Chapter 4

Vehicle Electrification and Consumption of Mineral Resources in East Asia Summit Countries

December 2021

This chapter should be cited as

Study Team (2021), 'Vehicle Electrification and Consumption of Mineral Resources in East Asia Summit Countries', in Morimoto, S., S. Gheewala, N. CHollacoop and V. Anbumozhi (eds.), *Analysis of Future Mobility Fuel considering the Sustainable Use of Biofuel and Other alternative Vehicle Fuels in EAS Countries.* ERIA Research Project Report FY2021 No. 18, Jakarta: ERIA, pp.97-134.

Chapter 4

Vehicle Electrification and Consumption of Mineral Resources in East Asia Summit Countries

1. Introduction

The introduction of hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), electric vehicles (BEVs), and fuel cell vehicles (FCVs), hereinafter described as 'xEVs') and biofuels in East Asia Summit (EAS) countries is advancing rapidly. For instance, the Indian automobile market has registered over 638,000 electric vehicle (EV) units since 2011–2012. There were more than 1,000 electric cars registered in Viet Nam at the end of 2020, which consist of 99% HEV+PHEV and 1% BEV. There were 32,264 HEV/PHEVs and 2,999 BEVs registered in Thailand in 2020.

The electrification of automobiles will greatly contribute to CO_2 reduction and complement the introduction of renewable energy programmes. This suggests that EAS countries will continue to promote the electrification of automobiles in order to achieve the ambitious targets set out in the Paris Agreement (UN, 2015).

However, the electrification of cars requires significant increases in battery requirements, including the development of high-efficiency motors and lithium ion batteries. High-efficiency motors use neodymium magnets, which are high-performance permanent magnets designed to maintain their efficacy; however, they require several rare earth elements including neodymium (Nd) and dysprosium (Dy), which preserve the thermotolerance of these magnets. This implies that it is becoming increasingly necessary to secure long-term access to these rare-earth elements (Morimoto et al., 2019). Similarly, critical raw materials such as lithium, nickel, and cobalt (Co) are also all required for lithium-ion batteries (Chan, 2021). Therefore, the electrification of automobiles relies on the sustainability of these mineral resources and promotes the idea of creating a circular economy that recycles these resources.

Circular economies are designed to improve resource efficiency and minimise the amount of resources needed and their waste by improving both the production system and product design of these items. This prolongs the lifespan of these products and promotes their reuse, remanufacture, repair, and recycling. Currently, EAS countries only consume 'cradle-to-grave' products, i.e. those that are produced, designed, and discarded. Therefore, there is a need to shift the consumption of mineral resources to a 'cradle-to-cradle' model rather than the cradle-to-grave model mentioned above (ERIA, 2020).

This study estimates the long-term mineral resource demand associated with automobile electrification in EAS countries. In addition, the study aims to assess the potential for recycling in these countries by determining the amount of waste of these mineral resources and evaluate the effectiveness of introducing a circular economy under these conditions.

1.1. Background

At present, the electrification of vehicles and the introduction of biofuels is being promoted in EAS countries to reduce CO_2 emissions from the transport sector.

The details are described in Section 2. The current status of motor vehicle motorisation in various EAS countries is as follows:

Indonesia

In Indonesia there were 219 4-wheeled electric vehicles and 5,000 2-wheeled vehicles registered in 2020. The target of mobility electrification in Indonesia for 4-wheelers is 400,000 units by 2025, 600,000 units by 2030, and 1,000,000 units by 2035. The target of 2-wheeler electric vehicles is 1,760,000 units by 2025, 2,450,000 units by 2030, and 3,225,000 units by 2035.

Malaysia

The government is targeting 10% of new additions to the fleet being battery electric vehicles (BEVs) by 2022, with the percentage increasing to 20% from 2023 to 2025. From 2026 to 2030, 50% of the new additions to government and government-link company fleets are targeted to be locally manufactured BEVs.

Philippines

Registered EVs (includes e-trikes, e-motorcycles, e-jeepneys, e-cars, e-SUVs, e-trucks, e-trucks, and e-buses) with the Land Transportation Office (LTO) for 2010–2020 were reported at 12,965 units (EVAP, 2021). The market projection for additional EVs in 2021 are 1,930 units (PDOE, 2021). According to the Department of Trade and Industry (DTI) and the Electric Vehicle Association of the Philippines EV Comprehensive Road Map, the industry is targeting about 21% EV utilisation by 2030 out of the total vehicle population, specifically focusing on public transportation. By 2040, industry target is set at 50% EVs of the total vehicles being utilised in the country for the said period (Cahiles-Magkilat, 2020).

Thailand

The number of xEVs registered in Thailand is explained below:

2017: 11,945 units hybrid electric vehicles/plug-in hybrid electric vehicles (HEV/PHEV) and 165 units BEV

2018: 20,344 units HEV/PHEV and 325 units BEV

2019: 30,676 units HEV/PHEV and 1,572 units BEV

2020: 32,264 units HEV/PHEV and 2,999 units BEV

2021 (until March): 14,248 units HEV/PHEV and 1,253 units BEV

The target of mobility electrification in Thailand for four-wheelers is 243,000 units in 2025, 473,000 units in 2030, and 1,237,000 units in 2035. For two-wheelers the target of electric vehicles is 360,000 units in 2025, 650,000 units in 2030, and 1,800,000 units in 2035.

Viet Nam

Registered electric cars in Viet Nam until 2020 are more than 1,000 units, which consists of 99% HEV+PHEV and 1% BEV. For electric two-wheelers, the numbers of registered vehicles in Viet Nam are listed below:

2018: 46,370 units of e-bikes and 212,920 units of e-motorcycles

2019: 52,940 units of e-bikes and 237,740 units of e-motorcycles

2020: 21,320 units of e-bikes and 152,710 units of e-motorcycles

India

The Indian automobile market has registered over 638,000 EVs since 2011–2012. India's 2030 EV ambition signalled by NITI Aayog, states that 70% of all commercial cars, 30% of private cars, 40% of buses, and 80% of the two- and three-wheeler sales in 2030 would be electric.

However, advancing these electrification efforts will lead to a substantial increase in demand for mineral resources such as Nd, Dy, Li, Ni, and Co. For example, the United States (US) Geological Survey (USGS, 2021) Minerals Commodity Summary for 2021 reports that the global rare earth elements (REE) production was approximately 220,000 tons/year in 2019, with China accounting for the highest share of global production (60%), followed by the US (13%) and Myanmar (11%). The global REE production increased to 240,000 rare earth oxides (REO) tons/year in 2020. Notably, China's share of the global production declined from 60% in 2019 to 58% in 2020, while production outside China, such as in the US, Burma (Myanmar), and Madagascar increased during the same period.

Furthermore, with neodymium making up approximately 18% of all REE produced, the production of neodymium increased from 39,600 REO tons/year in 2019 to 43,200 REO tons/year in 2020.

Based on the same data from the USGS, the global cobalt production was approximately 144,000 tons/year in 2019 and decreased to 140,000 tons/year in 2020. Congo boasts the highest share of global cobalt production, followed by Russia, Australia, and the Philippines. Congo's share of global production declined from 70% in 2019 to 68% in 2020, with the production outside Congo mostly decreasing over this same period.

When promoting automobile electrification in EAS countries, a circular economy should be introduced efficiently by taking into account the productive limitations of these mineral resources. For example, the Association of Southeast Asian Nations (ASEAN) is currently concerned about the environmental disruption resulting from natural resource mining, and more efforts are being made to develop sustainable industries. This was taken into account at the ASEAN Summit 2021 (27 October 2021), which focused on strategies to strengthen the resilience of ASEAN economies by making them more sustainable and less vulnerable to future disturbances via stabilisation of manufacturing, thereby promoting complementarities in the regional supply chain through technology exchange and formalising these ideas in the ASEAN Community Vision 2025, the ASEAN Integrated Food Security Framework, the ASEAN Network

for Combating Illegal, Unreported, Unregulated Fishing, and the ASEAN Framework of Action on Marine Debris (ASEAN Storage, 2020).

1.2 Objective and Scope

This project analyses future scenarios for EAS mobility, which may strongly contribute to the regional SDGs (7, 12, and 13) and provide a balance between transport CO_2 reduction, biofuel use, and the demands on mineral resources. In this chapter, the demand for Nd and Co were forecast and the amount of waste resulting from the promotion of automobile electrification in EAS countries were also estimated. The possibility of a future supply–demand gap is also examined and the recycling potential for these items are evaluated.

1.3 Methodology

This section describes a method for predicting the demands for Nd and Co and estimating the amount of waste after the promotion of electrified automobiles in EAS countries.

Several EAS countries were selected for evaluation and the relationship of the number of vehicles owned as per the International Organization of Motor Vehicle Manufacturers (OICA, 2020) with the growth rate and gross domestic product purchasing power parity (GDP-PPP)/capita (international dollars/year) between 2005 and 2015 (IMF, 2020) was analysed. The results are shown in Figure 4.1.

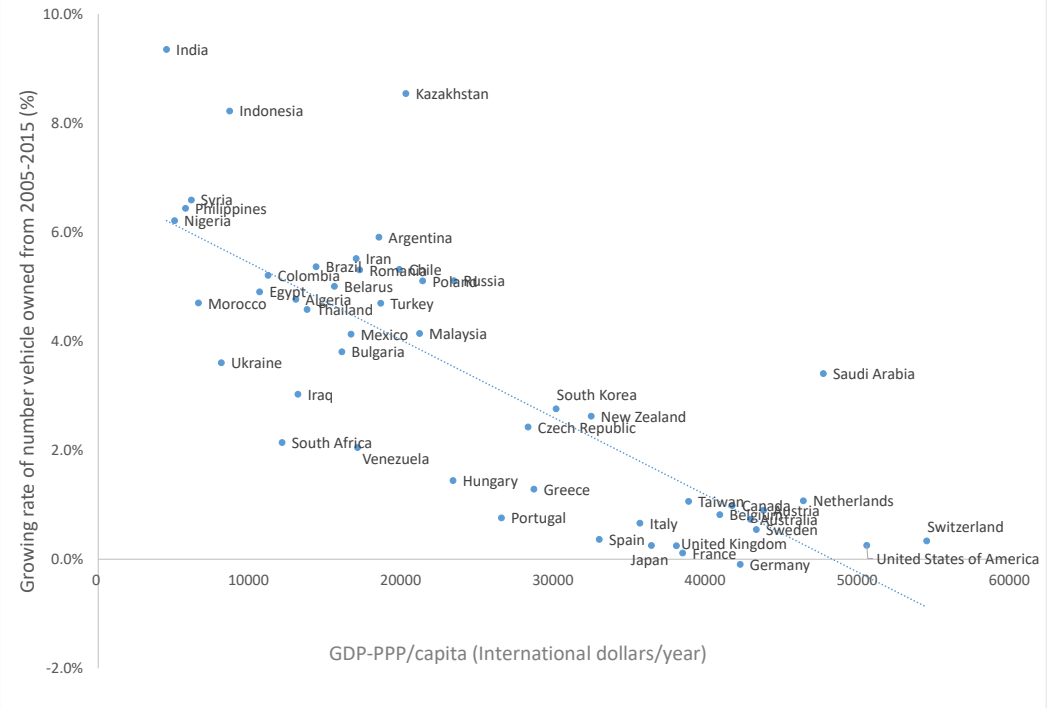
As shown in Figure 4.1, a higher GDP-PPP/capita due to economic growth causes a linear decrease in the growth rate of the number of cars held. This study then predicted the number of cars in each country using the projected future national GDP values published by the International Monetary Fund. This data were also used to predict the number of vehicles in the market and the number of discarded vehicles for each country. The number of discarded vehicles was estimated using the Weibull distribution, when assuming a car's life span to be 14.4 years (Morimoto et al., 2020).

Finally, the demand and disposal of Nd and Co were calculated by integrating the data on the amount (contained rate) of Nd and Co in these automobiles with the number of automobiles that were sold and disposed of during these projections.

The demand and disposal of Nd and Co were determined using two methods. **Method 1** predicted the number of automobiles that were sold and discarded as described above, and then the number of xEVs sold was calculated by using Deloitte's prediction (Deloitte, 2020) of automobile electrification and integrating the Nd and Co contents.

Method 2 estimated the demand and disposal of Nd and Co by using the target values for vehicle electrification in each country, which were evaluated in this project.

Figure 4.1. Relationship Between Growing Rate of Number of Vehicles Owned and GDP-PPP/capita



Deloitte's projection describes five different enablers that are crucial to realise electrification in ASEAN. In that study, the level of maturity for each enabler was assessed and used to calculate the total weighted average score. Subsequently, the average percentage for each enabler was calculated and the final value was determined (Deloitte, 2020).

2. Vehicle Electrification Policies

At present, each EAS country has its own goal for the electrification of automobiles. This chapter describes the electrification targets in each of these countries.

A. Thailand

Like many other countries around the word, Thailand has been preparing to cope with disruptive technology like electric vehicles to enter the domestic market, where Thailand has been a hub of conventional automotive production. After 1-ton pickup trucks and eco cars, Thailand aims to push EVs as the next project champion for the Thai automotive industry.

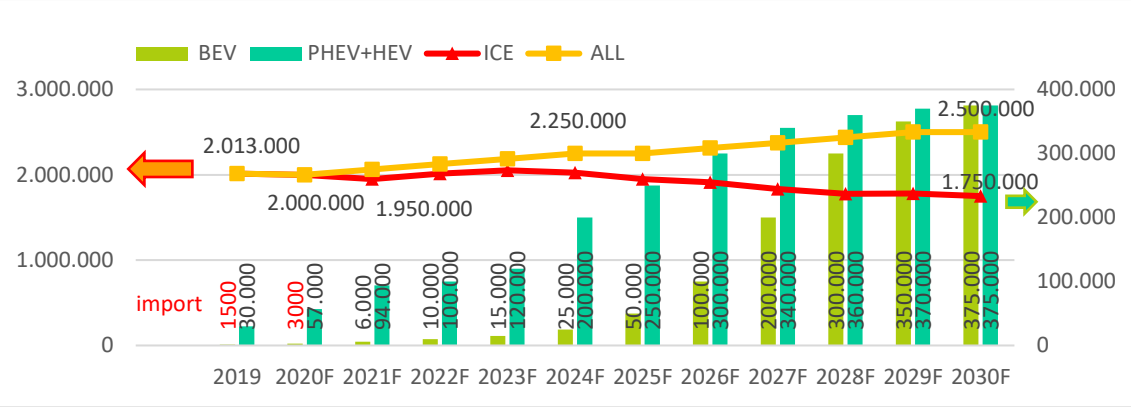
National Plan for xEVs (HEV, PHEV, BEV, FCEV) Promotion (existing and developing)

The national plan with targets for EVs had not been formulated until early 2020, when the Prime Minister established the National Electric Vehicle Policy Committee on 7 February 2020, chaired

by the Deputy Prime Minister on Economics with 18 members from related ministries (Ministry of Industry, Ministry of Transport, Ministry of Energy, Ministry of Finance, and Office of Prime Minister), industrial sectors (Federation of Thai Industries, Board of Trade of Thailand, Thai Automotive Industry Association) and national experts. This national committee has a task to identify the direction and target of EVs in alignment with the 20-Year National Strategy: 2018–2037 (OESDB, 2018).

This National EV Policy Committee had its first meeting on 11 March 2020 with the proposed Thailand Smart Mobility 30@30 to target 30% of domestic automotive production in 2030 from xEVs (15% from BEVs and 15% from HEVs and PHEVs). As shown in Figure 4.2 (Thailand National EV Policy Committee, 2020), 2030 domestic automotive production is forecast at 3 million vehicles so 750,000 vehicles would be xEVs from 375,000 BEVs and 375,000 HEVs and PHEVs.

Figure 4.2: Thailand Smart Mobility Road Map 30@30



BEV = battery electric vehicle, F = forecast, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle.
Source: Thailand National EV Policy Committee (2020).

Since the first meeting of the National EV Policy Committee, there have been subsequent supporting mechanisms from the Board of Investment (BOI) in order to reach 30@30 target. The second meeting of the National EV Policy Committee on 24 March 2021 accelerated the EV target to be 100% newly registered zero emissions vehicles (ZEV = BEV + FCEV) by 2035 across three vehicle classifications: cars and pickups, motorcycles, and buses and trucks under strategic vision in Table 4.1 (Thailand National EV Policy Committee, 2021).

Table 4.1: Thailand Strategic Vision for Electric Vehicles

Key Drivers	Air pollution reduction (PM2.5, NOx, Sox) Greenhouse gas reduction New industry foundation			
Key Strength	High demand for vehicle	Strong automotive industry	Stable electricity infrastructure with high potential for renewable energy	Strategic location for export
Thailand's Vision	Global EV and parts production hub			
Key Objective	EV production and export EV production becomes main products in industry	Usage and infrastructure EV usage becomes widespread with supporting infrastructure	Sustainability Sustainability in financial and environmental aspects	
Key Initiatives	–Establish incentives for domestic EV part and battery productions –Establish EV standards	–Establish EV demonstration projects –Prepare electricity infrastructure with enough charging stations under standard, incentive, and compulsory mechanism –Regulate suitable electricity price	–Establish protocol to manage waste from EVs and battery –Balance government income	
Key Support	Supporting measures in finance, regulation, R&D, HRD, and information management			

EV = electric vehicle, R&D = research and development, HRD = human resource development.
Source: Thailand National EV Policy Committee (2021).

Urgent and short-term measures include:

Urgent measures

- ✓ Provide incentives to boost the use of two-wheeled, three-wheeled, and four-wheeled EV.
- ✓ Provide national standards, battery testing centres, energy plans, and charging stations for electric vehicles and electric motorbikes.
- ✓ Set up an electric bus rental project that should implement the use of 2,511 electric buses.

Short-term measures (within next 1–5 years)

- ✓ Restructure the taxation system, e.g. update the excise tax for new vehicles from 2026 onwards, and annual vehicle taxes calculated based on the age of the vehicle, i.e. the older the vehicle, the more expensive the tax.
- ✓ Set up facilities to manage and treat used vehicles, batteries, and solar PV.

- ✓ Build ecosystem and infrastructure to support the use of ZEV.
- ✓ Develop human resource and capacity to support the use of ZEV.

Government Support and Incentives for xEVs (HEV, PHEV, BEV, FCEV), e.g. subsidy, mandate

Thus far, Thailand has been launching mostly supply-side incentives for EVs through the BOI. For instance, the BOI has already approved 24 projects for vehicle manufacturers to domestically produce HEVs, PHEVs, and BEVs with a combined capacity of over half a million units per year and charging stations of over 4,000 per year (Thailand BOI, 2020a). The approved projects include:

- ✓ Mitsubishi Motors (Thailand): investment to upgrade the company's existing car production line at Laem Chabang Industrial Estate to allow the annual production from 2023 of a total of 39,000 vehicles, consisting of 9,500 BEVs and 29,500 HEVs.
- ✓ Sammitr Group: investment for the production in Phetchaburi Province of 30,000 BEVs. Similar to the Mitsubishi Motors (Thailand) project, the Sammitr Group project, like most others, will be aimed at the local market and exports, mainly to other ASEAN countries.
- ✓ BMW: production of PHEVs and partnership with the DRÄXLMAIER Group for the production of high-voltage batteries and battery modules.
- ✓ FOMM: a new Japanese EV brand (FOMM = First One Mile Mobility) with compact BEVs production at a plant in Chonburi province.
- ✓ Nissan Motors: investment in hybrid car production in Thailand with and received approval recently for a new BEV production project.

In November 2020 (Thailand BOI, 2020b), the BOI has rolled out a new package for EVs to replace its first EV package that expired in 2018. The new approved projects with THB35.7 billion (US$1.1 billion) worth of investment covering a comprehensive range of electrical vehicles including passenger cars, buses, trucks, motorcycles, tricycles, and ships can be summarised as follows:

- ✓ Four-wheelers:
    - ➢ For qualified projects with total investment package worth at least THB5 billion: PHEVs receives 3-year tax holidays while BEVs receive 8-year corporate income tax exemption period with extendable option in the case of R&D investment and/or expenditures.
    - ➢ For qualified projects with total investment worth less than THB5 billion: PHEVs and BEVs both receive 3-year tax holidays with extendable tax holidays period for BEVs under special requirements, such as production commencement by 2022, additional part production, minimum production of 10,000 units within 3 years, and R&D investment and/or expenditures.
- ✓ Motorcycles, three-wheelers, buses, and trucks: qualified projects will receive 3-year corporate income tax exemption, extendable if meeting additional requirements.

- ✓ Electric-powered ships: qualified projects for vessels with less than 500 gross tonnage will be eligible for 8 years of corporate income tax exemption.
- ✓ Critical EV parts, such as high voltage harness, reduction gear, battery cooling systems, and regenerative braking systems, will receive 8-years corporate tax exemptions.
- ✓ Battery modules and battery cells for the local market will receive a 90% reduction of import duties for 2 years on raw or essential materials not available locally.

CO_2-related Information (well-to-tank) for Electricity

The Ministry of Energy has regularly published Power Development Plans (PDP) for electricity infrastructure development. In preparation for upcoming EV usage in the country, the current PDP version 2018 revision 1 (EPPO, 2020) has been updated to include regional load forecast including EV load. In addition, emissions factors for the entire grid have been updated, as shown in Table 4.2 (EPPO, 2020).

Table 4.2: Forecast Emissions Factors for National Grid until 2037

Year	PDP2018		PDP2018 Revision 1	
	Annual ($kgCO_2/kWh$)	Annual (kton)	Annual ($kgCO_2/kWh$)	Annual (kton)
2018	0.413	83,975	0.413	83,976
2019	0.395	83,607	0.395	83,668
2020	0.386	84,825	0.381	83,698
2021	0.384	87,576	0.374	85,359
2022	0.368	86,947	0.359	84,841
2023	0.365	89,406	0.354	86,686
2024	0.362	91,536	0.351	88,799
2025	0.337	88,021	0.329	85,947
2026	0.333	89,689	0.322	86,744
2027	0.339	97,007	0.323	89,458
2028	0.332	94,885	0.319	91,041
2029	0.329	97,006	0.318	93,783
2030	0.326	98,743	0.315	95,472
2031	0.320	99,765	0.310	96,675
2032	0.291	93,357	0.281	90,228
2033	0.292	96,509	0.282	93,026

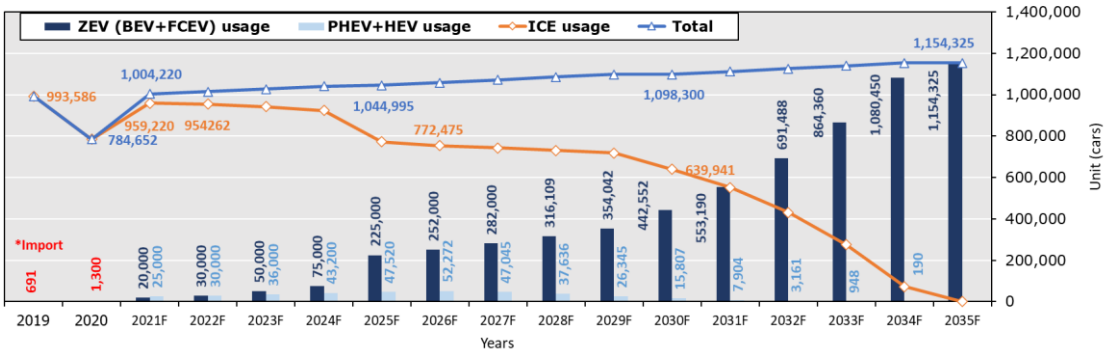
Year	PDP2018		PDP2018 Revision 1	
	Annual ($kgCO_2/kWh$)	Annual (kton)	Annual ($kgCO_2/kWh$)	Annual (kton)
2034	0.302	102,319	0.291	98,797
2035	0.295	102,717	0.284	98,871
2036	0.289	103,248	0.277	99,184
2037	0.283	103,845	0.271	99,712

kg = kilogram, kton = kiloton. PDP = Power Development Plan.
Source: EPPO (2020).

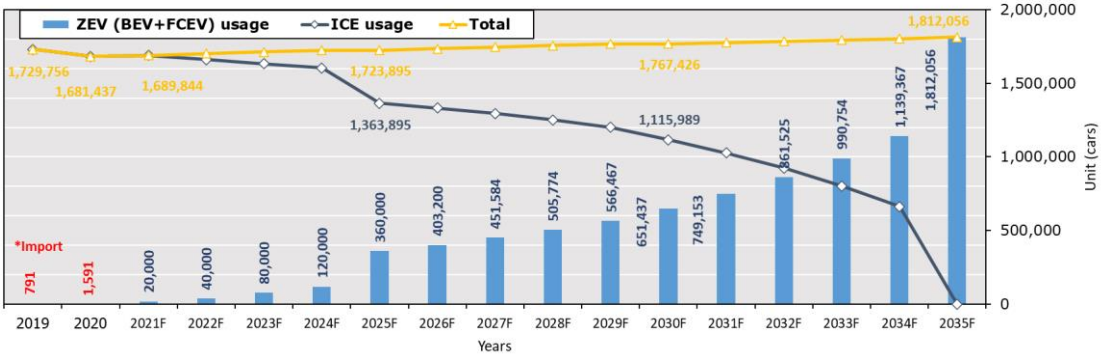
Official xEV Targets (at least up to 2030)

From the second meeting of the National EV Policy Committee on 24 March 2021, the detailed target for 100% ZEV registration is shown in Figure 4.3, as well as ZEV production target in Figure 4.4.

Figure. 4.3: Target of 100% ZEV Registration by 2035 for (a) Cars and Pickups, (b) Motorcycles, and (c) Buses and Trucks



(a)



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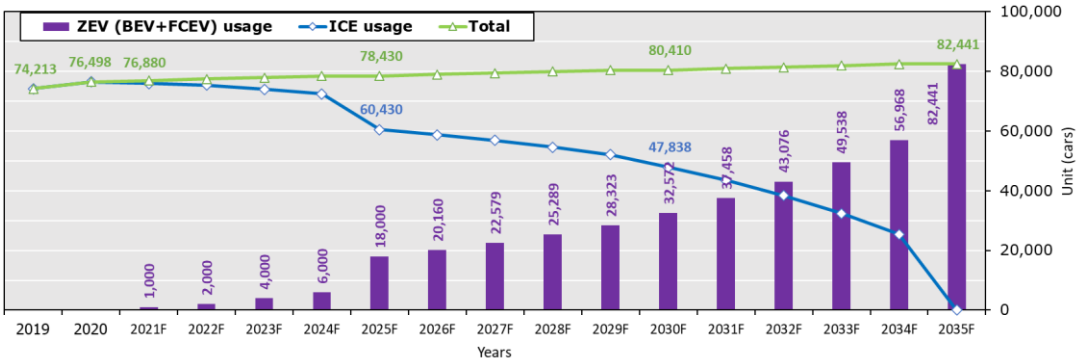
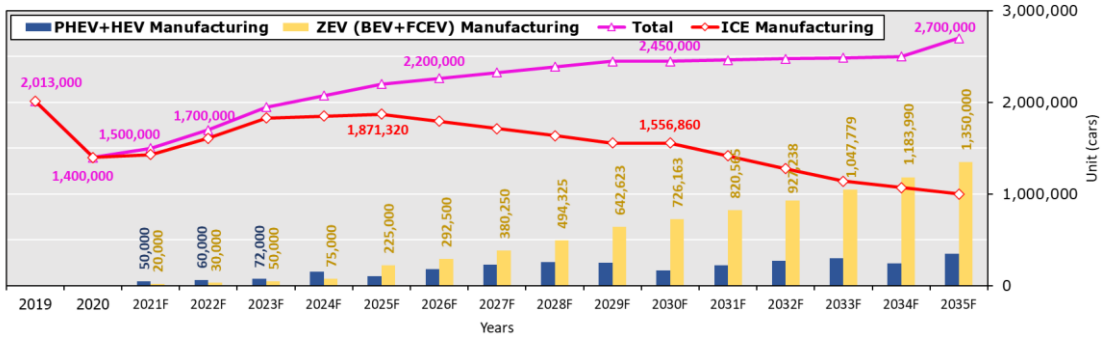


(c)

BEV= battery electric vehicle, FCEV = fuel cell electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle, ZEV = zero emissions vehicle.
Source: Thailand National EV Policy Committee (2021).

Figure 4.4: Target of ZEV Production by 2035



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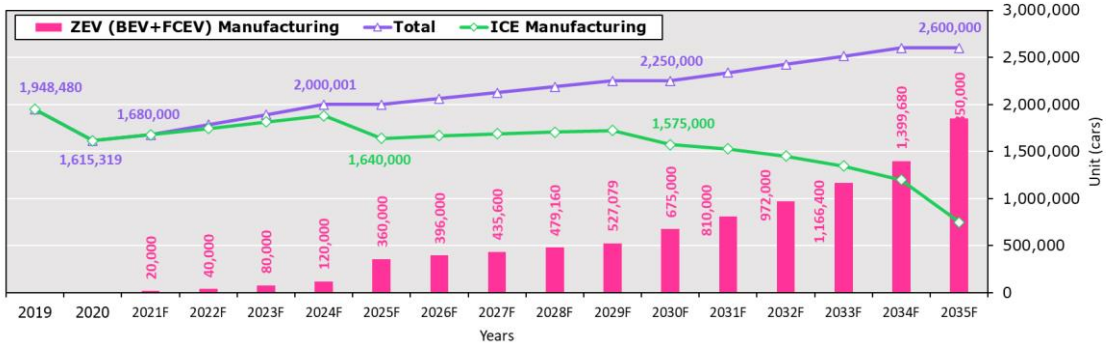

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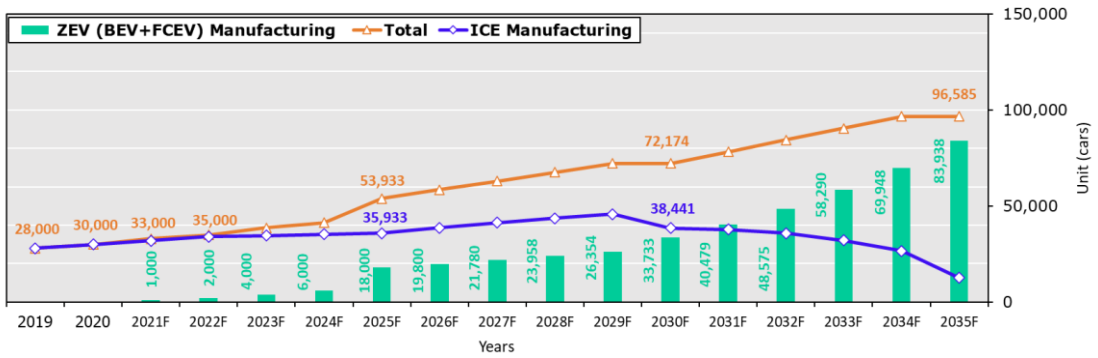


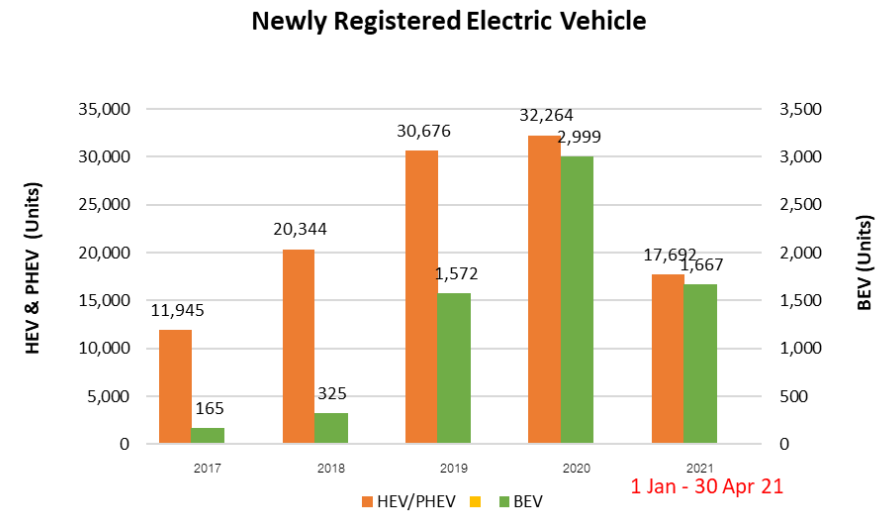
(c)

BEV= battery electric vehicle, FCEV = fuel cell electric vehicle, HEV = hybrid electric vehicle, ICE = internal combustion engine, PHEV = plug-in hybrid electric vehicle, ZEV = zero emissions vehicle.
Source: Thailand National EV Policy Committee (2021).

Statistics of Vehicle (gasoline and diesel type) and xEV (HEV, PHEV, BEV, FCEV) Registrations since 2011

Thailand has seen increasing interest in EV usage trends with more than 30,000 new HEVs/PHEVs and more than 1,200 battery electric cars and motorcycles registered in 2019, with approximately 750 charging outlets were setup in some 500 locations, as shown in Figure 4.5 (DLT, 2021) and Figure 4.6 (EVAT, 2021), respectively.

Figure 4.5: Statistics of Conventional Vehicles and xEV Registrations



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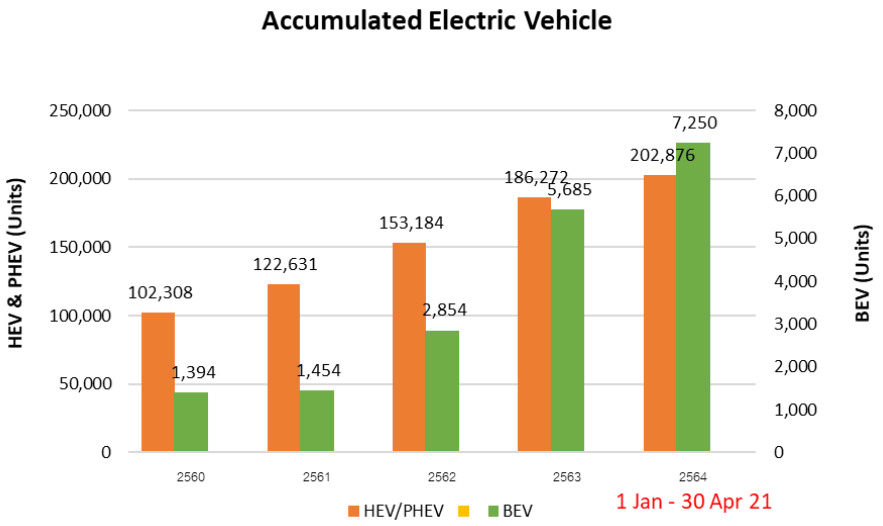
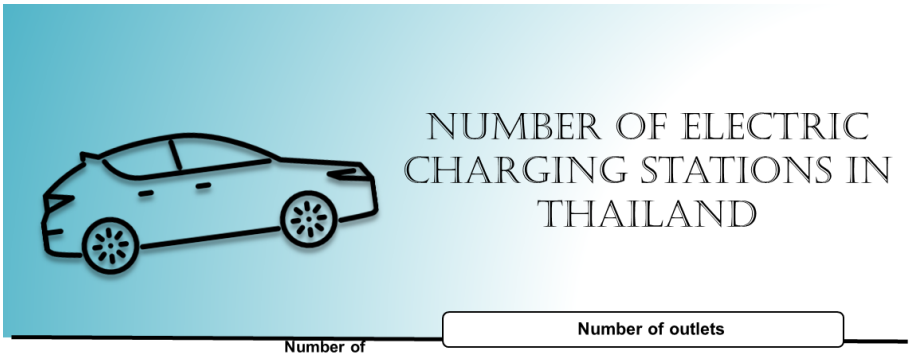


(b)

BEV= battery electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle, xEV = electrified vehicle.
Source: DLT (2021).

Figure 4.6: Statistics of EV Charging Stations



Service Providers	Number of Locations	Number of outlets		
		AC Normal Chargers	DC Fast Chargers	All Total Chargers
EA ANYWHERE	417	1,062	571	1,633
CHARGING STATION	68	42	32	80
EVOLT	49	79	23	102
PEA EV	32	36	111	147
pttstation	30	38	10	48
ChargeNow	18	62	1	63
EleX by EGAT	14	16	21	37
SHARGE	14	65	0	65
MEA EV	10	11	5	16
PUMP CHARGE	6	18	0	18
EVen	4	7	0	7
onion	2	8	0	8
TOTAL	664	1,459	771	2,224

Source: EVAT (2021).

Vehicle Assumption, e.g. Average Vehicle Kilometre of Travel, Average Vehicle Fuel Economy (gasoline and diesel)

To analyse future mobility fuel scenarios, vehicle assumptions, such as average vehicle kilometre of travel (VKT), average vehicle fuel economy (FE) are necessary. Although these kind of data are preferably to be record periodically, only project-based data are available in Thailand. EPPO has been conducting surveys every 5 years with latest data on VKT and FE collected in 2019 (EPPO, 2019). Together with efforts from the Ministry of Transport (OTP, 2016) and the Ministry of Industry (OIE, 2021), more data have been collected resulting in Table 4.3 and Table 4.4.

Table 4.3: Average VKT in Thailand

Vehicle Classification	VKT (km/year)
Car	20,230
Van	24,742
Pickup	24,270
Motorcycle	13,960
3-wheeler	30,285
Taxi	86,297
Bus Fixed Route	77,258
Bus_Non-Fixed Route	55,601
Truck	61,048

VKT = vehicle kilometre of travel.
Sources: EPPO (2019); OTP (2016); OIE (2021).

Table 4.4: Average FE in Thailand

Vehicle Classification	FE (litres of gasoline equivalent/100 km)
1: Eco car	4.76
2: City car, subcompact : Sedan and Hatchback	5.83
3: Compact car C-segment : Sedan and Hatchback Coupe Roadster	6.13
4 : D-segment full size sedan	6.71
5 : mini-MPV and B-SUV	5.79
6 : SUV and MPV	7.37
7 : PPV	8.13

8 : Single cab pickup	7.42
9 : Extra cab pickup	7.47
10 : 4 doors pickup	7.83

FE = fuel economy.
Sources: EPPO (2019); OTP (2016); OIE (2021).

Indonesia

Indonesia is in the very early stage of electric vehicle development. The majority of people support vehicle electrification and many people do not care where the electricity come from. There are currently about 220 electric cars and 5,000 electric motorbikes in the country.

On 8 August 2019, through Presidential Regulation no. 55/2019 on the Acceleration Program for Battery-powered Electric Vehicles for Road Transportation, Indonesia promulgated the country's first regulation on electric vehicles. Within 37 articles, the decree sets the legal framework for the future of the production of electric vehicles in Indonesia. However, the follow up of this presidential regulation is not so clear. For example, the present National Energy General Plan states that the target for electric vehicles is 2,200 cars and 2.1 million motorbikes by 2025. On the other hand, the Ministry of Industry has an even more ambitious targets as shown in Table 4.5.

Table 4.5: Production Targets of Electric Vehicles in Indonesia

Vehicle Type	2025		2030		2035	
	Number of units	% of total production	Number of units	% of total production	Number of units	% of total production
Four-wheeler	400,000	20	600,000	20	1,000,000	20
Two-wheeler	1,760,000	20	2,450,000	25	3,225,000	30

Source: Indonesian Minister of Industry Decree no. 27/2020.

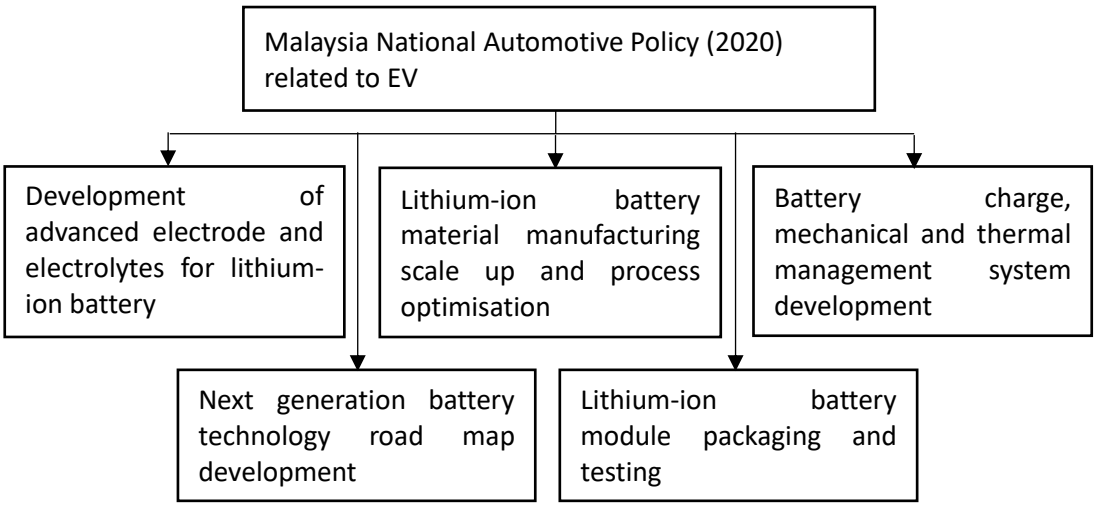
Considering that currently the electric vehicle production ecosystem in Indonesia still needs a lot of development, the targets shown in Table 4.5, especially those for 2025, are considered ambitious.

Malaysia

The government of Malaysia has formulated a series of policies in the last decade to encourage the use of alternative vehicles such as battery electric vehicles (BEVs). One such recent policy is the National Automotive Policy (NAP) (2020) (Ministry of International Trade and Industry Malaysia, 2020; Iskandar and Araffin, 2019; Rahim et al. 2019). Based on the government's

National Automotive Policy (2020), depicted in Figure 4.7, several technology developments project has been mapped out to improve the ease of owning EVs in Malaysia.

Figure 4.7: EV Components of the Malaysia National Automotive Policy (2020)



EV = electric vehicle.
Source: Ministry of International Trade and Industry Malaysia (2020).

The Ministry of International Trade and Industry Malaysia and the Malaysia Automotive, Robotics and IoT Institute (MARii) are finalising the last phase of the new policy on EVs as part of the upcoming revision of the NAP 2020. The policy would contain revisions that would jump start the road to electrification in Malaysia and enable the country to attract investment in the particular field. The policy proposes incentives for EVs including allowance for foreign automakers to bring in a number of completely built-up (CBU) units with the absence of tariffs, zero excise and import duties, full sales tax exemption, and zero road tax.

Coinciding with the NAP 2020, a draft of the Low Carbon Mobility Blueprint 2021–2030 under the Ministry of Environment and Water Malaysia and the Malaysian Green Technology and Climate Change Centre is being finalised by Cabinet, aimed at driving increased use of electric vehicles and low-carbon transportation in the public and private sectors to lower Malaysia's carbon emissions output. The transport sector contributes around 20% of the country's total emissions levels (Ghadimzadeh et al., 2015). The blueprint covers four key areas: vehicle energy efficiency improvement, EV adoption and related tax exemptions, alternative fuel adoption, and greenhouse gas (GHG) emissions and energy reduction.

Among the notable plans in the blueprint are the requirement of exhaust emissions testing for all new cars with the introduction of new GHG standards for new vehicles and a national average target, and full tax exemptions for government fleets, taxis, and ride-hailing vehicles, as well as excise duty and import tax exception for up to 10,000 individual CBU battery EVs until the end

of 2022. From 2023 to 2025, CBU EV units will be given a 50% import and excise duty exemption until locally assembled BEVs become available on the market.

Plug-in hybrid (PHEV) specific incentives also will also be introduced. These include tax exemption for qualified complete knocked-down models, with 100% exemption being given until 2022, 75% exemption from 2023 to 2025, and 50% exemption from 2026 to 2030. To ensure penetration, a sufficient EV charging infrastructure is needed, and the plan calls for the establishment of a national target of having 7,000 AC public charging points and 500 DC charging points. A public tender for a national fast charging network is planned with providing tax incentives under Green Income Tax Exemption for such services until 2030. In areas not serviced by private operators, the installation of a fast charger for every 100 kilometres and at every R&R stop along major highways, commencing from next year until 2025. Elsewhere, the new requirement guidelines for installing EV charging facilities proposes to be incorporated in planning permission for all new buildings, and a tariff revision for public EV charging services to be studied before the specific rates are implemented.

The government-led initiatives include plans to push EV (presumably both BEV and PHEV) adoption for taxi use as part of the modernisation process for such services. Incentives for the purchase of EVs and income tax exemption until 2030 are being proposed to offset the higher capital cost of EVs. The blueprint also lays out the adoption of BEVs for use in government and GLC fleets as a means to encourage wider adoption. For use in government targets for 10% of new additions to the fleet being BEVs by next year, with the percentage increasing to 20% from 2023 to 2025 while GLC fleets, with tax incentives being provided until 2030. From 2026 to 2030, 50% of the new additions to government and GLC fleets are targeted to be locally manufactured BEVs.

Buses and motorcycles are also set to feature in the move towards electrification, with plans to establish an e-bus central procurement agency, offering subscriptions of these to ministries and state governments. As for electric motorcycles, support will also be provided to local manufacturers, by giving tax incentives to operators purchasing these for use as delivery service vehicles. There is also a plan to develop a battery swapping standard for e-bikes and have it in place by 2023.

The electrification action plan aims to grow localisation through providing R&D grants and support for local manufacturers of electric vehicles. Presently, there are no dedicated tax incentives for investment in ‘green’ production and distribution activities, and the idea is to introduce a tax incentive scheme for industries in the production, distribution, and services related to low-carbon transpiration.

The blueprint is targeted to reduce GHG emissions by 165 million tons of CO_2, save fuel expenditure of RM150 billion over 10 years, and increase the use of electric vehicles and low-carbon transportation.

To support the government's efforts on EV policy plans, the Iskandar Malaysia Bus Rapid Transit together with the Iskandar Regional Development Authority started pilot testing of hybrid electric and biodiesel buses (Figure 4.8) from nine local and international suppliers on 8 April

2021 in line with Johor's modernisation of its public transport system. The project is said to have identified feeder, direct, and main routes that reach 2,043 kilometres or around 90% of Iskandar Malaysia's populated areas. Once fully implemented, the Iskandar Malaysia Bus Rapid Transit will be able to connect 55 feeder routes and 44 direct routes with the main route and its 33 stations. In addition, the Sarawak Tourism, Arts and Culture Ministry launched the first public bus running on electric power (e-Bus) in Malaysia, in line with the state government's policy to focus on sustainable development. The city e-Bus service that started in February 2019 on a trial basis with a single bus has been well received by visitors and locals, who commended the free, innovative, green energy bus services (Figure 4.9).

Figure 4.8: Iskandar Malaysia Bus Rapid Transit Pilot Test of Hybrid Electric and Biodiesel Buses

Source: Scania Malaysia (2021).

Figure 4.9: The City e-Bus Service, Kuching, Sarawak

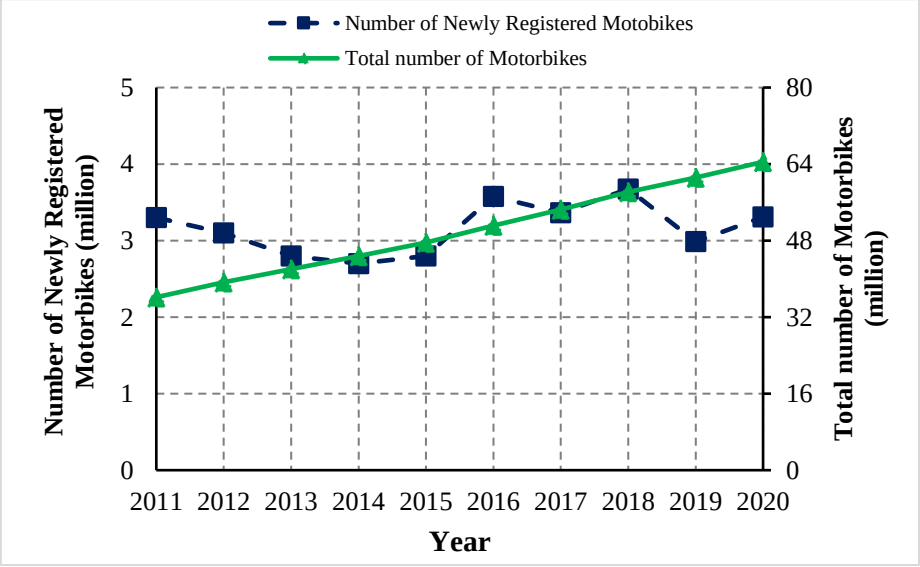
Source: Sarawak Tourism (2021).

B. Viet Nam

Motorbikes are the most popular transport means in Viet Nam, with the average number of motorbikes sold annually of about 3 million units, due to their low cost and flexibility (Figure 4.10). In 2019, Viet Nam had about 60 million motorbikes and was the fourth-highest country in the world for the number of motorbikes, and in 2020 the number of motorbikes incr

eased to about 64 million units (Vietnamnet, 2016; VAMM, 2021; Vietnam Register, 2021a).

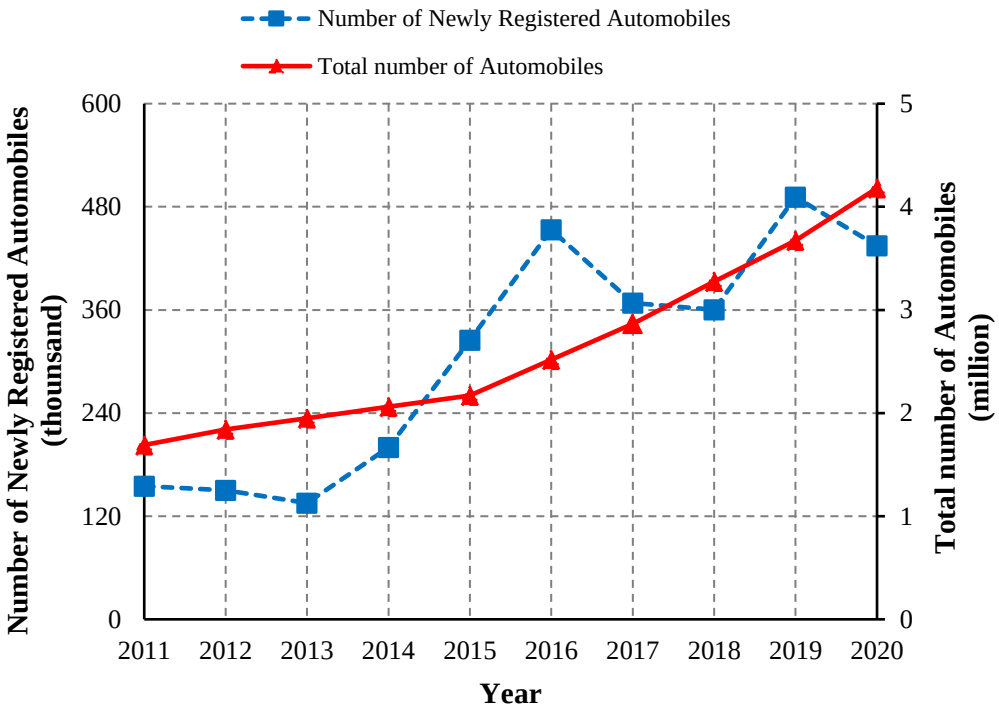
Figure 4.10: Number of Newly Registered and In-use Motorbikes



Sources: Vietnamnet (2016); VAMM (2021); Vietnam Register (2021a).

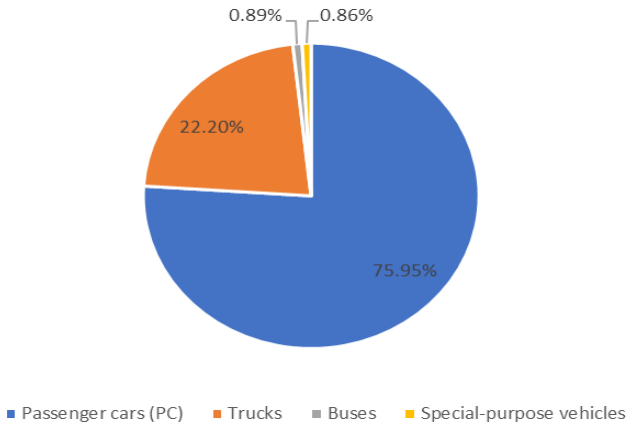
Viet Nam's automotive industry is also growing rapidly and has been doing so continuously during recent years. On average, the growth of the automobile market has been 20% to 30% annually. The total number of registered automobiles until 2020 was about 4.2 million units, as shown in Figure 4.11 (CEIC, 2015; Vietnam Register, 2021a). In 2020, the number of domestically assembled and imported automobiles are about 324,000 and 110,000 units, respectively (Vietnam Register, 2021a). The sales report of the Vietnam Automobile Manufacturer's Association in 2020 shows that passenger cars contribute to 76%, commercial vehicles contribute to 23% of total automobiles sold, as shown in Figure 4.12 (VAMA, 2021). From the passenger car's fuel consumption list based on the compound driving cycles (Vietnam Register, 2021b), it is estimated that the average fuel consumption is about 8.02 litre/100km for gasoline cars, and 7.52 litre/100km for diesel cars.

Figure 4.11: Number of Newly Registered and In-use Automobiles



Source: CEIC (2015); Vietnam Register (2021a).

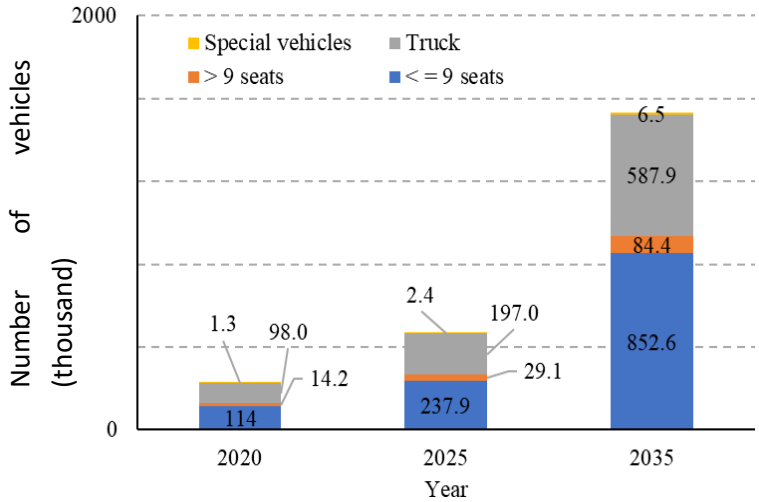
Figure 4.12: Share of Automobiles Sold in 2020 Based on Type



Source: VAMA (2021).

In 2014, the Viet Nam government issued Decision No 1168/QD-TTg approving the strategy for development of Viet Nam's automobile industry up to 2025, with a vision to 2035. The decision also set target numbers for domestically assembled cars (Figure 4.13).

Figure 4.13: Specific Target of the Strategy for Development of Viet Nam's Automobile Industry

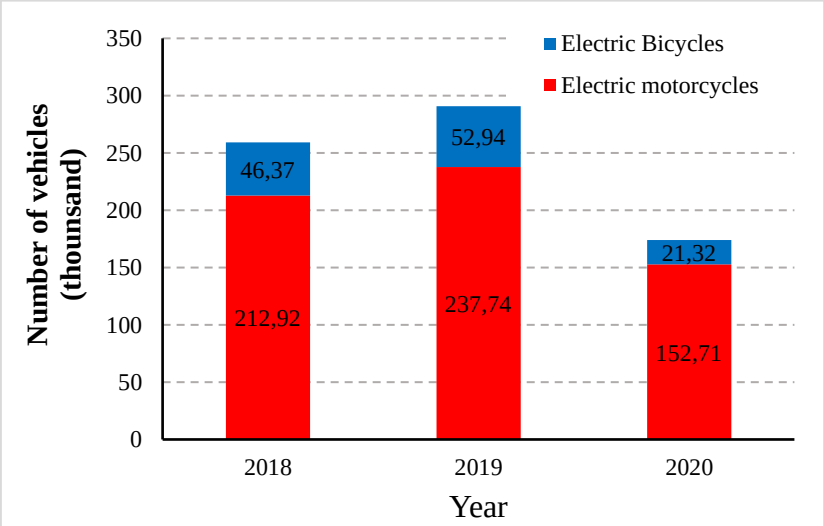


Source: Decision of The Prime Minister of Vietnam Government (2014). About approval for strategy to develop automotive industry in VietNam by 2025, orientation towards 2035. https://vanbanphapluat.co/decision-no-1168-qd-ttg-dated-2014-strategy-to-develop-automotive-industry-in-vietnam-by-2025

The Decision also encourages the manufacture of environment friendly vehicles (fuel efficient vehicles, hybrid, biofuel-powered, and electric vehicles, etc.) to meet the requirements on emissions standards.

Currently, the electric vehicle market is dominated by electric bikes and electric motorcycles. In 2018, there were 14 e-bike and 39 e-motorcycle manufacturers that produced 46,373 units of e-bikes and 212,924 units of e-motorcycles. These numbers have seen some changes in 2019 and 2020, as shown in Figure 4.14 (ICT News, 2020). In the first quarter of the year 2021, about 76,184 units of e-bikes and e-motorcycles were sold (Tienphong, 2021).

Figure 4.14: Number of E-Bikes and E-Motorcycles Produced in 2018–2020



Source: ICT News (2020).

In contrast, the electrified car market in Viet Nam, especially electric cars, is still in its early stage. Some projects on the development of electric cars have been carried out. In 2012, Siemens Vietnam and Vinamotor signed a contract to jointly produce a prototype bus with ELFA hybrid technology. This hybrid bus was officially introduced in 2013 and also approved by Vietnam Register in accordance with the operating conditions of our country's urban areas. However, this bus had a huge cost and still lacks support from the government (Automation Today, 2015; Tuan, 2019).

In 2016, the Mai Linh Group, one of the biggest taxi companies in Viet Nam, signed a memorandum of understanding with the genuine distributor of French carmaker Renault to import electric motor cars for use as taxis. However, this plan failed because there were no charging stations for electric taxis, and the long charging times are unsuitable for taxis (Vietnamnet, 2021). In 2017, VinFast, a part of Vingroup which is Viet Nam's biggest private enterprise, was established with the aim to be a leading automobile and motorcycle manufacturer in Southeast Asia. Initially targeting the domestic vehicle market, VinFast fabricates electric motorbikes, electric buses, and (electric) cars. In its first phase, VinFast aims

to produce 100,000–200,000 vehicles per year, including five-seat sedans, seven-seat sport utility vehicles (SUVs), and electric motorbikes. In 2018, Vinfast's first two prototypes, a sedan and an SUV, were introduced at the Paris Motor Show and a small car model called Fadil was also unveiled in Ha Noi. Vinfast's e-scooter factory has first-phase capacity of 250,000 scooters each year and the capacity designed for the second phase is 500,000 scooters each year and could reach 1 million (Vietnamplus, 2018). Its electric scooter models under the brand Klara have already been available on the market since November 2018 (now some other electric scooter models of Vinfast are also available including Feliz, Theon, and Ludo). Recently Vinfast has just also introduced a model of electric buses (Vinbus) and electric cars (VF E34) (but are not on the road yet).

Based on the report of Toyota Vietnam, the current hybrid and EV sales are very low with no more than 1,000 units (up to end 2020), adding about 600 units in the first quarter of the 2021, in which EVs contribute just about 1% (Toyota Vietnam, 2021; MOIT, 2021). These numbers do not include electric vehicles that are mostly less than 16 seats and without doors, sold to tourism companies, hotels, and households engaged in tourism services.

The obstacles of electric car development in Viet Nam include low income per capita, a lack of charging infrastructure, a lack of government incentives, and a lack of a comprehensive e-vehicle development strategy.

Furthermore, electricity generation source in Viet Nam is dominated by coal. As planned in Decision No 428/QD-TTg approval of the Revised National Power Development Master Plan for the 2011–2020 Period with the Vision to 2030, coal-fired thermal power contributes to 42.7% in 2020, 49.3% in 2025, and 42.6% in 2030 of the total capacity of power plants. In the Notification 263/BDKH-TTBVTOD of the Ministry of Natural Resources and Environment, the emissions factor of the electric grid in Viet Nam was calculated at 0.913 tCO_2/MWh.

C. Philippines

National Plan for xEVs (HEV, PHEV, BEV, FCEV) Promotion (existing and developing)

The Philippine Department of Energy (PDOE) is continuously embarking in prioritising plans and programmes regarding the promotion of alternative fuels and energy technologies (AFETs) as it is deemed necessary to address the issue on the increasing demand of the transport sector and the high dependency on imported conventional fuels. This is in partnership with other national government agencies (NGA) and the private sector to craft viable mechanisms and build-up local capacities. The use of AFETs in the energy mix for supply security and reduction of GHG emissions result in enhanced quality of air by providing options for gradual replacement of fossil-based fuels. In relation thereto, this shall serve as one of the key strategies in meeting the country's Nationally Determined Contribution to the Paris Agreement.

Following are the PDOE's medium and long-term objectives covering 2019 to 2040: (1) review, update, and formulate energy-related policies, guidelines, and standards; (2) scale-up the use of AFET; (3) pursue the use of sustainable energy efficient technologies; (4) collaboration with

stakeholders; (5) alternative fuel vehicle mainstreamed in the transport sector; (6) continuing government initiatives; (7) priority AFETs; (8) assessment of non-transport energy technologies will be pursued; and (9) infrastructure support, the promotion, and deployment of EVs may come to fruition.

In May 2021, Senate Bill No. 1382 otherwise known as the Electric Vehicles and Charging Stations Act was approved to primarily promote EVs and aid in the country's emissions reduction objectives. One of the main highlights of the Act is the formulation of the Comprehensive Road Map on EVs (CREV) as well as the crafting of the guidelines specifically for the 'manufacturing, importation, utilisation, and regulation of EVs and hybrids as well as parts, components, and batteries' and mechanisms for charging stations across the country (Laurel, 2021).

Consistent with the Electric Vehicles and Charging Stations Act and the plans for increasing EV utilisation in the country, the Philippines is also aiming to be an auto-manufacturing hub, particularly to place third in the Southeast Asian region, through its 'low cost transportation and commercial vehicles' by banking on the country's significant contribution to exports of machinery and transport equipment (Cahiles-Magkilat, 2020).

Government Support and Incentives for xEVs (HEV, PHEV, BEV, FCEV), e.g. Subsidy, Mandate

Through the Electric Vehicles and Charging Stations Act, fiscal incentives are to be availed by entities engaged in the activities concerning manufacturing, importation and utilisation through several NGAs such as the Department of Trade and Industry (DTI), the Land Transportation Office, and the Metropolitan Manila Development Authority. The fiscal incentives include the income tax holiday, import exemption from excise taxes, duties and value-added tax, and discounts from payment of motor vehicle user's charges, registration, and inspection fees, amongst others. Also, the DTI through its Board of Investments shall formulate and carry out an EV incentive strategy in line with the CREV.

While non-fiscal incentives can also be granted for EV activities related to the expedition of applications and registrations with NGAs and local government units, exemption from some existing mechanisms for conventional vehicles fleets is imposed by the Metropolitan Manila Development Authority. Other support initiatives are to be provided by institutions through financial assistance in accordance with the Act.

CO_2-related Information (well-to-tank) for Electricity

In line with the PDOE's objectives, a technology demonstration was conducted for the validation and pilot testing of AFETs with potential for commercialisation. Among those included in the said activity were EVs, hybrid vehicles, and plug-in hybrids. EVs involved in the demonstration were described as 'powered by electricity through battery packs' and were identified with 51km/litre equivalent efficiency and no tailpipe emissions as compared to gasoline with 29.23 km/litre equivalent efficiency and 101 g CO_2/km emissions.

Official xEV Target by Year (at least up to 2030)

According to the DTI and the Electric Vehicle Association of the Philippines' EV Comprehensive Road Map, the industry is targeting about 21% EV utilisation by 2030 out of the total vehicle population specifically focusing on public transportation. By 2040, the industry target is set at 50% EVs of the total vehicles being utilised in the country for the said period (Cahiles-Magkilat, 2020).

Further, based on the Electric Vehicles and Charging Stations Act and its corresponding CREV, it is mandated that around 5% EV utilisation shall be realised through a gradual increase involving the vehicle fleets of those belonging to the government and corporate sectors.

Statistics of Vehicle (gasoline and diesel type) Registration

According to the LTO (2021), registered motor vehicles using gasoline and diesel fuel as of end 2020 reached 11.85 million or a decrease of 6.87% as compared to the 2019 level which was around 12.73 million. The decrease was attributed to the absence of transactions relating to registrations during the month of April 2020 due to the quarantine classifications imposed across all regions in the Philippines during the pandemic.

Statistics of xEV (HEV, PHEV, BEV, FCEV) Registration

The number of registered EVs through the LTO as of 2019 was recorded at 5,002 units encompassing e-trikes, e-quads, e-jeeps, e-motorcycles, e-trucks and e-buses including the 3,000 units of e-trikes from the PDOE E-trike Project. While market projections for 2020 and 2021 are set at 1,750 and 1,930 additional units, additional registered EVs for 2020–2021 are seen to be greatly affected by the ongoing pandemic and recovery in the EV market is targeted to come in the second semester of 2021.

Vehicle Assumption, e.g. Average Vehicle Kilometre of Travel, Average Vehicle Fuel Economy (gasoline and diesel)

Based on the PDOE's 2016 Fuel Economy Run at 280-kilometre distance consisting of various vehicle types and models, the average fuel consumption at Euro 4 is at 12.894 litres for gasoline and 13.205 litres for diesel.

D. India

To ensure a cleaner and sustainable energy security and to establish a net zero emissions regime, the Government of India is promoting deployment of electricity vehicles at the larger scale. The major initiative towards this direction started in 2013 when the National Electric Mobility Mission Plan was launched. Under this plan an outlay Rs14,000 crore (1 crore is 10,000,000) were envisaged up to 2020. The focus of this plan was to promote demand incentives, manufacturing,

charging infrastructure development, and R&D. Since then, various plans have been launched. The important plans are:

FAME 1: In 2015 The Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME 1) was launched. The salient features of this plan are:

- Budget outlay: Rs895 crore
- Focus: market Development of EVs focusing on demand incentives, technology development, pilot project, and charging infrastructure
- Outcome: 2.78 lakh (1 lakh is 100,000) XEVs and 465 buses received subsidy

National Mission on Transformative Mobility and Storage (Policy Statement) was launched in 2017. The important features of this plan are:

•Policy with a mission to coordinate with key stakeholders in ministries, departments, and the states for integrated actions.

•Focus: Road Map for Battery Manufacturing (Phased Manufacturing Plans), Support sustainable mobility ecosystem. Progressive support across regulations. charging technologies, manufacturing, recreational vehicle (RV) integration.

FAME 2 was launched in 2019. The salient features are:

•Total outlay of Rs10,000 crore for a period of 3 years

•Focus: Electrification of public and shared transportation (7,000 e-buses, 5 lakh electric 3W, 55,000 electric 4W, and 10 lakhs electric 2W).

State Policies: While the above polices have been launched by the Central Government of India, except for five states, most states have yet to come out with EV policies. The following depicts the state policies (NITI Aayog, Government of India):

Delhi: Targets 25% EV sales by 2024. State-level incentives over and above central incentives. Purchase incentives for all categories of private and commercial EVs. Waiver in fees, allowance to sell EVs without batteries (battery as a service concept), scrappage incentives, subsidy for private charging points, special tariffs, introduction of feebates (fee collection from polluting vehicles), tax waivers.

Andhra Pradesh: Targets 1 million EVs by 2024 and 100% e-buses by 2029. Focus: Support for setting up manufacturing through in-kind support, fee waivers, and reimbursement.

Karnataka: Focus: R&D, production, services, and customer support with indirect incentives for R&D units, manufacturing and charging networks, and start-up ecosystems.

Kerala: Targets 1 million EVs on the road by 2022. Focus: R&D, production, services, and customer support with indirect incentives for R&D units, manufacturing and charging networks.

Uttar Pradesh: Targets 1 million EVs and 70% electrification of public transport by 2030. 2 lakh charging points by 2024. Focus on manufacturing.

Current Status and Indicators of EVs

The indicators of EV progress and current status are:

- India's 2030 EV ambition, signalled by NITI Aayog, states that 70% of all commercial cars, 30% of private cars, 40% of buses, and 80% of two- and three-wheeler sales in 2030 would be electric.
- At the end of March 2020, the total number of registered electric vehicles in India stood at only half a million.
- The EV sector registered nearly 1.35 lakh EVs in FY21. Three-wheeler EVs made up 65% of all EV registrations in FY21, having comprised 83% of the market in the year
- The Indian automobile market has registered over 6.38 lakh EVs in 2020–21 since 2011–12.
- According to the Council of Energy, Environment and Water-Centre for Energy Finance study, the cumulative EV sales in all vehicle segments could cross over 100 million units by FY2030 which is 200 times its current market size.
- India's EV ambition would require an estimated annual battery capacity of 158 GWh by FY2030.
- India would also need a network of over 2.9 million public charging points by FY2030, beyond the in-home charging points. Currently, there are just 1,800 public charging points across the country.
- It will require a cumulative investment of up to $2.9 billion (Rs20,600 crore) until 2030.

Challenges

Although India has an ambitious plan to deploy electrical vehicles at the larger scale covering about 70% to 80% of transportation vehicles by 2030, there are some challenges which need to be addressed.

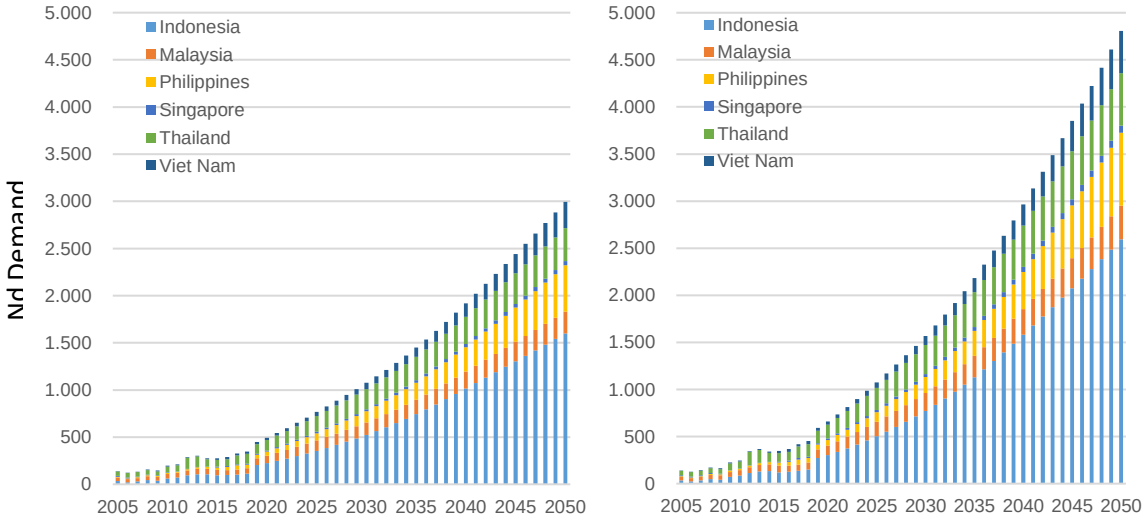
- Demand incentives absent for private EVs (except for Delhi): FAME 2 slow to pick up – 1.4% utilisation of incentives as of July 2020.
- Significant challenges in scaling-up manufacturing value chains, especially for batteries, mainly on account of raw material and technology constraints.
- Limited support and capability in innovation and technology development and R&D.
- Weak and highly-loaded distribution grid infrastructure posing potential challenges to implementation of charging infrastructure, especially high-power charging infrastructure
- Lack of coordination between the central and state governments to implement EV policies.

3. Evaluation of Mineral Resource Consumption Regarding Vehicle Electrification

This study describes the results of our predictions for the demand and waste of Nd and Co in response to the electrification of automobiles in each country, as predicted by each of the two evaluation methods described in Section 2.

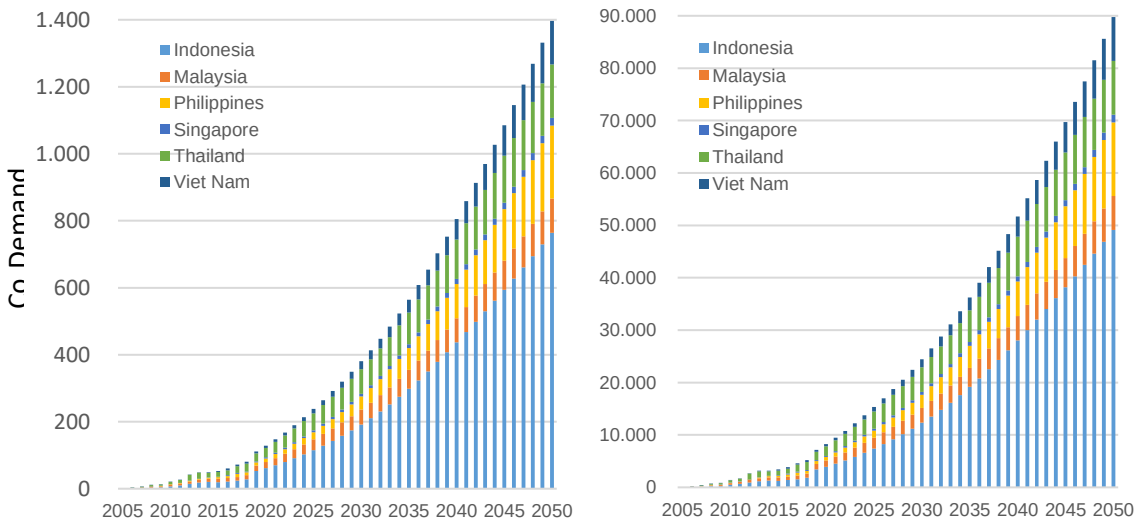
Figures 4.15 to 4.18 show the results of these estimations by first calculating the number of vehicles that were sold and the number of vehicles that were discarded; these values were then compared to the calculated values in Method 1.

Figure 4.15: Neodymium Demand Minimum (left) and Maximum (right) Value



Nd = neodymium, t/y = ton/year.
Source: Authors

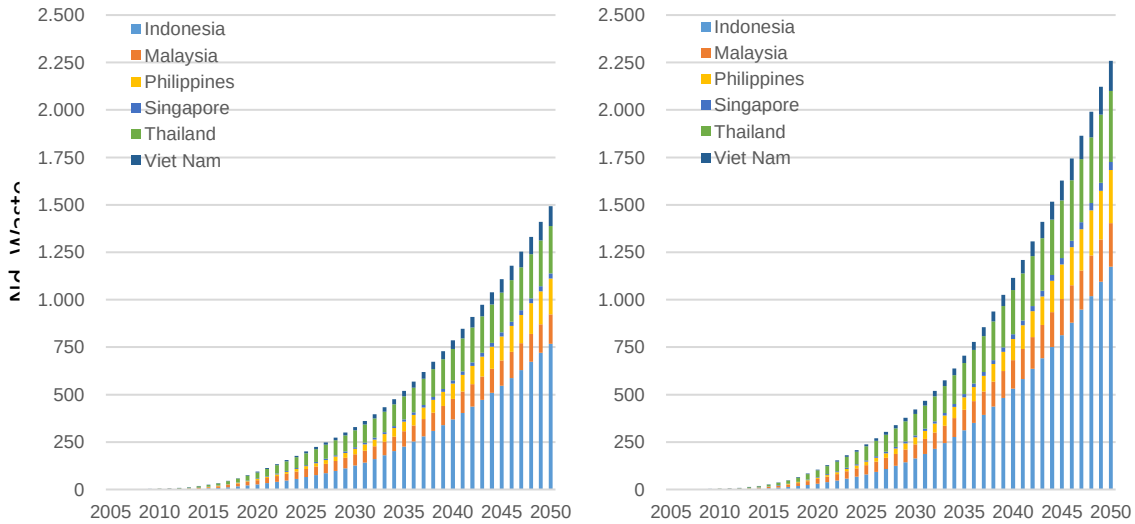
Figure 4.16: Cobalt Demand Minimum (left) and Maximum (right) Value



Co = cobalt, t/y = ton/year.
Source: Author.

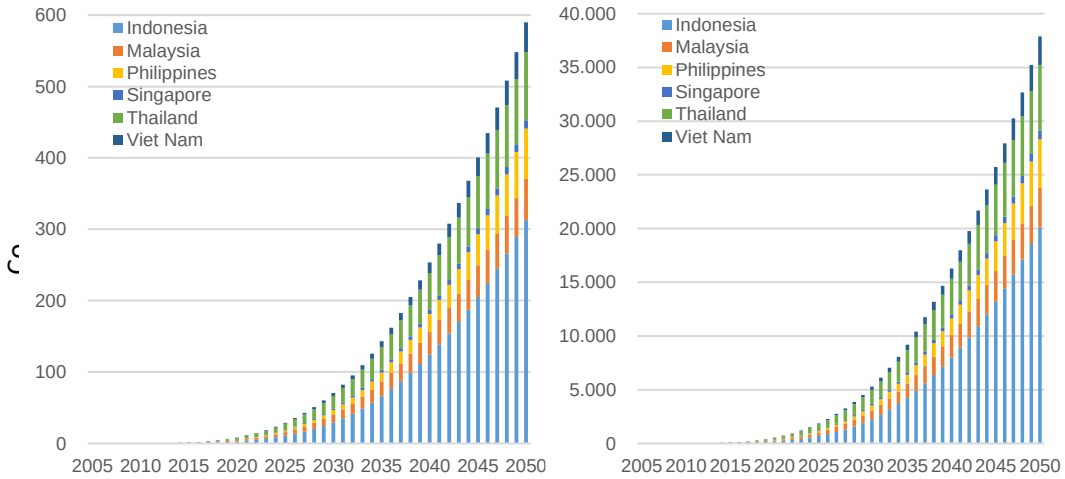
From the result of Figures 4.15 and 4.16, the total demand of neodymium is predicted to be a minimum of 2,996 t/y to a maximum of 4,809 t/y in 2050 based on Method 1. Moreover, the total demand of cobalt is predicted to be a minimum of 1,397 t/y to a maximum of 89,762 t/y in 2050.

Figure 4.17: Neodymium Waste Minimum (left) and Maximum (right) Value



Nd = neodymium, t/y = ton/year.
Source: Morimoto (2021).

Figure 4.18: Cobalt Waste Minimum (left) and Maximum (right) Value

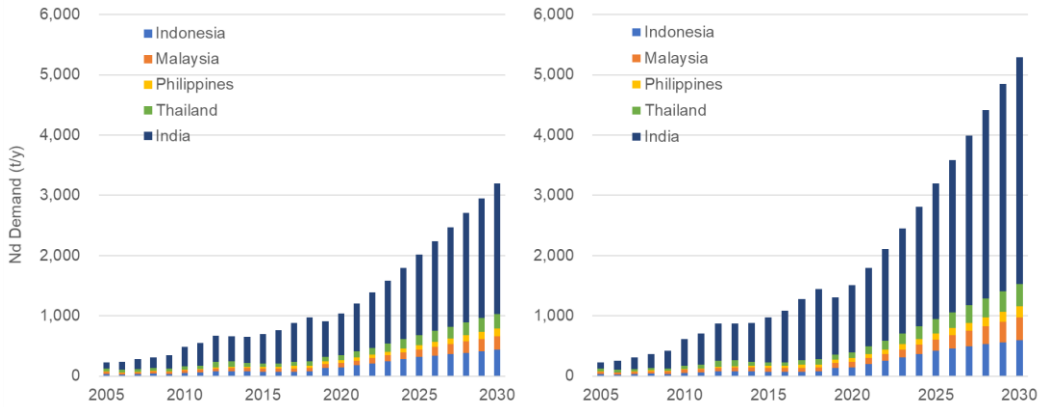


Co = cobalt, t/y = ton/year.
Source: Morimoto (2021).

From the result of Figures 4.17 and 4.18, the total waste of neodymium is predicted to be a minimum of 1,494 t/y to a maximum of 2,260 t/y in 2050. Moreover, the total waste of cobalt is predicted to be a minimum 590 t/y to a maximum 37,896 t/y in 2050. Therefore, based on Method 1, secondary resource can cover 47% to 50% of neodymium demand and 42% of cobalt demand if the recycle rate is 100%.

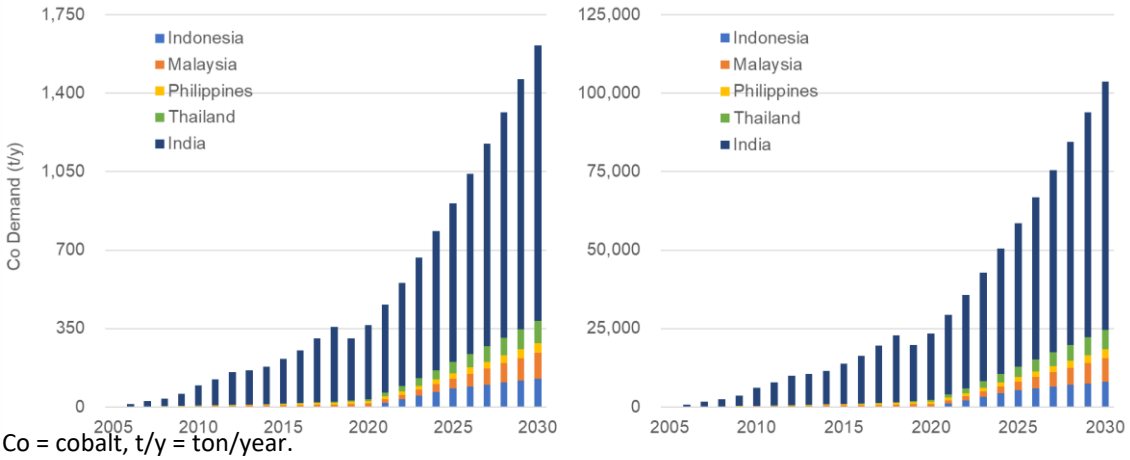
Figures 4.19 to 4.22 show the results of these estimations by first calculating the number of vehicles that were sold and the number of vehicles that were discarded; these values were then compared to the calculated values in Method 2. However, countries that included in the estimation is deferent between Method 1 and Method 2. This is due to the difference in source data that Deloitte's data did not include India, but original data was collected from projected member in Method 2.

Figure 4.19: Neodymium Demand Minimum (left) and Maximum (right) Value



Nd = neodymium, t/y = ton/year.
Source: Morimoto (2021).

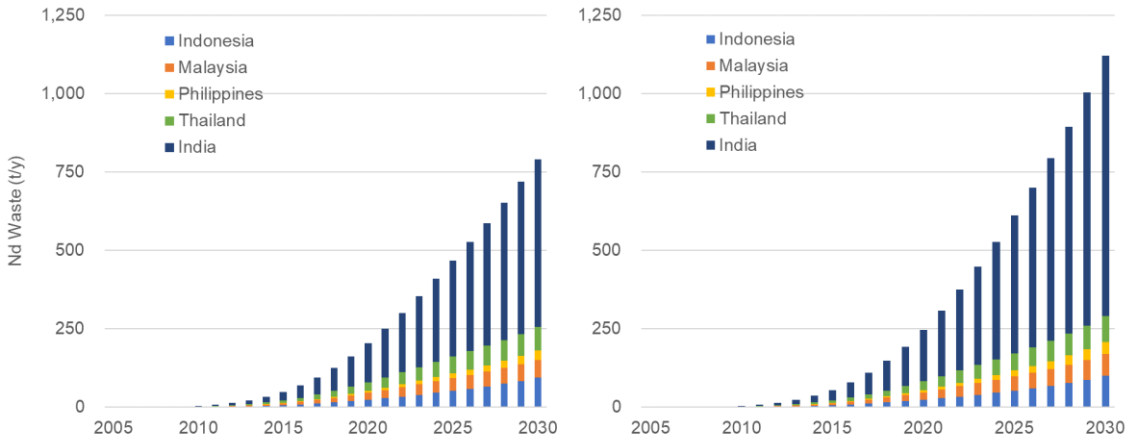
Figure 4.20: Cobalt Demand Minimum (left) and Maximum (right) Value



Co = cobalt, t/y = ton/year.
Source: Morimoto (2021).

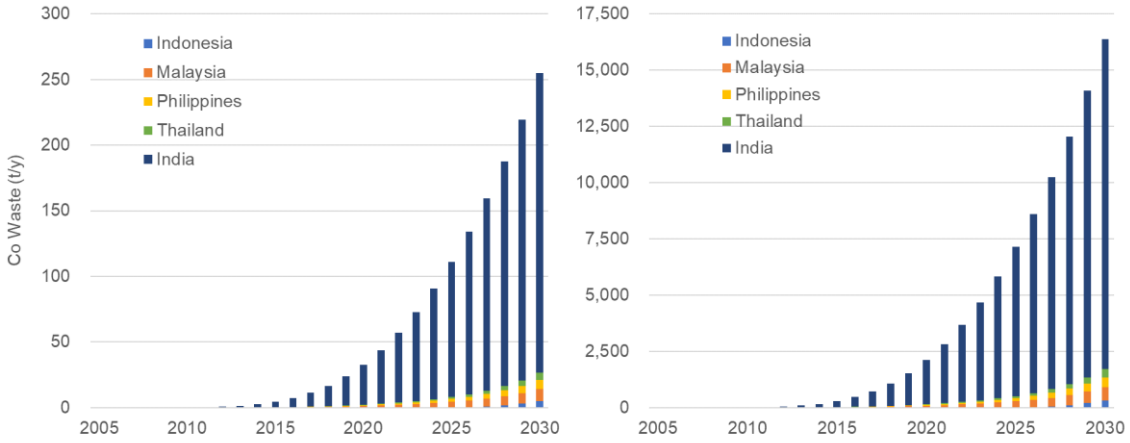
From the results of Figures 4.19 and 4.20, the total demand of neodymium is predicted to be a minimum of 3,200 t/y to a maximum of 5,295 t/y in 2030 based on Method 2 (including India). Moreover, the total demand of cobalt is predicted to be a minimum of 1,614 t/y to a maximum of 103,720 t/y in 2030.

Figure 4.21: Neodymium Waste Minimum (left) and Maximum (right) Value



Nd = neodymium, t/y = ton/year.
Source: Morimoto (2021).

Figure 4.22: Cobalt Waste Minimum (left) and Maximum (right) Value



Co = cobalt, t/y = ton/year.
Source: Morimoto (2021).

From the results of Figures 4.21 and 4.22, the total waste of neodymium is predicted to be a minimum of 791 t/y to a maximum of 1,121 t/y in 2030. Moreover, the total waste of cobalt is predicted to be a minimum t/y 255 to a maximum of 16,374 t/y in 2030. Therefore, based on Method 2, secondary resource can cover 21% to 25% of neodymium demand and 16% of cobalt demand if the recycle rate is 100%.

4. **Discussion**

This chapter described the results of the estimation for the long-term mineral resource demand associated with automobile electrification in EAS countries. In addition, this chapter described the results of the assessment of the potential for recycling in these countries by determining the amount of waste of these mineral resources.

As the conclusion, the demand for neodymium is predicted to be a minimum of 2,996 t/y to a maximum of 4,809 t/y in 2050 based on Method 1 and a minimum of 3,200 t/y to a maximum of 5,295 t/y in 2030 based on Method 2 (including India). If the recycle rate is 100%, secondary resources can cover 47% to 50% of neodymium demand based on Method 1 and 21% to 25% based on Method 2.

Moreover, the total demand for cobalt is predicted to be a minimum of 1,397 t/y to a maximum of 89,762 t/y in 2050 based on Method 1 and a minimum of 1,614 t/y to a maximum of 103,720 t/y in 2030 on Method 2. If the recycle rate is 100%, secondary resources can cover 42% of cobalt demand based on Method 1 and 16% based on Method 2.

However, considering that production of neodymium was 43,200 REO tons/year and cobalt was 140,000 tons/year in 2020, it is predicted to be difficult that world supply will meet the target of EAS mobility electrification regarding the large increase of demand in China, the European Union, and United States.

Therefore, it is necessary to consider the balance between biofuels and mobility electrification based on the potential of secondary resources and circular economy.

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