Chapter 1

Current Situation of Electric Vehicles in ASEAN

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CHAPTER 1:

CURRENT SITUATION OF ELECTRIC VEHICLES IN ASEAN

Martin Schröder and Fusanori Iwasaki

1. Introduction

Interest in electric vehicles (EVs) is growing in the Association of Southeast Asian Nations (ASEAN) and East Asia. In 2019, the total number of vehicle sales in ASEAN Member States was 3.4 million, according to the ASEAN Automotive Federation.[1] The number will increase in the coming 50 years due to population growth and economic development. Since automobiles are expected to be increasingly sought after with economic growth, it is necessary to consider how to cope with the growing demand for fuel consumption and air pollution, such as greenhouse gas (GHG) emissions, particulate matter (PM), nitrogen oxide (NO_x), and sulphur oxide (SO_x) in some city areas. Emerging EV technology could bring about improvements in energy efficiency as well as the environment and health of human beings.[2]

According to the International Energy Agency (IEA, 2018), the sales of new EVs worldwide surpassed 1 million units in 2017. The total stock of electric cars surpassed 3 million vehicles, with China occupying the largest portion at around 40% of the total in the world.

We shall outline basic definitions for analysing EV[3] supply chains in the ASEAN region. Within EVs, there exist various subtypes, namely hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell vehicles (FCVs).[4] Despite differences between and within these subtypes, all these subtypes share a number of components that differentiate them from internal combustion engine vehicles (ICEVs) (Table 1). Hence, EVs require a supply chain that is different from conventional vehicles.

[1] The actual number will be slightly higher as reported data only cover Brunei Darussalam, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam, i.e. data on Cambodia and Lao PDR are not reported. However, as both countries are least developed countries with relatively small populations, the total number of vehicle sales should only be marginally higher.

[2] It should be stressed that this view presupposes that electricity is generated in a sustainable way. Research grounded in well-to-wheel analysis (Wang, 2001) highlights that EVs overall environmental impact depends on a country's electricity mix, i.e. some countries may actually have higher total emissions if they switch to EVs without simultaneously changing their electricity generation (Woo et al., 2017).

[3] The following description is a simplified overview that seeks to briefly explain the differences between EV types and the function of different EV components. As the purpose of the research project is to investigate industrial competitiveness and readiness for EV production, a lot of technical details, such as differences between series, parallel, and series-parallel hybrids, are omitted. For a recent, detailed discussion of EV types and components from a technological point of view, refer to the work of Un-Noor et al. (2017).

[4] As FCVs are still highly expensive and only produced in very low numbers, this subtype will not be excluded from the following investigation. Also, as will be shown in the subsequent discussion, no ASEAN Member State supports FCVs through policy.

Table 1.1: Components Used in Internal Combustion Engine Vehicles and Electric Vehicle Subtypes

Component	ICEV	HEV	PHEV	BEV
Engine	●	●	●	
Electric traction motor		●	●	●
Converter		●	●	●
Inverter		●	●	●
Traction battery		●	●	●
Of which: Battery cell		●	●	●
Of which: Battery management system		●	●	●
Plug			●	●

BEV = battery electric vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Authors.

As the name implies, hybrids share components with both conventional and purely electric vehicles. It should be stressed that BEVs do not utilise a significant number of ICEV components, such as engines, exhaust systems, filters, fuel injection system, fuel pumps, radiators, and spark plugs, which, however, are all part of hybrids. It is, however, also obvious that all EV types share a significant number of components that constitute an enlarged or alternative supply chain.

To clarify the function of the EV components listed above, a brief summary of the components' functions is given below. It should be highlighted that these components constitute a significant share of the total cost of making EVs, so local manufacturing operations may mean that host countries capture value-added.

Electric motors have the task of transforming energy stored in the traction battery into motion, which turns the wheels. In the case of BEVs, the motors solely perform this task, whilst motors and internal combustions engines work in tandem to power the wheels of hybrids.

The traction battery is the source of energy. Whilst it is the only source of energy in BEVs, HEVs and PHEVs utilise chemical energy from the battery and engine fuel. Here, it needs to be stressed that battery production alone may not constitute significant value-added capture. EV batteries typically are packaged into so-called 'battery packs', which consist of various battery modules that in turn are constituted by several battery cells. In the case of lithium-ion (Li-ion) batteries, cells are the costliest component, and subsequent processing into modules and packs adds relatively limited value (Coffin and Horowitz, 2018). If one divides the costs of a final battery pack into the stages of the production process, 14% of costs stem from the pack production stage, 11% from the module production stage, and 20% from the cell production stage. Simultaneously, cells constitute 75% of the total costs of a battery pack. This is mainly due to the fact that relatively costly materials used in Li-ion batteries, such as lithium, cobalt, manganese, and (natural) graphite, are utilised during the cell production stage.[5] Whilst assembly into modules and packs is necessary, the costs mainly stem from the battery cells.

[5] The list of important raw materials may be extended to nickel, copper, aluminium, silicon (metal), and tin.

Thus, only if battery cells are manufactured locally are host countries capturing noteworthy value-added.

In general, an inverter's primary function is to convert direct current (DC) into alternating current (AC). This component is required as the traction battery releases electric energy in the form of DC whilst the motor utilises AC.

A converter is an electrical device that increases or decreases the voltage – either DC or AC – of an electrical power source. Inside EVs, inverters and converters may be combined into a single unit that functions as a managing device for the electric drive system. For instance, if the EV is utilising a so-called 'regenerative brake', kinetic energy from the brake is fed into the electric motor, which acts a generator. The electric load produced may be stored as chemical energy in the battery, as electric energy in capacitors, or as mechanical energy in a flywheel.

In PHEVs and BEVs, the plug has the basic function of allowing the re-charging of the traction battery.

2. Literature Review

We aim to explore the role of developing countries as both markets and producers of EVs. Since the literature on these topics is relatively scarce, we also compare developing and developed economies. In both cases, we look at the role of governments in promoting the adoption of EVs and the local production of these vehicles.

2.1. Developing countries as electric vehicle markets

Globally, EVs are still a niche market because these vehicles only occupied a global market share of 0.2% in 2016. Whilst some forecasts expected that 11 million EVs would be sold by 2020 (Automotive News 2009 quoted by Brown, Pyke, and Steenhof (2010: 3797)), progress has been significantly slower, with an accumulated 3 million sales in 2017.

Several factors may explain this slow progress. Studying EV adoption in 30 countries, Sierzchula et al. (2014) found that financial incentives and charging infrastructure played a main role in explaining EV adoption. Interestingly, they also found that sociodemographic variables, such as income, education, and concern for the environment had no explanatory power. Thus, countries with no or minimal consumer incentives and/or weakly developed charging infrastructure cannot be expected to have significant EV adoption. In general, this finding suggests that governments must play a proactive role in promoting the transition towards electromobility. Further, it has been found that current battery technology is not serving three distinct transportation markets, i.e. long-range, low-cost, and high-utilisation transport (Cano et al., 2018). For all developing countries, the absence of low-cost EVs must be assumed to be a major explanatory factor in the scarce adoption of these vehicles. EVs still command a price premium of about US$5,000 in comparison with conventional vehicles of similar size in both developed and emerging markets. Thus, even in developed markets, EV market shares so far remain limited.

One particularly exceptional case is China, which despite still being a developing country, has emerged as the main EV market in the world since 2016 when the country overtook the United States (US). Despite this leading position, it should be pointed out that EVs only accounted for a mere 1.43% of all vehicle sales in China in 2016 (Lin and Wu 2018: 234). Thus, whilst China is the principal EV market,

the market penetration of EVs still remains limited. Nevertheless, it is meaningful to ask what kinds of factors led to China's emergence as the principal EV market.

Regarding Chinese consumers, comparative studies have found that Chinese consumers are more open to EVs than consumers in developed countries. Compared to their US counterparts, Chinese consumers are more open to considering adopting EVs despite the fact that subsidies from both national governments were similar but the average income of Chinese consumers was lower (Helveston et al., 2015). Simultaneously, it has been found that consumers in Brazil, China, India, and Indonesia are less willing to pay for the additional mileage of EVs (Cano et al., 2018). This suggests that general openness towards EVs may be moderate by practical considerations such as driving range. Also, it should be stressed that China's success needed considerable staying power. Studies pointed out that despite high subsidies of US$9,200 from the central government plus additional incentives from local governments, which amounted to combined total incentives of up to US$27,600 in Shanghai, initial adoption was low (Wan et al., 2015: 117). It appears that insufficient charging infrastructure was the main reason why consumers did not choose to buy EVs (Wang et al., 2017: 187). Studying the EV promotion policies of 88 Chinese cities, Qiu, Zhou, and Sun (2019: 27) found that EV adoption was positively influenced by infrastructure construction subsidies. Another important factor was that despite existing subsidies, the total cost of ownership was still considerably higher for consumers (Zhang et al., 2017: 705). Only when the central government introduced restrictions on ICEV registrations in major cities at the end of 2014 did consumers opt to purchase EVs (Wang et al., 2017: 187; Zhang et al., 2017: 704). This highlights that even generous subsidies will not persuade consumers to acquire EVs if the infrastructure required for daily operation is insufficient. In such cases, only radical restrictions on consumer choice seem to result in EV adoption.

Another exceptional case is Norway, which achieved a high EV share of total new vehicle sales with a combination of substantial subsidies and favourable framework conditions[6] (Figenbaum, 2017: 15f.). Nevertheless, even in the leading country of Norway around, 80% of new vehicle sales are not EVs. This suggests that even extensive policy support may only induce a gradual shift towards electromobility. Thus, critics have pointed out that Norway's EV support policy should not be adopted by other countries because it is costly, results in a limited reduction in GHG, and may even promote the adoption of EVs as households' second cars, where there used to be no demand for second cars prior to subsidisation (Holtsmark and Skonhoft, 2014).

Given lower per capita income in most ASEAN markets, the persisting absence of low-cost EVs may explain why these vehicles are not – and in the absence of extensive subsidies arguably will not be – widely adopted by ASEAN consumers. Nevertheless, a recent simulation of policy support for EV carsharing in Brazil found that even limited government intervention could induce the adoption of EVs and result in lowered CO_2 emissions (Luna et al., 2020). This suggests that ASEAN countries could also utilise EV support policy to reduce harmful GHG emissions.

[6] Norway produces 96% of its electricity through hydropower. Thus, EV use is indeed mitigating harmful GHG emissions. Further, the majority of households are capable of charging EVs as three-quarters of households use electricity for space heating. Finally, transportation is heavily taxed, i.e. there are high taxes on vehicle acquisition, road use, and fuels. Hence, Norwegian regulators could make EV adoption highly attractive by not only subsidising EV acquisition but also through exempting EVs from various indirect costs. Finally, Norway hosts no vehicle production, meaning that there are no powerful vested interests in ICEV technology.

Overall, the literature on developing countries as EV markets suggests that even massive government intervention may only result in a gradual transition towards electromobility. It is likely to require serious, long-term fiscal support to result in increased adoption. The exceptional cases of China and Norway suggest that both governments created a rather artificial market demand by strongly distorting consumer prices in favour of EVs. In the case of China, restrictions on ICEV registrations in major cities also forced adoption on consumers seeking individual mobility. Thus, it must be expected that only countries willing to make considerable investments in EV adoption will succeed in influencing consumer behaviour.

2.2. Developing countries as electric vehicle producers

Whilst developing countries, especially China, have been extensively studied as EV markets, studies on their role as EV producers are relatively scarce. There may be one main hypothetical explanation for this lack of research: EV production tends to be located within carmakers' countries of origin. As EV technology is still novel, there may be benefits from feedback from production to development in conducting EV production close to original equipment manufacturer (OEM) headquarters. This tendency makes it less likely that EV production is conducted in developing countries. Nevertheless, it is somewhat surprising that China's role as an EV producer is not as extensively analysed as is Chinese consumer behaviour as discussed in the preceding section. Chinese carmakers accounted for 43% of global EV production in 2016, according to a report by McKinsey (Hertzke, Muller, and Schenk, 2017). Also, Chinese lithium-ion battery makers are increasingly challenging the once-dominant Japanese and South Korean producers.

One point that must be stressed is that China promoted EVs due to multiple reasons, including industrial, environmental, public health, and national security considerations. Thus, its emergence as the principal market for EVs is closely linked to the ambition to become a leading industrial country with a sustainable industrial business model. Chinese support can be traced back to the early 1990s when the country started to sponsor EV research and development (R&D) (Zheng et al., 2012: 18). Support became more encompassing in the mid-2000s when demonstration programmes were sponsored to explore commercialisation. Clearly, China aimed to leapfrog towards EVs in order to pursue continued industrialisation whilst simultaneously mitigating the negative consequences of ICEV deployment, namely costly oil imports and air pollution (Wang and Kimble, 2011).

Overall, developing countries aside from China so far have not received much attention as EV production sites. This may be due to the relatively low scale of production and the relative novelty of shifting production towards developing countries. Thus, the subsequent section on EVs in ASEAN sheds some light on the role of smaller developing countries as EV producers. Further, it cannot be surprising that EV production in ASEAN is dominated by foreign carmakers. In comparison to China, ASEAN countries started to support EVs relatively late, so there are few cases of local firms engaging in EV or EV component production.

3. Country Cases

In this section, we would like to illustrate the current situation and the foreseeable policy directions of individual ASEAN Member States. This is due to the fact that there is no coordinated policy towards EVs amongst member states. As will be shown in the following discussion, some member states seek to establish themselves as (regional) hubs for EV production. Consequently, individual member states seek to attract and build supply chains inside their national borders. This is remarkable because the ASEAN automotive industry is currently characterised by regionally integrated supply chains, where the production of vehicle components is fragmented across national borders. Whilst Thailand is the current central ASEAN production hub for most OEMs, it appears that certain countries intend to challenge this leadership in production by promoting EV production. From the following discussion, we excluded Cambodia, the Lao PDR, and Myanmar because these countries do not have dedicated EV policies.

3.1. Brunei Darussalam

At present, Brunei Darussalam has only a small fleet of EVs. Moreover, data from Brunei's Land Transport Department indicate that the number of EVs has decreased. Whilst 600 HEVs and 32 BEVs were registered as active vehicles in 2014, the numbers dropped to 282 and 18 units, respectively, in 2017. With more than 300,000 registered vehicles, the share of EVs in the total fleet was below 0.1% in 2017. In other words, the rate of EV adoption is very low.

Brunei has only recently considered the promotion of EVs. Initiatives are embedded in the so-called Land Transport Master Plan (LTMP) (MTIC, 2014).[7] This plan is part of the overall Wawasan (Vision) 2035, the country's overall development plan. In general, it can be stated that EV promotion does play a very minor role in the LTMP. Regarding the LTMP's budget, only 0.2% is earmarked for green vehicle technologies, and it is currently unclear how actual policy towards these technologies will be implemented. However, it can be claimed that Brunei intends to mainly strengthen public transport to reduce harmful emissions as the budget is strongly concentrated in related projects such as bus rapid transit (40.4%), national school buses (10.4%), and buses (5%). Despite the so-far unclear support scheme for EVs, it is nevertheless clear that EV promotion is regarded as one tool amongst others to promote energy efficiency in transport. Thus, the LTMP states that the use of HEVs, BEVs, and so-called fuel-efficient vehicles (FEVs) should be increased. FEVs appear to not only include different types of alternative fuels, such as LPG (liquefied petroleum gas) and CNG (compressed natural gas), but also conventional ICEVs with low energy consumption.

Moreover, Brunei has announced that it plans to implement fuel economy standards in the near future (17.2 kilometres per litre (km/L) by 2020 and 21.3 km/L by 2025). Whilst the government is considering introducing subsidies for environmentally friendly vehicles, including inter alia EVs, concrete consumer subsidies have not been introduced as of May 2019.

Regarding Brunei's approach towards EVs, we can highlight that Brunei's strategy must be interpreted against the background of its electricity generation mix, which is almost entirely based on thermal

[7] If not indicated otherwise, the below description is based on the LTMP, the central policy document for the transport sector.

power plants. Thus, based on ERIA's research survey, Brunei's shifts towards EVs would achieve little reduction or even cause an increase in harmful emissions (Kimura et al., 2017: 60, Figure 32). Therefore, Brunei's EV policy may only change if the country diversifies its current energy policy, especially concerning electric power generation, towards renewable energy sources.

Overall, we can evaluate that so far, Brunei has not prioritised EV support. Instead, the country intends to gradually improve energy efficiency in its transport sector via strengthening public transportation and introducing fuel economy standards. Managing its rather abundant natural resources more efficiently and reducing environmentally harmful emissions from ICEVs apparently takes precedence over a more fundamental shift towards EVs. This lukewarm approach makes sense as a politically and financially supported shift towards these vehicles is inconsistent with the country's electricity mix.

3.2 Indonesia

It took Indonesia considerable time to decide upon a concrete policy towards EVs. However, EV development captured the imagination of Indonesia's leadership. In 2012, then-president Yudhoyono supported the idea to develop a national EV to be developed by the nation's leading universities. His successor, President Widodo, is regularly portrayed as a supporter of EVs and invested in the idea of producing EVs in Indonesia.[8] For this reason, the current status of Indonesia's EV policy deserves attention.

In 2017, President Widodo asked its cabinet to develop measures, so various proposals have been put forward. In line with the president's vision for a home-grown EV industry, Minister of Research, Technology and Higher Education Nasir supports four Indonesian universities, which seek to develop a national EV (Xinhua, 2017). The minister aimed to start the mass production of developed EV prototypes by 2020. Moreover, Vice President Kalla stated that EV owners could be granted reduced value-added tax and import duties and Minister of Industry Hartarto plans a quota of 20% EVs sales by 2025, including HEVs, PHEVs, BEVs, and reportedly also FCEVs (Tempo, 2017; Jakarta Post, 2017a). Also, officials indicated that EVs could be supported via the existing Low Carbon Emission Program (LCEP), which provides incentives in the form of a lower luxury tax on vehicles. It is important to point out that this programme is not just directed at EVs but supports all fuel-efficient vehicles – qualifying vehicles must have a fuel efficiency of between 20 km/L and 28km/L of gasoline (equivalent) to receive a 25% reduction; vehicles whose mileage exceeds 28km/L are entitled to a 50% luxury tax cut; and BEVs are completely exempted from the luxury tax under this scheme. Whilst BEVs clearly receive the highest incentives, it is nevertheless obvious that the LCEP is designed to promote fuel efficiency in general rather than EVs in particular. Finally, Minister of Energy and Mineral Resources Jonan has proposed that Indonesia should prepare a system to allow BEV drivers to exchange empty batteries against fully charged ones at existing filling stations (Jakarta Post, 2017b).

One emerging characteristic of Indonesia's EV policy is the linked promotion of EV and battery production. Indonesia possesses significant reserves of nickel (nickel laterite), which is utilised in the

[8] Similar to several other countries, such as France, India, the Netherlands, and the United Kingdom, Indonesia is considering introducing a ban on passenger ICEVs by 2040 to combat environmental and health issues related to emissions. Whilst concrete plans have not materialised at the time of writing, an ICEV passenger car ban has entered the draft of future transport policy. This idea alone indicates that the country indeed seeks to shift transportation towards EVs.

production of lithium EV battery cathodes. Recently, two projects have been launched to extract nickel on Sulawesi, one by the Japanese firm Sumitomo Metal[9] and another joint venture between three Chinese firms, namely battery maker CATL, battery recycler GEM, steel-maker Tsingshan, the Japanese Hanwa trading company, and the Indonesian Morowali Industrial Park.[10] In order to take advantage of the national resources, two state-owned enterprises, namely oil and gas extractor Pertamina and mining company Aneka Tambang, are planning to produce batteries (Asmarini, 2018).

Indonesia's strategy is explicitly about exporting EVs, especially to Australia and within ASEAN to leverage free trade agreements (Davies and Kapoor, 2019). Regarding the status of EV production, there are currently only plans or negotiations between carmakers and the Indonesian government. Whilst government sources suggest that Hyundai will produce EVs in a newly planned plant, it is unclear how much production capacity will be assigned to EVs (Soeriaatmadja, 2019). Hence, despite having formulated a straightforward strategy towards linking battery and EV production, there are currently no results.

However, Indonesia finally enacted an EV support policy in December 2019. The overall goal of the regulation is that EVs should constitute 20% of domestic vehicle sales by 2025. Incentives are granted only if investors meet local content requirements (see Table 1.2).

Table 1.2: Indonesia's Electric Vehicle Local Content Requirements for Investment Incentives

	Phase	**Time frame**	**Local Content** (in %)
E-motorcycles	1	2019–2023	40
	2	2024–2025	60
	3	2026–	80
Electric vehicles	1	2019–2021	35
	2	2022–2023	40
	3	2024–2029	60
	4	2030–	80

Source: FAMI.

Incentives require significant levels of local content, even in the early stages. Whilst investors will be allowed to import certain components during the initial stages of EV plant construction, the policy does not specify the time window. Aggressive targets indicate that policymakers indeed intend to utilise local nickel deposits for the domestic EV industry.

Incentives include (1) exemption from customs duty on semi-knock down (SKD) and complete knock down (CKD) kits during the initial stage of the project; (2) exemption from luxury sales tax; (3)

[9] Extracted materials will be exported for further processing to Japan. This suggests that the desired integration between EV battery and EV production may not be realised in each particular case.
[10] The project will produce battery-grade nickel sulphate and cobalt sulphate as by-products of nickel extraction dedicated for integrated stainless steel production.

reduction or exemption from regional or central government taxes (e.g. motor vehicle tax); and (4) exemption of customs duty on production-related capital goods, amongst others.

Overall, after extended periods of planning, Indonesia has formulated a concrete policy. However, the policy must still become more concrete, e.g. through the specification of which taxes are to be reduced or exempted. Regarding carmakers' responses to policy, BYD, Hyundai, JAC, and Toyota have expressed interest in producing EVs in Indonesia (Indonesia Economic Forum, 2019). Moreover, as the supply chain for EV batteries requires significant expertise and is dominated by a small number of firms from China, Japan, and the Republic of Korea, it remains to be seen if incentives are going to result in the creation of a local supply chain.

3.3 Malaysia

Compared to other ASEAN countries, Malaysia introduced policies supporting EVs relatively early. Malaysia's policy supports EVs due to a set of mixed motives, including environmental, energy, and industrial policy considerations.

EV support was put on the political agenda when the country launched its National Green Technology Policy in 2009. This policy rests on four pillars, representing energy, environmental, economic, and social considerations. This indicates that EV support is regarded as a part of a larger transformation towards a sustainable economy and society. As such, the transformation cuts across various political areas, and Malaysia set up Greentech Malaysia, a subsidiary organisation under the Ministry of Energy, Green Technology and Water, to promote this process according to the aims of the national policy.

Concerning EV use in Malaysia, the government later formulated the following goals (Greentech Malaysia, undated): until 2020, 100,000 passenger EVs, 2,000 bus EVs, and 100,000 electric scooters or motorcycles should be on national roads. In order to support the adoption of EVs, the government further aimed at installing 120,000 charging stations. Officially, BEVs are regarded as full EVs but HEVs and PHEVs as partial EVs (ibid). However, there is no information as to how partial EV types will be counted towards the 100,000 unit target. However, reaching this target will be difficult as less than 120 BEVs were registered by 2016. Further, it needs to be pointed out that the charging station target number includes the charging points of private PHEV and BEV owners as the government only wants to install 25,000 stations across the nation (The Sun Daily, 2016). Recently, news reports quoted Maximus Ongkili, Minister of Energy, Green Technology, and Water, that the goals, including a moderate increase to 125,000 charging stations, should be realised by 2030 (Clean Malaysia, 2017). As of December 2018, there were a total of 251 publicly accessible charging stations in Malaysia, suggesting that the minister's revision was a de facto acknowledgement that the infrastructure goal cannot be realised until 2020. Whilst press statements are currently not reflected in policy documents, the 2030 timeframe appears more realistic.

Regarding EV policy measures, Malaysia exempted HEVs and PHEVs with internal combustion engines below a 2L engine capacity from import tax and granted a 50% lower excise duty from 2011 to 2013. Whilst this measure provided consumer incentives, subsequent policies served industrial aims.

The National Automotive Policy (NAP) of 2014 supports EV production but, nevertheless, cannot be labelled as a dedicated EV policy. Rather, NAP aims to promote what it calls eco-efficient vehicles (EEVs). The government's definition of EEV is broad, i.e. it includes fuel-efficient ICEVs, HEVs, PHEVs, and BEVs, as well as ones using alternative fuels (biodiesel, CNG, LPG, ethanol, and hydrogen (for both

combustion engines and fuel cells)). Further, the initial policy declaration stated that EEVs would be specified via fuel efficiency and carbon emissions. Concerning the latter, a subsequent publication (MITI, 2014b) stated that emission criteria would only be applied after the Euro 4M[11] fuel quality standard is introduced. After this step, a government study with stakeholder participation would investigate how this standard could be implemented. Subsequently, the level of carbon emissions would become a second parameter defining EEVs. In the meantime, EEVs are specified through fuel efficiency criteria. Regarding this indicator, the government has defined fuel efficiency parameters for different vehicle segments (Table 3).

Table 1.3: Eco-efficient Vehicle Specifications via Fuel Efficiency

Segment	**Description**	**Curb Weight** (kilogrammes)	**Fuel Efficiency** (litres per 100 kilometres)*
A	Micro car	< 800	4.5
	City car	801–1,000	5.0
B	Super mini car	1,001–1,250	6.0
C	Small family car	1,251–1,400	6.5
D	Large family car	1,401–1,550	7.0
	Compact executive car		
E	Executive car	1,551–1,800	9.5
F	Luxury car	1,801–2,050	11.0
J	Large 4x4	2,051–2,350	11.5
Others	Others	2,351–2,500	12.0

*Government officials stated that consumption will be measured via the New European Driving Cycle. Available government documents do not specify a fuel type, so it must be presumed that the above values apply to gasoline fuel consumption.
Source: MITI (2014).

The NAP provided several incentives for OEMs and parts producers to locate manufacturing activities related to EVs in Malaysia (MITI, 2014). First, Malaysia exempted domestically assembled HEVs and PHEVs from all duties and taxes until the end of 2015, and BEVs even until the end of 2017. Second, the country extended the use of existing policy tools, namely Pioneer Status (PS) and Investment Tax Allowance (ITA), to hybrid and electric vehicles.[12] PS with full tax exemption is granted for 10 years and 100% ITA within 5 years. Moreover, grants are available for related customised training and R&D as well as exemption from excise duty for locally assembled or manufactured cars. Similar to the

[11] Euro 4M is the official name for the Malaysian version of the Euro 4 fuel standard. The technical requirements are identical to the European standard.

[12] Both instruments are the most important policy tools that Malaysia has employed in its industrial policies since the 1970s: PS, which granted income tax exemption for 10 years to investors, and ITA, which is a tax allowance on capital investment (Gustafsson, 2007: 42–44). In automotive policy (MIDA, 2010; MITI, 2014), both incentives are alternatives, so investors have to choose which scheme is more beneficial. In general, ITA is designed to compensate large capital investments, whereas PS appears to be directed at companies that do not require much investment in machinery and production equipment.

promotion of conventional vehicle components, the producers of components critical for electric and hybrid vehicles – electric motors, electric air conditioning, electric batteries, battery management systems, air compressors, and inverters, as defined by the Malaysian authorities – can choose between PS or ITA with the aforementioned benefits.

The impact of EV policies must be described as limited at the time of writing. Regarding BEV adoption, there are fewer than 120 of these vehicles registered in Malaysia. Turning to production, some OEMs have taken advantage of the provided incentives and located CKD assembly in Malaysia: Honda started to assemble the Jazz Hybrid (HEV) in 2012, Nissan the Serena S Hybrid (HEV) in 2014, Toyota the Camry Hybrid (HEV), and Daimler commenced assembly of the Mercedes-Benz S400 L Hybrid (HEV) in 2014, and added the C350e (PHEV) and E350e (PHEV) in 2016 and 2017, respectively.

It is noteworthy that Malaysia's two national[13] carmakers, Proton and Perodua, did not display strong support for EV development and commercialisation. Whilst Proton announced that it would sell BEVs from 2014 and showcased a prototype EV version of its Iriz minicar in 2015, this plan was never realised (Hamid, 2016). Only after the recent partnership with Geely does Proton appear to be able to manufacture BEVs based on Geely's electric powertrain technology. Perodua, whose vehicle line-up consists of mini and small cars, stated that it does not plan to produce EVs (Saieed, 2017). Regarding the negative stance towards EVs, Perodua stated that the Malaysian charging infrastructure was insufficient to support EVs and that the firm intends to focus on improving ICEV technology. As Perodua heavily relies on Daihatsu for vehicle technology, this stance cannot be surprising because Daihatsu is also only offering a few HEV models.

Overall, despite the mixed motives for EV support, measures aimed at consumers have been phased out and those for producers were sustained for a longer period. Therefore, it may be concluded that policy is mainly motivated by industrial policy with environmental undertones. Malaysia did not create a dedicated EV policy programme but supports all emission-reducing technologies. Subsuming EVs under general automotive sector policy in such a way appears to have the drawback whereby issues such as charging infrastructure have been addressed in planning but not in policy implementation. Malaysian policy towards EVs has only been mildly successful in attracting manufacturing activities but largely a failure in consumer adaption. As most manufacturing is only assembly, the effectiveness of policy appears limited. Moreover, the key question is whether EV assembly will remain in Malaysia after the incentives are removed.

[13] In 2017, Geely acquired 49.9% of Proton, Malaysia's first national carmaker. Whilst Proton thus technically remains Malaysian-owned, it appears relatively clear that Proton requires technical assistance from the outside. Thus, it may be concluded that Geely will strongly influence, or perhaps even de facto control, the future direction of Proton. As for Perodua, the company has transferred control over its manufacturing operations to Daihatsu, its long-term technology partner. Thus, whilst Perodua management controls several aspects of the business, manufacturing, and by extension product development and policy, are largely controlled by Daihatsu.

3.4 Philippines

In the Philippines, EVs have been supported through public policy since 2006. That year, the government allowed the import of EV components free of tariffs to encourage local manufacturing.[14] Whilst this marks a head start in comparison with other ASEAN countries, the Philippines did not follow up by adding additional measures. In other words, the Philippines only granted benefits to the supply side, without addressing demand issues or infrastructure.

The latter issue was only addressed in the Investment Priorities Plan of 2014, which included charging stations (DTI-BOI, 2014). Under this plan, investors are eligible to a six-year income-tax holiday. However, this means that the country rather seeks foreign investment or public-private partnership projects instead of public infrastructure investment. Whilst the country's investment capability and geography indeed make public investment difficult, this nevertheless means that the key condition for EV utilisation and thus by extension adoption largely lies outside government control and depends on foreign investment.

As charging infrastructure is largely absent, the market must also be described as undeveloped. This is at least true for EVs that resemble conventional cars. The Chinese BYD is the only carmaker that currently sells BEV and PHEV models in the Philippines. On the other hand, leading EV producers, such as Mitsubishi and Nissan, do not offer EVs in the local market at the time of writing. This indicates that the consumer market for conventional EVs is limited. Despite this situation, there are signs that change may start. Recently, Mitsubishi has agreed to work with Philippine academia to develop policy proposals for supporting EV adoption. However, there appears to be a limited market for unconventional EVs, which are often produced locally. So far, locally produced EVs are not actual cars but can be described as various types of NEVs, including low-speed scooters, rickshaws, quads, and jeepneys,[15] which are all predominantly used for local transport.

Regarding policy, the so-called E-Trike Program appears to be a good example to illustrate the current state of EVs in the Philippines. Initiated by the Department of Energy (DOE) and largely financed by the Asian Development Bank (ADB) and the World Bank's Clean Technology Fund, the programme aimed to replace 100,000 internal combustion engine (ICE) tricycles through BEV versions until the end of 2017. The programme aimed to reduce emissions, create more sustainable transport, and support (local) EV parts manufacturers and assemblers. The Japanese Uzushio Electric (BEMAC) won the assembly contract for US$10,000 per unit. In 2016 however, the DOE stopped the programme after 3,000 EV tricycles had been manufactured without finding driver-operators willing to utilise the vehicles as the initial costs and maintenance proved to be too expensive for operators.[16] Further, the DOE argued that the number of charging stations in planned deployment areas in Manila was

[14] The actual directive (Executive Order 488 (s. 2006)) eliminated import tariffs not only for EV components but also for components of other low-emission vehicle types, such as CNG and so-called flex-fuel, i.e. internal combustion engines that can utilise fuel blended with varying degrees of (bio-)ethanol.

[15] Jeepneys are best described as crossovers of jeeps and minibuses. Originally converted from US military jeeps left in the Philippines after the Second World War for public transport means or taxi services, jeepneys are today quintessential Philippine vehicles and are mainly used for commuting.

[16] Indeed, ADB's target price had been US$3,000–US$4,000 in order to realise lower operating costs for drivers (ADB, 2012). Thus, it may be concluded that despite an initial assessment indicating the need for a minimal purchase (or lease) cost for would-be operators, the project was driven forward even as costs increased by 250% above the intended maximum price. Against this background, it cannot be surprising that the EV tricycles could not be leased.

insufficient to enable utilisation (Rivera, 2016).[17] Subsequently, the DOE worked on a solution to get the already produced units on the road. The programme was redesigned as a part of the already existing tricycle modernisation programme under the aegis of the Department of Transport (DOT). The redesign mainly resulted in lower cost for operators. Now, units are sold to municipalities which in turn sell them to operators. In the case of Manila, the city gives them to operators for a daily fee of ₱150 (US$2.92) for five years under the so-called E-Vehicle and Assistance Program (Barahan, 2017).[18] Moreover, vehicles given out under this programme can be charged freely, indicating that the programme is now part of municipal social policy. Obviously, the price for operators is highly subsidised as the total amount of fees is US$5,329 for five years, roughly half of the original cost.

Last, it appears questionable whether EVs could contribute to lower or at least slower-growing emissions. The country's Power Development Plan suggests that the bulk of newly installed electricity generation capacity will be constituted by thermal power plants. Hence, EVs only contribute to lower local emissions but increase the total emissions of the Philippines. As mentioned previously, however, the country only has to achieve relative reductions, so environmental concerns play a lesser role.

Overall, the Philippine government has rather shown than practised public support for EVs. It appears that the key issue of infrastructure has only recently been addressed through tax incentives for investors. Besides this issue, it is questionable if still-expensive EVs can be adopted without any kind of consumer incentive. However, there appears to be a potential niche market for unconventional, low-speed EVs utilised for short-range commuting and public transport.

3.5. Singapore

Until recently, the city state of Singapore had not adopted a proactive policy stance towards EVs. Whilst Singapore's Land Transport Authority (LTA) and Energy Market Authority (EMA) initiated an EV taskforce that represented multiple agencies in 2010, actions may be best described as a large-scale feasibility study. Also in 2010, the task force appointed Bosch to develop, install, and operate the EV charging infrastructure on behalf of the city state. In 2011, it was decided to conduct a field test with Daimler (smart) and Mitsubishi BEVs to collect additional data. Beyond these steps, Singapore did not deploy any special policies towards EVs. This may explain why EVs are rarely utilised in Singapore. According to data from the LTA, all EV types (HEVs, PHEVs, BEVs) only occupied a share of 3.61% of the country's vehicle fleet of roughly 930,000 vehicles in 2018. The lion's share of EVs is constituted by HEVs (97.75%), meaning that only a minute share of EVs in use need to be charged externally. Thus, despite Singapore's status as one of the wealthiest countries in terms of per capita gross domestic product, the still relatively costly EVs are currently only a niche product.

The low share of PHEVs and BEVs in the EV fleet hints to a major obstacle for the application of these EV types in Singapore. Currently, there are only about 100 publicly accessible charging points.[19] i.e.

17 The validity of this argument appears questionable. According to Uzushio, the e-trikes do not require dedicated charging infrastructure but can be charged through conventional electrical outlets. The author would like to thank Yasushi Ueki for providing this information.

18 The programme's acronym ERAP hints to former President Joseph Estrada, commonly called Erap, the present mayor of Manila.

19 Charging points refer to individual chargers that are grouped into so-called charging locations (stations).

basically one charger per vehicle that requires external charging. Lacking infrastructure development for EVs is, thus, one main reason why the number of EV early adopters is rather small.

Recently, Singapore's government has implemented several measures that support EV usage. First, Singapore allowed the French Bolloré Group[20] to set up a car-sharing service. The service, called blueSG, debuted in December 2017 and aims at providing 1,000 BEVs. Amongst the contractual obligations the French investor agreed to is the installation of 2,000 charging points (divided into 500 charging stations) across the country until 2020, of which 400 should be accessible to the public. At the time of writing, blueSG had installed 531 charging points (at 135 charging stations) (Channel News Asia, 2019). The service operates under the condition that users park rented vehicles at one of the charging points when ending use. Moreover, charging stations were made accessible to private EV owners in 2019.[21] The introduction of an EV car-sharing programme and included infrastructure development are positive steps. The number of charging points is sufficient to support the vehicles of the car-sharing service and private EVs.

Second, Singapore has clarified the so-called Vehicle Emission Scheme (VES), which is basically an emission penalty-rebate scheme which specifies emissions ratings for all vehicles sold in Singapore. Based on categorisation, consumers can receive a rebate on the additional registration fee which must be paid when registering a purchased vehicle (Table 4).

Table 1.4: Vehicle Emission Scheme

	Pollutant					Rebate (in S$)	Surcharge (in S$)
Band	**CO_2** (g/km)	**HC** (g/km)	**CO** (g/km)	**NO_x** (g/km)	**PM** (mg/km)		
A1	≤90	≤0.020	≤0.15	≤0.007	0.0	20,000	
A2	91–125	0.021–0.036	0.151–0.19	0.0071–0.013	0.01–0.30	10,000	
B	126–160	0.037–0.052	0.191–0.27	0.0131–0.024	0.31–0.50	0	0
C1	161–185	0.053–0.075	0.271–0.35	0.0241–0.030	0.51–2.00		10,000
C2	>185	>0.075	>0.350	>0.030	>2.00		20,000

CO = carbon monoxide, CO_2 = carbon dioxide, g = gramme, HC = hydrocarbon, km = kilometre, mg = milligramme, NO_x = nitrogen oxides, PM = particulate matter.
Note: Rebates and surcharges apply to private car owners. Taxis are subject to rebates and surcharges of S$30,000 (A1/C2) and S$15,000 (A2/C1).
Source: Land Transport Authority (https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/upfront-vehicle-costs/emissions-charges.html#VES_At_a_glance) (accessed 01 February 2021).

20 Bolloré Group is conglomerate active in diverse fields such as logistics, paper, and plantations. The group co-developed a BEV dubbed the Bolloré Bluecar together with Pininfarina and Renault. It is deployed in various BEV car sharing programmes across the world, including, Paris, Lyon, and Bordeaux in France, London in the United Kingdom, Torino in Italy, and US cities such as Indianapolis and Los Angeles.
21 Parallel to Bolloré, public utility Singapore Power also plans the installation of a total of 1,000 charging points in the city state. This should result in sufficient EV charging infrastructure, because Singapore basically applies a zero growth policy towards the vehicle fleet via its quota system, known as Certificate of Entitlement.

As the VES covers various pollutants, vehicles are categorised according to the worst-ranked pollutant, i.e. if a car's emissions fall into category A1 for four pollutants but category B in the fifth, the vehicle is designated as category B.

Clearly, the VES is designed to encourage consumers to adopt less-polluting vehicles. The maximum rebate of S$20,000 (roughly US$15,000) is considerable. However, only BEVs can be categorised as A1 because they are the only vehicle type that emits no PM. Whilst EV operation itself is emission-free, these vehicles nevertheless cause emissions related to electricity generation and distribution. In essence, this means that Singapore does not treat EVs as zero-emission vehicles. Whilst the rating had been set at 0.5 g CO_2/watt hour (Wh), a detailed review conducted by LTA concluded that the rating was lower, namely 0.4 g CO_2/Wh in 2016. This means that PHEVs and BEVs will be regarded as causing fewer emissions under the VES from 2018. Whilst this measure will make said types more attractive vis-à-vis ICEVs, the impact of this measure is likely to remain limited. Also, it is noteworthy that ICEVs are only rated based on their use-related emissions, i.e. emissions from petrol and diesel fuel production and distribution are not included in their VES rating (Tan, 2017). Thus, it can be criticised that ICEVs are still enjoying structural preferential treatment in Singapore.

Third, the LTA started to shift its procurement policy for public transport towards EVs. As a means to improve air quality and reduce emissions, the LTA has recently procured 50 diesel hybrid buses from Volvo and plans to procure 60 BEV buses to be introduced to the fleet from 2019. As measures are mainly aiming at emission reduction in the public sector, the benefits for private car users will likely remain zero.

Regarding the impact of policy on EV adoption, the newly introduced VES seems to have promoted sales by increasing the costs for ICEVs. In 2018, the year VES became effective, the number of registered HEVs and PHEVs increased from roughly 25,000 in 2017 to almost 33,000 units. Similarly, the number of BEVs more than doubled from 349 to 707 units. Nevertheless, it should be pointed out that Singaporean policy rather promotes adoption in a limited way and maintains a general policy of limiting private car ownership. Whilst it can be expected that the penalty-rebate nature of the VES is continuing to promote the proliferation of EVs within Singapore's vehicle fleet, it stands to reason that this shift will be slow as Singapore is basically a replacement market.

Overall, Singaporean policy measures are introducing fairly limited benefits for EV adoption by private car owners. Adopted policy instruments or instrument calibrations are rather promoting car sharing and public transportation in the city state. This is in line with established transport policies, such as the Certificate of Entitlement, which is basically a quota system that effectively limits private car ownership via regulating the fleet size. Therefore, the preference for policy tools that promote public and intermodal forms of transportation is consistent with past Singaporean transport policy and should be understood against this background. The case of Singapore nevertheless deserves attention as it demonstrates that even wealthy consumers still seem to prefer ICEV over EV technology despite incentives. This may be explained by the still higher price of EVs compared to ICEVs, so that either a price reduction from the supply side or incentives for the demand side are necessary to promote EV adoption.

3.7. Thailand

According to the International Organization of Motor Vehicle Manufacturers (OICA), Thailand was the world's eleventh-biggest vehicle producer in 2018, documenting its position as the leading vehicle manufacturing country of the ASEAN region. Thailand's EV support is mainly motivated by securing the country's current position in regional and global production networks. Following the assumption that EVs are indeed the future of the automobile industry, Thai policy is seeking to manage the technological transition. Thus, as will be shown below, policy not only addresses consumers and producers but also the local production of specific EV components.

On the demand side, Thailand revised taxation in a way that makes EVs more attractive to consumers. In 2016, Thailand introduced a new excise tax scheme that shifted taxation away from being based on engine capacity alone towards one based on CO_2 emissions (Table 5).

Table 1.5: Thai Automotive Excise Tax Scheme as of January 2018

Vehicle Type	**Engine Size**	**CO_2 g/km**			
		< 100	**100–150**	**150–200**	**> 200**
Passenger car	< 3,000 cc		30%	35%	40%
	E85/CNG		25%	30%	35%
	> 3,000 cc	50%			
Hybrid vehicle	< 3,000 cc	5%	20%	25%	30%
	> 3,000 cc	50%			
BEV	-	2%			
Eco-car	1,300–1,400 cc	14%	17%		
	E85	12%			
		< 200		**> 200**	
Pickup	Single cab	3%		5%	
	Space cab	5%		7%	
	Double cab	12%		15%	
Pickup passenger	< 3,250 cc	25%		30%	
	> 3,250 cc	50%			

BEV = battery electric vehicle, cc = cylinder capacity, CNG = compressed natural gas, CO_2 = carbon dioxide, km = kilometre.
Note: E85 signifies a fuel blend of 85% ethanol and 15% gasoline.
Source: Thai Board of Investment.

Whilst the table indicates that CO_2 emissions and engine capacity are actually combined to determine the payable taxes, emissions play a more crucial role under the new scheme. Besides this new tax

regime, Thailand also reduced import tariffs on BEVs to zero to lower costs for consumers. Measures suggest that Thai policymakers prefer supporting BEVs over hybrids.

On the supply side, Thailand has promoted the local production of eco-cars since 2007. According to the definition of the Thai administration, eco-cars are vehicles that have a mileage above 20 km/L gasoline (or diesel equivalent) and emit less than 120g CO_2/km and meet criteria for other pollutants as required by the Euro 4 standard. To further the domestic production of such eco-cars, the Thai Board of Investment (BOI) granted several incentives to both producers and consumers under the condition that investors agree to production target figures of 100,000 units, which had to be reached after a certain period of operation.[22] Clearly, this policy is designed to promote the evolution of the Thai automotive industry. As past targeting policies led to the specialisation of one-tonne pickup trucks, this new policy consciously seeks to emulate its success. As Thai policymakers, and especially the BOI, understand that pickup trucks are both relatively polluting and technologically simple in comparison to eco-cars, this also indicates that the intention is to stimulate industry development towards more complex, higher value-added products.

Whilst the eco-car programme has provided incentives for fuel-efficient ICEVs, Thailand has also introduced support measures for EV parts manufacturing in the country. From 2012, it offered exemptions from corporate income tax (with a maximum cap) for eight years for investments directed at the production of advanced vehicle technologies. These included ICEV components as well HEV, PHEV, and BEV batteries, and traction motors for HEVs, PHEVs, BEVs, and FCEVs.

In March 2017, the Thai government issued its EV policy. In comparison with other ASEAN Member States, the formulated aims are more long-term oriented. The target number for EVs on Thai roads is 1.2 million vehicles by 2036 and 690 charging stations. The available information suggests that the Thai government only includes all types except FCEVs in its definition of EVs. However, the incentives are most generous for BEVs, reflecting a clear preference of government planners for this type.

BEV investment projects are entitled to a corporate tax exemption of between five to eight years. The duration of this tax exemption can be extended under the following condition: investment in manufacturing in more than one EV core component in Thailand is rewarded by an additional year per component up to a maximum duration of 10 years.

PHEV and BEV bus investment projects are eligible for corporate income tax exemption for three years and import tariff exemptions on production machinery. As in the case of BEVs, production beyond the first EV core component entitles additional years of tax exemption to a maximum of six years.

Investment into HEV manufacturing is entitled to fewer incentives than PHEVs and BEVs. Investing firms will only be granted import tariff exemption on production machinery. Some striking aspects should be highlighted. First, whilst there is still a minimum investment required, the amount is only B1 million (roughly US$26,000). In comparison to the preceding eco-car programmes, this sum is very low, one may say symbolic. Secondly, differing from eco-car policy, production targets are not included under this scheme. This suggests that policymakers are unable to define a target production figure. Taken these less strict requirements into consideration, it may be concluded that whilst EVs are regarded as important for the future of Thai car manufacturing, the technology is too novel and the demand too uncertain to apply standard policy instruments.

[22] Due to limitations in space, additional investment conditions and incentive details cannot be discussed. Detailed information may be obtained from the author through email communication.

Further, incentives will be granted for producing important EV components. Firms investing in manufacturing the following components are entitled to eight years of corporate income tax exemption: batteries, traction motors, battery management systems, DC/DC converters, inverters, electric circuit breakers, portable EV chargers, and EV smart charging systems. Most remarkable is that battery technology has not been specified clearly. The way the policy is phrased, it appears possible that both major EV battery types, i.e. nickel metal hydride (NiMH) and Li-ion batteries are entitled to government support. Whilst the overall direction of policy measures shows a strong tendency to favour BEVs, it would make sense to give priority to Li-ion batteries, which are commonly used in BEVs and PHEVs, and no or at least lower incentives to NiMH batteries, which are mainly utilised in HEVs.

According to the plan, EV policy is divided into three phases. The first was conducted in 2016 and 2017. It should basically prepare subsequent activities by setting up a limited number of charging stations and organise field tests with a limited number of BEVs. The actual research was to be conducted in the second phase, scheduled to last from 2018 to 2020. Trials should test the performance of different battery types and motors and determine the technical standards for vehicles and charging infrastructure. Further, this phase should be utilised to prepare legal and tax frameworks, train bureaucratic staff, and conduct user promotion. The phase should produce a coordinated action plan for the implementation of concrete policy measures from 2021 onwards. Thus, the third stage should see the actual deployment of infrastructure and BEVs in Thailand. Here, it is noteworthy that the EV Action Plan is intended to integrate with other policies, most notably Thailand's Industry 4.0 plans and the smart grid. BEVs should not only be charged through the grid but also be able to feed stored electricity into the grid (so-called vehicle-to-grid capability (V2G)). Therefore, it can be stated that BEV use and production are part of an intended large-scale transformation of the Thai economy away from a country that faces the 'middle-income trap' towards an industrially and economically advanced nation.

Looking at current automobile manufacturing in Thailand, Toyota is locally producing the Camry Hybrid (HEV) since 2009 and manufactured the Prius (HEV) from 2010 to 2015. The Japanese OEM recently announced that it would intensify HEV production in Thailand to take advantage of the provided incentives. Before the Thai government announced its production incentives, Toyota stated that it regarded charging infrastructure as insufficient, indicating the main reason why it would not invest into PHEV or BEV production (Bangkok Post, 2017). Apparently, the incentives did not convince the carmaker to rethink its approach. Nissan located manufacturing of the X-trail Hybrid (HEV) in 2015, i.e. before government incentives were granted. After incentives were introduced, Nissan applied and pledged to produce hybrids and batteries at its plant in Samut Prakan. In January 2019, it was disclosed that the carmaker seeks to make Thailand its second EV production hub besides Japan, which should produce for local demand and export markets (Maikaev, 2019a). Honda has assembled HEV versions of its Jazz, Civic, and Accord models since 2012, 2013 and 2014, respectively. After the BOI's EV scheme was introduced, Mazda decided to produce an undisclosed hybrid model and several components in Thailand (Maikaev, 2018). After gaining approval from the BOI, Mazda recently even applied to extend production to BEVs (Maikaev, 2019b).

Daimler started to assemble CKD kits of the HEV version of its C-class and E-class (C300 and S300 BlueTEC Hybrid) in 2013 and 2014. In 2016, the carmaker updated its model line-up by starting assembly of PHEV versions of the Mercedes-Benz C-class and S-class (C350e and S500e). After Thailand offered incentives, Daimler decided to deepen its production footprint by applying for PHEV battery

production and the production of the EQC, a battery-powered SUV (Maikaev, 2019c). Premium rival BMW adopted a similar model strategy by assembling PHEV versions of its X5 and 3-series (330e) in Rayong since 2017. Government support policy convinced the German carmaker to extend PHEV production to the 5-series and 7-series (530e and 740Le, respectively) (BMW, 2018). As part of the localisation effort, German supplier Dräxlmaier will produce traction batteries for BMW Thailand. Whilst the two German premium brands produced and offered EVs prior to government incentives, the joint venture between Shanghai Automotive Industry Corporation and local conglomerate Charoen Pokphand (SAIC-CP) pledged to produce PHEVs under the BOI's scheme (Apisitniran, 2018).

Also, there is the case of Vera Automotive, a firm founded by five Thai engineers of King Mongkut's Institute of Technology Ladkrabang (Bangkok Post, 2017). The firm developed a BEV called V1, but the vehicle is produced by Geely in China and then exported to Thailand. Thus, whilst the firm is Thai, production is not located in the country, obviously due to the costs related to entering automobile manufacturing. The vehicles are not only sold domestically but also exported to other ASEAN markets and China. First One Mile Mobility (FOMM), a Japanese start-up, entered the Thai market with an investment of roughly US$30 million to build its first factory with annual production capacity for 10,000 units in Chonburi Province (Kotani, 2018). The newcomer will produce its FOMM One minicar and actually was the first project that was approved under the BOI's EV scheme.

Overall, it appears that most firms already had limited EV assembly operations in Thailand before incentives were offered. This suggests that OEMs made these decisions based on brand strategy in order to increase local sales. Only premium brands currently manufacture PHEVs, indicating that this type of vehicle is a niche market. However, incentives convinced numerous carmakers to invest in the production of various EV types for both local consumption and export.

It has to be pointed out again that the Thai government will be concentrating its efforts on BEV technology, continuing its 'product champion' approach (Natsuda and Thoburn, 2013) to target specific products and promote production and usage. Indeed, representatives of the Thai Automotive Industry Association (TAIA) have already lobbied for EVs to become the third product champion after pickup trucks and eco-cars (The Nation, 2012). However, as an industry lobby that represents carmakers that prioritise different EV types, the fact that the TAIA did not advocate a concentrated BEV push as a strategy is clearly risky in a situation where competition between different technologic solutions – ICEVs, HEVs, PHEVs, BEVs, and even FCEVs – is still open-ended. On the other hand, Thailand's policy to pick winners has been successfully employed in the past, so it is understandable that policymakers prefer to use and further develop tried and tested policy instruments. In the end, Thai policymakers apparently decided to maintain a clear preference whilst simultaneously offering incentives to all EV types. Thailand's vision is clearly the most ambitious of all EV policies, but the strategic approach of how to actually implement this vision is also more concrete than any other national EV policy within ASEAN. As policy has only been recently drafted, there are currently no concrete results visible. Given Thailand's past track record, it may only be stated that the country has demonstrated the ability to attract export-oriented manufacturing and promote domestic sales of targeted vehicle types. Therefore, it is reasonable to assume that a similar strategy could be implemented again with a new product champion. From an academic standpoint, the question of whether the related targets, such as for V2G-capable smart grids and Industry 4.0, can be implemented is highly speculative, because even countries regarded as leading in Industry 4.0 initiatives, such as Germany, cannot state with certainty if or how this Fourth Industrial Revolution will be realised.

Regarding Thai environmental and energy policies, there are two main development goals. Firstly, despite its official status as an upper middle-income country, Thailand nevertheless is amongst those countries that have to achieve relative emission reductions under its commitments against climate change (the Paris Accord), not total reductions. Thus, the aforementioned measures such as the altered vehicle taxation scheme may be appropriate tools for achieving targeted reductions. Secondly, the country seeks to diversify its electricity generation mix towards renewable energy. Currently, renewable sources constitute 8.5%, whilst the remaining 91.5% is based on fossil sources, predominantly gas (70.6%) (IEA, 2016). Until 2036, the country aims to increase the share of renewables to 30%, accounting for growing electricity demand. Moreover, plans to introduce nuclear energy to lower emissions. Whilst plans indicate a shift towards less thermal power generation, a sizable part will remain based on fossil fuels. Against this background, it appears questionable whether targeted BEVs could make an actual contribution towards lower emissions in Thailand. Overall, however, Thailand's environmental and energy policies aim at achieving relative improvements, i.e. improving energy efficiency and diversification of the currently strongly fossil fuel-based electricity mix. Therefore, achieving gradual improvements in fuel efficiency through EV use can be regarded as consistent with environmental policy commitments.

Overall, Thailand's policy on EVs can be regarded from two standpoints. From perspectives that consider market demand and infrastructure, the aims appear highly ambitious and difficult to implement. However, as the aims are rather long-term than short-term and linked to various other plans in the energy and environmental policy fields, many open questions are to be expected. Due to the transformational character of EVs however, policy plans that are aware of various challenges and seek integration and coordination may be appropriate for managing EV-related issues. From an industrial policy standpoint, the measures are straightforward and clearly structured. This may be interpreted as a symbol of Thailand's ambition to defend its position as the leading automotive production hub in the ASEAN region. Policy is obviously concerned with attracting investment in what is regarded as a future core technology. Following by and large existing product champion strategy in industrial policy, Thailand mainly targets a specific type of EV, namely BEVs. At the same time, the absence of production targets indicates that this technology is indeed too novel to be subject to standard policy tool deployment. Whilst carmakers' reluctance toward establishing BEV production in Thailand should be noted, there is less reservation against HEV manufacturing. Despite some open questions, Thailand has drafted the most encompassing and ambitious aims and simultaneously put forward the clearest policy towards the industrial manufacturing of EVs. Therefore, this mixture of tried and tested industrial policy and an agenda that aims at transforming not just the automotive industry but the Thai national industry as a whole appears appropriate to achieve the minimum goal of defending the country's leading position in the regional automotive industry.

3.8. Viet Nam

Regarding electromobility, Viet Nam is an outlier within the ASEAN region. Whilst the government has so far not had electromobility on its agenda, private enterprises have attempted to promote EVs.

At the time of writing, Viet Nam has no policy to support EVs, be it incentives for adoption, production, or infrastructure creation. Only recently, electromobility is starting to be discussed. The Ministry of Industry and Trade (MOIT) has cooperated with Mitsubishi Motors to study the feasibility and potential promotion of EVs in Viet Nam (Hanoi Times, 2018). The cooperation has so far resulted in

the creation of the first EV charging stations in the country – one in Hanoi on the grounds of the MOIT, and one each in Da Nang and Hoi An in Quang Nam Prefecture. The latter two are part of a cooperation between Mitsubishi Electric, the University of Da Nang, and the Central Power Corporation, a subsidiary of Vietnam Electricity, which aims at training technical personnel and the production of charging stations. Thus, if one applies the policy cycle model of Howlett and Ramesh (2003), it may be stated that the topic of electromobility is currently moving from agenda-setting towards formulation. Government action appears to be largely a reaction to impulses set by member firms of the Mitsubishi Group that are active in EV production and EV infrastructure development.

Besides foreign business interests, there are also Vietnamese enterprises that promote electromobility. Most notably, newly founded carmaker Vinfast, a subsidiary of the local conglomerate Vin Group, plans to become an EV producer. Whilst its first three models are conventional vehicles, the fourth model scheduled for release in 2021 should be an EV (Vu, 2020).

Similar to Mitsubishi, Vinfast seems to have identified the lack of charging infrastructure as the Achilles heel of its pronounced business strategy. To overcome this bottleneck, the company has announced its intention to launch between 30,000 and 50,000 charging stations. A major step towards this realisation has been made by signing a memorandum of understanding with PetroVietnam Oil Corporation, the state-owned company in charge of the oil and gas sector, including service stations. According to the memorandum, charging stations should be constructed on 20,000 service stations operated by its partner until 2020 (Reuters, 2018).

It should be pointed out that Vinfast's first product, launched in late 2018, was an electric scooter dubbed Klara. With this move, Vinfast followed in the footsteps of several smaller firms. Pega, formerly HKBike, is a local start-up producing electric scooters since 2012. In 2017, Pega opened a factory with an annual production capacity of 40,000 units in Bac Giang Province that employs 300 workers. Reportedly, Vinfast unsuccessfully tried to take over Pega. Despite this failure, Pega claims that all members of Vinfast's Klara development team were former Pega employees (NNA Business News, 2018). Whilst electric scooters and motorcycles are still a niche, this market is currently exclusively served by local firms. However, this situation is going to change. MDI, a Korean transmission supplier, has set up a joint venture with the Vietnamese N&G Group to produce electric scooters (The Korea Economic Daily, 2017). Similarly, Son Ha Development of Renewable Energy JSC, a member of the local Son Ha Group, inaugurated a plant for electric motorcycle production with an initial annual capacity of 20,000–30,000 units in Bac Ninh Province in northern Viet Nam in October 2020 (Vietnam Plus, 2020). Amongst the major five motorcycle makers in Viet Nam, i.e. Honda, Yamaha, Suzuki, Sanyang Motor (SYM), and Piaggio, only the Italians will launch a competing product, the Vespa Elettrica, in 2019 (Vietnamnet, 2019).

Two aspects stand out from the above description of business activities. First, not electric cars but electric scooters are the focus of enterprise activity. This may be explained by several factors. As Vietnamese roads are still dominated by two-wheelers instead of four-wheelers, targeting this market appears more promising than offering EVs which still cost more than conventional vehicles of a similar size. Additionally, electric scooters do not require specialised charging infrastructure, which is, as aforementioned, currently non-existent. Instead, electric scooters can be charged through any conventional outlet. Second, the market is currently served by start-ups, joint ventures, or newcomers to the automotive industry. Incumbent car and motorcycle producers have refrained from trying to create a market or market niche. Whilst it remains to be seen if electric scooters or even EVs are a

sustainable trend or a dead end for business activity, it appears clear that smaller, partly or exclusively local firms seek to promote electromobility as a means to compete against industry incumbents that by and large stick to conventional vehicles.

To summarise, Viet Nam's move towards electromobility is a fairly recent phenomenon that is mainly promoted by private enterprises. It must be emphasised that local business has so far concentrated on electric scooters, and EV production is only planned to commence in 2021. Local motorcycle makers and the newly founded Vinfast regard electromobility as a way to challenge incumbent industry players whose extensive know-how in internal combustion engine technology is hard to challenge. Thus, it may be stated that local enterprises enter the electromobility niche market to avoid competition in an area where incumbents enjoy the depth of technological expertise. The Vietnamese government has only recently started to explore the topic of electromobility, seemingly due to foreign, private sector engagement. This, however, means that local enterprises entered a niche without any dedicated government support.

4. Discussion

Based on the preceding description of EV policy in ASEAN Member States, we would like to propose a division into groups of countries that share distinct characteristics in their policy approach towards electromobility (Table 6).

Table 1.6: Definition of Electric Vehicles, Electric Vehicle Fleets, Electric Vehicle Targets, and the Number of Charging Stations in ASEAN

Country	**EV Definition**	**EV Fleet** (year)	**EV Unit Target** (year)	**Charging Stations** (year)
Brunei Darussalam	HEV/PHEV/BEV	HEV: 293 (2018) BEV: 15	-	n.a.
Indonesia	HEV/PHEV/BEV	4.2 million by 2050 (proposal by National Energy Plan) (Tempo, 2017b)	400,000 EVs + 2.1 million E-motorcycles (20% locally manufactured) (2025)	479 10,000 units by 2050 (proposal by National Energy Plan) (Tempo, 2017b)
Malaysia	BEV (full EV) HEV/PHEV (partial EV)	BEV <120 (2016)	100,000 (2020; 2030?)	200 (309 charging points) (2020)
Philippines	HEV/PHEV/BEV/NEV	E-tricycle: 1,420 E-motorcycle: 952 HEV: n.a. PHEV: n.a. BEV: 64 NEV: 89 (2018)	1 million (2020)	4 (only 2 public) (2019)

Singapore	HEV/PHEV/BEV	HEV: 44,894 PHEV: 473 BEV: 1,336 (2019)	-	143 (569 charging points) (2019)
Thailand	HEV/PHEV/BEV	HEV: 153,184 BEV: 2,854 (2019)	1.2 million (2036)	527 (charging station) 817 (charging points) (2019)
Viet Nam	HEV/PHEV/BEV/NEV	1,086 (2016)	100,000 (2020) (included in 6 million eco-friendly vehicles target)	1 fast charging station

BEV = battery electric vehicle, EV = electric vehicle, HEV = hybrid electric vehicle, NEV = neighbourhood electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Author's investigation and Vietnam Economic News 22.11.2017.

First, Indonesia, Malaysia, and Thailand all seek to promote EV adoption and domestic EV production (Tab. 7). All three countries are mainly interested in promoting their automotive industries.

Second, a shared characteristic of the Philippines and Viet Nam is that they include low-speed vehicles resembling rickshaws, which cannot be used on highways in their target numbers. This in turn explains why target EV adoption numbers are relatively ambitious in comparison to both countries' levels of economic development. Whilst there is no common name for those vehicles, they may be called neighbourhood electric vehicles (NEVs), a term originally coined in California when debating the zero-emission vehicle mandate. A second shared characteristic is that both countries mainly rely on foreign investment or assistance for EV infrastructure development. This is due to the fact that both countries are still developing economies with low infrastructure investment budgets.

Third, Brunei and Singapore have not formulated any dedicated policy towards EVs. Nevertheless, both nations address EVs in their overall transport policies. In the case of Brunei, there are no signs that EVs should be promoted. Whilst government policy aims at improving energy efficiency, policy documents are rather vague and mention a large variety of vehicle and fuel types that should be utilised to achieve this aim.[23] It appears that Brunei's economic dependency on the export of fossil fuels is the main reason for it taking a rather lukewarm approach towards EVs.

The final group consists of Cambodia, the Lao PDR, and Myanmar, which all have no EV policy or aims put in place. All countries lack consumer purchasing power for costly EVs and the public budget to develop EV-related infrastructure. Hence, it cannot be surprising that these countries do not address EVs through public policy. This, however, does not mean that there are no EV projects. In the case of the Lao PDR, for instance, EV buses, mini buses, rickshaws, and motorcycles are promoted via Official Development Assistance (ODA) projects to take advantage of the country's abundant hydropower for sustainable mobility. In these countries, EVs in the conventional sense do not seem to have a bright future. The price gap between a conventional ICEV and an EV of comparable size is still around US$5,000, i.e. the price difference is greater than the per capita gross domestic product in these least

[23] Brunei's Land Transport Master Plan mentions BEVs and HEVs as well as fuel-efficient vehicles (FEVs), which include vehicles that use CNG, LPG, and fuel-efficient ICEVs. However, there is no further specification of which criteria define the latter type.

developed countries. Therefore, assuming widespread EV adoption appears highly unlikely. Simultaneously, electric scooters and motorcycles may be an option to foster personal mobility without creating negative externalities in the form of air pollution.

Table 1.7. Incentives for Electric Vehicle Adoption and Production

Country	Incentive
Brunei Darussalam	-
Indonesia	Producers: 1. Exemption from customs duty on SKD and CKD kits during the initial stage of the project 2. Exemption of customs duty on production-related capital goods 3. Incentives for charging station production (including equipment) Consumers: 1. Exemption from luxury sales tax 2. Reduction or exemption from regional or central government taxes (e.g. motor vehicle tax) 3. Lowered parking tariffs (determined by the local government)
Malaysia	Announced in National Automotive Policy (NAP) 2020 but not specified
Philippines	Under deliberation
Singapore	Consumers: EVs are subject to a rebate on the Additional Registration Fee under the Vehicle Emission Scheme
Thailand	Producers: 1. Corporate tax exemption (duration depends on electric vehicle type) 2. Import tariff exemption for production machinery Consumers: Lowered excise tax rates
Viet Nam	Under deliberation

SKD = semi-knock down, CKD = complete knock down.
Source: Authors' investigation.

5. Conclusion

Electromobility is a topic that receives differing levels of attention and support in the ASEAN region. The differences are due to different national objectives towards the topics of energy, environment, and transportation, which are all interrelated with electromobility. Despite differences in detailed policy, grouping countries that share basic policy objectives for EVs is possible.

First, Indonesia, Malaysia, and Thailand all seek to promote electromobility to defend and potentially expand their positions as vehicle manufacturing bases. Thai policy follows established policy to support assembly and component production. Simultaneous support aims at attracting a significant part of the EV supply chain to promote technological upgrading. Amongst all ASEAN members, Thailand has the strongest automotive industry, so it stands to lose significantly if the anticipated shift towards EVs is missed or mismanaged. Thus, Thai policy is the most comprehensive and seeks to link electromobility to issues such as smart grids and increased automation, often dubbed Industry 4.0. Malaysia also promotes EVs to support its local manufacturing industry. The main difference with Thailand's policy is in the details. Whilst Thailand formulates clear conditions for incentives, Malaysia's policy is vaguer and welcomes negotiations between the state and (foreign) investors. Indonesia's policy was only recently announced. The aim for EV market share must be called ambitious as EVs are still considerably more expensive than conventional cars. Whilst the intention is very clearly aimed at promoting local vehicle manufacturing and local supply chain creation, it can be doubted that ambitious local content requirements can be realised.

Second, the Philippines and Viet Nam also seek to promote electromobility but lack both the fiscal muscle and policy coordination to actively support private sector activity. It appears that policy in both countries consists of either just aims or is still under deliberation. Thus, whilst the policy objectives are similar to those of the first group, actual policy is too vague to effectively promote the aims.

Third, the small nations of Brunei and Singapore are somewhat reluctant proponents of electromobility. The sources of their reluctance, however, are different. As a country whose national economy is based on fossil energy sources, Brunei has little interest in promoting mobility based on electricity. Whilst electricity can be generated from fossil sources, electromobility is increasingly promoted in tandem with renewable energy generation, so the sultanate may not be inclined to actively promote EV use. In the case of Singapore, the city state simply follows its established policy practice to limit private car-ownership due to scarcity of land and air pollution. As Singapore has actively promoted public or at least multi-modal transport for almost two decades, the general tendency to limit private vehicle use in any form is also applied to EVs. Thus, whilst there are some trials, support is rather limited, especially considering the wealth of Singapore.

Fourth, the least developed ASEAN members, Cambodia, the Lao PDR, and Myanmar, lack the economic muscle to promote EVs. These countries are all still in a pre-motorisation phase, so national policymakers' priorities lie in other fields of economic development. Hence, they have not been covered in this analysis.

Our analysis strongly suggests that the basic question of whether an (ASEAN) country has an automotive industry influences its engagement with EV policies. Countries with an industry, especially one that goes beyond mere assembly, are all trying to convince carmakers to invest in EV production within their borders. Quite clearly, all countries in the first group perceive EVs as the likely evolutionary step for automotive industry development and seek to position their domestic industries within this

anticipated new paradigm. Whilst the Philippines and Viet Nam also seem to be interested in promoting EV production and adoption, their policies are less clearly defined. Arguably, these countries are still seeking to secure positions in current ICEV supply chains and further lack the level of economic development to be able to support demand for still-costly EVs. Countries without an industry, such as Brunei and Singapore, as well as Cambodia, the Lao PDR, and Myanmar, display a much lower tendency to support EV adoption. Whilst this is not unsurprising in the case of the latter three countries, the former two have distinct policy priorities that explain their lack of engagement.

Regarding lessons for other developing countries, the comparison with China may provide a basic differentiation. China was rather successful in promoting EVs, especially BEVs. It used supply and demand side policies to nurture domestic vehicle and component producers. Thus, Chinese firms have emerged as principal challengers against incumbent Japanese and Korean EV battery suppliers. Therefore, it may be stated that China is building a supply chain that encompasses domestic firms and know-how. In contrast, ASEAN countries, especially the described groups one and two, mainly seek to join supply chains as processors or final assembly destinations. It may be stated that China is attempting to build a highly integrated (B)EV industry, and ASEAN countries are attempting to moderate (anticipated) technological change that is spearheaded by China, the triad (Europe, Japan, and the US) and the Republic of Korea. Ambitions are simply different – whilst China sees BEVs as a chance to challenge incumbent industry leaders by leapfrogging into BEV technology, ASEAN countries basically seek to maintain their position as car-making countries without attempting to create industry leadership. This also explains why demand side policies differ. China artificially creates demand for BEVs in order to give domestic firms the opportunity to acquire skills in production as well as in product development and improvement. As this is not the motivation of ASEAN Member States, the countries currently concentrate incentives in the supply side to attract carmakers and component producers. Thus, China and ASEAN Member States' policies may be differentiated by the difference between creating and joining a supply chain.

References

Asian Development Bank (ADB) (2012), Philippines: 'Mitigation of Climate Change Through Increased Energy Efficiency and the Use of Clean Energy', Proposed Market Transformation through Introduction of Energy Efficient Electric Tricycle Project (Project Number: 43207) (project presentation). https://www.adb.org/sites/default/files/projects/163994/43207-012-phi-dpta-08.pdf (accessed 01 February 2021).

Apisitniran, L. (2018), BoI Approves 3 EV Projects, Including Charging Stations. Bangkok: Bangkok Post. https://www.bangkokpost.com/business/news/1600710/boi-approves-3-ev-projects-including-charging-stations (accessed 01 February 2021).

Asmarini, W. (2018), Construction of $4 Billion Indonesia EV Battery Project Begins Jan 2019: Minister. Reuters. https://www.reuters.com/article/us-indonesia-nickel-batteries/construction-on-4-billion-indonesia-ev-battery-project-begins-jan-2019-minister-idUSKCN1NZ1AB (accessed 01 February 2021).

Bangkok Post (2017), Thai Electric Car Rolls Out, (14 January 2017), https://www.bangkokpost.com/business/1179837/thai-electric-car-rolls-out (accessed 01 February 2021).

Bangkok Post (2017), Toyota Head Aims to Steer EV Market, (29 November 2017), https://www.bangkokpost.com/business/1368815/toyota-head-aims-to-steer-ev-market (accessed 01 February 2021).

Barahan, E.M. (2017), Estrada Distributes First 50 Units in Manila E-trike Program. Inquirer. http://newsinfo.inquirer.net/886762/estrada-distributes-first-50-units-in-manila-e-trike-program (accessed 01 February 2021).

BMW (2018), BMW Group Thailand Localizes High-voltage Battery Production, press release. BMW. https://www.press.bmwgroup.com/global/article/detail/T0287652EN/bmw-group-thailand-localizes-high-voltage-battery-production?language=en (accessed 01 February 2021).

Brown, S., D. Pyke, and P. Steenhof (2010), 'Electric Vehicles: The Role and Importance of Standards in an Emerging Market', Energy Policy, 38(7), pp.3797–806.

Cano, Z.P., D. Banham, S. Ye, A. Hintennach, J. Lu, M. Fowler, and Z. Chen (2018), 'Batteries and Fuel Cells for Emerging Electric Vehicle Markets', Nature Energy, 3(4), pp.279–89.

Channel News Asia (2019), SP Group Rolls Out First Wave of Electric Vehicle Charging Points. Channel News Asia. https://www.channelnewsasia.com/news/singapore/38-electric-vehicle-charging-points-rolled-out-sp-group-11101228 (accessed 01 February 2021).

Clean Malaysia (2017), Switching to Green Cars in Malaysia, Clean Malaysia (16 April 2017), https://cleanmalaysia.com/2017/04/16/switching-green-cars-malaysia/ (accessed 01 February 2021)

Coffin, D. and J. Horovitz (2018), 'The Supply Chain for Electric Vehicle Batteries', Journal of International Commerce and Economics, December 2018.

Davies, E. and K. Kapoor (2019), Indonesia to Tap Nickel Laterite, Make Batteries to Become EV Hub. Kitco. https://www.kitco.com/news/2019-02-22/Indonesia-to-tap-nickel-laterite-make-batteries-to-become-EV-hub.html (accessed 01 February 2021).

DTI-BOI (2014), 2014 Investment Priorities Plan. Industry Development for Inclusive Growth. Manila: DTI-BOI.

Figenbaum, E. (2017), 'Perspectives on Norway's Supercharged Electric Vehicle Policy', Environmental Innovation and Societal Transitions, 25, pp.14–34.

Greentech Malaysia (undated), Electric Mobility. Greentech Malaysia. https://www.greentechmalaysia.my/expertise/em (accessed 01 February 2021).

Gustafsson F. (2007), Malaysia Industrial Policy, 1986-2002, in Jomo K. S. ed., Malaysia Industry Policy, National University of Singapore (NUS) Press.

Hamid, A.J. (2016), Proton's Hybrid Misadventures. New Straits Times. https://www.nst.com.my/news/2016/04/138329/protons-hybrid-misadventures (accessed 01 February 2021).

Hanoi Times (2018), Vietnam to Cooperate with Mitsubishi Motors in Developing Electric Vehicles. Hanoi Times. http://www.hanoitimes.vn/science-tech/2018/01/81e0c051/vietnam-to-cooperate-with-mitsubishi-motors-in-developing-electric-vehicles/ (accessed 01 February 2021).

Helveston, J.P., Y. Liu, E.M. Feit, E. Fuchs, E. Klampfl, and J.J. Michalek (2015), 'Will Subsidies Drive Electric Vehicle Adoption? Measuring Consumer Preferences in the U.S. and China', Transportation Research Part A, 73, pp.96–112.

Hertzke, P., N. Muller, and S. Schenk (2017), Dynamics in the Global Electric Vehicle Market. McKinsey Center for Future Mobility. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/dynamics-in-the-global-electric-vehicle-market (accessed 01 February 2021)

Holtsmark, B. and A. Skonhoft (2014), 'The Norwegian Support and Subsidy Policy of Electric Cars. Should It Be Adopted by Other Countries?', Environmental Science & Policy, 42, pp.160–68.

Howlett, M. and M. Ramesh (2003), Studying Public Policy. Policy Cycles & Policy Subsystems. 2nd ed. Oxford: Oxford University Press.

Indonesia Economic Forum (2019), The Race Is On! Electric Vehicles in Indonesia. Indonesia Economic Forum. https://www.indonesiaeconomicforum.com/the-race-is-on-electric-vehicles-in-indonesia/ (accessed 01 February 2021).

International Energy Agency (2016), Medium-Term Renewable Energy Market Report 2016, IEA, Paris.

International Energy Agency (2018), Global EV Outlook 2018, IEA, Paris

International Energy Agency (2019), Global EV Outlook 2019, IEA, Paris.

Jakarta Post (2017a), Indonesia Pushes Electric Car Development. Jakarta: Jakarta Post. http://www.thejakartapost.com/news/2017/10/30/indonesia-pushes-electric-car-development.html (accessed 01 February 2021).

Jakarta Post (2017b), RI Prepares Regulation to Make Way for Electric Cars. Jakarta: Jakarta Post. http://www.thejakartapost.com/news/2017/07/20/ri-prepares-regulation-make-way-electric-cars.html (accessed 01 February 2021).

Kimura, S., R. Pacudan, and H. Phoumin (2017), Development of the Eco Town Model in the ASEAN Region through Adoption of Energy-Efficient Building Technologies, Sustainable Transport and Smart Grids. ERIA Research Project Report 2015-20. Jakarta: ERIA.

Kotani, H. (2018), Japanese Electric Car Startup FOMM to Open $30m Thai plant. Mass Production of Four-seater to Start from February. Tokyo: Nikkei Asia. https://asia.nikkei.com/Business/Startups/Japanese-electric-car-startup-FOMM-to-open-30m-Thai-plant (accessed 01 February 2021).

Lin, B. and W. Wu (2018), 'Why People Want to Buy Electric Vehicles: An Empirical Study in First-tier Cities of China', Energy Policy, 112, pp.233–41.

Luna, T.F., M. Uriona-Maldonado, M.E. Silva, and C.R. Vaz (2020), 'The Influence of E-carsharing Schemes on Electric Vehicle Adoption and Carbon Emissions: An Emerging Economy Study', Transport Research Part D, 79, pp.1–14.

Maikaev, P. (2018), BoI Approves Grant for Mazda Hybrid EVs. Bangkok: Bangkok Post. https://www.bangkokpost.com/business/news/1576094/boi-approves-grant-for-mazda-hybrid-evs (accessed 01 February 2021).

Maikaev, P. (2019a), Nissan Keen on Local Plant. First Manufacturing Hub Outside of Japan. Bangkok:

Bangkok Post. https://www.bangkokpost.com/auto/news/1612978/nissan-keen-on-local-plant (accessed 01 February 2021).

Maikaev, P. (2019b), Mazda Applies for Incentives to Produce Full EVs. Bangkok: Bangkok Post. https://www.bangkokpost.com/auto/news/1611954/mazda-applies-for-incentives-to-produce-full-evs (accessed 01 February 2021).

Maikaev, P. (2019c), Mercedes-Benz Ready to Rev Up EV Assembly. Local Sales of Battery Vehicles Planned. Bangkok: Bangkok Post. https://www.bangkokpost.com/business/news/1625538/mercedes-benz-ready-to-rev-up-ev-assembly (accessed 01 February 2021).

Ministry of International Trade and Industry, Malaysia (MITI) (2014), National Automotive Policy 2014. http://www.maa.org.my/pdf/NAP_2014_policy.pdf (accessed 01 February 2021). Kuala Lumpur: MITI.

MTIC (2014), Review to Formulate a Roadmap and Draft National Masterplan for a Sustainable Land Transportation System for Brunei Darussalam. Bandar Seri Begawan: MTIC.

The Nation (2012), 'Country will be among world's Top-10 producers: TAIA chief', 13 June.

Natsuda K. and J. Thoburn (2013). Industrial policy and the development of the automotive industry in Thailand, Journal of the Asia Pacific Economy, 18(3), pp. 413-437.

NNA Business News (2018), Electric Scooters Sparking Interest in Vietnam's Two-wheeler Market. NNA. https://www.nna.jp/english_contents/news/show/20181227_0001 (accessed 01 February 2021).

Qiu, Y.-Q., P. Zhou, and H.C. Sun (2019), 'Assessing the Effectiveness of City-level Electric Vehicle Policies in China', Energy Policy, 130, pp.22–31.

Panthong, Kanittha (2012), Country will be among world's Top-10 producers: TAIA chief. The Nation. https://www.nationthailand.com/auto/30184096 (accessed 01 February 2021).

Reuters (2018), Vietnam's VinFast in Deal with PV Oil for Electric Car Charging Stations. Reuters. https://www.reuters.com/article/vietnam-vinfast-autos/vietnams-vinfast-in-deal-with-pv-oil-for-electric-car-charging-stations-idUSL3N1X53VO (accessed 01 February 2021).

Rivera, D. (2016), DOE Defends E-trike Program Cancellation. Philstar. http://www.philstar.com/business/2016/12/04/1650112/doe-defends-e-trike-program-cancellation (accessed 01 February 2021).

Saieed, Z. (2017), No Plans for Electric Vehicles in Malaysia, Says Perodua. The Star. https://www.thestar.com.my/business/business-news/2017/10/25/no-plans-for-electric-vehicles-in-malaysia-says-perodua/ (accessed 01 February 2021).

Sierzchula, W., S. Bakker, K. Maat, and B. van Wee (2014), 'The Influence of Financial Incentives and Other Socio-economic Factors on Electric Vehicle Adoption', Energy Policy, 68, pp.183–94.

Soeriaatmadja, W. (2019), Indonesia to Decide on Electric Car Policy with Hyundai Keen to Invest in a Plant in the Country. Straits Times. https://www.straitstimes.com/asia/se-asia/indonesia-to-decide-on-electric-car-policy-with-hyundai-keen-to-invest-in-a-plant-in (accessed 01 February 2021).

Tan, C. (2017), Electric Cars Given Small Kick Start with LTA Tax Revision. Straits Times. http://www.straitstimes.com/singapore/transport/electric-cars-given-small-kick-start-with-lta-tax-revision (accessed 01 February 2021).

Tempo (2017), Govt Prepares Incentives for Electric Cars, Kalla Says. Tempo. https://en.tempo.co/read/news/2017/08/11/055899152/Govt-Prepares-Incentives-for-Electric-Cars-Kalla-Says (accessed 01 February 2021).

The Korea Economic Daily (2017), Korea's MBI to Establish EV Plant in Vietnam. The Korea Economic Daily. http://english.hankyung.com/news/2017/09/22/0836401/koreas-mbi-to-establish-ev-plant-in-vietnam (accessed 01 February 2021).

The Sun Daily (2016), Malaysia sets target of 100,000 EVs by 2020. The Sun Daily. https://www.thesundaily.my/archive/2015711-XTARCH403883 (accessed 01 February 2021).

Un-Noor, F., S. Padmanaban, L. Mihet-Popa, M.N. Mollah, and E. Hossain (2017), 'A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development', Energies, 10(8). https://www.mdpi.com/1996-1073/10/8/1217 (accessed 01 February 2021).

Vietnam Economic News (22.11.2017), First EV quick charging station put into use in Vietnam. Vietnam Economic News. https://ven.vn/first-ev-quick-charging-station-put-into-use-in-vietnam-29741.html (accessed 01 April 2021).

Vietnamnet (15.01.2019), Firms Show Interest in Vietnamese E-scooter Market. Vietnamnet. https://english.vietnamnet.vn/fms/business/216069/firms-show-interest-in-vietnamese-e-scooter-market.html (accessed 01 February 2021).

Vietnam Plus (2020), Son Ha Group Inaugurates EVgo Electric Vehicle Production Plant in Bac Ninh. Vietnam Plus. https://en.vietnamplus.vn/son-ha-group-inaugurates-evgo-electric-vehicle-production-plant-in-bac-ninh/188035.vnp (accessed 01 February 2021).

Vu, K. (2020), Vietnam's VinFast to Launch First Electric Car in 2021. Reuters. https://www.reuters.com/article/vietnam-vinfast-idUSL4N2DA2AZ (accessed 01 February 2021).

Wan, Z., D. Sperling, and Y. Wang (2015), 'China's Electric Car Frustrations', Transportation Research Part D, 34, pp.116–21.

Wang, H. and C. Kimble (2011), 'Leapfrogging to Electric Vehicles: Patterns and Scenarios for China's Automobile Industry', International Journal of Automotive Technology and Management, 11(4), pp.312–25.

Wang, M. (2001), Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Wystems – North American Analysis. Argonne National Lab.

Wang, N., H. Pan, and W. Zheng (2017), 'Assessment of the Incentives on Electric Vehicle Promotion in China', Transportation Research Part A, 101, pp.177–89.

Woo, J.R., H. Choi, and J. Ahn (2017), 'Well-to-Wheel Analysis of Greenhouse Gas Emissions for Electric Vehicles Based on Electricity Generation Mix: A Global Perspective', Transportation Research Part D, 51, pp.340–50.

Xinhua (2017), Indonesia to Kick Off Mass Production of Electric Vehicles in 2020. Xinhua. http://news.xinhuanet.com/english/2017-08/03/c_136497266.htm (accessed 01 February 2021).

Zhang, X., Y. Liang, E. Yu, R. Rao, and J. Xie (2017), 'Review of Electric Vehicle Policies in China: Content Summary and Effect Analysis', Renewable and Sustainable Energy Reviews, 70, pp.698–714.

Zheng, J., S. Mehndiratta, J.Y. Guo, and Z. Liu (2012), 'Strategic Policies and Demonstration Program of Electric Vehicle in China', Transport Policy, 19(1), pp.17–25.