 in both the BAU and the APS.

Figure 2.10. GHG Emissions based on Well-to-Wheel by Powertrain (Viet Nam)

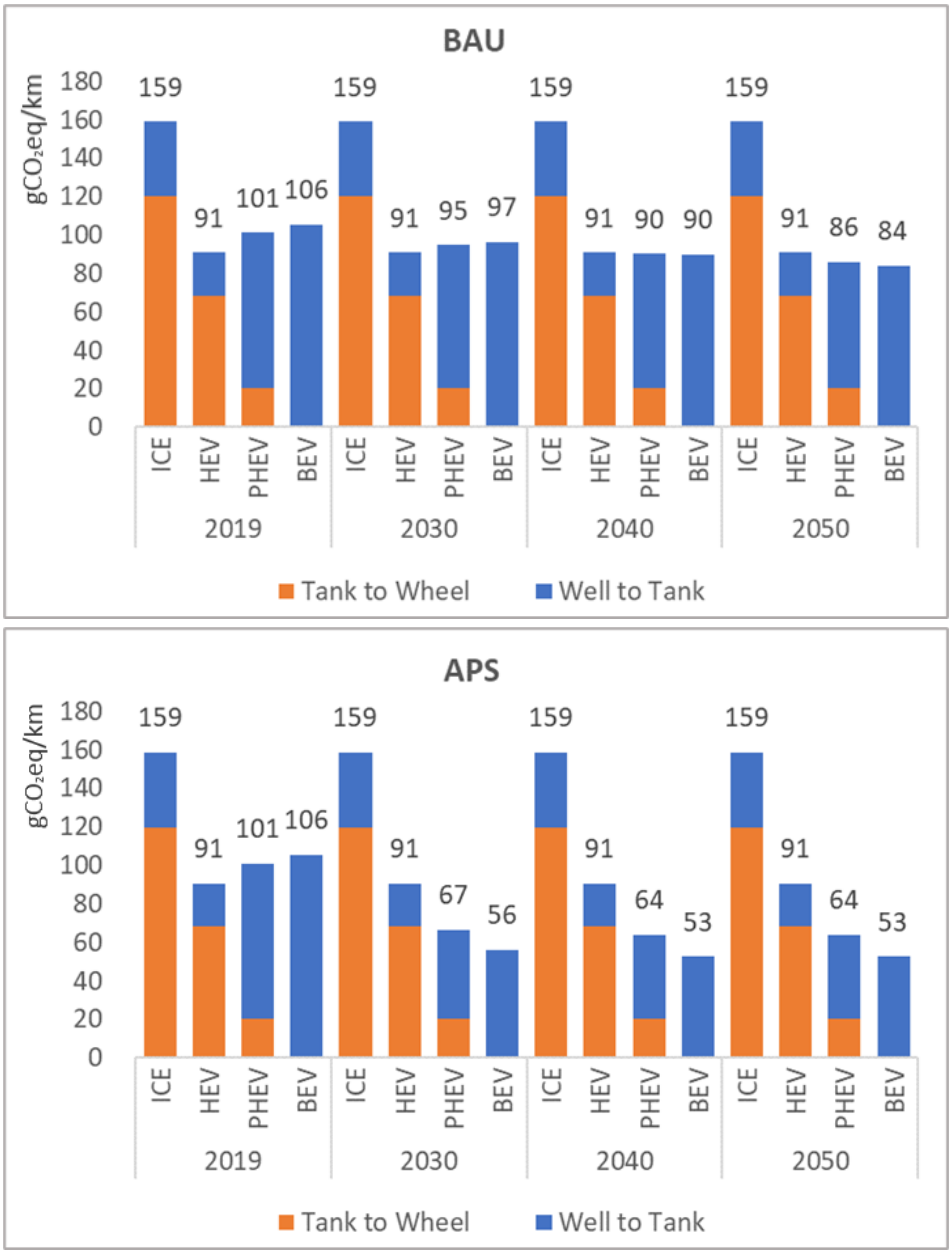


APS = advanced policy scenario, BAU = business-as-usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

3.5. Brunei Darussalam

Figure 2.11 shows the estimation results of the well-to-wheel basis emissions based on BAU and APS generation mix in Brunei Darussalam. Gas-fired power is the mainstream in the country, but the CO_2 intensity of power generation is high due to lower generation efficiency. At present, emissions from HEVs are the lowest. In the BAU, HEVs, PHEVs, and BEVs will be at almost the same level, and slightly lower for BEVs, in 2050. On the other hand, in the APS, BEVs will be the lowest emitter after 2030.

Figure 2.11. GHG Emissions based on Well-to-Wheel by Powertrain (Brunei Darussalam)



APS = advanced policy scenario, BAU = business-as-usual, BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

4. Conclusion

The TTW emissions are almost the same level amongst the studied countries since the fuel efficiencies of automobiles are identical. The emissions are relatively lower in Thailand, where biofuels are introduced. On the other hand, the differences in the WTT emissions amongst the countries are large. The emissions by using liquid fuels do not differ much, meanwhile the emissions by using electricity vary greatly not only amongst countries, but also in terms of the time axis and the scenarios (based on climate change measures).

Namely, the difference in the power generation mix affects the amount of WTW basis emissions. HEVs are the least emitters when the generation mix is dirty, whilst BEVs are the least emitters when it is clean. In the APS where power is cleaner, BEVs become the best option in terms of the WTW basis emissions by 2040 at the latest in all the five countries. It is essential that the automobile electrification progress along with the decarbonisation of the power generation mix.

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Chapter 3

Total Cost of Ownership and Tipping Point of Electric Vehicles in ASEAN Countries

1. Introduction

Amongst the Association of Southeast Asian Nations (ASEAN) countries, diffusion of electric vehicles (EVs) has not made much progress. Of the five analysed countries, three have already announced EV targets, and actions are taken to promote the battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (xEVs) diffusion through providing incentives for consumers and making necessary investments in infrastructure. This chapter presents the analysis of total cost of ownership of EVs and a comparison with internal combustion engine (ICE) vehicles, hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) for five countries in ASEAN: Brunei Darussalam, Indonesia, Malaysia, Thailand, and Viet Nam. The analysis reflects the country-specific factors, including travel distance, fuel economy, energy prices, costs for ownership such as registration fee, tax, and incentives. The total cost of ownership analysis can offer the insights into the cost competitiveness of EVs or identify the areas for further strengthening policy support.

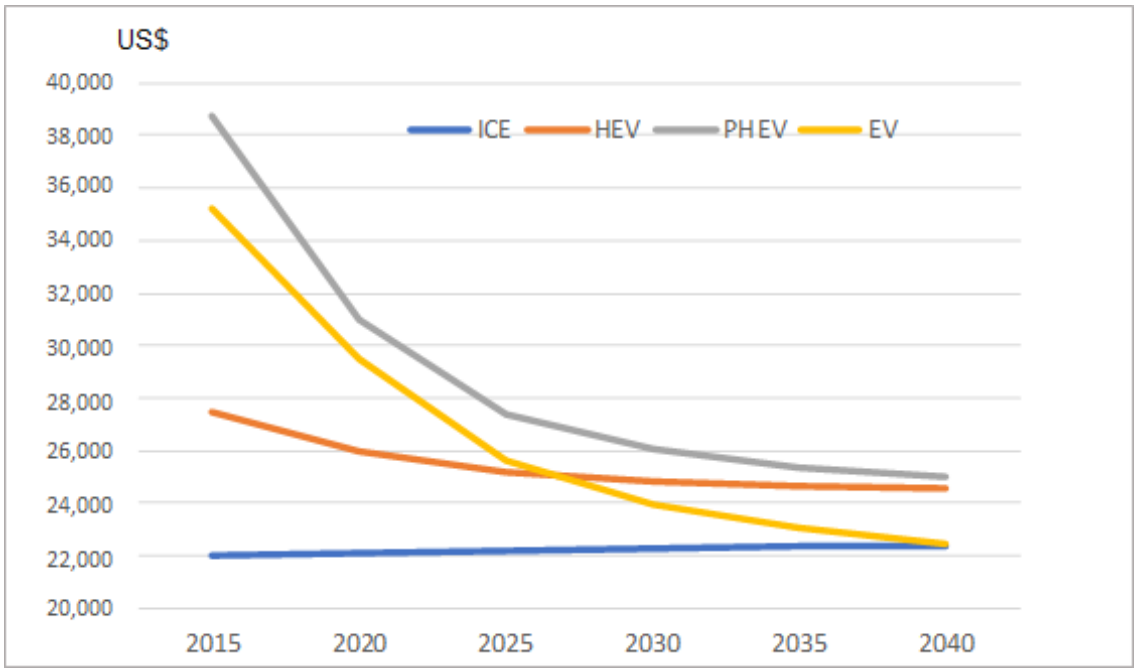
This chapter also presents the analysis results of the tipping point of EVs – when benefits of owing xEVs would surpass that of ICE vehicles and HEVs. Understanding the tipping point of EVs is an important reference as to when EVs would become cost competitive against ICE vehicles for policy planning, business development, and consumers' vehicle purchase. In this analysis, country-specific factors such as fuel economy of ICE vehicles, driving distance, and energy price are considered.

2. Study Method

Total cost of ownership is calculated by taking into consideration the annualised cost of vehicle by powertrain, payments for energy (gasoline, diesel, or electricity), and maintenance. The comparison is made by reflecting differentiated payments for registration, road tax, and excise tax depending on type of powertrain.

For the analysis of tipping point, vehicle costs are estimated up to 2040 (Figure 3.1). The estimated cost represents the basic technology cost, which excludes the other equipment such as safety and interior. The cost of ICE vehicles is assumed to increase slightly from the 2020 level as the technological requirements for fuel economy improve. The cost of HEVs will decline as the cost of batteries decreases; substantial cost reductions are expected with regard to PHEVs and EVs due to the estimated reduction in the cost of lithium-ion batteries.

Figure 3.1. Vehicle Cost Assumptions ($)



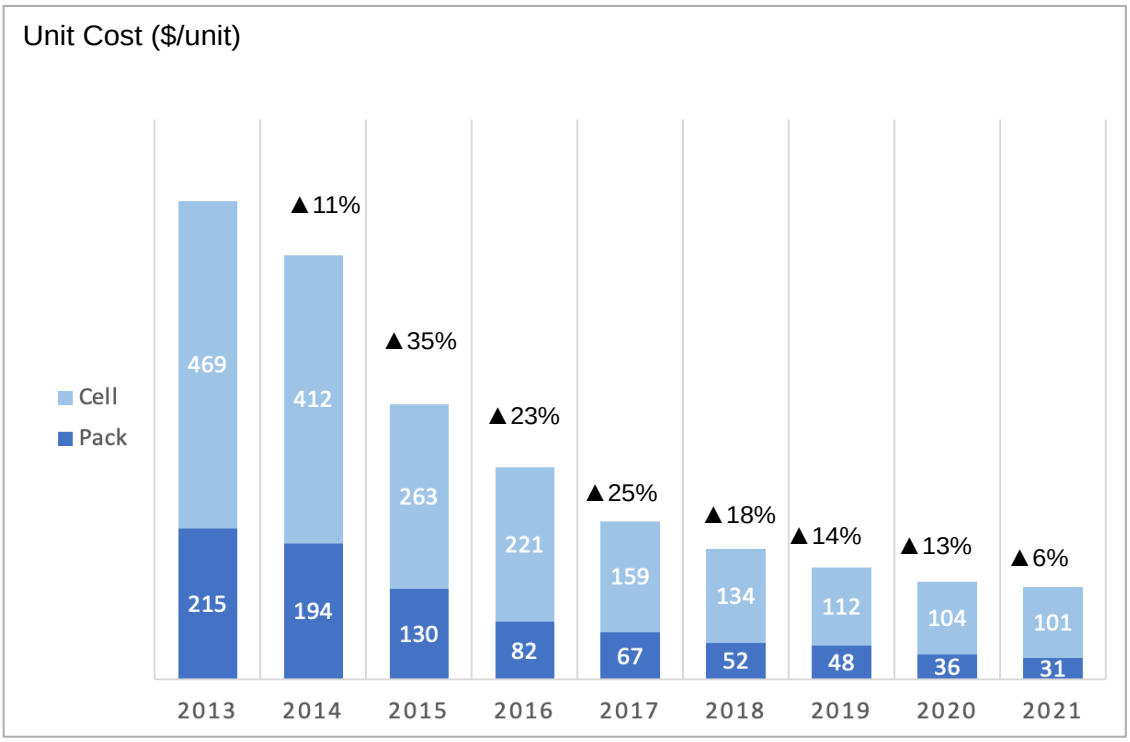
EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

2.1. Estimation of the Cost of Lithium-Ion Batteries

The estimated cost of lithium-ion batteries is critically important for future cost estimations with regard to HEVs, PHEVs, and EVs. In fact, costs have been decreasing substantially over the past few years due to economies of scale, technological improvements, and the ongoing maturation of the manufacturing process (Figure 3.2). The cost of lithium-ion battery modules has decreased from $1,000 per kilowatt hour (kWh) in 2010 to $209 per kWh in 2017, a 79% reduction in 7 years, or an average annual reduction of 20%.

To estimate the cost of lithium-ion batteries, the learning curve analysis method is utilised. The basic concept of the learning curve analysis is that, as the quantity of production unit doubles, the cost of producing a unit decreases by a constant percentage. For example, an 80% learning curve implies that the cost associated with incremental output will decrease to 80% of the previous level (or a 20% reduction from the previous level).

Figure 3.2. Lithium-Ion Battery Module Cost Trends



kWh = kilowatt hour.
Note: The figures include the cell plus pack price.
Source: Bloomberg New Energy Finance (2017).

The learning curve can be explained as follows.

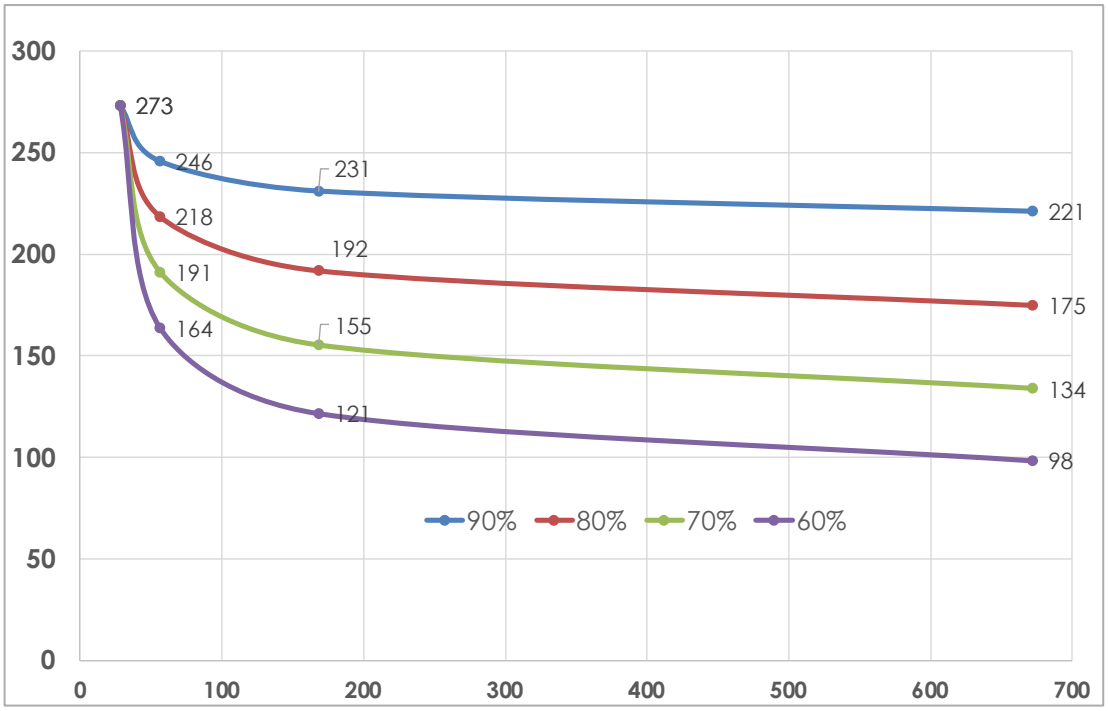
$$Y = AX^b$$

Y = average cost of unit X
A = the first unit cost
X = unit number (cumulative volume)

b = slope coefficient = $\frac{\log(slope\ of\ the\ learning\ curve)}{log2}$

Figure 3.3, which presents an example of lithium-ion battery cost estimates using the learning curve, shows that the estimated cost per kWh differs when production units double, at different learning rate assumptions of 60%, 70%, 80%, and 90%. For example, when lithium-ion battery module production doubles from the current 28 GWh to 56 GWh, the cost is estimated to decrease from $209/kWh to $167/kWh at a learning rate of 80%. When production doubles further to 168 gigawatt hours (GWh), the cost is estimated at $147/kWh at the same learning rate.

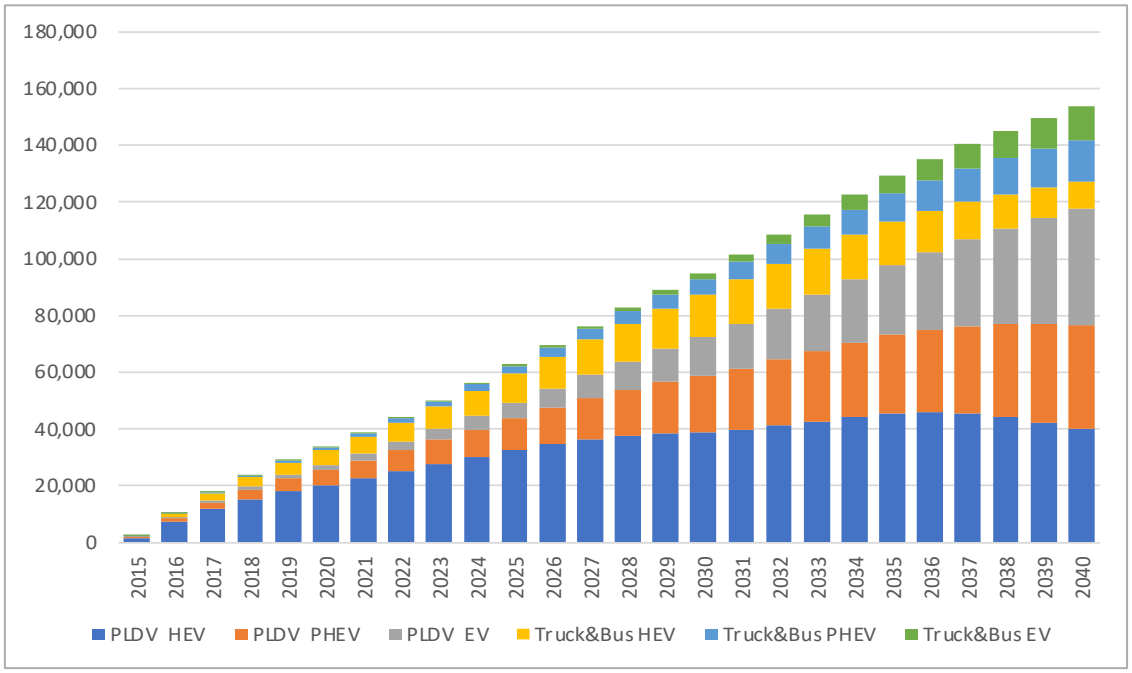
Figure 3.3. Example of Lithium-Ion Battery Cost Estimates Using the Learning Curve



kWh = kilowatt-hour, GWh = gigawatt-hour.
Source: Institute of Energy Economics, Japan (2022).

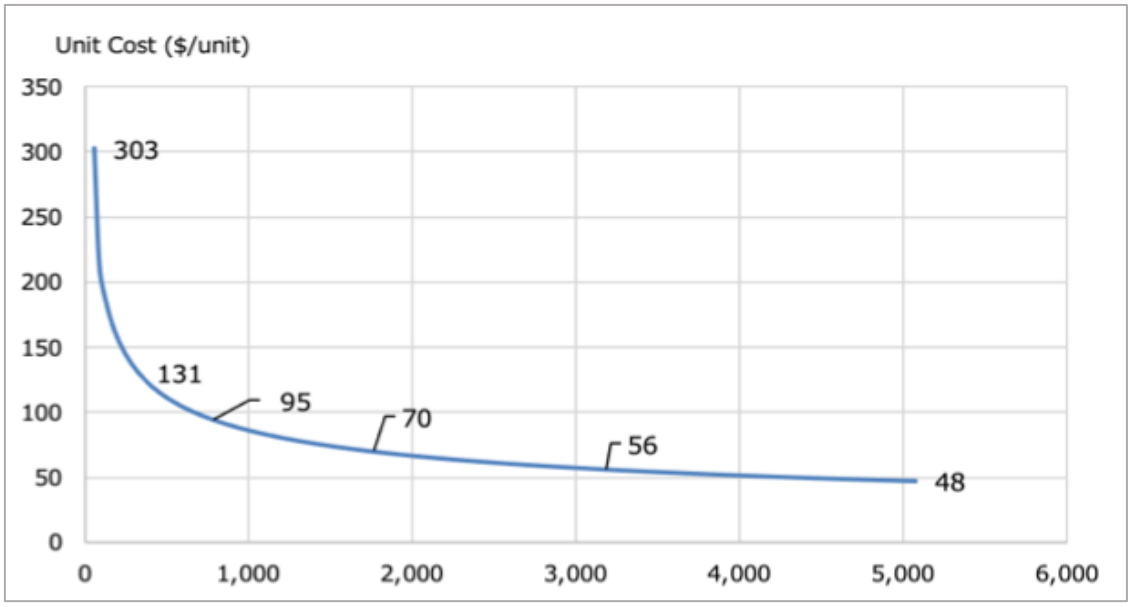
The cost estimate depends on the future production volume of lithium-ion battery modules. This analysis uses the outlook of the Institute of Energy Economics, Japan for lithium-ion battery modules (required to meet the future demand for HEVs, PHEVs, and EVs). The analysis assumes that EVs will account for 30% of total vehicle sales by 2030, and 100% by 2050. According to this analysis, the total production volume of lithium-ion batteries will reach a cumulative 5,076 GWh by 2040, compared to a mere 34 GWh in 2014 (Figure 3.4).

Figure 3.4. Global Outlook for Lithium-Ion Batteries for Hybrid Electric Vehicles, Plug-In Hybrid Electric Vehicles, and Electric Vehicles (Cumulative)



EV = electric vehicle, GWh = gigawatt-hours, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: Institute of Energy Economics, Japan (2021).

Figure 3.5. Estimated Cost of Lithium-Ion Batteries (2016–2040)



kWh = kilowatt hour.
Source: Institute of Energy Economics, Japan (2018).

Figure 3.5, which shows the estimated cost of lithium-ion battery modules up to 2040 at the learning rate of 75%. This demonstrates the estimated relationship between the cumulative production of lithium-ion batteries by 2040 and corresponding module cost per kWh. As the figure shows, this cost is projected to decline to $72/kWh by 2030, and further to $51/kWh by 2040.

2.2. Tipping Point Analysis Framework

Table 3.1 shows the total annual cost of using each type of passenger vehicle technology from 2015 to 2040. Gasoline or electricity costs for each type of technology (included in the table) are calculated by determining the energy requirements for driving a distance of 10,000 km per year. The maintenance cost is smaller for PHEVs and EVs compared with those for ICE vehicles and HEVs, due to their relatively simple technological composition. However, PHEVs and EVs require personal chargers, incurring additional costs.

Table 3.1. Cost of Driving by Type of Technology

		2015	2020	2025	2030	2035	2040
ICE							
Initial Vehicle Purchase	$/10 years	22000	22066	22165	22248	22319	22381
Vehicle Purchase	$/year	2420	2427	2438	2447	2455	2462
Gasoline	$/year	493.8	477.7	462.4	444.6	427.1	409.9
Maintenance	$/year	121.0	121.4	121.9	122.4	122.8	123.1
Total Annual Cost	**$/year**	**3035**	**3026**	**3022**	**3014**	**3005**	**2995**
HEV							
Initial Vehicle Purchase	$/10 years	27500	25992	25175	24835	24651	24537
Vehicle Purchase	$/year	2915	2755	2669	2633	2613	2601
Gasoline	$/year	334	304	297	291	284	277
Maintenance	$/year	73	69	67	66	65	65
Total Annual Cost	**$/year**	**3322**	**3128**	**3033**	**2989**	**2962**	**2943**
PHEV							
Initial Vehicle Purchase	$/10 years	38500	31000	27410	26083	25388	24959
Vehicle Purchase	$/year	4043	3255	2878	2739	2666	2621

		2015	2020	2025	2030	2035	2040
Gasoline+Electricity	$/year	229	208	206	204	201	199
Maintenance	$/year	101	81	72	68	67	66
Personal charger	$/year	72.8	58.6	51.8	49.3	48.0	47.2
Total Annual Cost	**$/year**	**4445**	**3603**	**3208**	**3060**	**2982**	**2932**
EV							
Initial Vehicle Purchase	$/10 years	35200	29502	25639	23974	23054	22472
Vehicle Purchase	$/year	3696	3098	2692	2517	2421	2360
Electricity	$/year	144.4	131.9	130.2	130.2	129.5	128.8
Maintenance	$/year	92	77	67	63	61	59
Personal charger	$/year	66.5	55.8	48.5	45.3	43.6	42.5
Total Annual Cost	**$/year**	**3999**	**3363**	**2938**	**2756**	**2654**	**2590**

EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

In this study, a tipping point analysis is being made for passenger vehicles and motorcycles, whilst the analysis for buses and trucks is excluded as the standardised size for these modes cannot be obtained.

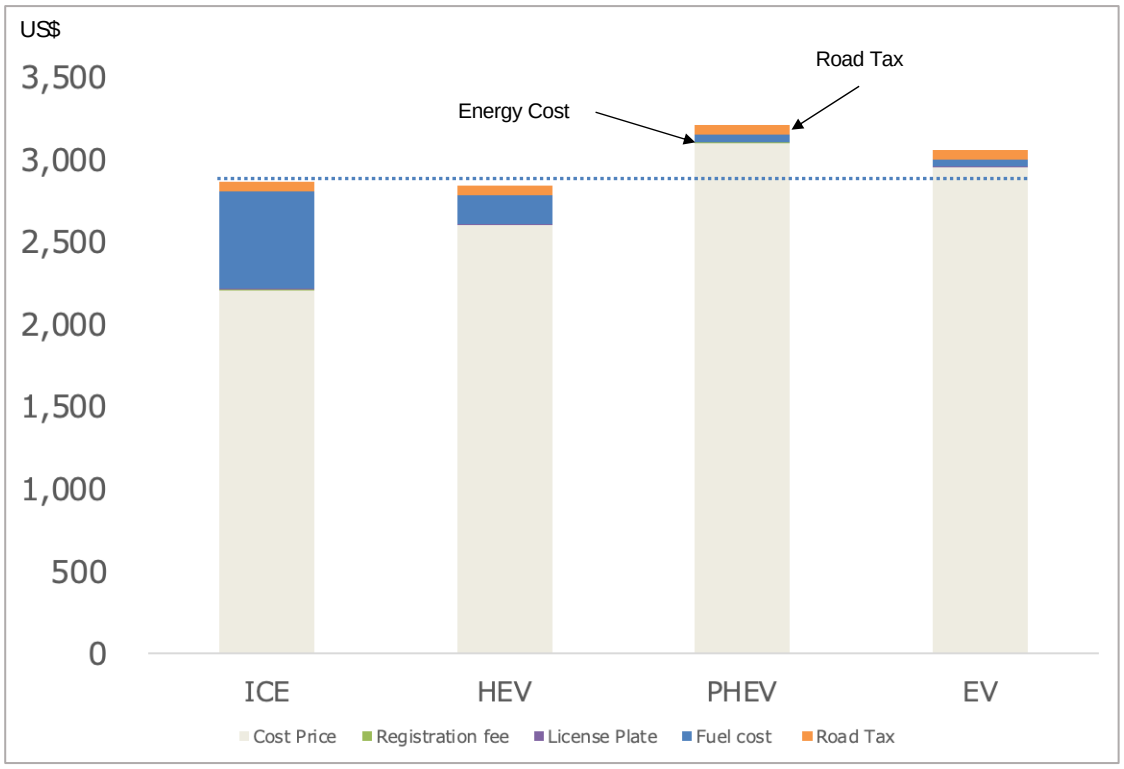
3. Analysis Results

3.1. Brunei Darussalam

Figure 3.6 shows Brunei's annualised total cost of passenger vehicle ownership in 2022. As the figure shows, no incentives are provided to EV owners yet, nevertheless, low electricity price at 0.08 cent/kWh would benefit the EV owners.

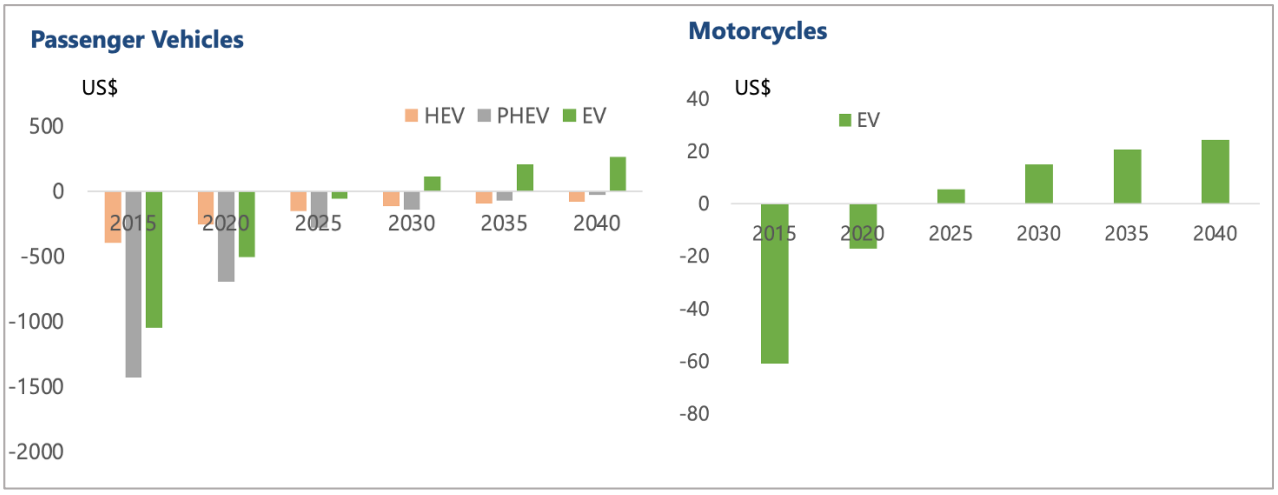
The tipping point for EV passenger vehicles would be sometime after 2030 due to the relative low gasoline/diesel price in contrast to electricity (Figure 3.7).

Figure 3.6. Brunei Darussalam's Total Cost of Passenger Vehicle Ownership (2022)



EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

Figure 3.7. Brunei Darussalam's Tipping Point for Passenger Vehicles and Motorcycles



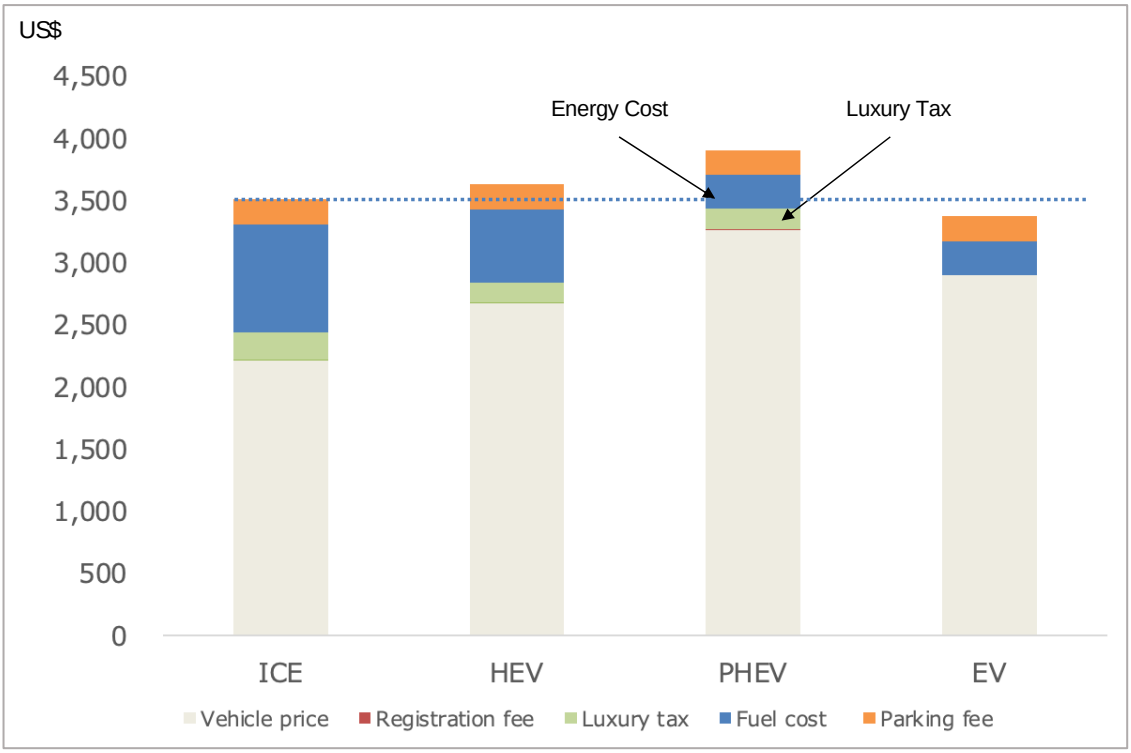
EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

3.2. Indonesia

As Figure 3.8 shows, annualised EV's total cost of ownership for passenger vehicles is lower than ICE vehicles. In Indonesia, as the incentive for consumers, luxury tax is differentiated by powertrain. Besides, PLN offers a 30% electricity tariff discount between 10:00 pm to 5:00 am for those who own EVs.

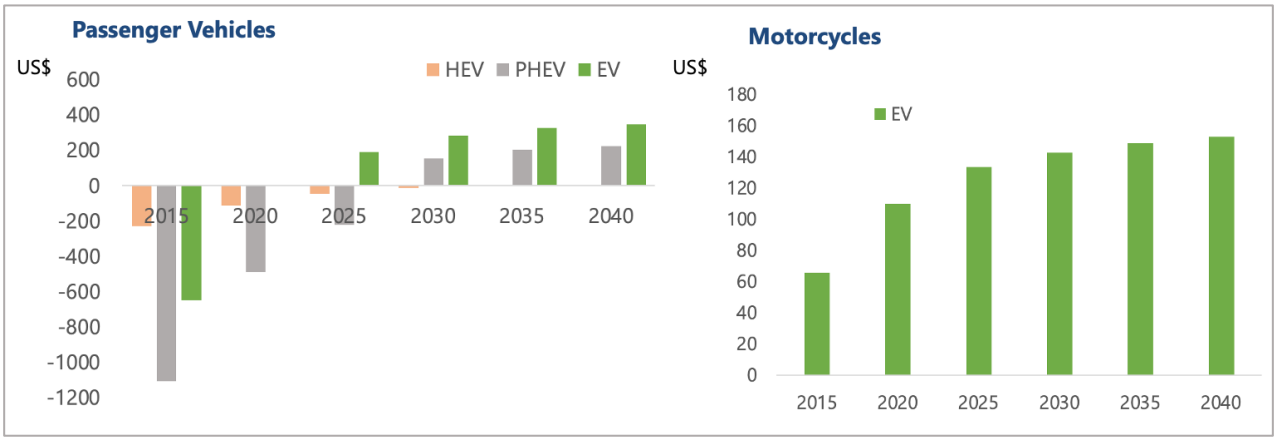
The tipping point for Indonesia's passenger vehicles would be sometime after 2025 (Figure 3.9). Relative low electricity price would benefit the EV owners. For buses and trucks, combination of low fuel economy of buses/trucks and relative low electricity price would benefit the EV owners.

Figure 3.8. Indonesia's Total Cost of Passenger Vehicle Ownership (2022)



EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

Figure 3.9. Indonesia's Tipping Point for Passenger Vehicles, Buses and Trucks, and Motorcycles

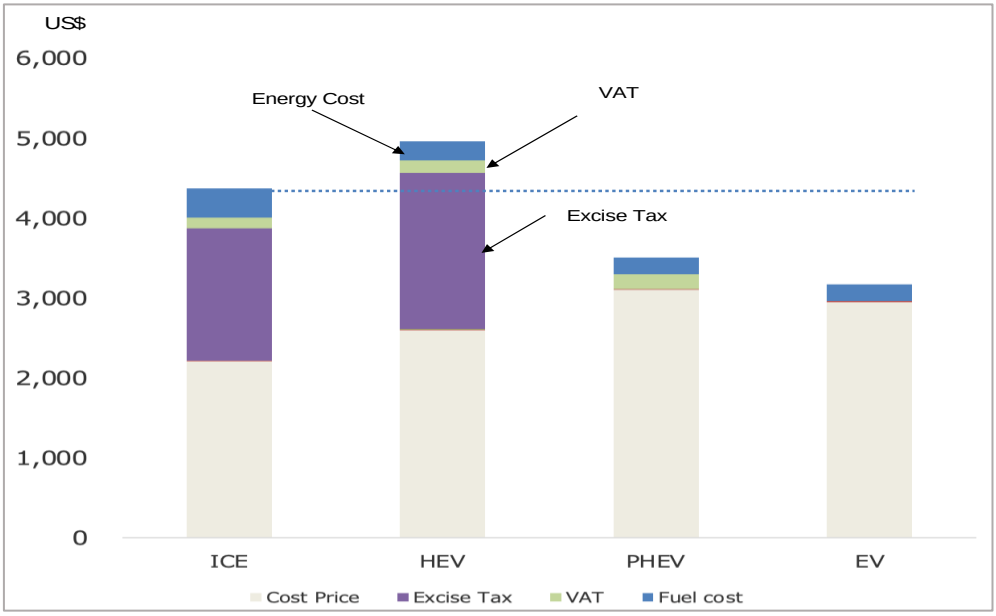


EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

3.3. Malaysia

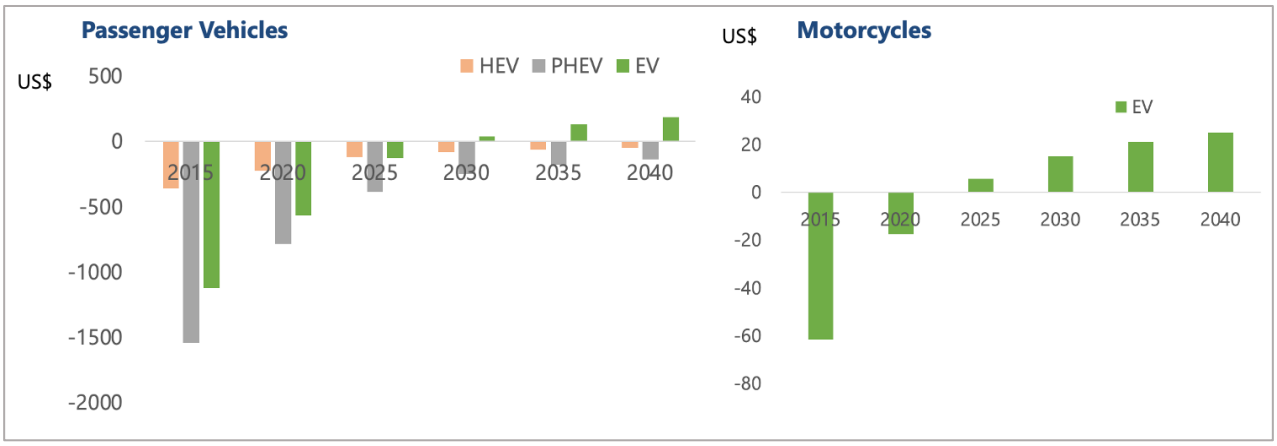
In Malaysia, various incentives are planned in the Low Carbon Mobility Blueprint 2021-2030, including the exemption of excise tax and value added tax (VAT). Exemption of excise tax would greatly benefit EV owners despite the low gasoline price at $0.466/litre. In contrast, as Figure 3.11 shows, unless economic incentives are provided, the cost of owning EVs would be much higher than that of ICE vehicles due mainly to the low gasoline/diesel price (46% lower than electricity in toe terms).

Figure 3.10. Malaysia's Total Cost of Passenger Vehicle Ownership (2022)



EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle, VAT = value added tax.
Source: Institute of Energy Economics, Japan (2022).

Figure 3.11. Malaysia's Tipping Point for Passenger Vehicles, Buses and Trucks, and Motorcycles



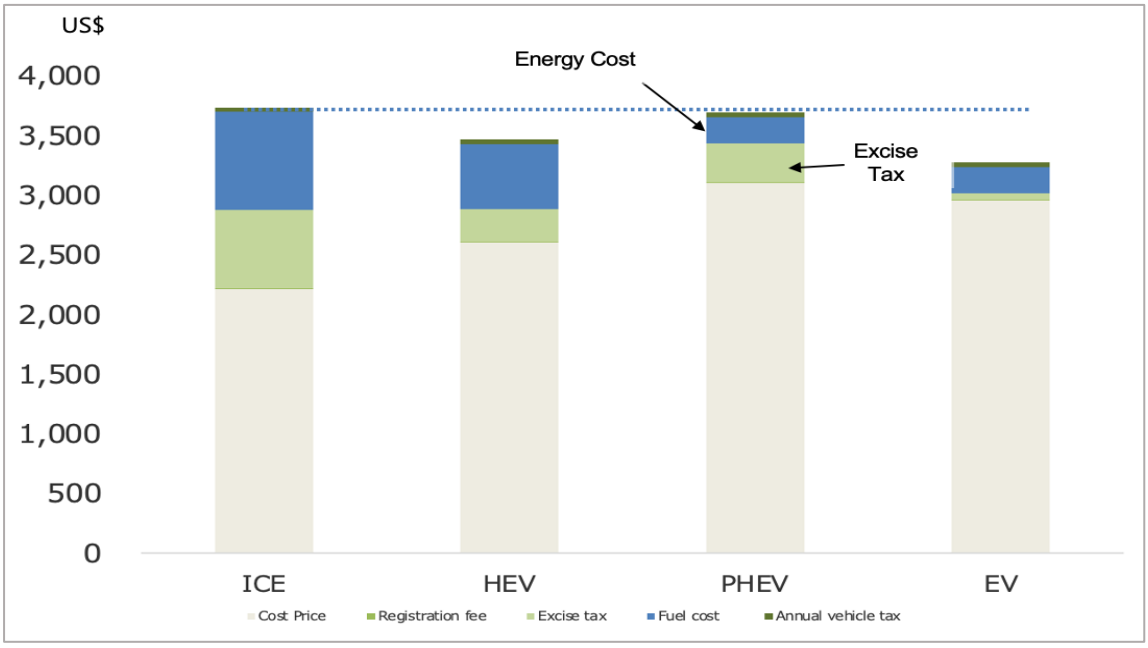
EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

3.4. Thailand

As Figure 3.12 shows, incentives in the form of lower excise tax for EV owners and high gasoline price at US$1.435/litre would benefit the EV owners against that of ICE.

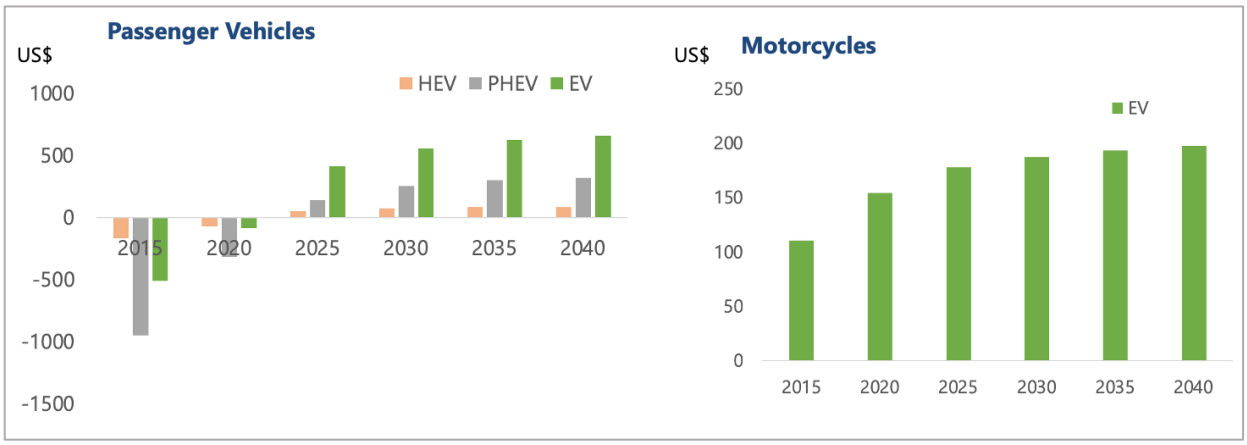
Unless economic incentives are provided, the cost of owning EVs would be much higher than that of ICE vehicles. Provision of economic incentives (in a form of tax waiver) needs to be maintained by 2025 (Figure 3.13).

Figure 3.12. Thailand's Total Cost of Passenger Vehicle Ownership (2022)



EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

Figure 3.13. Thailand's Tipping Point for Passenger Vehicles, Buses and Trucks, and Motorcycles



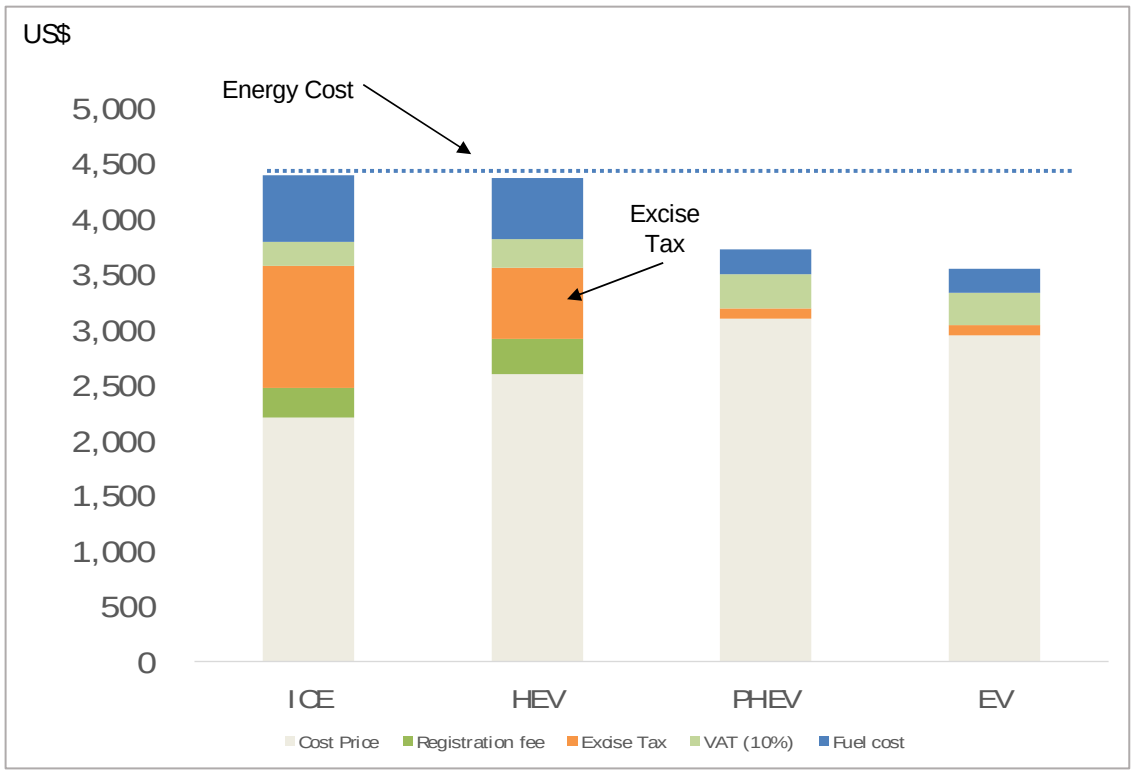
EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

3.5. Viet Nam

As Figure 3.14 shows, incentives in the form of lower excise tax for EV owners and high gasoline price at US$1.324/litre (or low electricity price at 8 US cent/kWh) would benefit the EV owners against that of ICE.

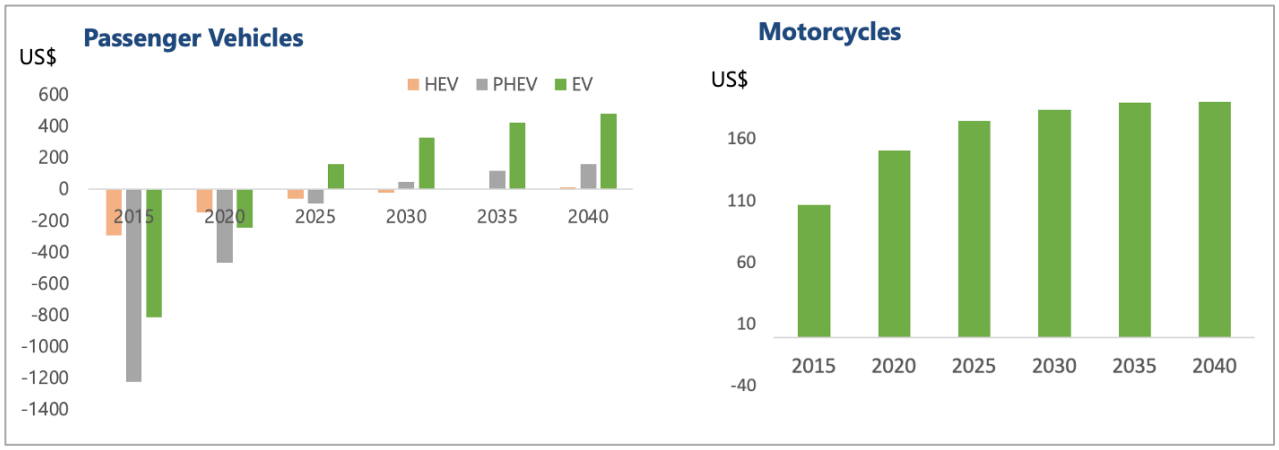
The tipping point for EVs for passenger vehicles would be sometime after 2025, whilst that for buses and trucks would be much earlier (Figure 3.15). Fuel efficiency of buses and trucks is low (almost one quarter of EVs); therefore, a combination of low fuel efficiency and low electricity price (44% lower than that of diesel) would benefit EV owners.

Figure 3.14. Viet Nam's Total Cost of Passenger Vehicle Ownership (2022)



EV = electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

Figure 3.15. Viet Nam's Tipping Point for Passenger Vehicles, Buses and Trucks, and Motorcycles



EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2022).

4. Conclusions

The five analysed ASEAN countries offer different incentives for the wider diffusion of EVs. The methods are mainly focused on passenger vehicle ownership, in a form of differentiated luxury tax (Indonesia), exemption of excise tax (Malaysia), and lower excise tax (Thailand and Viet Nam). Discounts on electricity prices as provided by Indonesia can benefit EV owners as well. No countries have yet provided subsidies for EV owners.

For passenger vehicles, the tipping point (when the benefit of owning EVs would surpass that of ICE vehicles) may come sometime between 2025 and 2030. However, it is important to note that the timing for the tipping point would be different based on the assumptions. Particularly, the main factor affecting the tipping point would be the declining cost of lithium-ion batteries. If the assumed 75% learning rate cannot be achieved (for the high demand surpassing that of supply) in the near-term, the tipping point would be delayed to a much later time. Other factors such as longer vehicle ownership and need for EV battery replacement (if it is beyond a 10-year lifetime) are not considered in this study. This would substantially increase the cost of passenger vehicle ownership, thus the tipping point would be delayed from the estimated timing.

Aside from the initial cost of vehicle purchase, operational costs – particularly energy prices – continue to be the important factor for an owner's decision on the vehicle purchase. Future 'average' electricity prices may increase because of the need for new replacement for low-carbon energy sources. Instead of providing the flat rate, time of use pricing for electricity may encourage the purchase of EVs.

The benefits of driving e-motorcycles have already outweighed that of conventional motorcycles (excluding the case in Brunei Darussalam). Charging infrastructure development as well as business development should be ready for the expected rise in e-motorcycles.

Chapter 4

SWOT Analysis of EV Introduction in Brunei Darussalam, Indonesia, Malaysia, Thailand, and Viet Nam

1. Introduction

This chapter presents the result from strengths (S), weaknesses (W), opportunities (O), and threats (T) (SWOT) analysis regarding electric vehicle (EV) deployment strategies for five Association of Southeast Asian Nations (ASEAN) countries: Brunei Darussalam, Indonesia, Malaysia, Thailand, and Viet Nam. A summary of the five countries' SWOT is shown in the Table, SWOT Reference. Based on the analysis, the study draws a few policy implications for each country for their wider diffusion of EVs.

2. Brunei Darussalam

- **Bus electrification (public bus and school bus) may be the best initial target.**

(Energy, Climate Change)

(O): The national transportation policy, Land Transportation Master Plan recognises the importance of energy efficiency and CO_2 reduction.

(Policy on Transport Electrification)

(S): The National Green development policy has a year 2035 target to reduce CO_2 emissions by 40% during the morning peak hours.

(S): The National Green development policy has target with public bus transportation system development increase by 22% by 2035, especially developing the national school bus system.

(Transport Infrastructure)

(O): The government of Brunei recognises the importance of energy efficiency with a vehicle fuel efficiency standard and the public bus system deployment.

- **The government of Brunei Darussalam may want to make sizable investments on clean power resources, when the fossil fuel export brings large revenues.**

(Energy, Climate Change)

(S): The electricity tariff is inexpensive by government control.

(W): Power generation is almost entirely dependent on domestic fossil fuels.

(W): The power consumption per capita is big enough, as much as the top consumption Singapore, more than twice as much as Thailand or Indonesia.

(T): Until the power sector CO_2 emissions are reduced with fewer fossil fuel generations, the greenhouse gas (GHG) reduction by transportation electrification will remain minimum.

3. Indonesia

- **To establish an EV production hub in Indonesia, it is important to become one of the top battery production countries. The government may want to keep close partnerships with Chinese and the Republic of Korea's battery manufacturers to establish domestic production factories. Making EV manufacturing early commitment to purchase the good size of domestic batteries, in return for tax incentives, may help the initial stage of domestic battery production business.**

(Energy, Climate Change)

(S): Indonesia has plenty of precious minerals, such as nickel and cobalt.

(Auto Manufacture Industry)

(S): Indonesia's auto industry is the second largest in ASEAN region.

(S): A new battery production company has been established with four national corporations as a joint investment.

(O): Indonesia has an advantage of battery production by abundant precious mineral resources.

(T): The battery electric vehicle (BEV) production investment policy incentives are not equivalent with those by Thailand.

- **Considering the size of investments on domestic battery production factories, the domestic EV production factories, and the EV charging infrastructure, with relatively higher prices of EVs, Indonesia may want to start with motorbike electrification. The electric motorbike cost barrier is not significant and electric motorbikes may not require many charging stations for a while. The big size of motorbike electrification may also help to decrease the gasoline demand growth as well as improving air quality in big cities.**

(Energy, Climate Change)

(W): Increasing gasoline demand is worsening the international trade balance.

(Policy on Transport Electrification)

(W): There is limited charging infrastructure.

(O): Trials of battery-swapping are carried out with electric motorbikes.

(T): Battery swapping model may not become a popular model.

(Auto Market)

(S): The motorbike market size is four times bigger than the car market, and it will keep growing.

(O): With a large market size of motorbikes, electric motorbike deployment may result with a sizable GHG reduction as well as the decrease of gasoline demand growth.

- **The government may want to accumulate the knowledge and experiences on charging stations development as well as effective charging tariff development through government support pilot projects, with the lead of PLN.**

(Policy on Transport Electrification)

(O): The development of charging infrastructure, the charging tariff, and the transportation electrification policies are well under control of the government.

(O): Official licensing of the electricity business is required for a charging business; players should have adequate technology and safety skills.

(O): Trials of battery-swapping are carried out with electric motorbikes.

(T): A robust system of charging service business with a requirement of licensing may prevent business innovations with continuous technology evolvement and market changes.

(T): Battery swapping model may not become a popular model.

(Auto Manufacture Industry)

(W): EV/battery knowledge and experiences are limited, and more skilled human resources are required.

(W): The battery knowledge and engineering are dominated by Chinese and Republic of Korean players.

- **It is important to decrease the dependence on fossil fuel power and to accelerate the clean power resources development.**

(Energy, Climate Change)

(W): Power generation may keep depending on fossil fuels.

(T): Until the power sector CO_2 emissions are reduced with less fossil fuel generation, the GHG reduction by transportation electrification will remain minimum.

- **It is important to invest in the power grid capacity and reliability, so that electricity demand increase by growing the economy and the additional EV charging loads will be met.**

(Energy, Climate Change)

(W): The efficiency of power generation and the transmission may need to improve.

(W): Geographical islands separation hinders the cross regional power transmission capacities.

(W): The politically-controlled low electricity tariff has limited the grid investment. The grid capacity improvement is necessary.

4. Malaysia

- **With the smaller domestic auto industry with lower growth in car sales, government investment on EV production may not be effective compared with neighbouring Thailand and Indonesia. Two national car manufacturers may lead the EV deployment in the domestic market.**

(Policy on Transport Electrification)

(W): Lower EV deployment target, compared with neighbouring ASEAN countries.

(W): A fewer policy incentives are provided, compared with neighbouring ASEAN countries (Thailand, Indonesia).

(Auto Market)

(W): The car sales market is already saturated.

(Auto Manufacture Industry)

(S): Malaysia has two national car manufacturers, Proton and Perodua.

(W): The EV production incentives are not attractive enough to bring manufacturing investment.

(T): Two national car manufacturers are both practically managed by (i) a Chinese entity (Proton with GWM), and (ii) a Japanese entity (Perodua by Daihatsu). Their business strategy may not perfectly align with the government policy.

(Transport Infrastructure)

(W): There is limited charging infrastructure.

- **Malaysia has advantages in digital technologies. Malaysia may be able to develop a unique position to provide software platforms and services, such as charging service applications, optimum charging control, car sharing/ride hailing platform, and battery assessment.**

(Auto Market)

(O): Malaysia Automobile Robotic IOT Institute (MARii)) and PEKEMA (Automobile Import Association) are jointly investing in the EV Center of Excellence (COE). The COE intends to become the regional hub for EV maintenance, repair, and customer support.

5. Thailand

- **Thailand has already implemented key strategic policies to enhance the BEV production industry to become a global production hub of electric vehicles and parts. Additional measures to strengthen the key technology, namely EV battery production will be the focus policy area.**

(Policy on Transport Electrification)

(S): The government of Thailand has clear BEV focus policies, especially to become the global BEV production hub.

(O): The government has a clear policy to become an EV global production hub by keeping the car industry strength. More domestic and international EV policy communication will help to understand such policies.

(O): The government of Thailand is considering the update of EV30@30 plan to EV50% by 2030.

(Auto Market)

(O): Many auto manufacturers are starting to enter the BEV market.

(T): Available BEV models are either in high-end import models with longer range of 200–480 kilometres, or the low-end models with less than 160 kilometre range. There is less choice in the most needed middle range.

(Auto Manufacturing Industry)

(O): Many auto manufacturers are starting to enter the BEV market.

(O): PTT and Foxconn (Taiwan) has set a joint venture to develop an EV production platform.

(T): Although there are incentives for BEV production, the standalone battery import is still subjected to import taxes, and auto manufactures need to speed up domestic battery production.

- **The government of Thailand may want to develop a new electricity tariff for EV charging.**

(Energy, Climate Change)

(O): The transport sector has a big potential in reducing GHG emissions, the sector is currently responsible for as much as 30%of emissions.

(T): The decrease of cheap domestic natural gas production with more expensive LNG import increase are affecting the electricity rates rise.

(Policy on Transport Electrification)

(S): The government of Thailand has clear BEV focus policies, especially to become a global BEV production hub.

(O): The government of Thailand is considering the update of EV30@30 plan to EV50% by 2030.

(Auto Market)

(T): The share of xEVs in new cars sales in increasing as much as 6% in 2021, the share of BEV remains as low as 0.3% (2021).

(Transport Infrastructure)

(O): Egat is developing EV charging infrastructure and charging applications, with collaborations with auto manufacturers such as Audi, BMW, Mercedes, Nissan, Porsche, and GM.

(O): Chinese EV auto makers (SAIC, GWM) are developing their own charging networks.

- **It is important to invest in the capacity of the power grid capacity and increase in reliability so that the increase in electricity demand from the growing economy and the additional EV charging loads will be met.**

(Energy, Climate Change)

(O): The transport sector has a big potential to reduce GHG emissions. The sector is currently responsible for as much as 30%.

(T): Thailand will need to increase investment in the power grid to meet the increasing demands, increasing the renewables, and improving the supply reliability.

(Policy on Transport Electrification)

(S): The government of Thailand has clear BEV focus policies, especially to become a global BEV production hub.

(O): The government is considering the update of EV30@30 plan to EV50% by 2030.

- **EV battery recycling standards and regulations should be developed. A few pilot projects involving EV and battery manufacturing and regulatory parties will help to understand the design of the battery recycling industry.**

(Policy on Transport Electrification)

(S): The government of Thailand has clear BEV focus policies, especially to become a global BEV production hub.

(W): There are only a few recycling standards and regulations on hazardous materials, including EV batteries.

(O): The government of Thailand has a clear policy to become an EV global production hub, by keeping the car industry strength. Greater domestic and international EV policy communication will help to understand such policies.

(O): The government of Thailand is considering the update of EV30@30 plan to EV50% by 2030.

(Auto Manufacture Industry)

(S): A good car industry base exists, the top in ASEAN region, 10th largest in the world.

(O): PTT and Foxconn (Taiwan) has set a joint venture to develop an EV production platform.

- **Thailand is one of the most susceptible countries to climate change, and the country's investment on climate change mitigation, including transition to clean electricity and electrification of the transpor sector should bring effective results. It is recommended that the incentive policies keep tracking the expected GHG reduction performance.**

(Energy, Climate Change)

(T): Thailand is one of the most susceptible countries to climate change risks, with sea level rising and severe floodings, which may affect more than half the country's population.

(Policy on Transport Electrification)

(S): The government of Thailand has clear BEV focus policies, especially to become a global BEV production hub.

(S): The government of Thailand has already implemented BEV incentives with exempting import taxes to key BEV parts and excise tax redemption.

(Auto Manufacture Industry)

(S): A good car industry base exists, top in the ASEAN region, and 10th largest in the world.

- **It is recommended that the Thai government invest in human resources using joint projects with international institutes on battery production, charging infrastructure development, and battery recycling. Using ODA financing should help on top of the investment incentives.**

(Policy on Transport Electrification)

(W): There are few recycling standards and regulations on hazardous materials, including EV batteries.

(Auto Manufacture Industry)

(S): A good car industry base exists, top in the ASEAN region, the 10th largest in the world.

(W): Thailand will need more experienced and knowledgeable human resources on EV batteries and EV charging.

(W): There are only limited numbers of EV charging infrastructure facilties.

(T): Although there are incentives for BEV production, the standalone battery import is still subjected to import taxes, and auto manufacturers need to speed up domestic battery production.

6. Viet Nam

- **By utilising the hydropower resources and the constant renewable resources in the power sector, the transportation electrification policy may effectively reduce GHG emissions.**

It is important to ensure the deployment of solar and wind resources as planned in the 8th Power Development Plan. Without improving the GHG emissions factor in the power sector, transportation electrification may not be able to deliver effective GHG reduction.

(Energy, Climate Change)

(S): Plenty of hydropower resources (>25% of total power production), thanks to many big rivers.

(W): Relatively high dependency on fossil fuel power generation for a while, especially with coal.

(O): Viet Nam updated the NDC in 2020 to continue the commitment to the Paris Agreement.

(O): There is a policy to increase renewable power sources by 2030. The 8th Power Development Plan aims for renewable capacity as much as more than double by 2030.

(T): Frequent droughts and water shortage prevent constant hydropower production.

- **It is also important to invest in the power grid capacity and reliability increase so that the electricity demand increase by growing the economy and the additional EV charging loads will be met.**

The investment in the power grid becomes internationally recognised as important in almost every country, and Viet Nam is no exception. The increase of renewable resources and the electricity demand growth from continuous economic growth in Viet Nam and the EV charging load will demand a new level of power grid planning and thus investment. The world is experiencing a challenging time with securing the energy resources and maintaining the energy tariff stable. The government will need a careful design to make the grid investment plan whilst adequately managing the electricity rate.

(Energy, Climate Change)

(W): Less investment on the power grid due to controlled low electricity tariff.

- **Considering the mobility market size and the EV charging infrastructure readiness, a two-wheel (motorbike) electrification policy looks like a wise choice.**

Motorbikes are the predominant transportation measure in Viet Nam, and the size of the motorbike market is one of the world's largest. The automobile demand (four-wheels) will keep increasing, whilst the relatively higher ownership cost, the current higher price tags of BEVs, and the smaller size of the automobile industry compared with neighbouring ASEAN countries, a motorbike (two-wheels) electrification strategy seems a wise choice for the government. E-bikes have already become popular in the country, and electric motorbikes may be suitable for home charging with an option of battery-swapping station use. City municipals may want to introduce e-bike-friendly policies, such as creating e-bikes priority access zones and/or street lanes and support investing in e-bikes for rental/ride-hailing/delivery service businesses.

(Auto Market)

(S): 4th largest motorbike market in the world.

(Auto Manufacture Industry)

(W): The smaller scale of the auto manufacturing industry in Viet Nam, compared with neighbouring Thailand and Indonesia. No major BEV and key components factories in Viet Nam.

(Transport Infrastructure)

(W): Narrow streets with heavily congested roads in major cities due to large numbers of motorbikes.

(W): A small public transport system and the development of reliable and convenient public transport may take decades.

(W): Very limited numbers of public EV charging stations.

(O): An e-bike driver's licence allows easy use of e-bikes for students and others by test-free licensing.

(O): There is a good amount of awareness of air pollution and noise problems in cities with too many motorbikes.

(T): Most Japanese automakers are slow in electrification.

- **It is necessary to build confidence in the policy as well as accumulate experiences and knowledge through a series of pilot projects in mobility electrification.**

The need for mobility electrification may be hard to understand in the early deployment stage, because users may not see immediate problems in using internal combustion engine vehicles. One of the barriers to EV use is the anxiety of charging and the distance that can be travelled with a battery. Most EV users become comfortable with the charging behaviour and the practical drivable distance, whilst business users with many fleets will find a new challenge in the charging schedule and the charging infrastructure investment. There is no textbook solution for the optimum charging design, and the only effective tool is ‘to learn from experiences’. It is, therefore, highly recommended to start pilot projects with business EV fleet

operators, such as public bus operators, taxi operators, rental/ride-hailing operators, and delivery service companies.

(Policy on Transport Electrification)

(T): A lack of knowledge and experience due to the limited pilot programmes on EV deployment and EV charging infrastructure development. Because of the lack of technical and business understanding, it is not easy to design effective policy support.

(Auto Market)

(S): 4th largest motorbike market in the world.

(Auto Manufacture Industry)

(W): The smaller scale of the auto manufacturing industry in Viet Nam, compared with neighbouring Thailand and Indonesia. No major BEV and key components factories in Viet Nam.

(W): Lack of human resources with skilled and experienced engineers or business development.

(O): A new auto manufacturer/retailer VinFast is rapidly expanding its presence in all automobile markets (four-wheels, two-wheels, e-buses, and EV charging stations).

(Transport Infrastructure)

(W): Narrow streets with heavily congested roads in major cities due to large numbers of motorbikes.

(W): A small public transport system and the development of reliable and convenient public transport may take decades.

(W): Very limited numbers of public EV charging stations.

(O): Am e-bike driver's licence allows easy use of e-bikes for students and others by test-free licensing.

(O): There is a good amount of awareness of air pollution and noise problems in cities with too many motorbikes.

7. Conclusions

From the SWOT analysis, it was found that the five analysed ASEAN countries share common issues that are required to overcome.

The five ASEAN countries need to accelerate the decarbonisation of the power sector.

In most countries, coal and natural gas power generations have been the most affordable choices for a few decades. Renewable generations, such as solar PV and wind power cost are continuously decreasing with battery storage use. Transportation electrification does not

result in sizable CO_2 emission reductions until the CO_2 emissions from power generation decreases.

It is also important to invest in the power grid capacity and reliability improvement so that the electricity demand increase from the expected rise in EV charging will be sufficiently met.

The five ASEAN countries should accumulate knowledge and experiences on EV charging through implementing pilot projects. The implementation needs to be carefully considered with the financial and technical support from the respective government that may be in cooperation with the donor agencies.

ASEAN countries are in the very early stage of charging station development. There are many challenges in the charging infrastructure development, both in hardware and software. The former includes the AC/DC charging stations' optimum allocations, design/engineering standards, the safety system standard, and the home/office charging equipment distribution and installation. The latter includes the charging electricity tariff development, the optimum charging scheduling, the battery-friendly charging support application, the payment system, and the charging support applications.

Depending on different level of progress in the electrification of the transport sector, different implications can be drawn as below.

- **Indonesia and Viet Nam**: For the transport sector electrification, these countries are better positioned to start from motorcycle electrification in view of the current consumers' heavy dependence on motorcycles.

  Motorbikes are the main mode of transport in Indonesia and Viet Nam. The purchase cost of motorbikes is much more affordable even in electric motorbike models, compared with EV cars (four wheels). Electric motorbikes charging can be mostly managed by AC charging both at home and offices, whilst the public DC charging stations deployment may take years. With the very big size of the motorbike market, the electric motorbike deployment will help decrease oil demand, less air pollution, and fewer noises in big cities.

- **Brunei Darussalam, Malaysia, and Viet Nam:** At the initial stage of electrifying the transport sector, these countries may want to focus on public bus electrification because

  Public transportation development is one of the key transportation policies in many countries, including ASEAN region countries. They may want to consider using EV buses to mitigate GHG emissions increases, reduce traffic congestion, reduce air pollution, and also avoid problems with fewer charging stations.

- **Indonesia and Thailand:** As these countries aspire to become the BEV production hub, they may need to develop the rules for regulation and standard for BEV battery reuse and recycling.

  Early BEV market development and the recent incidents of raw materials price soaring indicate the importance of battery reuse and recycling. There are challenges with battery recycling, and the recycling business will need long-time span views in both economical as well as safety.

8. Table. SWOT Reference

8.1. Brunei Darussalam

Domestic Environment	
Strength	**Weakness**
- The electricity tariff is inexpensive by the government control. - The National Green development policy has a year 2035 target to reduce CO2 emission by 40% during the morning peak hours. - The National Green development policy has target with public bus transportation system development increase by 22% by 2035, especially developing the national school bus system. - The sizable wealthy pollution has exceptionally high automobile ownership rates in ASEAN region, as much as 720 per 1000 capita. - The ownership increased more than three folds from 2000 to 2015.	- Power generation is almost entirely dependent on domestic fossil fuels. - The power consumption per capita is big enough, as much as the top consumption Singapore, more than twice as much as Thailand or Indonesia. - The annual mileage per capita is exceptionally big in ASEAN region, as much as 30,000 km. - The EV production incentives are not attractive enough to bring manufactures investment. - Brunei has a wide range of problems in transportation sector. The GHG reduction is not always the government's higher priority.

External Environment	**Opportunity**	- Brunei has submitted NDC plan in 2020. The country has a target of EV sales share as much as 60% by 2035. - In 2019, the government of Brunei has established a joint taskforce (EV Joint Task Force) to develop strategies on domestic EV production and the charging infrastructures development. - Vehicle licensing fee is exempted for EV during the 2-year pilot programme, starting March 2021. - With practically zero EV market, the government has a challenging target of 65% sales share by 2035. - The national transportation policy, the Land Transportation Master Plan recognises the importance of energy efficiency and CO_2 reduction. - Land Transportation Master Plan recognises that the fuel efficiency regulation may be effective to reduce CO_2 emission from road transport sector.	**Strength x Opportunity**	**Weakness x Opportunity**
			(1) Bus electrification (public bus and school bus) may be the best initial target.	

	Threat	- Until the power sector CO_2emissions are reduced with fewer fossil fuel generations, the GHG reduction by transportation electrification will remain minimum.	**Strength x Threat**	**Weakness x Threat**
				(2) The government may want to make sizable investments on clean power resources, when the fossil fuel export brings large revenues.

8.2. Indonesia

Domestic Environment	
Strength	**Weakness**
- Indonesia has plenty of fossil fuels (coal, natural gas) - Indonesia has plenty of precious minerals, such as nickel and cobalt. - The government of Indonesia has been developing and promoting low-emission fuels, such as diesel CN 48 and Gasoline RON 80. - The excise tax has reformed to reflect CO_2 emissions with exemption to zero emission by BEVs. - Transportation electrification is one of the core areas in National Green Development Strategy.	- The power generation may keep depending on fossil fuels. - The efficiency of power generation and the transmission may need to improve. - Geographical islands separation hinders the cross regional power transmission capacities. - The politically controlled low electricity tariff has limited the grid investment. The grid capacity improvement is necessary. - Increasing gasoline demand is worsening the international trade balance.

	- The government of Indonesia has published EV roadmap in 2020. - The government of Indonesia has implemented various tax incentives for EV users and EV manufactures. - Indonesia is one of the most populated countries in ASEA region and the auto market is expected to grow steadily with population increase and the economic growth - The motorbike market size is four times bigger than the car market, and it will keep growing. - Indonesia's auto industry is the second largest in ASEAN region. - Indonesia has motorbike industry factories. - A new battery production company has been established with four national corporations as a joint investment.	- There are limited numbers of charging infrastructures. - xEV share in the new car sales remains minimum as much as 0.36% in 2021. - Vehicle ownership has not penetrated in the growing middle-class. - The car market has not yet recovered from COVID19 pandemic effect in 2021, with the 2020 market had decreased to half of 2019. - EV battery knowledge and experience is limited, and more skilled human resources are required. - Battery knowledge and engineering is dominated by Chinese and Republic of Korean players. - Increasing motorbikes and vehicles worsen air pollution and congestion in cities. - A lack of development of public transportation system.

External Environment	**Opportunity**	- The development of charging infrastructure, the charging tariff, and the transportation electrification policies are well under control of the government of Indonesia. - Official licensing of electricity business is required for charging business, players should have adequate technology and safety skills. - Trials of battery swapping are carried out with electric motorbikes. - With a large market size of motorbikes, electric motorbike deployment may result with a sizable GHG reduction as well as the decrease of gasoline demand growth. - Indonesia has an advantage of battery production by abundant precious mineral resources.	**Strength x Opportunity** (3) The government may want to accumulate the knowledge and experience on charging stations development as well as the effective charging tariff development through the government support pilot projects, with the lead of PTPLN. (2) Considering the size of investments on domestic battery production factories, the domestic EV production factories, and the EV charging infrastructures, with relatively higher prices of EVs, Indonesia may want to start with the motorbike electrification. The electric motorbike cost barrier is not significant and the electric motorbike may not require many charging stations for a while. The big size of motorbike electrification may also help decreasing the gasoline demand growth as well as improving the air quality in big cities. (1) To establish the EV production hub in Indonesia, it is important to become one of	**Weakness x Opportunity** (4) It is important to decrease the dependence on fossil fuel power and to accelerate the clean power resources development, (5) It is important to invest in the power grid capacity and reliability increase, so that the electricity demand increase by growing the economy and the additional EV charging loads will be met.

			the top battery production countries. The government of Indonesia may want to keep close partnership with Chinese and Korean battery manufactures to establish the domestic production factories. Making EV auto manufactures early commitment to purchase the good size of domestic batteries, in return to the tax incentives, may help the initial stage of domestic battery production business	
	Threat	- Until the power sector CO_2 emission is reduced with fewer fossil fuel generations, the GHG reduction by transportation electrification will remain minimum. - Indonesia is experiencing negative effects from climate changes. - A robust system of charging service business with a requirement of licensing may prevent from business innovations with continuous technology evolvement and market changes. - Battery swapping model may not become a popular model.	**Strength x Threat**	Weakness x Threat

8.3. Malaysia

	Domestic Environment	
	Strength	**Weakness**
	- Low Carbon Mobility Blueprint was published in 2021. - Malaysia has two national car manufactures, Proton and Perodua.	- The power generation may keep depending on fossil fuels. - A fewer EV deployment target, compared with neighbouring ASEAN countries. - Fewer policy incentives are provided, compared with neighbouring ASEAN countries (Thailand, Indonesia). - The car sales market has already saturated. - The EV production incentives are not attractive enough to bring manufactures investment. - Transport sector is responsible of 25% of total GHG emissions. - There are limited numbers of charging infrastructure.

<table>
<tr><td rowspan="4">External Environment</td><td rowspan="2">Opportunity</td><td rowspan="2">- Malaysia is committed to tackle climate change, with an updated NDC in 2021.
- BEVs are exempted with import taxes and excess taxes.
- Malaysia Automobile Robotic Institute and Automobile Import Association are jointly investing in an EV Centre of Excellence (COE). The COE intends to become the region hub of EV maintenance, repair, and customer support.
- The government expects transportation electrification may help in reducing air pollution.</td><td>Strength x Opportunity</td><td>Weakness x Opportunity</td></tr>
<tr><td></td><td>(2) Malaysia has advantages on digital technologies. Malaysia may be able to develop a unique position to provide software platforms and services, such as charging service applications, optimum charging control, car sharing/ride hailing platform, and battery assessment.</td></tr>
<tr><td rowspan="2">Threat</td><td rowspan="2">- Two national car manufactures are both practically managed by Chinese entity (Proton with GWM) and Japanese entity (Perodua by Daihatsu). Their business strategy may not perfectly align with the government policy.
- Most of the domestic production factories are responsible with the final assembling. There is less key components production.</td><td>Strength x Threat</td><td>Weakness x Threat</td></tr>
<tr><td></td><td>(1) With the smaller domestic auto industry with a fewer growth in the car sales, government investment on EV production may not be effective compared with neighbouring Thailand and Indonesia. Two national car manufactures may lead the EV deployment in the domestic market.</td></tr>
</table>

8.4. Thailand

Domestic Environment	
Strength	**Weakness**
- Renewable resources are increasing, exceeding 30% of total power production capacities. - The government has clear BEV focus policies, especially to become the global BEV production hub. - The government has already implemented BEV incentives with exempting import taxes to key BEV parts and excise tax redemption. - A relatively large domestic auto market, the second largest in ASEAN. - A long relationship with Japanese auto manufacturers to develop the country's production industry and the big car market. - New Chinese players are emerging in the middle-class vehicles market, including GWG using a popular MG brand. - A good car industry base exists, the top in ASEAN region, 10th largest in the world.	- The power generation still depends on natural gas, as much as 60% as of 2021. - There is few recycling standards and regulations on hazardous materials, including EV battery. - Thailand will need more experienced and knowledgeable huma resources on EV battery and EV charging. - There is only a limited number of EV charging infrastructure**.**

			Strength x Opportunity	Weakness x Opportunity
External Environment	**Opportunity**	- Transportation sector has a big potential in reducing GHG emissions, the sector is currently responsible as much as 30%. - The government of Thailand has a clear policy to become the EV global production hub, by keeping the car industry strength. More domestic and international EV policy communication will help understanding such policies. - The government of Thailand is considering the update of EV30@30 plan to EV50% by 2030. - A relatively high vehicle ownership in ASEAN region, 267 per 1000 capita. - The new trading agreement with China exempts import taxes from vehicles from China and imported EV models are increasing. - Many auto manufacturers are starting to enter to BEV market. - Although the current numbers of registered EVs are small, they are fast increasing at the rate of 24% (2021–	(1) Thailand has already implemented key strategic policies to enhance the BEV production industry to become the global production hub of electric vehicles and parts. Additional measures to strengthen the key technology, namely EV battery production will be the focus policy area. (2) The government may want to develop a new electricity tariff for EV charging.	(4) The EV battery recycling standard and regulation should be developed. A few pilot projects involving EV and battery manufacturers and regulatory parties will help understanding the design of the battery recycling industry.

		2016), the fastest growth in the market. - The Board of Investment of Thailand provides various support for domestic EV production investments.		
	Threat	- Thailand is one of the most susceptible countries by climate change risks, with sea level rising and severe floodings, which may affect more than half of country's population. - The decrease of cheap domestic natural production decrease with more expensive liquefied natural gas imports increases are affecting the electricity rates increase. - Thailand will need to increase the investment on the power grid to meet the increasing demands, increasing the renewables, and improving the supply reliability. - The share of xEVs in new cars sales in increasing as much as 6% in 2021, the share of BEV remains as low as 0.3% (2021).	**Strength x Threat** (5) Thailand is one of the most susceptible countries from climate changes, and country's investment on climate change mitigation, including clean electricity transition and the transportation electrification should bring effective results. It is recommended that the incentive policies keep tracking the expected GHG reduction performance. (2) The government may want to develop a new electricity tariff for EV charging, (3) It is important to invest in the power grid capacity and reliability increase, so that the electricity demand increase by growing the economy and the additional EV charging loads will be met.	**Weakness x Threat** (6) It is recommended that the government should invest in human resources using joint projects with international institutes on battery production, charging infrastructure development, and battery recycling. Using official development assistance financing should help on top of the investment incentives.

		- Available BEV models are either in high-end import models with longer mileage range of 200-480km, or the low-end models with less than 160 km mileage range. - There is less choice in the most needed middle-class. - Although there are incentives for BEV production, the standalone battery import is still subjected to import taxes, and auto manufactures need to speed up domestic battery production. - The constant increase of labour cost is pushing up the domestic car production cost.		

8.5. Viet Nam

	Domestic Environment	
	Strength	**Weakness**
	- Plenty of hydropower resources (>25% of total power production), thanks to number of big rivers. - Less expensive electricity tariff - Historical relationship with Japanese motorbike manufacturers results in a very big motorbike market. - 4th largest motorbike market in the world.	- Relatively high dependency on fossil fuel power generation for a while, especially with coal. - Fewer investment on the power grid due to controlled low electricity tariff. - Oil import is increasing due to the decline of domestic oil production. Oil price is higher, compared with cheaper electricity tariff. - No clear policy on transportation electrification. Less policy incentive programmes on BEV promotion. - Hazardous material regulations on recycling have not been developed yet, including BEV battery recycling. - Compared with neighbouring Indonesia and Thailand, the policy incentive programmes on EV manufacturing is not sufficient to attract international manufacturers' investment.

			Strength x Opportunity	Weakness x Opportunity
External Environment	**Opportunity**	- Viet Nam updated the NDC in 2020 to continue the commitment on Paris Agreement. - There is a policy to increase renewable power sources towards 2030. The 8th Power Development Plan aims renewable capacity as much as more than double by 2030. - An incentive for BEV purchase by decreasing excise tax rates for BEV, especially between 2022/3 and 2027/2. - The population of middle-class income is strongly increasing, and a strong automobile demand growth is expected. - A small number of second-hand cars are on the road. - A new auto manufacture/retailer VinFast is rapidly expanding the presence in all automobile markets (four-wheels, two-wheels, e-buses, and EV charging stations). - Am e-bike driver's licence allows easy use of e-bikes for students and others by test-free licensing.	(1) By utilising the hydro power resources and the constant renewable resources in the power sector, the Transportation Electrification policy may effectively reduce GHG emissions. (3) Considering the mobility market size and the EV charging infrastructure readiness, 2-wheels (motorbike) electrification policy looks like a wise choice.	(2) It is also important to invest in the power grid capacity and reliability increase, so that the electricity demand increase by growing the economy and the additional EV charging loads will be met.

	Threat	- A frequent drought and water shortage starts preventing constant hydro power production. - A-world-wide oil supply shortage may continue for a while. - A lack of knowledge and experiences due to the limited pilot programmes on EV deployment and EV charging infrastructure development. Because of the lack of technical and business understanding, it is not easy to design an effective policy support. - Most Japanese auto makers are slow in electrification.	**Strength x Threat** (4) It is necessary to build confidence in the policy as well as accumulating experiences and knowledges through a series of pilot projects in mobility electrification.	**Weakness x Threat**

Chapter 5
Policy Implications

In the Association of Southeast Asian Nations (ASEAN) countries, electric vehicles (EVs) are considered an important option for tackling local air pollution and enhancing energy security – away from oil dependence. Some countries such as Indonesia and Thailand consider EVs as an important option for developing a manufacturing base. Indonesia has laid out its plan for developing battery manufacturing industry with the use of local resources, whilst Thailand aims to become the regional hub for the EV manufacturing industry.

Meanwhile, EVs have not seen a leapfrog yet in the ASEAN countries. Initial high purchase costs, the lack of necessary charging infrastructure, and limited availability of vehicle line-ups are the key factors affecting the relative slow progress in the deployment of EVs in the analysed ASEAN countries.

Well-to-Wheel Analysis

The well-to-wheel (WTW) analysis indicates that unless the pace of decarbonisation of the power sector accelerates, the full benefits of EVs – as a means to CO_2 emissions reduction – would not be realised. The case of Indonesia, for example, indicates that under the business-as-usual scenario, CO_2 emissions of HEVs would be lower than that of EVs by 2050. This is an important implication for policymaking where **concerted efforts amongst the stakeholders are necessary to coordinate the policies and planning related to EVs. In other words, EV policies need to take due consideration towards the progress in decarbonisation of the power sector.** Otherwise, originally intended outcomes – in terms of CO_2 emissions reduction – would not be obtained.

EV Incentives

With the focus on passenger vehicles, the four analysed countries (Indonesia, Malaysia, Thailand, and Viet Nam) have introduced economic incentives in the form of tax waivers or lower tax rates either at the time of purchase or at the time of operation. Meanwhile, faced with the recent rise in energy prices, Indonesia and Malaysia have provided subsidies to control the rise in oil prices, and Thailand and Viet Nam have reduced taxes for oil products. The current rise in energy prices have sent mixed signals to consumers, and a **level playing field for EVs is not ready despite the provision of incentives and lower battery costs.** In other words, the policy should be tailored to make more coherent to resolve short-term impacts from the rise in energy prices, and long-term climate change goal.

Strengths, Weaknesses, Opportunities, and Threats Analysis

The strengths, weaknesses, opportunities, and threats of owning EVs differ by country. This reflects precious resources' endowment, decarbonisation policy of the power sector, economic policy for EVs, the maturity of the automobile industry, and mobility choice. Key implications are:

- **Indonesia and Viet Nam**: For electrification of the transport sector, these countries are better positioned to start from the electrification of motorcycles in view of the current heavy dependence on motorcycles.
- **Brunei Darussalam, Malaysia, and Viet Nam:** At the initial stage of electrifying the transport sector, these countries may need to focus on the electrification of public buses.
- **Indonesia and Thailand:** As these countries aspire to become BEV production hubs, they may need to develop rules for regulations and standards for BEV battery reuse and recycling.

Total Cost of Ownership Analysis

As the total cost of ownership analysis indicates, e-motorcycles have become economically competitive against conventional ones. In view of the popularity of motorcycles in the ASEAN market, and the potential for electrification, **the development of charging infrastructure and battery swap business should make substantial progress** in those countries where the dependence on motorcycles is high (such as Indonesia and Viet Nam). The standardisation of battery packs should also be made to facilitate battery swapping at charging stations.

EV passenger vehicles are not yet economically competitive against internal combustion engine (ICE) vehicles. In the assumption that the cost of lithium-ion batteries would continue to decline at the learning rate of 75%, **the tipping point where EV benefits outweigh those of ICE vehicles would come sometime between 2025 and 2030 depending on oil products prices, electricity prices, travel distance, and fuel economy of ICE vehicles in respective countries**. In other words, continued provision of economic incentives should be kept at this time. **Economic incentives could take the form of tax waivers, lower taxes at registration, or time of use electricity pricing**.