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An Analysis of Alternative Vehicles' Potential and Implications for Energy Supply Industries in Indonesia

Edited by
Shigeru Kimura
Shigeru Suehiro
Naoko Doi

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Disclaimer

This report was prepared by a working group under the Economic Research Institute for ASEAN and East Asia Energy Project. The members of the working group agreed to use certain data and methodologies to assess the potential benefits of introducing alternative vehicles in Indonesia. As these data and methodologies may differ from those normally used in Indonesia, the calculated results presented here should not be viewed as an official national analysis.

Foreword

An increasing demand for oil is one of Indonesia's top policy priorities as it is linked to many of the country's concerns, such as the deteriorating security of its oil supply, growing fiscal imbalances, and worsening air quality.

Indonesia has announced that it aims to ban sales of internal combustion engine vehicles by 2040. The country also intends for alternative vehicles to account for 20 percent of all vehicles produced by 2025. The impacts of these targets are expected to transform the energy industry, with significant repercussions for electricity generation, transmission, and distribution; as well as refineries, oil product retailers, and gas stations.

This study aims to support policy makers in East Asia Summit countries[*] by analysing the shift towards electric vehicles as a way to improve the efficiency of the transport sector and mitigate oil demand concerns. A quantitative analysis was carried out to present the magnitude of the impact of this shift on energy demand, carbon dioxide emissions, and investment requirements. In addition, a qualitative analysis comparing international vehicle incentives was carried out to support policy makers in formulating similar incentives in Indonesia.

I hope that this study will offer new insights to those involved in this issue.

Akihiro Kuroki

Managing Director

The Institute of Energy Economics, Japan

September 2018

[*] These are the 10 countries in the Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam); as well as Australia, China, India, Japan, New Zealand, the Republic of Korea, the United States, and Russia.

Acknowledgement

This analysis was carried out by a working group under the Economic Research Institute for ASEAN and East Asia. It was a joint effort by working group members from Indonesia and the Institute of Energy Economics, Japan. We would like to acknowledge the support provided by everyone involved, and would especially like to express our gratitude to the members of the working group.

Valuable insights were provided by a number of government officials in Indonesia, including members of the National Energy Council, Coordinating Ministry for Maritime Affairs, Fiscal Policy Agency, Ministry of Industry, and Ministry of Energy and Mineral Resources. We offer our profound appreciation to Saleh Abdurrahman, Secretary General of the National Energy Council, for joining the working group meeting to provide insights and direction. Comments from the Economic Research Institute for ASEAN and East Asia were also useful in developing scenarios and policy implications. Special thanks are given to the members from Pertamina and Mitsubishi Corporation for their comments and discussions, and for providing data, information, and analysis that were integral to the implementation of this study.

Naoko Doi
Group Manager, Senior Economist
The Institute of Energy Economist, Japan
October 2018

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List of Project Contributors

SALEH ABDURRAHMAN, Secretary General, National Energy Council

KEMAL SINATRA DEA, Coordinating Ministry for Maritime Affairs

PUTU JULI ARDIKA, Ministry of Industry

ATENA FALAHTI, Ministry of Energy and Mineral Resources

GUSTI SIDEMEN, Migas, Ministry of Energy and Mineral Resources

NASRUDDIN DJOKO SURJONO, Fiscal Policy Agency

HERUTAMA TRIKORANTO, Special Vice President, Research and Technology Center (RTC), Pertamina

ANDIANTO HIDAYAT, Vice President Planning and Commercial, RTC, Pertamina

HERY HAERUDIN, Chief of Power Development and Storage Management Research, RTC, Pertamina

FUADI ARIF NASUTION, Power Development and Storage Management Research, RTC, Pertamina

TARO ARAKI, Counsellor, Trade, Investment and Industry, Embassy of Japan in Indonesia

FUMIHIRO NAKAYAMA, Energy and Natural Resources Attaché, Embassy of Japan in Indonesia

TOSHIHIKO SUMITA, Marketing Director, Group Leader, Energy Business Group, Mitsubishi Corporation

KENSEI KURODA, Assistant General Manager, Infrastructure and Machinery Business Development Group, Jakarta Representative Office, Mitsubishi Corporation

HITOSHI MEGA, Marketing Manager, Energy Business Group, Mitsubishi Corporation

MASAO OKAWARA, Manager, Business Development, Upstream Business Team, Indonesia Oil and Gas Business Development, Mitsubishi Corporation

RIZKI YALDI, Manager, Energy Business Group, Mitsubishi Corporation

MARIA THEODRA ROSARY, Development, Global Marketing Department, Mitsubishi Corporation

BURHAN SIDQI MUCHTAR, Energy Business Group, Mitsubishi Corporation

SHIGERU KIMURA, Special Adviser to the President of Energy Affairs, Economic Research Institute for ASEAN and East Asia

AKIHIRO KUROKI, Managing Director, Institute of Energy Economics, Japan (IEEJ)

KOICHI SASAKI, Deputy Director, Global Environment and Sustainable Development Unit, IEEJ

SHIGERU SUEHIRO, Senior Researcher, Manager, Energy Data and Modeling Center, IEEJ

NAOKO DOI, Senior Economist, Energy Conservation Group, Global Environment and Sustainable Development Unit, IEEJ

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List of Abbreviations and Acronyms

BEV	battery-powered electric vehicle
CO_2	carbon dioxide
COE	Certificate of Entitlement
EEV	energy-efficient vehicle
ERIA	Economic Research Institute for ASEAN and East Asia
EV	electric vehicle
FCV	fuel-cell vehicle
GDP	gross domestic product
HEV	hybrid electric vehicle
ICEV	internal combustion engine vehicle
IEA	International Energy Agency
IEEJ	Institute for Energy Economics, Japan
NAP	National Automotive Policy
NCT	National Capital Territory
OMV	open market value
PLDV	passenger light-duty vehicle
PHEV	plug-in hybrid electric vehicle
RTC	Research and Technology Center (Pertamina)
TCO	total cost of operation
VES	Vehicular Emissions Scheme

Executive Summary

Indonesia became a net oil importer in 2003 due to the rise in transport-related oil consumption and dwindling domestic production. The Institute of Energy Economics, Japan projects that, under the reference scenario, 75 percent of Indonesia's demand for oil products will be met by imports by 2040.

To reduce the expected potential increase in oil imports and to nurture the domestic automobile manufacturing industry, Indonesia has set a target to abandon sales of internal combustion engine vehicles (ICEVs) by 2040. Indonesia also intends for alternative vehicles to account for 20 percent of total vehicle production by 2025. If these targets are reached, their expected impacts are likely to transform the energy industry as a whole, with significant repercussions for electricity generation, transmission, and distribution, as well as refineries, oil product retailers, and gas stations.

This study analyses the potential impacts (through 2040) of using alternative vehicles such as electric vehicles (EVs) – including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery-powered EVs – as motorcycles, passenger vehicles, trucks, and buses in Indonesia. The study also considers the implications of such changes for energy policy and energy supply industries. As many East Asia Summit countries[*] are expected to rely increasingly on imported oil products in the future (mostly driven by the growing demand for energy in the transport sector), the conclusions of this study examining the targeted shift away from ICEVs will provide important perspectives for the countries in this region.

The study delivered the following outcomes:

1. Alternative vehicles' potential to contribute to oil savings and reduce carbon dioxide (CO_2) emissions was ascertained by developing three scenarios: a reference scenario, a moderate EV scenario, and an advanced EV scenario.
2. In the moderate EV scenario, oil demand in the road sector continued to increase but remained 20 percent lower by 2040 than in the reference scenario. On the other hand, in the advanced EV scenario, oil demand peaked around 2025 and declined rapidly to almost half of the current level.
3. In the reference scenario, the demand for electricity more than tripled from 200 terawatt-hours (TWh) to 680 TWh, led by the industry and the building sectors. In the advanced EV scenario, rapid EV penetration increased the electricity demand further to around 900 TWh, more than four times the current level.

[*] These are the 10 countries in the Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam); as well as Australia, China, India, Japan, New Zealand, the Republic of Korea, the United States, and Russia.

4. EVs could be an effective tool for reducing CO_2 emissions when decarbonisation of the electricity generation mix takes effect. Assuming that Indonesia will remain dependent on fossil fuels for power generation through 2040 (these fuels currently account for 90% of the total generation mix), this analysis found that massive deployment of EVs (in the advanced EV scenario) would only reduce CO_2 emissions by 2 percent compared with the reference scenario. In contrast, based on the assumption of the National Energy Council (*Dewan Energi Nasional*) that renewables would account for 23 percent of the primary energy mix by 2040, EVs could contribute to a 17 percent reduction of CO_2 emissions by 2040.
5. Estimating the cost of the lithium-ion battery module is critically important to estimate the future cost of HEVs, PHEVs, and EVs. By using the learning curve analysis method and applying the IEEJ's assumptions as to the global penetration of EVs, this study estimated that the cost of the lithium-ion battery module will decline from $209 per kilowatt-hour (kWh) in 2017 to $72/kWh by 2030 and $51/kWh by 2040.
6. An analysis of the annualised cost of ICEVs and EVs, including payments for energy (gasoline, diesel, or electricity) and maintenance, revealed that a shift to EVs would benefit drivers of different modes of transport at different times. For example, the cost of driving an electric motorcycle would be lower than that of a conventional motorcycle sometime after 2020, suggesting that the benefits of shifting to electric motorcycles would outweigh those of using conventional motorcycles by that date. This shift happens much earlier for motorcycles than for trucks (2025), passenger vehicles (2025), and buses (2035) due to faster upfront cost reduction.
7. Assuming an annual driving distance of 19,000 kilometres (km), bus drivers will be able to enjoy the benefits of the shift to electric buses after 2035. Based on upfront costs in 2017, it is estimated that electric buses will become cost-competitive at a travel distance of more than 90,000 km. In contrast, based on estimated upfront costs in 2040 (which are 41 percent lower than in 2017), the total cost of electric buses will be lower than that of conventional buses when the travel distance exceeds 10,000 km. These findings suggest that, given the current cost gap, EV buses should be used on routes with long travel distances to ensure drivers' benefits. Also, until upfront costs are reduced, supporting measures (such as the provision of subsidies or battery leasing) should be instituted to realise the full benefits from the introduction of EV buses.
8. The use of EVs in Indonesia can be an effective tool for various policy purposes, including energy security enhancement, climate change mitigation, air quality improvement, and manufacturing industry development. The analysis results show that a shift towards EVs would benefit drivers in Indonesia, as well as society as a whole by boosting oil savings, reducing CO_2 emissions, and improving air quality. The cumulative monetary benefits of these developments would reach $79.6 billion by 2040. Meanwhile, the additional cumulative costs of developing electricity generation (including the increased deployment of renewables) will amount to $187 billion by 2040. To realise the full benefits of EVs in Indonesia, it is important to consider the specific characteristics of locations where the existing electricity supply infrastructure can accommodate the massive introduction of EVs.

9. The upfront costs are currently the biggest hurdle for the introduction of EVs, and it is important for the Government of Indonesia to provide necessary incentives to help drivers and other consumers realise the potential benefits of EVs. Mechanisms should be put in place to secure necessary funds for the provision of incentives. A good lesson in this regard can be found in India, where the state of Delhi charges an additional fee on diesel consumption and uses this fee as the basis for incentive funds.

10. Another important lesson can be found in Malaysia, where the introduction of energy-efficient vehicles (including HEVs and EVs) is considered an important strategic area and effective tool for developing the manufacturing industry. To this end, the country is providing incentives to the industry, specifically to assembly and manufacturing companies that produce parts, including electric motors, HEV and EV batteries, battery management systems, inverters, air conditioning units, and air compressors. This case offers some important insights for the stepwise development of the manufacturing industry in Indonesia.

Chapter 1
Introduction

Indonesia became a net oil importer in 2003 due to increasing consumption of transported oil and dwindling domestic production. The Institute of Energy Economics, Japan (IEEJ) projects that, under the reference scenario, 75% of Indonesia's demand for oil products will be met by imports in 2040.

To reduce the expected potential increase in oil imports and to nurture the domestic automobile manufacturing industry, Indonesia has set a target to abandon sales of internal combustion engine vehicles (ICEVs) by 2040. Indonesia also intends for alternative vehicles to account for 20% of total vehicle production by 2025. If these targets are reached, their expected impacts are likely to transform the energy industry as a whole, with significant repercussions for electricity generation, transmission, and distribution as well as refineries, oil product retailers, and gas stations.

This study analyses the potential of using alternative vehicles such as electric vehicles (EVs), biofuel blended vehicles, and fuel-cell vehicles (FCVs) in Indonesia, and considers the implications for energy policy and energy supply industries. As many East Asia Summit countries[1] are expected to rely increasingly on imported oil products in the future (mostly driven by the growing demand for energy in the transport sector), the conclusions of this study examining the targeted shift away from ICEVs offer important perspectives for the countries in this region.

1. Research Objectives

The objectives of this study were follows:

(i) To analyse the potential use of alternative vehicles in Indonesia;

(ii) To estimate the benefits and costs of alternative vehicles by technology and energy type in Indonesia;

(iii) To ascertain the implications for energy policy and energy supply industries in Indonesia; and

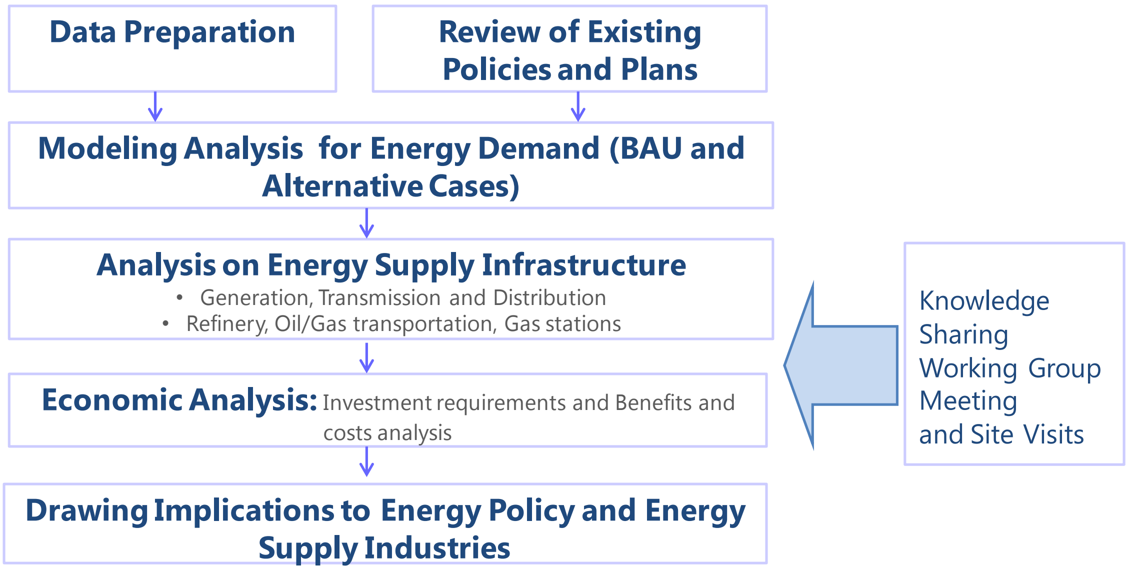
(iv) To share Japan's relevant technology, policy, and business models.

[1] These are the 10 countries in the Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam), as well as Australia, China, India, Japan, New Zealand, the Republic of Korea, the United States, and Russia.

2. Study Methodologies

This study quantitatively analyses the potential use of alternative vehicles in Indonesia and presents implications for energy policy and energy supply industries (Fig. 1.1). The study effectively engaged stakeholders in both Indonesia and Japan through knowledge-sharing working group meetings. These occasions for discussion and information exchange were utilised to draw implications for Indonesia, Japan, and the wider East Asia Summit region.

Figure 1.1: Study Framework



BAU = business as usual.
Source: Authors.

3. Report Structure

This report is structured as follows to analyse the potential economic benefits and costs of shifting to EVs in Indonesia.

Chapter 1 outlines the study background, objectives, and methodologies.

Chapter 2 discusses the potential shift to using alternative vehicles in Indonesia (with a special focus on EVs), and considers its impacts on oil demand and CO_2 emissions.

Chapter 3 analyses the costs and benefits of shifting towards alternative vehicles in Indonesia, with due consideration of infrastructure investment in the electricity sector as a cost, and benefits from oil savings, reduced CO_2 emissions, and cost savings for drivers.

Chapter 4 considers cases where economic incentives were provided to promote alternative vehicles, including EVs. The study analysed cases in India, Singapore, and Malaysia as a means of capturing policy trends in East Asia.

Chapter 5 presents the policy implications of this study.

Chapter 2

Transport Energy Demand Outlook

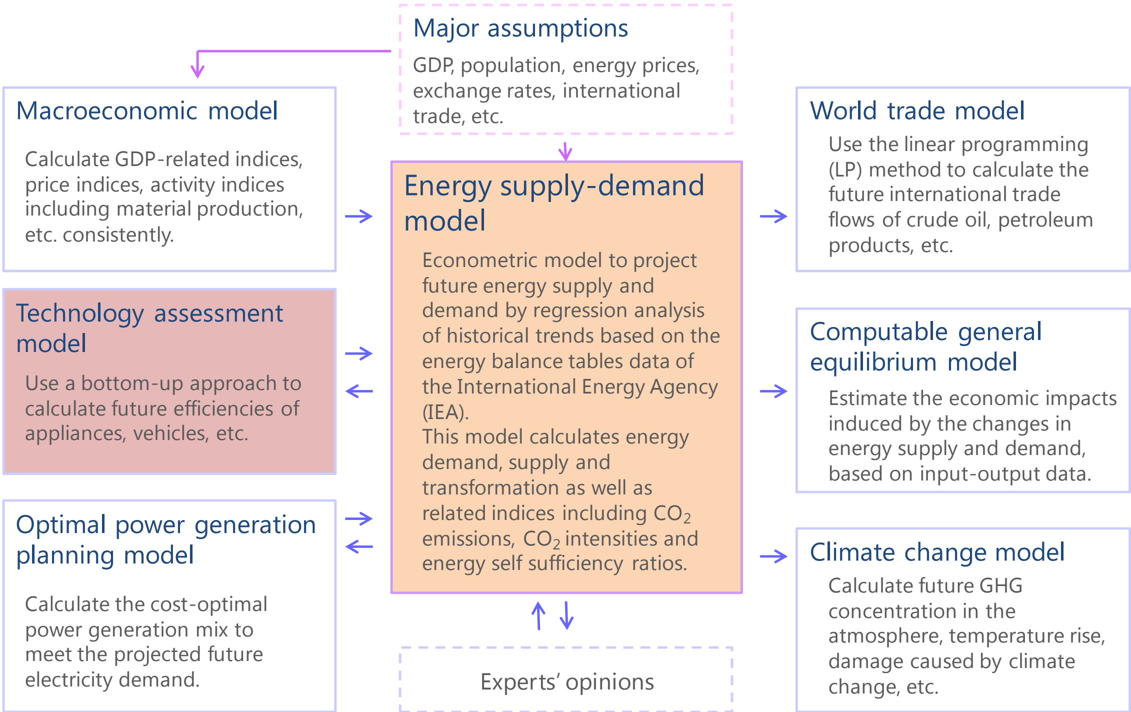
1. Introduction

1.1 Energy Analysis Model

This analysis uses the IEEJ's energy analysis model, known as the energy supply–demand model (Fig. 2.1). This model, shown at the center of a group of various models, allows the projection of future energy supply and demand through a regression analysis of historical trends. The energy demand and supply structure is based on the energy balance tables of the International Energy Agency. This model can calculate energy demand, supply, and transformation as well as related indices, including CO_2 emissions and the energy self-sufficiency rate.

The energy supply–demand model requires several assumptions such as gross domestic product (GDP), population, international energy prices, and economic activities such as material production and commercial services activity. These are fed directly into the model or provided indirectly through the macroeconomic model.

Figure 2.1: Institute of Energy Economics, Japan Energy Modelling Framework



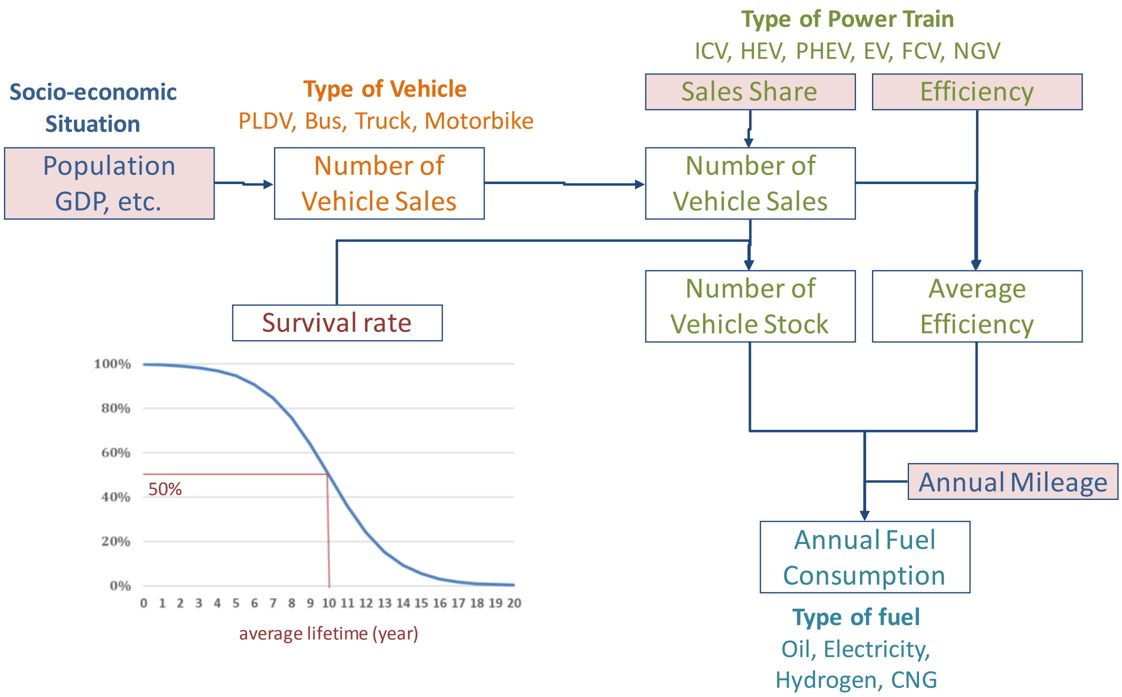
GDP = gross domestic product, GHG = greenhouse gas, CO_2 = carbon dioxide.
Source: Institute of Energy Economics, Japan.

The energy supply–demand model also requires assumptions for energy efficiency improvement with respect to household appliances and automobiles. These assumptions are calculated in the technology assessment model, which uses a bottom-up approach to calculate the future efficiencies of appliances and vehicles, amongst other items.

1.2. Technology Assessment Model for Automobiles

The technology assessment model for automobiles employs the turnover model, which deals with four vehicle types: passenger light-duty vehicles (PLDVs), buses, trucks, and motorcycles. To analyse how the powertrain mix (especially electrification) could affect fuel demand in the road sector, this model considers six types of powertrain, namely ICEVs, hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), EVs, FCVs, and natural gas vehicles.

Figure 2.2: Technology Assessment Model (Vehicle Turnover Model)



CNG = compressed natural gas, EV = electric vehicles, FCV = fuel-cell vehicle, GDP = gross domestic product, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, NGV = natural gas vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: Institute of Energy Economics, Japan

After estimating numbers of future vehicle sales and shares by powertrain type (see Section 2.1.3), the model estimates numbers of future vehicle stocks by powertrain type, based on the survival rate (how many vehicles are on the road a certain number of years after being sold). This analysis uses a logistic curve to shape the survival rates and set 50% of the rate at the average lifetime. By assuming fuel efficiency by powertrain type for each year's sales (Fig. 2.2), the model can determine the average fuel efficiency on the road.

Total fuel consumption for each year can be calculated by multiplying the number of vehicle stocks, average fuel efficiency, and annual mileage. The fuel types analysed in this study are oil, electricity, hydrogen, and compressed natural gas.

1.3 Multinomial Logit Model for Sales Share

Sales shares by powertrain type are estimated using the multinomial logit model. For this model, we set utilities for using each powertrain, then calculate the ratio of the exponential function of its utility using Napier's number (e). In the model, this ratio is considered a selection probability, namely sales share.

$$(\textbf{equation 1})\ Sales\ Share_i = \frac{exp(Utility_i)}{\sum_i exp(Utility_i)}$$

i (type of powertrain) = ICEV, HEV, PHEV, EV, FCV, NGV

$$(\textbf{equation 2})\ Utility_i = U(Vehicle\ cost_i, Fuel\ cost_i, Crusing\ distance_i, GDP, etc.)$$

The utility is estimated based on initial cost, running cost, income level, cruising distance, and so on. When the initial and running costs are lower, the utility is higher. The utility for EVs depends on cruising distance. In this analysis, a higher income is assumed to enable the purchasing of more expensive cars.

2. Main Assumptions for the Study

2.1 Demographic Assumptions

For this study, we assumed that Indonesia would have an average annual economic growth rate of 5.0% and a population growth rate of 0.8%. GDP per capita will increase from around $4,000 to more than $10,000 (in 2010 prices) by 2040.

Table 2.1: Assumptions for Gross Domestic Product and Population

		2015	2020	2030	2040	2015/2040
GDP	bil. USD ($2010price)	988	1,276	2,124	3,329	5.0%
Population	million	258	272	295	312	0.8%
GDP per capita	USD/person	3,834	4,698	7,194	10,671	4.2%

GDP = gross domestic product.
Sources: World Development Indicators, United Nations, and Institute of Energy Economics, Japan analysis.

2.2 Automobile Assumptions

To use the automobile model, it is necessary to provide various data (such as the number of vehicles owned, number of sales, fuel consumption, and travel distance) for each type of vehicle and engine. However, although the number of vehicles owned can be obtained from the Central Bureau of Statistics (*Badan Pusat Statistik*), the other statistical data are difficult to obtain in Indonesia.

Therefore, it is necessary to estimate actual data such as fuel consumption and mileage based on a survey of the literature. Table 2.2 shows the estimated average fuel efficiency and travel mileage by vehicle type. In calibrating these averages, we considered fuel consumption (based on International Energy Agency data) in the road sector as a control total.

Table 2.2: Calibration of 2011 Levels

	Actual	Calibration		Estimation	Actual
	No. of Stock*1 (1000unit)	Average Fuel Efficiency (km/L-gsl)	Average Mileage (km/yr)	Fuel Consumption (ktoe)	Fuel Consumption*2 (ktoe)
PLDV	9,549	11.4	11,000	7,292	
Bus	2,254	5.8	20,000	6,175	
Truck	4,959	5.4	15,000	10,973	
Motorbike	68,839	30.0	4,500	8,200	
Total				32,640	32,682

km = kilometre, ktoe = kilotonne of oil equivalent, L-gsl = gasoline litre equivalent , No. = number, PLDV = passenger light-duty vehicle, yr = year.
Sources: Institute of Energy Economics, Japan analysis, Central Bureau of Statistics (Indonesia), and the International Energy Agency.

Assuming constant average mileage during the outlook period, it is expected that automobile fuel efficiency will gradually improve with technological improvement (Table 2.3). Annual improvement rates in efficiency are set based on historical trends (0.5%–0.9% for ICEVs, 0.6%–0.7% for HEVs, 0.4%–0.5% for PHEVs, and 0.2%–0.4% for EVs).

Table 2.3: Assumptions for Fuel Economy in 2017 and 2040 (km/L-gasoline eq.)

	ICV	HEV	PHEV	EV
PLDV	12.4	18.5	36.9	49.2
Bus	6.4	9.6	19.6	25.4
Truck	6.0	9.0	19.7	24.0
Motorbike	30.9	-	-	115.2

	ICV	HEV	PHEV	EV
PLDV	15.2	21.6	41.4	54.5
Bus	7.6	10.9	21.5	27.7
Truck	7.2	10.3	21.6	26.1
Motorbike	34.7	-	-	120.6

EV = electric vehicle, FCV = fuel-cell vehicle, GDP = gross domestic product, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, km = kilometre, L-gasoline eq. = gasoline litre equivalent, NGV = natural gas vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Sources: WWF, International Energy Agency, and Institute of Energy Economics, Japan analysis.

Automobile sales prices are an important element of the multinomial logit model. Prices are assumed to decline gradually (rising for ICEVs) along the learning curve (Table 2.4). Learning rates for the learning curve are set as 101% for the base components and 80% for batteries. For other components of specific powertrain types, the rates are set at 95% for HEVs, 85% for PHEVs, and 85% for EVs.

Table 2.4: Assumptions for List Price in 2017 and 2040

($/unit)

	ICV	HEV	PHEV	EV
PLDV	22,000	27,500	38,720	35,200
Bus	67,000	77,050	184,250	167,500
Truck	47,000	58,750	82,720	75,200
Motorbike	1,500	-	-	2,400

	ICV	HEV	PHEV	EV
PLDV	22,381	24,537	24,959	22,472
Bus	67,934	74,419	88,909	83,422
Truck	47,852	54,998	53,077	48,587
Motorbike	1,523	-	-	1,618

EV = electric vehicle, FCV = fuel-cell vehicle, GDP = gross domestic product, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, NGV = natural gas vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.

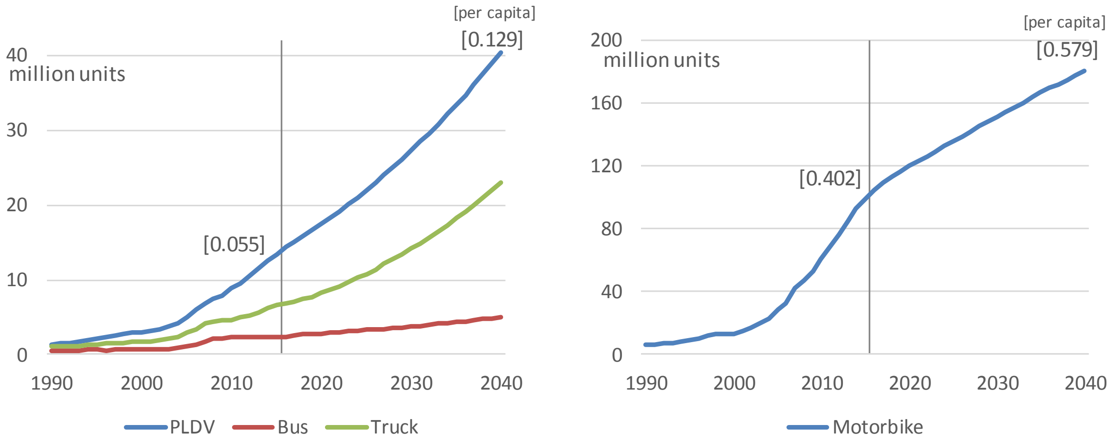
Sources: Mitsubishi Fuso, Toyota, Nissan, Hino, and Institute of Energy Economics, Japan analysis.

3. Reference Scenario

3.1. Automobile Penetration

Based on the above assumptions, the outlook for automobile vehicles is analysed in the reference scenario. In this study, it is assumed that historical trends will continue in the reference scenario without strengthening policy measures.

Figure 2.3: Outlook for Vehicle Stocks



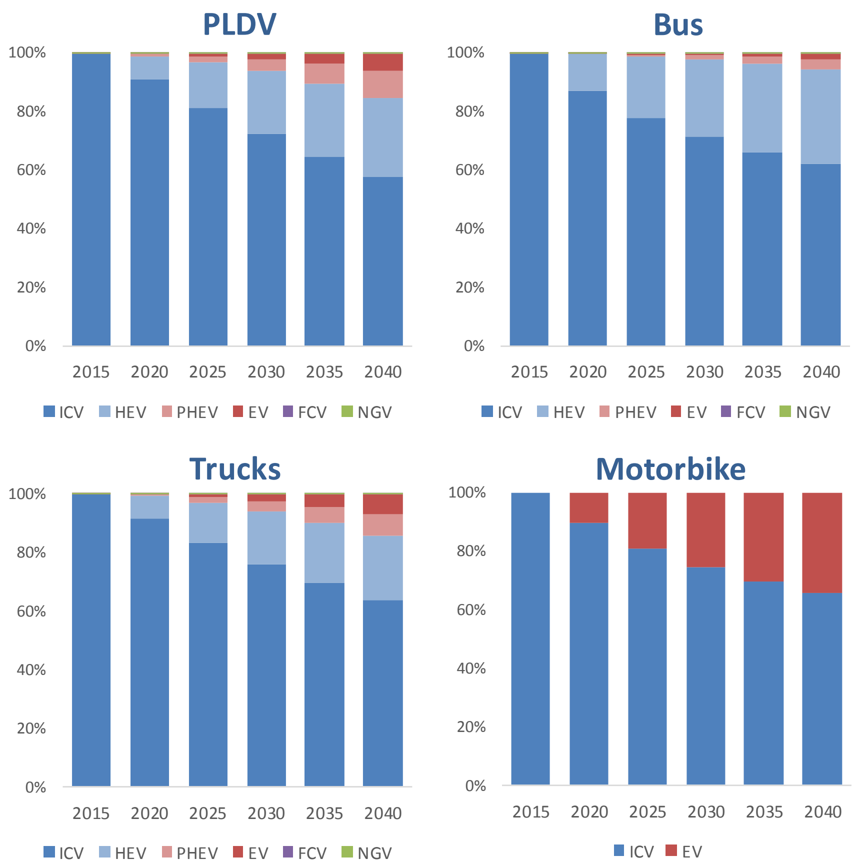
PLDV = passenger light-duty vehicle.

Sources: Central Bureau of Statistics (Indonesia) and Institute of Energy Economics, Japan analysis.

In the outlook, the number of PLDV stocks is projected to triple to more than 40 million units by 2040.[2] Per capita, this figure increases to 129 per 1,000 people (similar to the current global average). The number of freight trucks and vans increases faster than that of PLDVs (3.5 times), due to economic expansion. On the other hand, motorcycle stocks nearly double by 2040.

In terms of the mix by powertrain type, conventional ICEVs remain mainstream and the share of HEVs gradually increases in the reference scenario. The EV sales share is projected to account for only 6% of total car sales (PLDVs, buses, trucks, and motorcycle) by 2040. On the other hand, EV motorcycles will gain a more than 30% share in the motorcycle market due to the relatively small price gap between ICEVs and EVs.

Figure 2.4: Sales Share by Powertrain Type



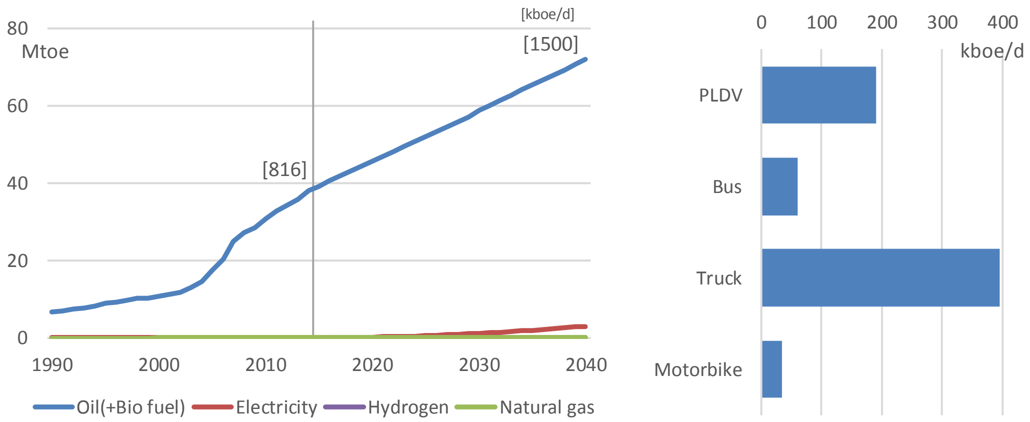
EV = electric vehicle, FCV = fuel-cell vehicle, GDP = gross domestic product, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, NGV = natural gas vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: Institute of Energy Economics, Japan analysis.

[2] This study does not consider the effects of car-sharing, a topic that makes it challenging to estimate the future situation.

3.2. Fuel Consumption in the Road Sector

The energy demand of the road sector is calculated by multiplying the number of vehicles owned, the average fuel efficiency, and the average mileage for each vehicle type and powertrain. Fuel consumption (almost oil consumption) in the road sector almost doubles from 816 kilograms of barrel of oil equivalent per day (kboe/d) to 1,500 kboe/d by 2040 in the reference scenario. Electricity demand also increases but still accounts for a tiny portion of the road sector. Of the growth in oil demand from 2015 to 2040, around 60% comes from freight trucks and around 30% from PLDVs. This is because freight trucks are relatively less efficient and travel longer distances than PLDVs.

Figure 2.5: Demand by Fuel and Oil Growth Type in the Road Sector



kboe/d = kilograms of barrel of oil equivalent per day, Mtoe = million tonnes of oil equivalent, PLDV = passenger light-duty vehicle.
Source: International Energy Agency and Institute of Energy Economics, Japan analysis.

4. Alternative Scenario

4.1. Scenario Assumptions for Electric Vehicle Penetration

In the reference scenario the penetration of EVs is minimal. To reflect the Government of Indonesia's target to increase the share of EVs, this study presents alternative scenarios of EV penetration. Specifically, we set the EV sales share at 35% in 2040 for a moderate EV scenario and at 100% for an advanced EV scenario (compared to 6% in the reference scenario) (Table 2.5 and Fig. 2.6).

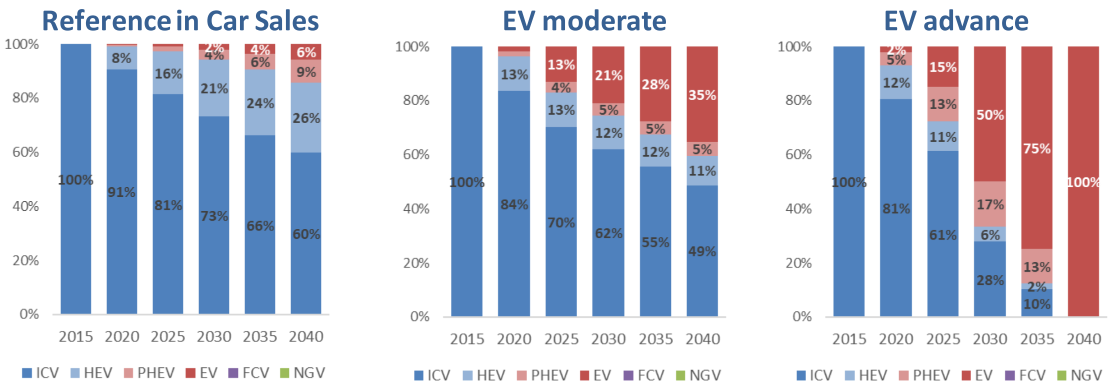
The assumed 35% share in the moderate EV scenario is based on the estimation provided by the Ministry of Energy and Mineral Resources. The 100% share in the advanced EV scenario is based on the assumption that ICEVs will be no longer sold by 2040. On the other hand, low-carbon emission vehicles are projected to account for 40% of sales in the reference scenario, which is close to the Ministry of Industry's target of 30% by 2035.

Table 2.5: Alternative Scenarios for Vehicle Sales Mix

	EV sales share in 2040		LCEV share In 2040	
	PLDV	Motorcycle		
1) Reference	6%	34%	40%	Close to the Ministry of Industry's roadmap
2) Moderate EV	35%	36%	51%	Close to the Ministry of Energy and Mineral Resources' scenario
3) Advanced EV	100%	100%	100%	Refer to the statement by the Ministry of Energy and Mineral Resources

LCEV = low-carbon emission vehicle, PLDV = passenger light-duty vehicle.
Source: Authors.

Figure 2.6: Sales Share by Powertrain for Each Scenario

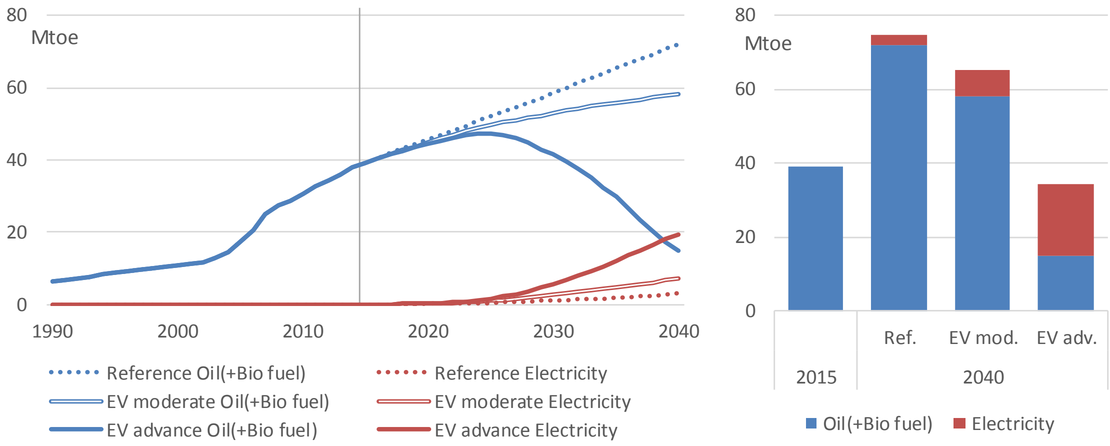


EV = electric vehicle, FCV = fuel-cell vehicle, GDP = gross domestic product, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, NGV = natural gas vehicle, PHEV = plug-in hybrid electric vehicle, PLDV = passenger light-duty vehicle.
Source: Institute of Energy Economics, Japan analysis.

4.2. Fuel Consumption in the Road Sector

In the moderate EV scenario, oil demand in the road sector still increases but is 20% lower in 2040 than the reference scenario projection. On the other hand, in the advanced EV scenario, oil demand peaks sometime around 2025 and declines rapidly to almost half of the current level. Electricity demand increases to the same level as the total electricity demand in 2017 (around 200 terawatt-hours [TWh]). Due to more efficient EVs, total fuel demand in 2040 will be lower than the current demand.

Figure 2.7: Fuel Demand in the Road Sector by Scenario

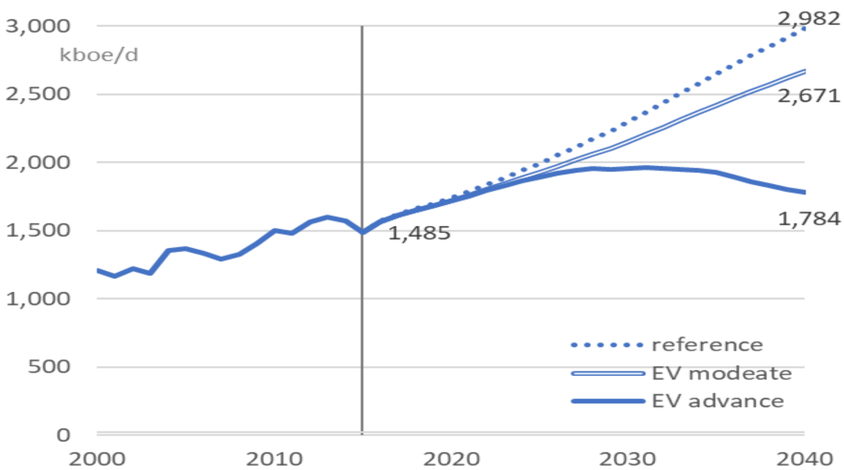


adv. = advanced, EV = electric vehicle, mod. = moderate, Mtoe = million tonnes of oil equivalent, Ref. = reference.
Source: International Energy Agency and Institute of Energy Economics, Japan analysis.

4.3. Primary Demand and Carbon Dioxide Emissions

In the reference scenario, the primary oil demand, including demand in other sectors (industry, commercial, and residential), more than doubles to around 3,000 kboe/d. In contrast, in the advanced EV scenario it would peak at around 1,800 kboe/d by 2030. However, this is still higher than the current level.

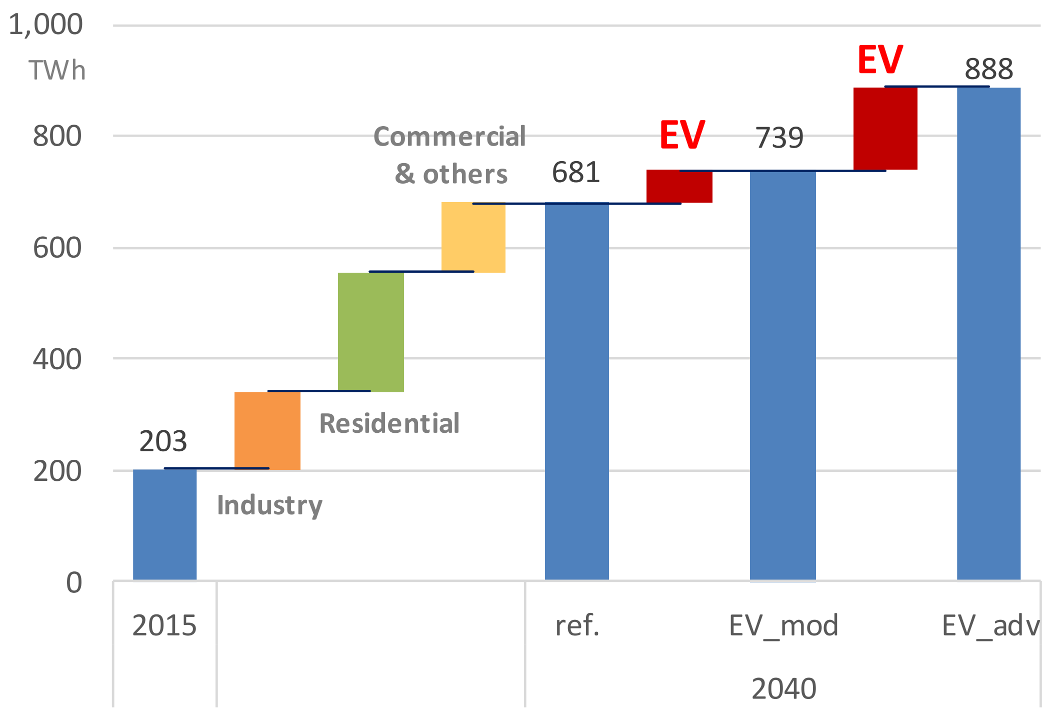
Figure 2.8: Primary Oil Demand by Scenario



EV = electric vehicle, kboe/d = kilograms of barrel of oil equivalent per day.
Sources: International Energy Agency and Institute of Energy Economics, Japan analysis.

Similarly, the electricity demand more than triples in the reference scenario from 200 TWh to 680 TWh led by the industry and the commercial sectors. The rapid penetration of EVs will increase the electricity demand further to around 900 TWh, quadruple the current level. Around 200 TWh of the additional electricity demanded by EVs requires additional power generation capacity, which is the same level as the existing capacity.

Figure 2.9: Electricity Demand by Sector and Scenario

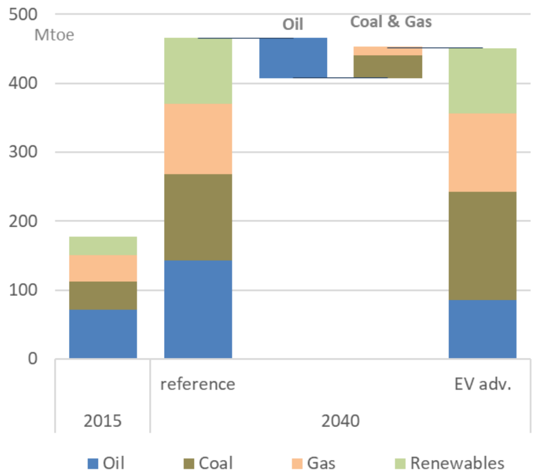


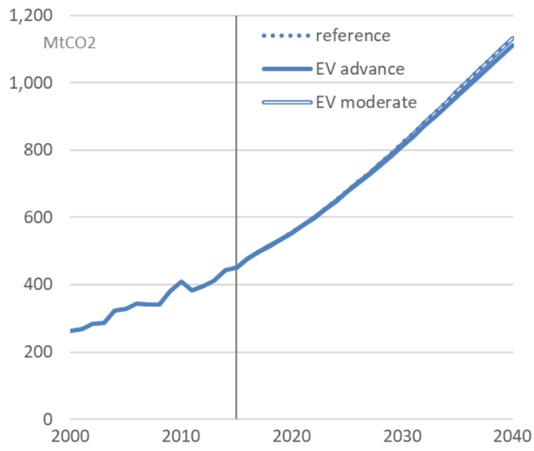
EV = electric vehicle, EV_adv = advanced EV scenario, EV_mod = moderate EV scenario.
Sources: International Energy Agency and Institute of Energy Economics, Japan analysis.

Led by fossil fuels, the total primary energy demand nearly triples in the reference scenario, meaning that CO_2 emissions also nearly triple by 2040 (Fig. 2.10).

In the advanced EV scenario, oil demand in the road sector decreases, but coal and gas in the power sector increase to meet the increased electricity demand resulting from the penetration of EVs. Coal-fired generation retains a dominant share of the power generation mix (around 60%). As a result, CO_2 emissions remain at almost the same level, only 2% lower than in the reference scenario.

Figure 2.10: Primary Energy Demand and Energy-Related Carbon Dioxide Emissions





$MtCO_2$ = metric tonnes of carbon dioxide, Mtoe = million tonnes of oil equivalent.
Note: Primary energy demand excludes traditional biomass use.
Sources: International Energy Agency and Institute of Energy Economics, Japan analysis.

5. Alternative Power Generation Mix

5.1. Scenario Assumptions for the Generation Mix

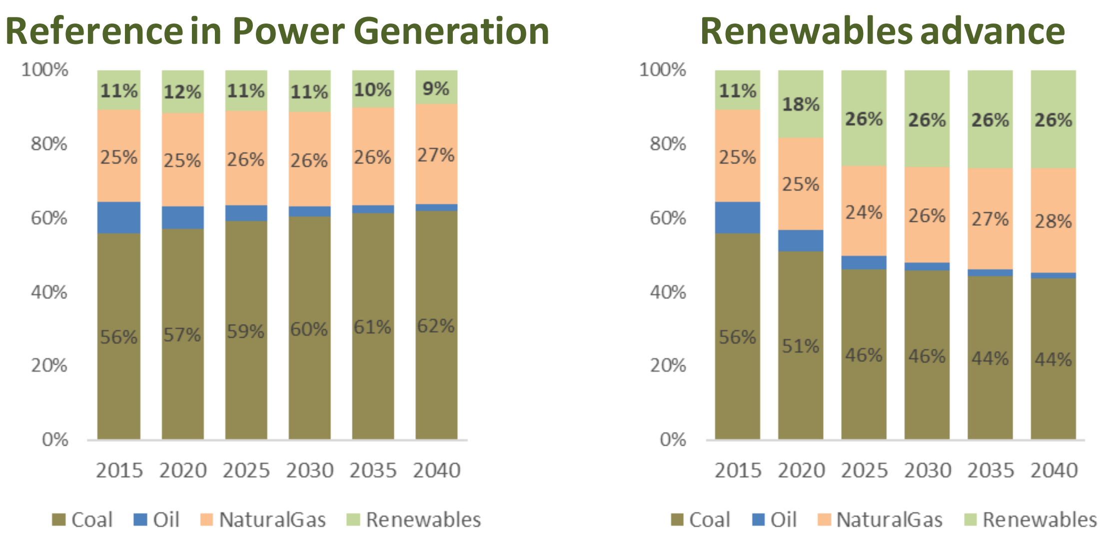
From the viewpoint of utilising EVs effectively to reduce CO_2 emissions, the power generation mix is very important. In the reference scenario, renewable power generation accounts for less than 10% of the total generation mix even in 2040; therefore, substantial penetration of EVs does not significantly impact the reduction of CO_2 emissions.

In the reference scenario, it is estimated that renewable energy (excluding traditional biomass use) will account for 9% of the power generation mix and 21% of the primary energy mix by 2040. However, the Government of Indonesia aims to increase the share of renewables to 23% of the primary energy mix by 2025. This corresponds to a 26% share in the power generation mix, according to the National Energy Council (*Dewan Energi Nasional*). In this study, we use this figure for the power generation mix in the advanced renewables scenario.

5.2 Carbon Dioxide Emissions

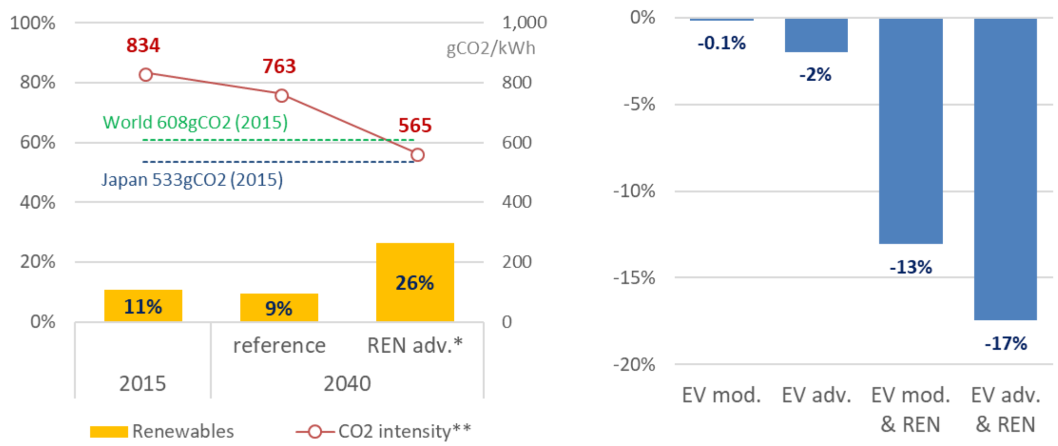
The power generation sector currently emits 834 grams (g) of CO_2 per electricity demand of 1 kilowatt-hour (kWh) (receiving-end basis), about 40% higher than the global average. In the reference scenario, CO_2 intensity decreases to 763 g in 2040 due to improvements in the efficiency of thermal power generation and transmission and distribution losses. On the other hand, in the advanced renewables scenario, the intensity drops further to 565 gCO_2/kWh, which is close to the current level in Japan (Fig. 2.12). Under this generation mix, CO_2 emissions could be reduced by 13% in the moderate EV scenario and 17% in the advanced EV scenario, compared with the reference scenario.

Figure 2.11: Power Generation Mix for Each Scenario



Sources: International Energy Agency and Institute of Energy Economics, Japan analysis. See also National Energy Council (*Dewan Energi Nasional*) (2016), *Outlook Energi Indonesia*. Jakarta.

Figure 2.12: Renewables Share and Carbon Dioxide Intensity in Power Generation in 2040 (left-side) and Carbon Dioxide Reduction from Reference in 2040 (right-side)



CO_2 = carbon dioxide, EV = electric vehicle, EV adv. = advanced EV scenario, EV mod. = moderate EV scenario, gCO_2 = grams of carbon dioxide, REN = renewables, REN adv. = advanced renewables scenario.

*Refer to Sekretariat Jenderal *Dewan Energi Nasional* (2016), 'Indonesia Energy Outlook 2016'. Jakarta.

**Receiving-end basis.

Sources: International Energy Agency and Institute of Energy Economics, Japan analysis.

6. Conclusion

According to this study, the advanced EV scenario would significantly impact oil and electricity demand. The primary oil demand would peak in 2030, compared to a continued increase in the reference scenario. On the other hand, rapid EV penetration will increase the electricity demand by around 200 TWh, matching the current level of total electricity demand in Indonesia. This means additional power generation capacity will be needed, by the same level as the existing one. In the moderate EV scenario, the impacts on electricity and oil demand will necessarily be smaller. The primary oil demand continues to increase but remains 10% lower than in the reference scenario in 2040. Additional power plants will need to provide about 30% of the existing capacity.

However, it is important to note that both scenarios produce the same results in terms of CO_2 emission reductions. This is because the decrease in emissions (from oil) in the road sector is offset by the increase in emissions (from coal and natural gas) in the power sector. Thus, EVs do not reduce CO_2 emissions significantly in the reference power generation mix, in which fossil thermal power generation accounts for around 90%.

In the advanced renewables scenario, assuming that the government meets its renewables target, the rapid penetration of EVs would lead to at most a 17% reduction in emissions from the reference scenario. To reduce CO_2 emissions, EVs need to be integrated with low-carbon electricity generation.

This study, which focused mainly on the effects on energy supply and demand, revealed that EV penetration leads to major impacts on oil and electricity demand; however, its influence on CO_2 emissions depends on the power generation mix. The results of this study might affect the planning of refineries and power generation facilities. When considering CO_2 reduction, it is also necessary to decarbonise the power generation mix, for example, through many more solar photovoltaic systems and more wind power generation. Thus, in addition to measures to promote low-carbon power generation sources (mainly renewables), incentives should be provided to promote renewable electricity sources.

Chapter 3

Benefits and Costs of Alternative Vehicles

1. Introduction

This chapter presents the results of the cost–benefit analysis of alternative vehicles in Indonesia. Understanding the benefits and costs of alternative vehicles is important to support both personal and society usage of these vehicles.

The upfront costs of alternative transport (including HEVs, PHEVs, and EVs) are currently greater than that of conventional ICEVs. These additional costs are generally related to expensive electric components such as batteries, electric motors, and power electronics, as well as engineering development work on system management.[3] Such electronic components require stable conditions for operation, and liquid cooling is used to control the thermal balances, adding to the system costs.[4]

Nevertheless, it is important to note that the cost of lithium-ion batteries, the main determinant of the additional cost of alternative vehicles, has been declining substantially in recent years, and is expected to decline even more in the future due to research and development efforts as well as economies of scale stemming from the introduction of giga-production factories. Combined with the declining cost of batteries, the greater energy efficiency of alternative vehicles has great potential to benefit consumers in Indonesia, particularly starting with vehicles that travel long distances.

In recognition of the changing global market environment surrounding alternative vehicles, this chapter analyses the potential reduction in the cost of alternative vehicles, and how this would benefit both Indonesia's drivers and society as a whole. For this purpose, a cost–benefit analysis is made to ascertain policy implications for Indonesia in relation to Indonesia's announced plan to ban ICEV sales by 2040.

2. Analysis Framework

2.1. Cost–Benefit Analysis

Understanding the benefits and costs of alternative transport for both personal use and society as a whole is important for policy-making purposes.

This analysis estimates the benefits from Indonesia's shift towards alternative vehicles, considering in particular the following aspects: (i) total benefits for Indonesian drivers, (ii) oil

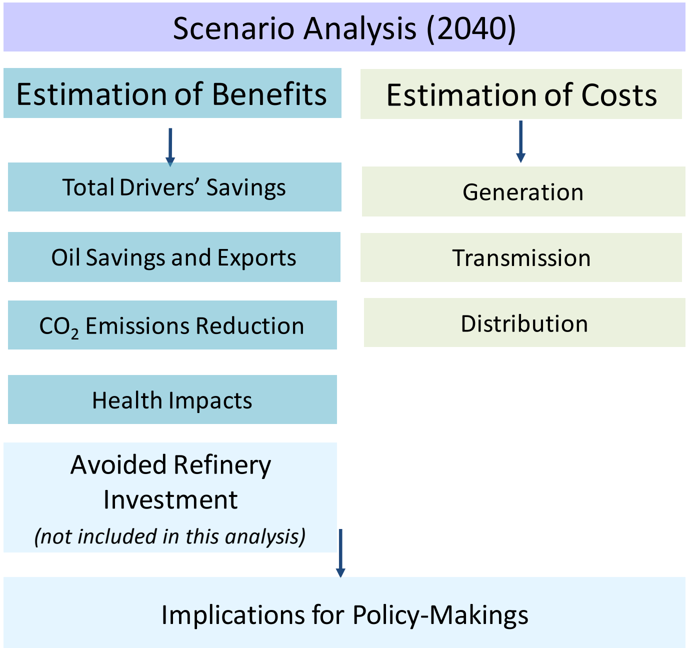
[3] Lajunen, A. (2013), 'Energy Consumption and Cost–Benefit Analysis of Hybrid and Electric City Buses', *Transportation Research Part C*, 38(2014), pp.1–15.

[4] Ibid.

savings benefits derived from increased export earnings, (iii) benefits of reduced CO_2 emissions, and (iv) health benefits from improved air quality.

This analysis excludes the benefits of avoiding investment in refinery systems. Meanwhile, the estimated costs are those of generation, transmission, and distribution.

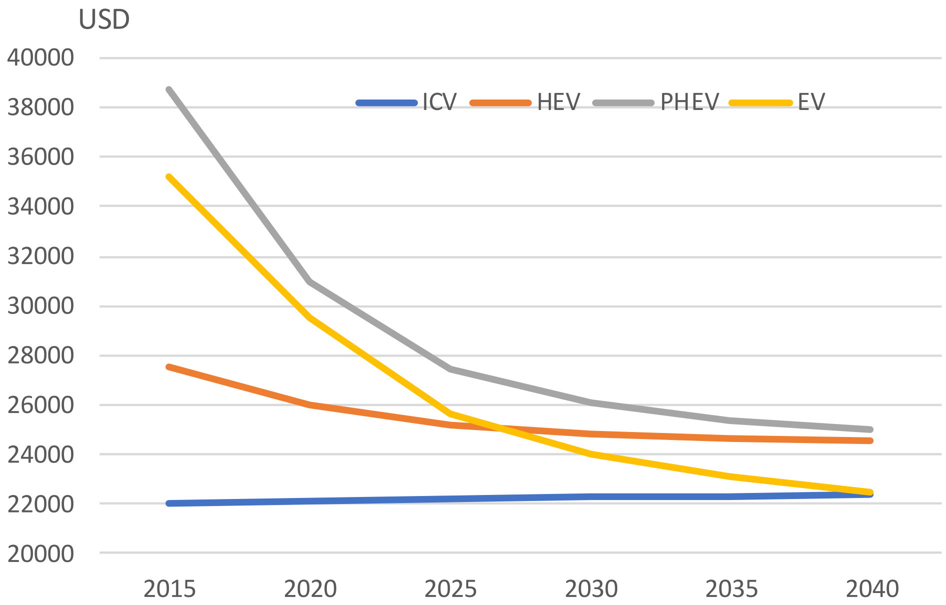
Figure 3.1: Analysis Framework



CO_2 = carbon dioxide.
Source: Authors.

Drivers' benefits are calculated by taking into consideration the annualised cost of vehicle ownership (by technology type), payments for energy (gasoline, diesel, or electricity), and maintenance. Vehicle costs are estimated through 2040 to analyse the different factors inherent in each type of technology (Fig. 3.2). The cost of ICEVs is assumed to increase slightly from the current level as the technological requirements for fuel economy improve. The cost of HEVs will decline as the cost of batteries decreases, and substantial cost reductions are expected with regard to PHEVs and EVs due to the estimated drop in the cost of lithium-ion batteries.

Figure 3.2: Vehicle Cost Assumptions ($)



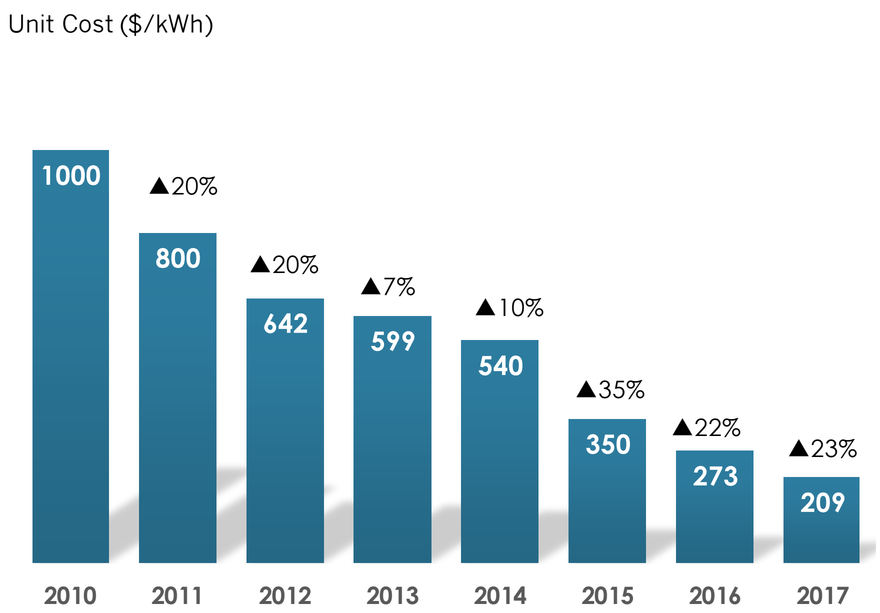
EV = electric vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

2.2 Estimation of the Cost of Lithium-Ion Batteries

The estimated cost of lithium-ion batteries is critically important for future cost estimations with regard to HEVs, PHEVs, and EVs. In fact, costs have been decreasing substantially over the past few years due to economies of scale, technological improvements, and the ongoing maturation of the manufacturing process (Fig. 3.3). The cost of lithium-ion battery modules decreased from $1,000 per kWh in 2010 to $209 per kWh in 2017, a 79% reduction in 7 years, or an average annual reduction of 20%.

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

Figure 3.3: Lithium-Ion Battery Module Cost Trends



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

The learning curve can be explained as follows.

$$Y = AX^b$$

Y = average cost of unit X

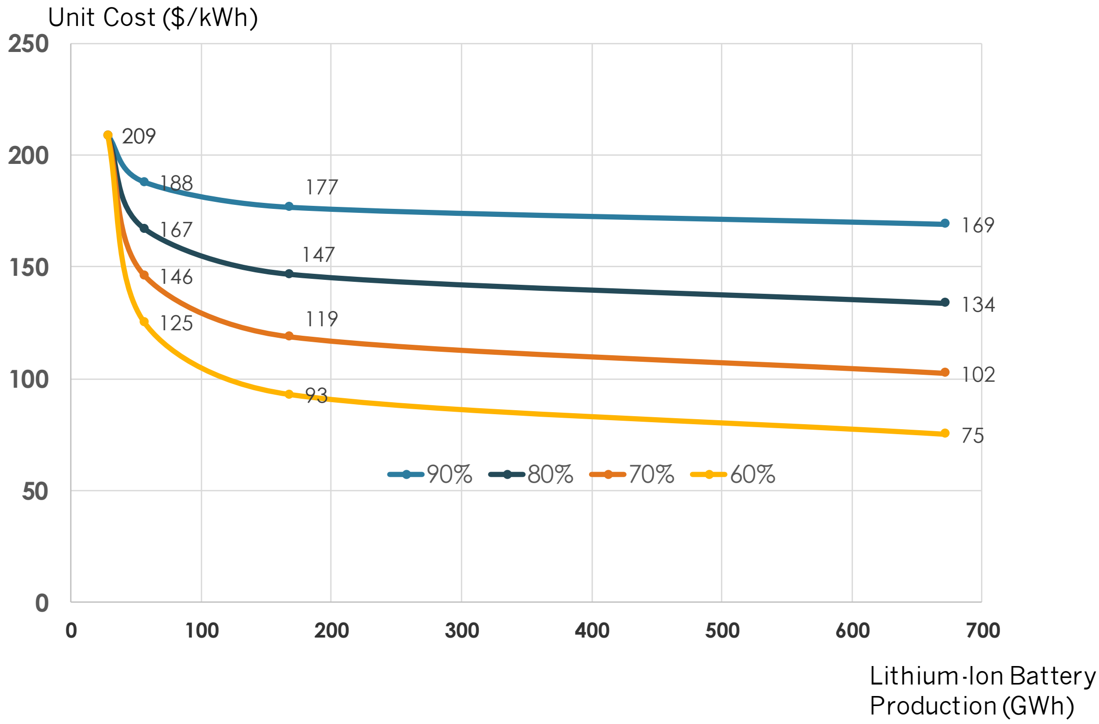
A = the first unit cost

X = unit number (cumulative volume)

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

Figure 3.4, which presents an example of lithium-ion battery cost estimates using the learning curve, shows that the estimated cost per kWh differs when production units double, at different learning rate assumptions of 60%, 70%, 80%, and 90%. For example, when lithium-ion battery module production doubles from the current 28 GWh to 56 GWh, the cost is estimated to decrease from $209/kWh to $167/kWh at a learning rate of 80%. When production doubles further to 168 GWh, the cost is estimated at $147/kWh at the same learning rate.

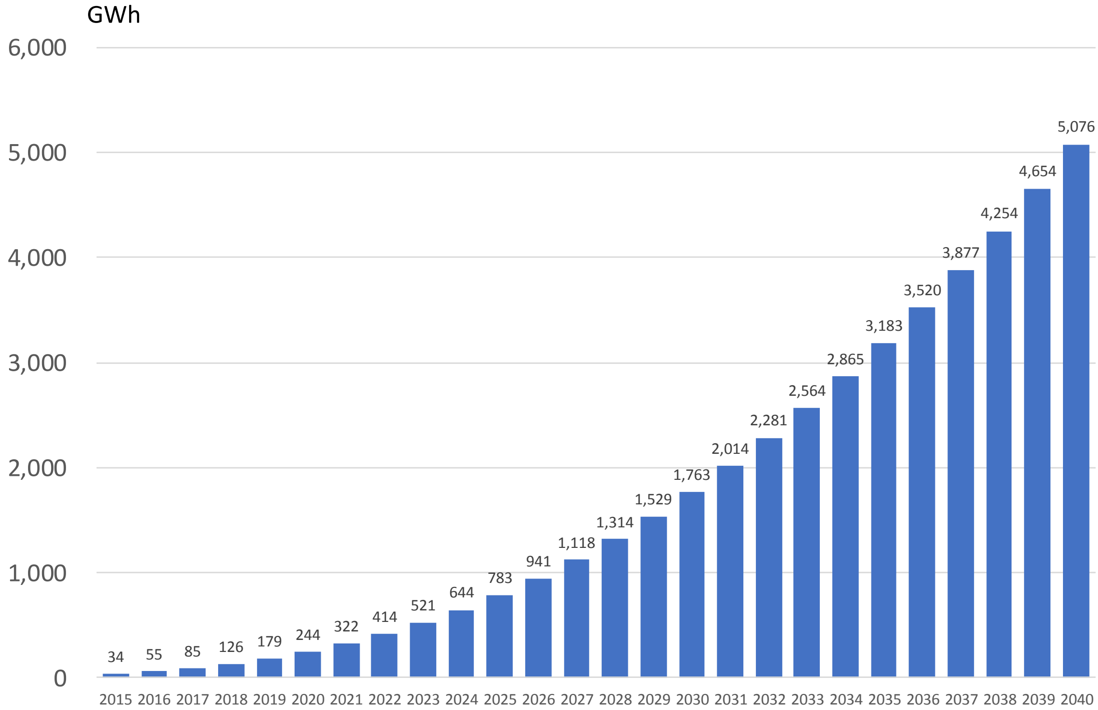
Figure 3.4: Example of Lithium-Ion Battery Cost Estimates Using the Learning Curve



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

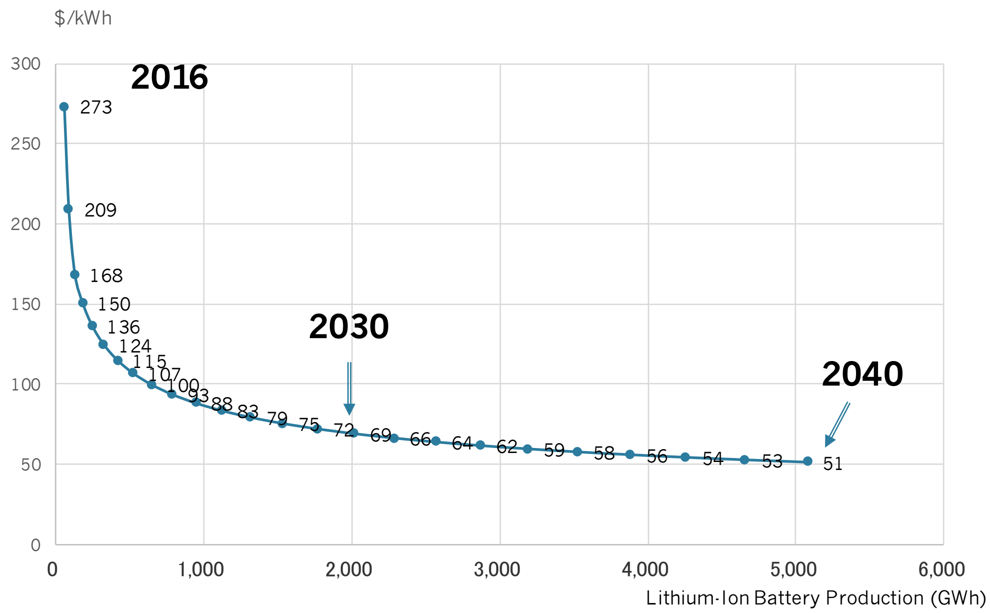
The cost estimate depends on the future production volume of lithium-ion battery modules. This analysis uses the outlook of the Institute of Energy Economics, Japan for lithium-ion battery modules (required to meet the future demand for HEVs, PHEVs, and EVs). The analysis assumes that EVs will account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

Figure 3.5: Global Outlook of the Institute of Energy Economics, Japan for Lithium-Ion Batteries for Hybrid Electric Vehicles, Plug-In Hybrid Electric Vehicles, and Electric Vehicles (Cumulative)



GWh = gigawatt-hours.
Source: Institute of Energy Economics, Japan (2017), *World/Asia Energy Outlook*.

Figure 3.6: Estimated Cost of Lithium-Ion Batteries (2016–2040)



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

Figure 3.6, which shows the estimated cost of lithium-ion battery modules through 2040, demonstrates the estimated relationship between the cumulative production of lithium-ion batteries by 2040 and corresponding module cost per kWh. As the figure shows, this cost is projected to decline to $72/kWh by 2030, and further to $51/kWh by 2040.

3. Passenger Vehicles

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

Table 3.1: Cost of Driving by Type of Technology

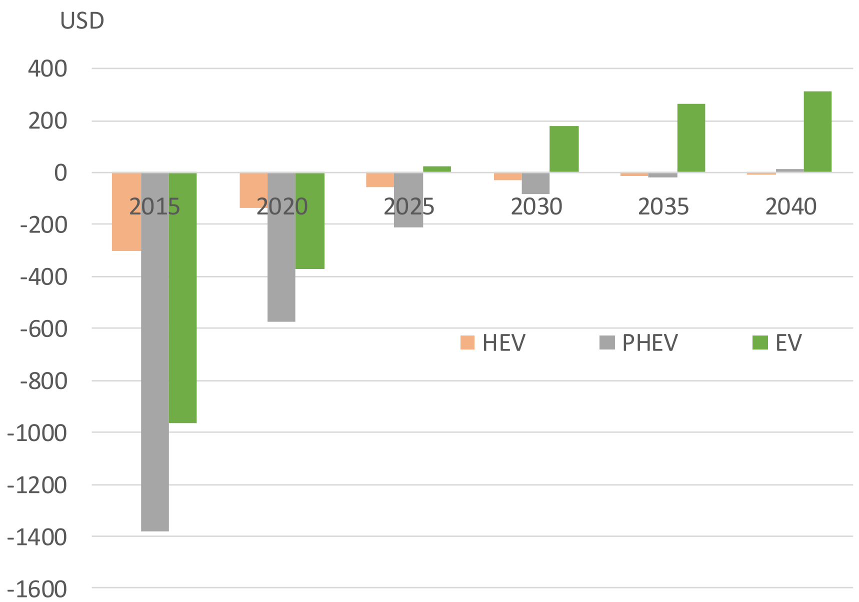
		2015	2020	2025	2030	2035	2040
ICV							
Initial Vehicle Purchase	$/10 years	22,000	22,066	22,165	22,248	22,319	22,381
Vehicle Purchase	$/year	2,200	2,207	2,217	2,225	2,232	2,238
Gasoline	$/year	634	611	586	561	537	514
Maintenance	$/year	110	110	111	111	112	112
Total Annual Cost	**$/year**	**2,944**	**2,928**	**2,913**	**2,897**	**2,881**	**2,864**
HEV							
Initial Vehicle Purchase	$/10 years	27,500	25,992	25,175	24,835	24,651	24,537
Vehicle Purchase	$/year	2,750	2,599	2,517	2,484	2,465	2,454
Gasoline	$/year	426	399	389	379	368	357
Maintenance	$/year	69	65	63	62	62	61
Total Annual Cost	**$/year**	**3,245**	**3,063**	**2,970**	**2,925**	**2,895**	**2,872**
PHEV							
Initial Vehicle Purchase	$/10 years	38,720	31,000	27,410	26,083	25,388	24,959
Vehicle Purchase	$/year	3,872	3,100	2,741	2,608	2,539	2,496
Gasoline+Electricity	$/year	287	270	264	259	254	248
Maintenance	$/year	97	78	69	65	63	62
Personal charger	$/year	70	56	49	47	46	45
Total Annual Cost	**$/year**	**4,325**	**3,503**	**3,123**	**2,980**	**2,902**	**2,851**
EV							
Initial Vehicle Purchase	$/10 years	35,200	29,502	25,639	23,974	23,054	22,472
Vehicle Purchase	$/year	3,520	2,950	2,564	2,397	2,305	2,247
Electricity	$/year	239	225	217	217	213	208
Maintenance	$/year	88	74	64	60	58	56
Personal charger	$/year	63	53	46	43	41	40
Total Annual Cost	**$/year**	**3,910**	**3,302**	**2,891**	**2,717**	**2,617**	**2,552**

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

Figure 3.3 shows the changing costs of using HEVs, PHEVs, and EV, calculated as the difference from the annual cost of using ICEVs. If the cost of using EVs is lower than that of using ICEVs, the resulting calculation shows a positive number in United States dollars.

As a result of the substantial reduction in the cost of EVs over the outlook period, drivers can expect to enjoy net benefits from EVs sometime after 2025. The reduced cost of purchasing EVs sometime after 2025 as well as the better fuel economy will lower the total usage cost of EVs below that of ICEVs (Fig. 3.7).

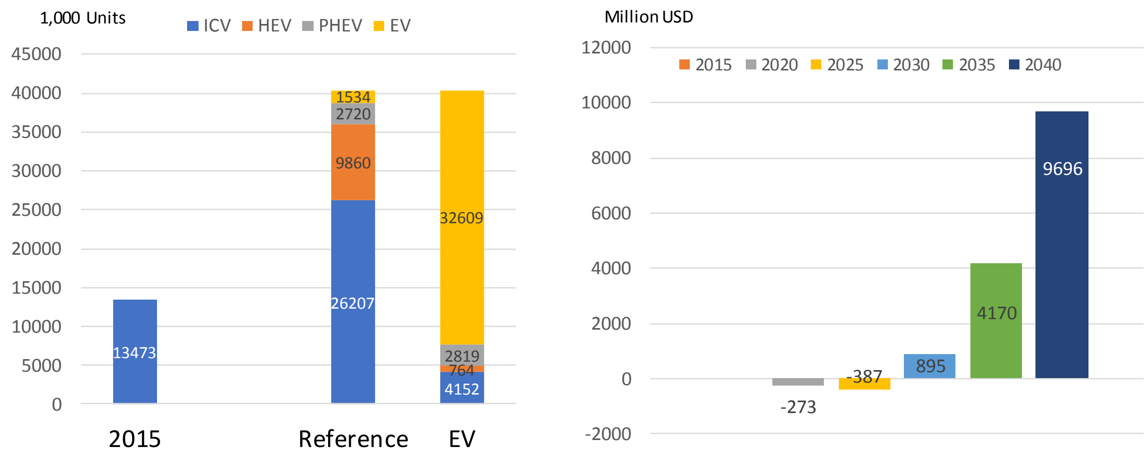
Figure 3.7: Tipping Point of Electric Vehicles (Passenger Vehicles)



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

Based on the analysis of individual driver benefits, the impacts of this shift on Indonesia as a whole is analysed. The left side of Figure 3.8 shows vehicle stocks by technology type. The calculation multiplies the estimated annual cost of usage by the number of vehicle stocks (by type of technology). As discussed in Chapter 2, stocks of EVs are projected to account for 81% of all passenger vehicle stocks by 2040. The impacts of shifting to alternative vehicles would yield net benefits of $9.96 billion by 2040, as shown on the right side of Figure 3.8.

Figure 3.8: Passenger Vehicle Stocks by Technology (left), and Driver Benefits in Indonesia (right)

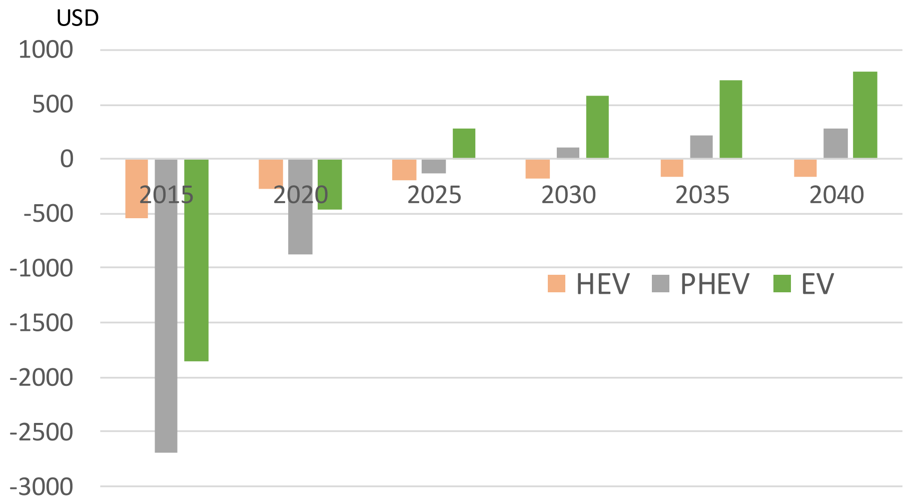


EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

4. Trucks

The net benefits to drivers of electric trucks are analysed using the same method used for passenger vehicles. As Figure 3.9 shows, drivers of electric trucks will enjoy these benefits from sometime after 2025, as a result of the substantial estimated reduction in the cost of lithium-ion batteries and a better fuel economy compared with that of ICEV trucks.

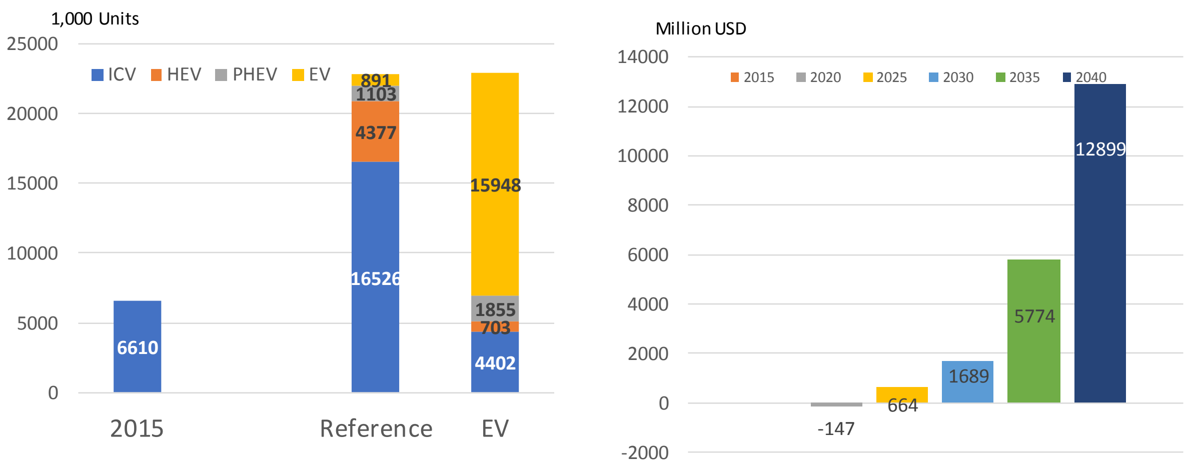
Figure 3.9: Tipping Point of Electric Vehicles (Trucks)



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

The impact of shifting to electric trucks would yield much larger benefits for Indonesia as a whole, compared with the shift to passenger EVs, mainly because trucks travel longer distances. As the right side of Figure 3.10 shows, Indonesia's truck drivers will enjoy net benefits of $12.9 billion by 2040.

Figure 3.10: Truck Stocks by Technology Type (left), and Drivers' Benefits in Indonesia (right)



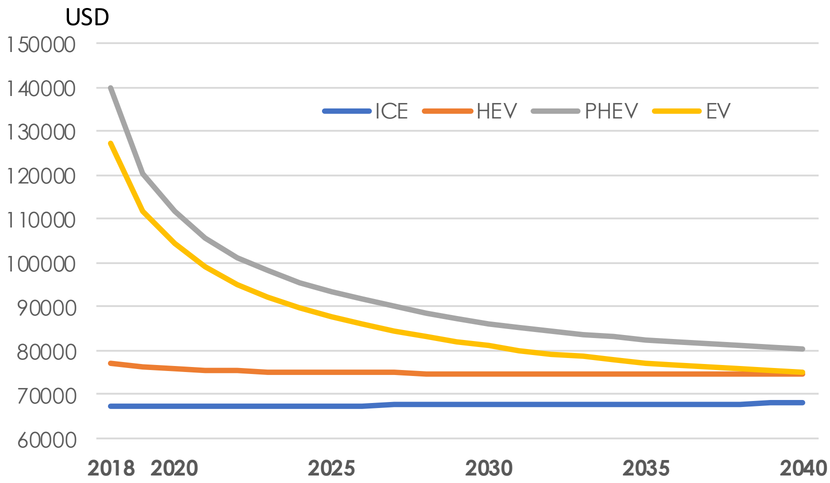
EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

5. Buses

It is difficult to estimate the costs of hybrid buses, plug-in hybrid electric buses, and pure electric buses because these have not yet been manufactured in large volumes, and because the development of this technology is not yet mature compared to conventional ICEVs. According to the literature, the cost of EV buses varies widely, ranging from 1.6[5] to 2.2[6] times that of conventional diesel buses.

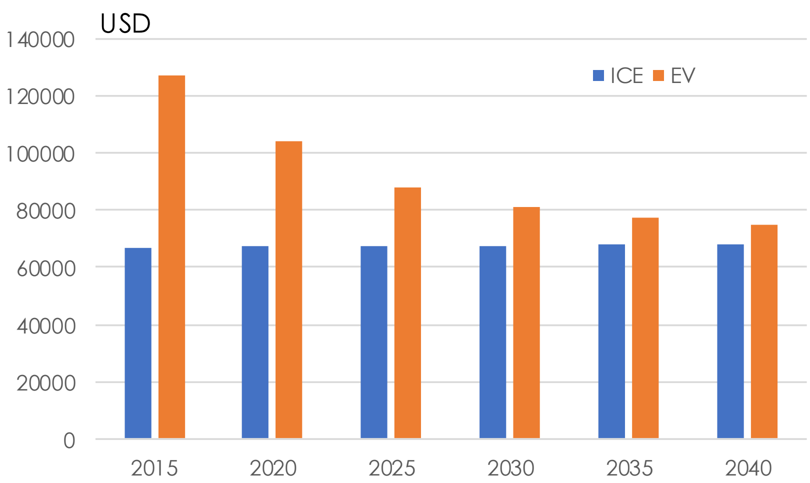
[5] Bloomberg New Energy Finance (2018). 'Electric Buses in Cities – Driving towards Cleaner Air and Lower CO_2', 29 March. London.
[6] Global Green Growth Institute (2016). 'Buses in India: Technology, Policy and Benefits'. Seoul.

Figure 3.11: Cost Assumptions



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

Figure 3.12: Cost Assumptions

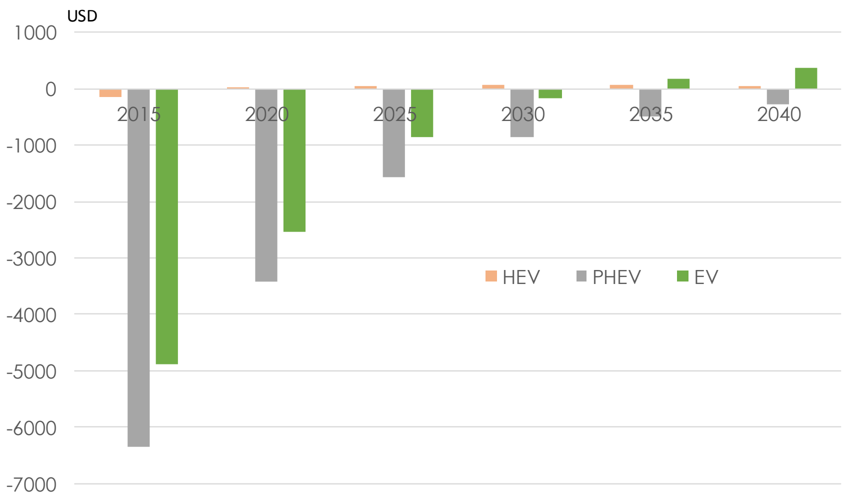


EV = electric vehicle, ICEV = internal combustion engine vehicle.
Source: Institute of Energy Economics, Japan (2018).

In this analysis, it is assumed that pure electric buses cost twice as much as ICEV buses (Figs. 3.7 and 3.8). It is important to note that bus size varies substantially in Indonesia, ranging from small mini-van types to large buses 12 metres in length, such as those deployed by Trans-Jakarta. The assumed cost in this analysis reflects an average of these various bus sizes.

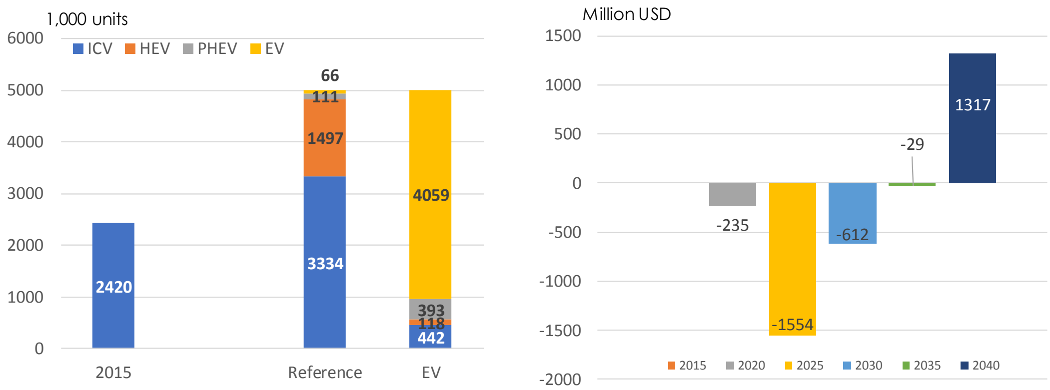
As the above figures show, the gap between the cost of ICEVs and that of pure electric buses will narrow in the future as the cost of lithium-ion batteries declines. By 2040, it is estimated that the cost of pure electric buses will have decreased from $127,300 in 2015 to $74,925, only 1.1 times the cost of ICEV buses. The benefits of making the bus system electric depend on distance travelled. This analysis assumes that each bus will travel 19,000 km per year, calibrated from the average fuel economy of buses and the number of bus stocks (analysed in Chapter 2).

Figure 3.13: Tipping Point of Electric Vehicles (Buses)



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

Figure 3.14: Bus Stocks by Type of Technology (left), and Drivers' Benefits in Indonesia (right)



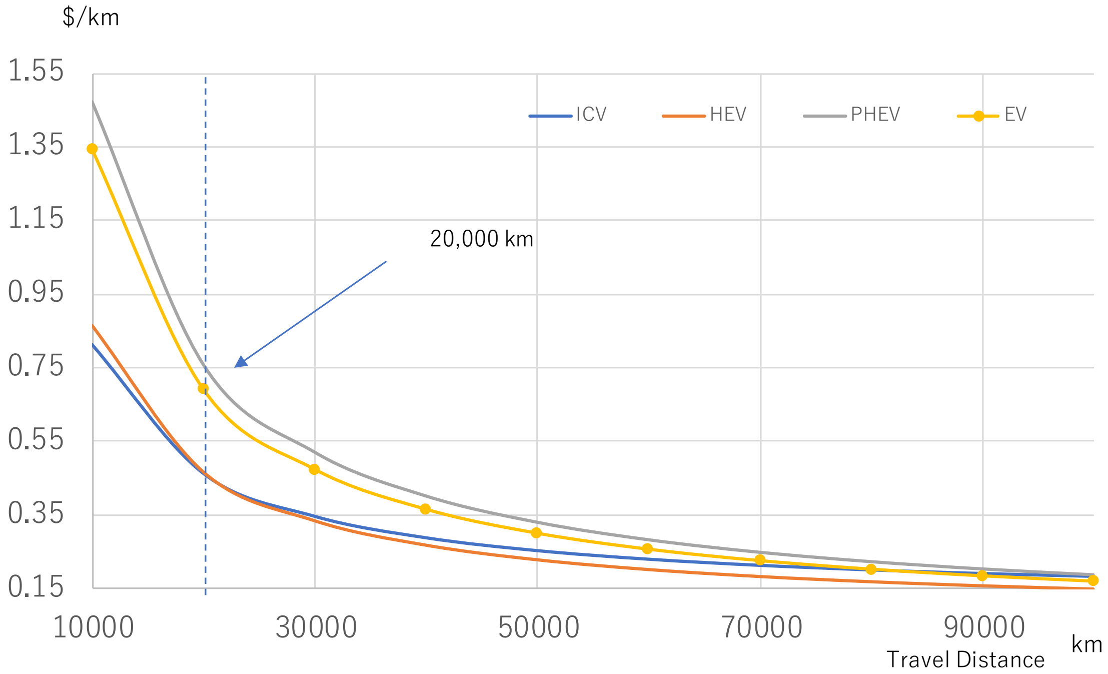
EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

As the cost gap between EV and ICEV buses narrows towards the end of outlook period, drivers will be able to enjoy the benefits from the shift towards pure electric buses, even assuming a relatively short annual travel distance of 19,000 km. This analysis places the estimated tipping point of pure electric buses sometime after 2035 (Fig. 3.13). Based on this assumption, societal benefits from the shift towards EV buses would amount to $1.3 billion by 2040 (Fig. 3.14).

5.1 Sensitivity Analysis

A sensitivity analysis was conducted to understand (i) the impact of travel distance on the total cost of operation (TCO), and (ii) the impact of both travel distance and unit cost reduction on TCO.

Figure 3.15: Travel Distance and Total Cost of Operation per Kilometre (Based on 2017 Upfront Cost Assumptions)

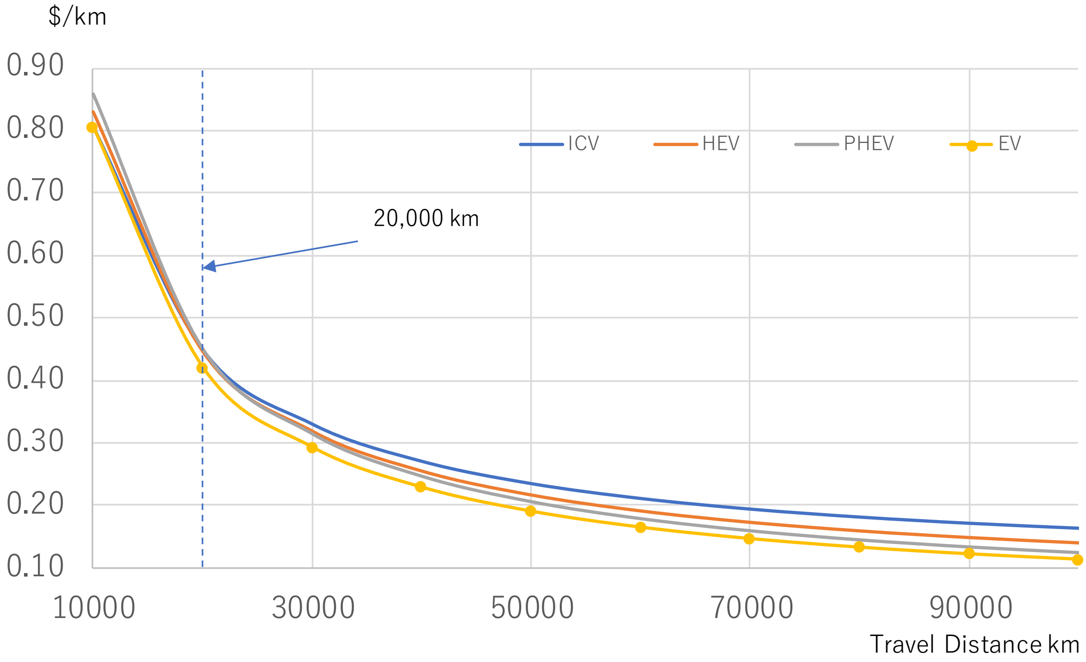


EV = electric vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, km = kilometre, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

Figure 3.15 compares travel distance and TCO/km for ICEV, HEV, PHEV, and pure electric buses. Based on the 2017 upfront cost assumptions, the figure clearly shows that the TCO/km of pure electric buses would be nearly 50% higher than that of ICEV buses at $0.69 per km, while EV buses would be cost-competitive at travel distances surpassing 90,000 km.

Figure 3.16 compares travel distance and TCO/km for ICEV, HEV, PHEV, and pure electric buses using the estimated 2040 upfront cost assumption, which is 41% lower than the 2017 level. The figure shows that the TCO/km of EV buses would be lower than that of ICEV buses after surpassing a travel distance of 10,000 km.

Figure 3.16: Travel Distance and Total Cost of Operation per Kilometre (Based on 2040 Upfront Cost Assumptions)



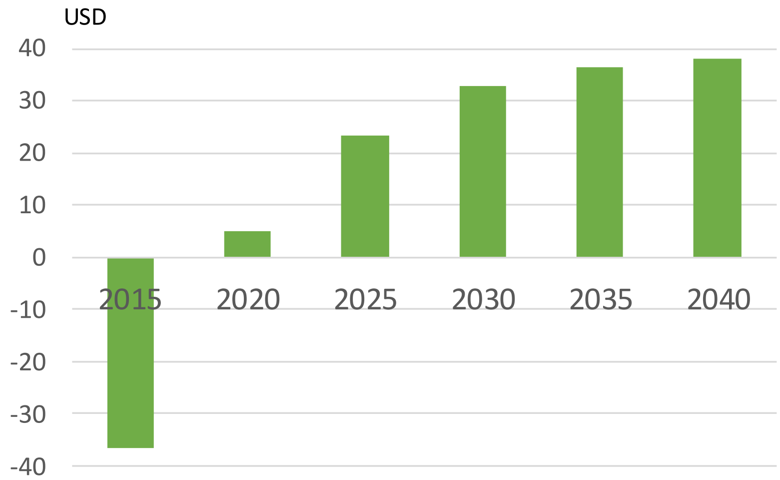
EV = electric vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, km = kilometre, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

These findings suggest that, given the current cost gap, EV buses would be used on routes with long travel distances to ensure the realisation of the potential benefits from oil savings, reduced CO_2 emissions, and improved air quality as well as the drivers' benefit of lowered TCO. Also, until the upfront cost declines, supporting measures (such as the provision of subsidies or battery leasing) should be instituted to realise the full benefits from the introduction of EV buses.

6. Motorcycles

The net benefits to drivers of electric motorcycles are analysed using the same method as that used for passenger vehicles. As Figure 3.17 shows, drivers will enjoy the benefits of electric motorcycles from sometime after 2020, much earlier than drivers of electric passenger vehicles and buses. Likewise, the substantial estimated reduction in the cost of lithium-ion batteries will benefit drivers of electric motorcycles sometime after 2020.

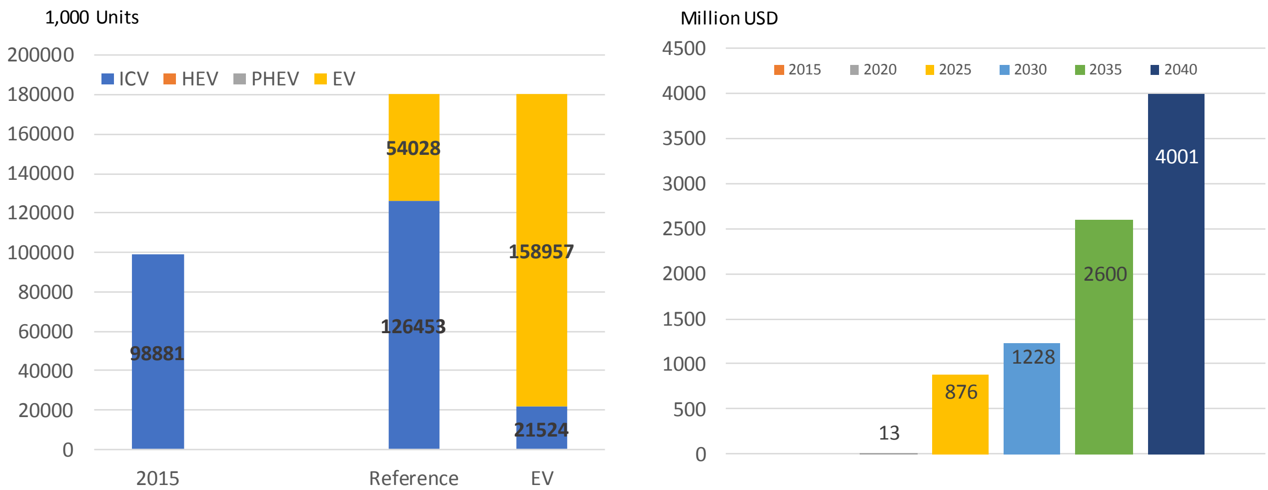
Figure 3.17: Tipping Point of Electric Vehicles (Motorcycles) ($)



Source: Institute of Energy Economics, Japan (2018).

Under the advanced EV scenario, the substantial introduction of EVs is estimated as resulting in 159 million electric motorcycles in 2040 (left side of Fig. 3.18). With this massive introduction of vehicles, drivers' benefits for shifting to electric motorcycles would amount to $4,001 million by this date.

Figure 3.18: Motorcycle Stocks by Type of Technology (left), and Drivers' Benefits in Indonesia (right)

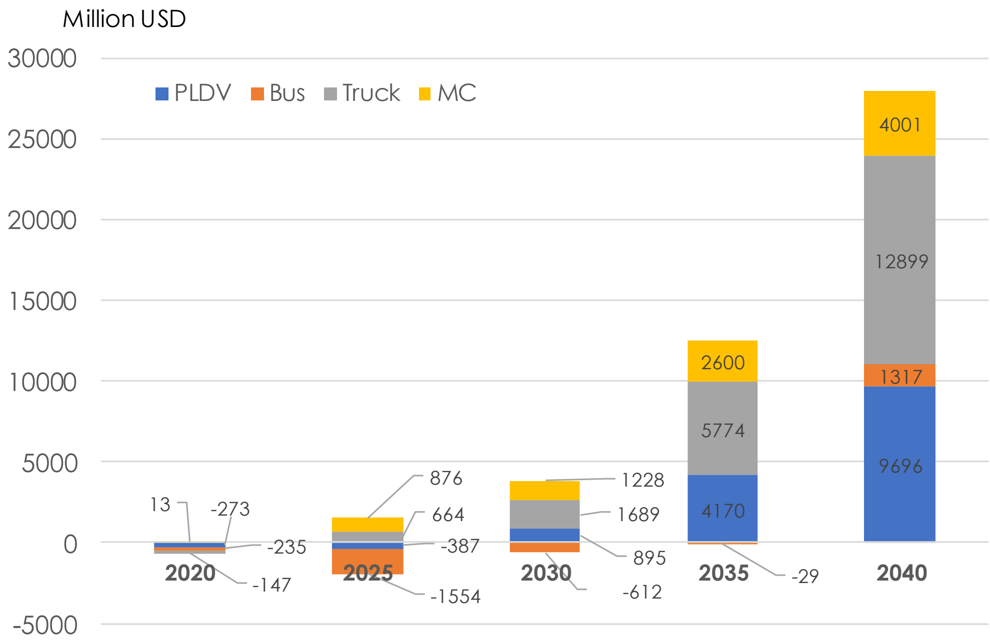


EV = electric vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, km = kilometre, PHEV = plug-in hybrid electric vehicle.
Source: Institute of Energy Economics, Japan (2018).

7. Summary of Drivers' Benefits

Figure 3.19 presents a summary of the net benefits to drivers from shifting the transport system in Indonesia to electric power. As the figure shows, truck drivers will enjoy the most net benefits ($12.9 billion by 2040) as they will incur the most oil savings due to relatively long travel distances (14,000 km per year). This group is followed by passenger vehicles at $6.7 billion, motorcycles at $4.0 billion, and buses at $1.3 billion.

Figure 3.19: Net Drivers' Benefits from Electrifying the Transport System (Passenger Vehicles, Trucks, and Motorcycles)



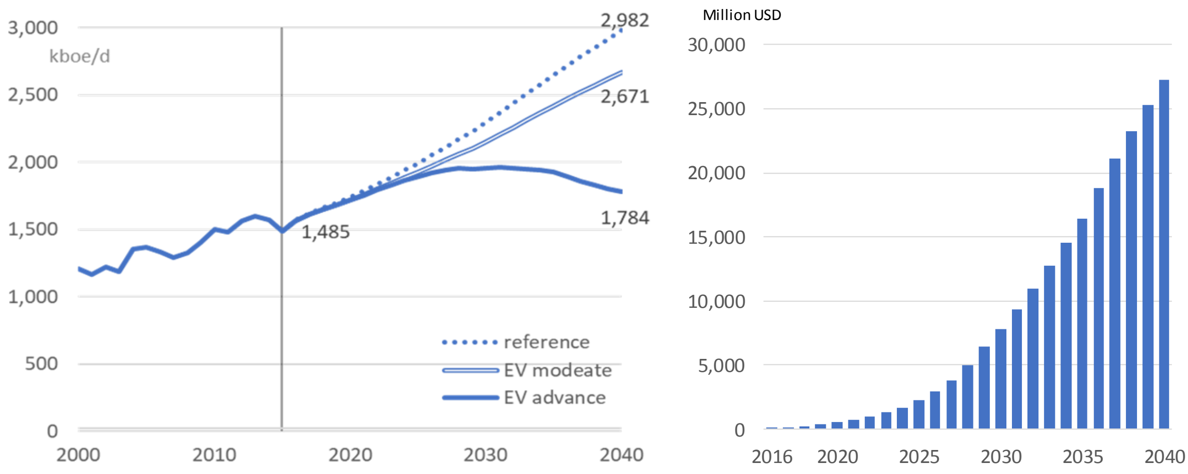
MC = motorcycles, PLDV = passenger light-duty vehicles.

8. Oil Savings Benefits

Under the advanced EV scenario, Indonesia's primary oil demand is expected to peak in 2031, and decline afterward at an average annual rate of 0.01% through 2040. Compared with the reference scenario, which assumed a demand of 2.98 million barrels per day (b/d) in 2040, the primary oil demand in the advanced EV scenario would be 40% lower at 1.78 million b/d. The oil savings would amount to 1.198 million b/d.

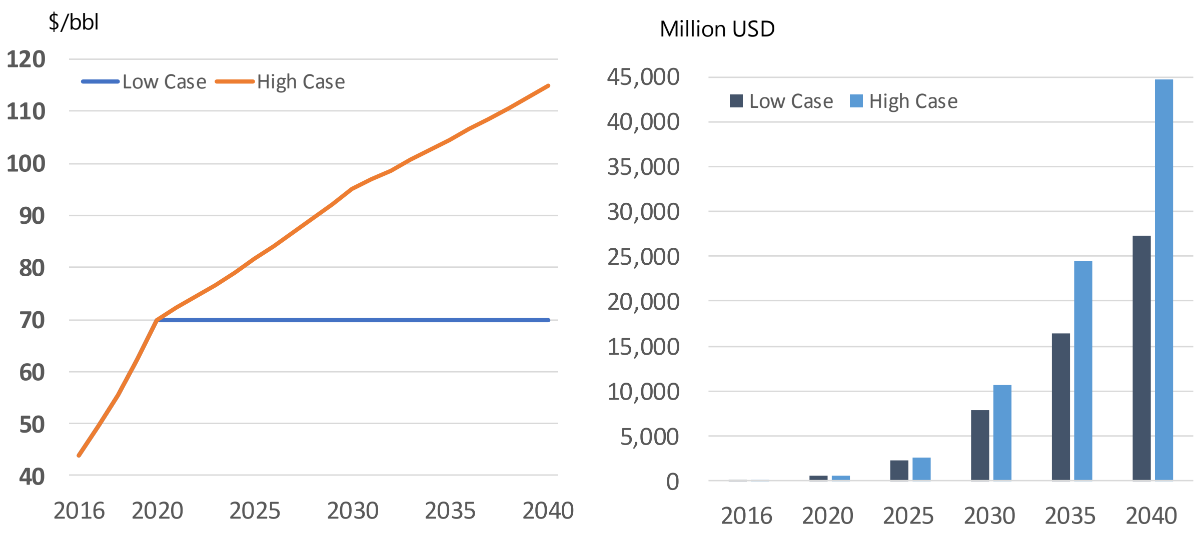
This analysis estimates the monetary benefits from primary oil demand savings at $27 billion by 2040, assuming that the saved oil would be exported to the global market at $70 per barrel (Fig. 3.21). A higher crude oil price assumption would of course lead to higher benefits from oil savings. For example, if the international oil price were to increase gradually to $115 per barrel, the benefits of oil savings from shifting to EVs would amount to $45 billion by in 2040 (Fig. 3.21).

Figure 3.20: Primary Oil Demand (left), and Oil Savings Benefits in Indonesia (right)



EV = electric vehicle, kboe/d = kilograms of barrel of oil equivalent.
Source: Institute of Energy Economics, Japan (2018).

Figure 3.21: Oil Price Assumptions (left), and Oil Savings Benefits in Indonesia (Low Case and High Case, right)



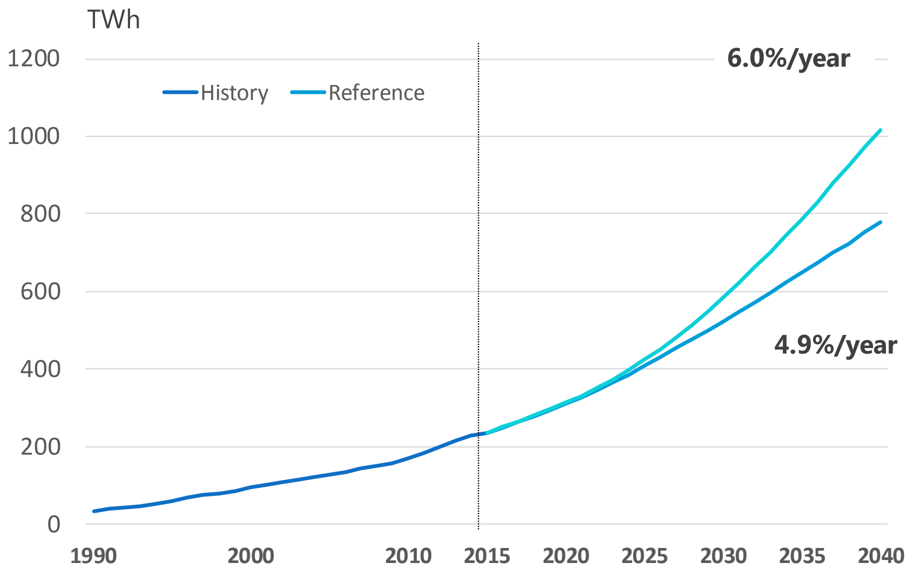
bbl = barrel.
Source: Institute of Energy Economics, Japan (2018).

9. Outlook of Electricity Generation

In addition to the economic benefits from shifting to EVs, it is important to consider the costs of meeting the increased electricity demand from EVs.

Figure 3.22 shows the projected electricity generation in both the reference and advanced EV scenarios.[7] Under the advanced EV scenario, electricity generation would increase by 6.0% per year, reaching 1,016 TWh by 2040. This figure is 30% higher than that in the reference scenario analysis. The gap between the EV and reference scenarios amounts to 238 TWh, almost equivalent to Indonesia's electricity generation requirements in 2015.

Figure 3.22: Oil Price Assumptions (left), and Oil Savings Benefits in Indonesia (Low Case and High Case, right)



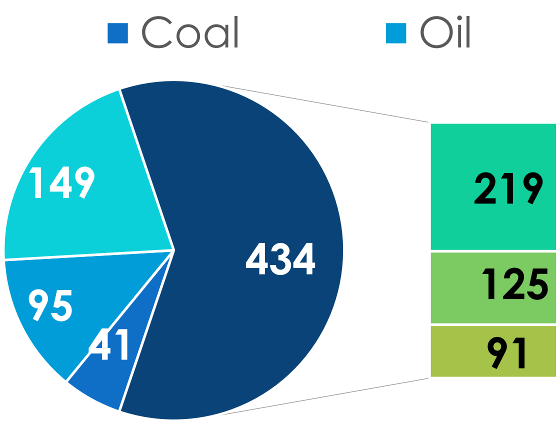
TWh = terawatt-hour.
Source: Institute of Energy Economics, Japan (2018).

To meet the energy demand as well as the necessary export and import of energy sources, Indonesia would require a cumulative investment of $719 billion, while the electricity sector represents the largest share (nearly 60%). Cumulative investment in the electricity sector alone would account for 14% of Indonesia's GDP in 2030. To meet the increased demand from EVs, investment in the electricity sector would need to increase by at least 30%.

[7] These generation requirements are estimated to meet the electricity demand for industry, transport, residential, and commercial, while covering losses during transmission and distribution.

Figure 3.23: Energy Sector Investment Requirements in Indonesia

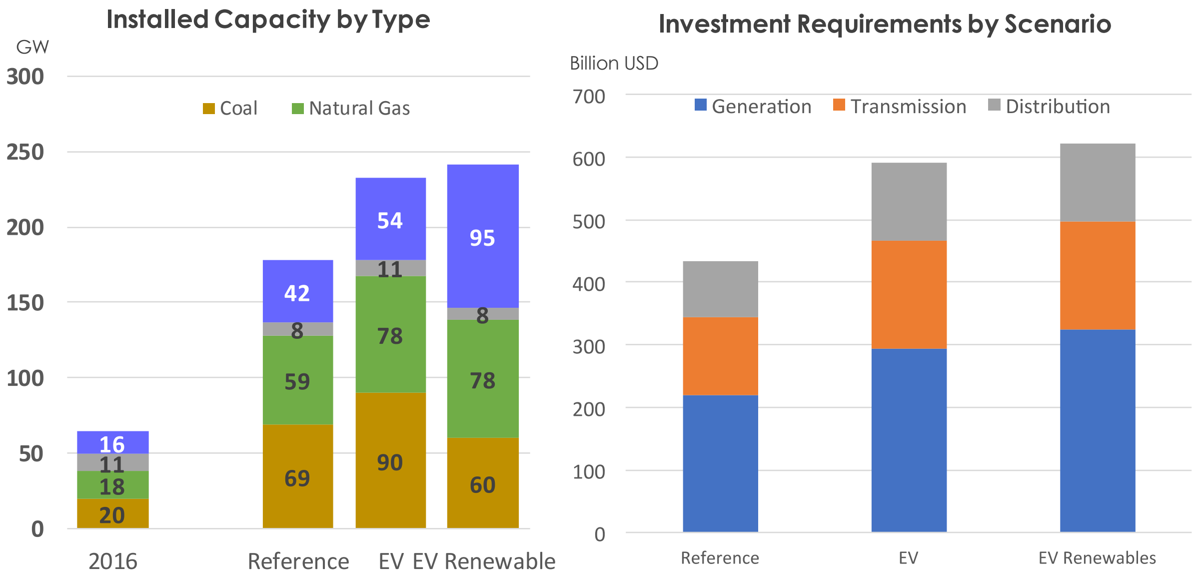
(reference case, $ billion)



Source: Institute of Energy Economics, Japan (2018).

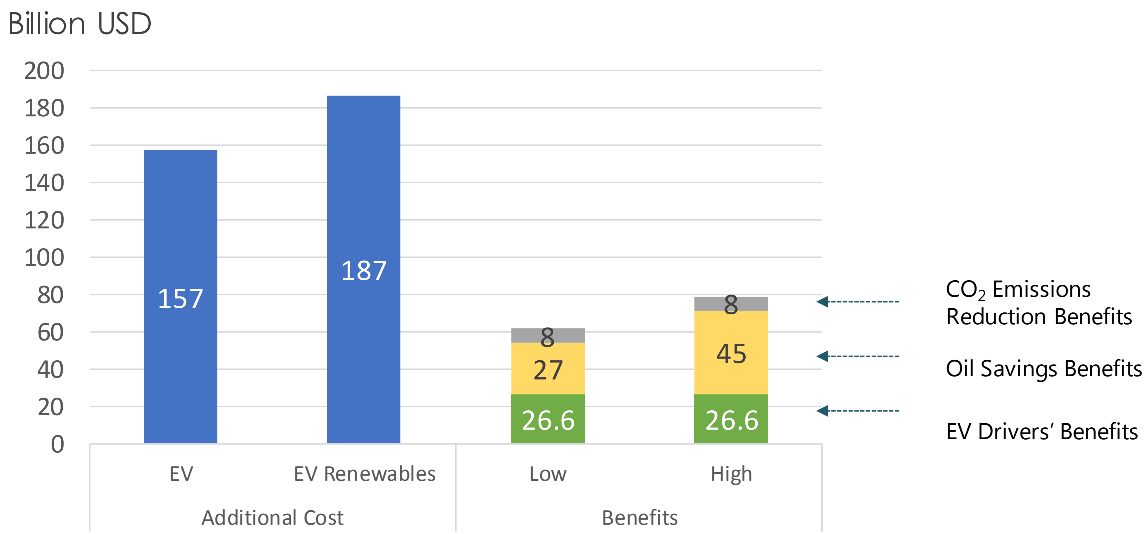
It is important to ensure integrated planning for the generation mix, as well as considering methods for the wider diffusion of EVs. The advanced EV scenario necessitates different investment requirements; by 2040 the electricity sector would require a cumulative investment of $591 billion under the conventional generation mix, and $621 billion with a higher share of renewables.

Figure 3.24: Electricity Investment Requirements in Indonesia (Scenario Comparison)



EV = electric vehicle, GW = gigawatt.
Source: Institute of Energy Economics, Japan (2018).

Figure 3.25: Electricity Investment Requirements in Indonesia (Scenario Comparison)



USD = United States dollars, CO_2 = carbon dioxide, EV = electric vehicle.
Source: Institute of Energy Economics, Japan (2018)

10. Conclusions

This chapter shows that introducing EVs would benefit Indonesian drivers by 2040. The substantial estimated reduction in the cost of lithium-ion batteries would ultimately lead to lower upfront costs in the future, and EVs' lower energy requirements per travel distance combined with lower maintenance cost requirements would benefit Indonesian drivers.

Meanwhile, it is important to note that the tipping point – when the estimated benefits from the shift to EVs would outweigh the lower cost of ICEVs – differs by mode. The tipping point is estimated to arrive much earlier for motorcycles (sometime after 2020) than for buses (sometime after 2035) due to the relative high upfront cost of EV buses compared with that of ICEV buses.

However, as the sensitivity analysis with regard to EV buses shows, the tipping point would differ depending on travel distance; this suggests that, given the current cost gap, EV buses would be used on routes with long travel distances to ensure that the potential benefits from oil savings, reduced CO_2 emissions, and improved air quality, as well as the drivers' benefit of lowered TCO are realised. In addition, until upfront costs are reduced, supporting measures (such as the provision of subsidies or battery leasing) should be instituted to realise the full benefits from the introduction of EV buses.

Substantial investment would be required to create the necessary electricity infrastructure. As the findings show, integrated planning would be necessary to consider both supply and demand and enable EVs to be used as an effective tool for reducing CO_2 emissions.

Chapter 4

Policies in Support of Electric Vehicles

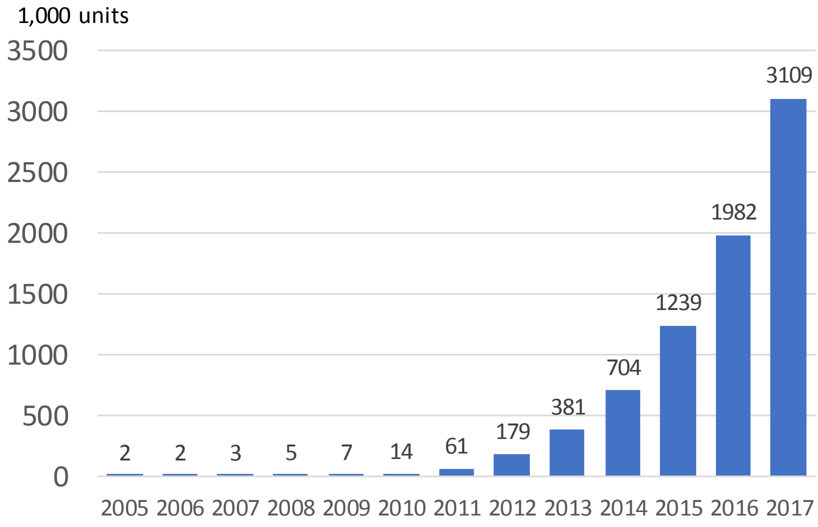
1. Introduction

In view of the potential benefits of expected oil savings and the development of new manufacturing bases, policies and measures should be introduced to encourage the use of EVs. To determine the implications for Indonesia, this chapter tries to capture the trends in Asian countries with a focus on targets, development plans, and economic incentives.

2. Global Trends

Globally, the number of EV stocks (including battery-powered electric vehicles (BEVs) and PHEVs reached 3.1 million in 2017, a 57% increase from 2016. However, this growth rate was relatively small compared with the 2016 growth rate, which hit 60% (Fig. 4.1). Much of the growth in 2017 came from China, which accounted for 51% of incremental growth between 2016 and 2017. The next biggest consumer by country was the United States, which accounted for 18% of the world's EV stock growth between 2016 and 2017.

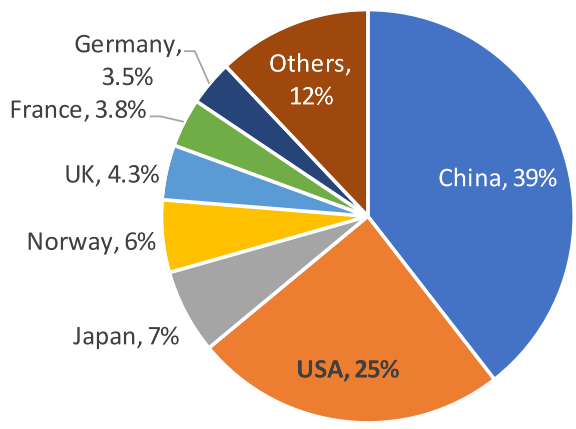
Figure 4.1: Trends in World Stocks of Electric Vehicles and Plug-In Electric Vehicles (2005–2017)



Source: Author's analysis from the International Energy Agency (2018), *Global EV Outlook*. Paris.

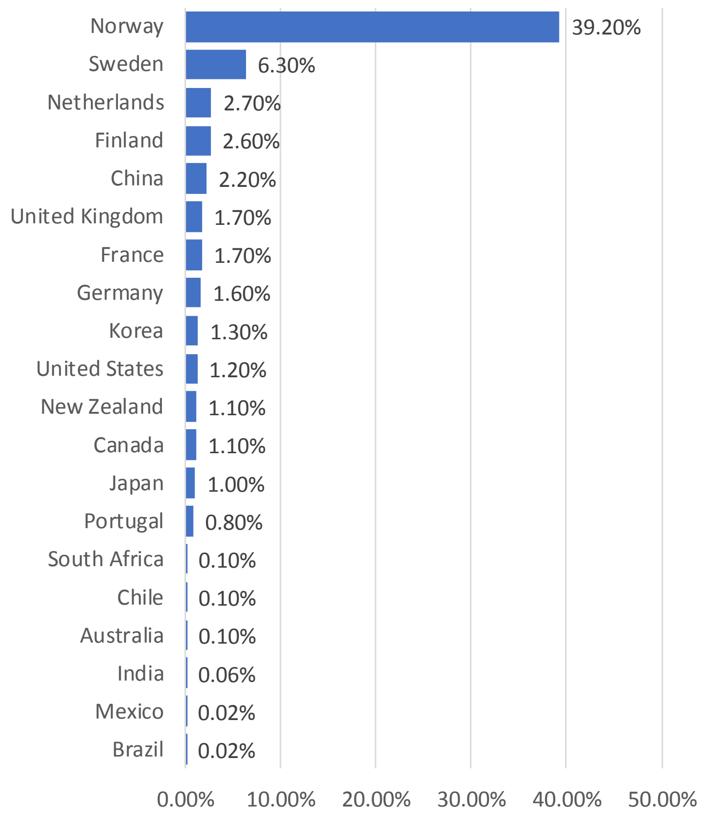
China accounted for the largest stock share in 2017 at 39%, followed by the United States at 25% and Japan at 7% (Fig. 4.2).

Figure 4.2: Trends in World Stocks of Electric Vehicles and Plug-In Electric Vehicles (2017)



UK = United Kingdom, USA = United States.
Source: Author's analysis from the International Energy Agency (2018), *Global EV Outlook*. Paris.

Figure 4.3: Electric Vehicle and Plug-In Hybrid Electric Vehicle Stock Share by Country



Korea = Republic of Korea.
Source: Author's analysis from the International Energy Agency (2018), *Global EV Outlook*. Paris.

Meanwhile, Norway holds the biggest share of total stocks of EVs (combining BEVs and PHEVs), reaching nearly 40% in 2017 (Fig. 4.3).

3. Targets

Globally, a number of countries formulate regulations or targets to increase the use of EVs and PHEVs. Drivers of different modes of transport are affected differently by the deployment of these targets. Table 4.1 shows the targets of countries in Asia and other regions.

Table 4.1: Electric Vehicle Targets in the Selected Countries

Country (Asia)	Targets
China	• Regulation requiring manufacturers to produce EVs, PHEVs, and FCVs accounting for 10% of their total sales in 2019, and 12% of total sales in 2020.
India	• The National Institute for Transforming India announced its directions for regulating the sale of EVs in the market by 2030 → The Government of India drops its direction (16 February) for EVs to account for 30% of sales by 2030.
Indonesia	• The Ministry of Energy and Mineral Resources announced that it will ban sales of ICEVs from 2040, and that it intends for EVs and HEVs to account for 25% of total vehicle sales by 2025.
Malaysia	• The National Electric Mobility Blueprint targets the following by 2020: 100,000 electric cars, 100,000 electric motorcycles, 2,000 electric buses, and 125,000 charging stations.
Thailand	• Ambitious plans to boost the number of electric cars from just under 68,000 to 1.2 million by 2036.
Philippines	• Development of a roadmap by the automobile industry association.
Singapore	• Electro-mobility roadmap study shows that 50% of vehicles in Singapore could be EVs by 2050.
Viet Nam	• Government targets 6 million eco-friendly vehicles in operation by 2020
Others	**Targets**
California	• Mandates the sale of zero-emission vehicles (excluding HEVs) to automobile manufacturers from 2018.
France	• The Minister of Environment announced that sales of gasoline and diesel-powered vehicles would be banned by 2040.
Germany	• The Bundesrat voted to ban sales of gasoline and diesel-powered vehicles by 2030.
Netherlands	• Draft law banning the sale of gasoline and diesel-powered engine vehicles from 2025 onwards submitted to the parliament.
Norway	• Zero-emissions vehicles will account for 100% of sales by 2025.
UK	• The Minister of Environment officially announced that sales of gasoline and diesel-powered vehicles will be banned from 2040.

EV = electric vehicle, FCV = fuel-cell vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, PHEV = plug-in hybrid electric vehicle, UK = United Kingdom.
Source: Authors.

4. Trends in Asia

In Asia, policies and programmes are being formulated to encourage the deployment of EVs (Table 4.2). Although the level of policy formulation differs by country, the following four issues can be extracted as general trends in the promotion of EVs in those countries.

1. EVs as industrial development

- India has set a target that EVs will account for 30% of vehicle sales by 2030. This ambitious target is placed to benefit both consumers and society as a whole through oil savings, climate change mitigation, and domestic industrial development. India has introduced a funding programme to boost hybrid and electric technologies. Known as the scheme for the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME), it provides subsidies for consumers, technology development, charging infrastructure, pilot projects, and IEC/Operations (see Section 4.5).
- Thailand plans to boost the introduction of alternative vehicles, with an initial focus on HEVs, and to expand the deployment of EVs through 2036. The Government of Thailand considers EVs key for industrial development, and is formulating incentives that target the manufacturing sector. To encourage investment in BEVs, a low excise tax (2%) was introduced in 2017, effective through 31 December 2025. The excise tax for HEVs and PHEVs is higher, with rates depending on cylinder size and CO_2 emissions. For example, the excise tax rate for HEV and PHEV passenger vehicles with higher CO_2 emissions and a larger cylinder size (compared with that of passenger vehicles) is set at 18%.
- Malaysia began focusing on energy-efficient vehicles (EEVs) in 2014 when the country formulated the National Automotive Policy (NAP). The objectives of this policy were to promote a competitive domestic automobile industry, make Malaysia the regional hub for EEVs, and promote value-added activities in a sustainable manner. Various incentives are provided in the form of grants (for research and development, and training) and infrastructure facilities.
- The Philippines, likewise, views the introduction of EVs as a means of developing the automobile industry. The country aims to introduce 1 million EVs by 2020, and to promote investment in the manufacturing industry. Incentives are provided to manufacturers or assemblers in the form of a 9-year exemption (from 2014) from paying excise taxes and duties, as well as the suspension of VAT for the purchase of parts related to manufacturing. Similar incentives are provided to importers and users.

2. EVs seen as a tool for reducing CO_2 emissions

- Singapore promotes the use of EVs in an attempt to reduce CO_2 emissions. According to the Energy Research Institute at Nanyang Technological University, increasing the use of EVs to account for half of all cars on the road by 2050 would reduce Singapore’s greenhouse gas emissions by 20% to 30% compared to a business as usual scenario. To help promote the wider use of EVs, Singapore provides a number of incentives for purchasing and using EVs (see Section 4.5).

- Viet Nam aspires to introduce HEVs and EVs in an effort to reduce CO_2 emissions. In its nationally appropriate mitigation actions Viet Nam specifies its target to introduce 6 million units of eco-friendly vehicles (including HEVs and EVs) by 2020. Progress toward achieving this target is currently slow. The only area of EV sales that has expanded is that of e-bikes (which have pedals and a slow speed of 25 km per hour). Sales reached 150,000 units in 2013, accounting for 14% of motorcycle sales.

Table 4.2: Summary of Policies and Incentives for Electric Vehicles in Asia

	India	Thailand	Malaysia
Policy	• National Electric Mobility Mission Plan issued in 2013. • 6 million–7 million electric and hybrid vehicles in India by 2020.	• Plans to boost the number of electric cars from just under 68,000 currently to 1.2 million by 2036. • HEVs are the initial focus for EV producers	• Strengthen the electric mobility eco-system and charging infrastructure nationwide • Accelerate the localisation of electric mobility technology to boost national economic growth.

Incentives	• FAME subsidy
	• Central government
	  • Excise duty
	  • Infrastructure cess
	• State government
	  • VAT
	• Delhi Pollution Control subsidy
		• Excise duty, effective through 31 December 2025
		  • Preferential rate for HEVs, PHEVs, and BEVs
			• Target
			  • Manufacturers, assemblers, and parts producers
			• Preferential treatment on
			  • excise duty
			  • import duty
			  • foreign direct investment

	Philippines	**Singapore**	**Viet Nam**

Policy	• Priority in the registration and issuance of plate numbers
	• Priority franchise application
	• Exemption from the Unified Vehicular Volume Reduction Programme
	• Free parking programme
		• Promotes the use of EVs to help meet emission reduction targets	• Government targets 6 million eco-friendly vehicles in operation by 2020
			  • Phase 1 (2013–2016): Application of hybrid vehicles
			  • Phase 2 (2013–2020): Application of EVs

Incentives	• Manufactures, assemblers, and importers
	  • Excise tax exemption
	• Users
	  • Motor Vehicle Users Charge
		• Vehicular emissions control system
		  • Rebates for HEVs and EVs
		• Road tax
		  • Lower charge for EVs
			• Not available

BEV = battery-powered electric vehicle, EV = electric vehicle, HEV = hybrid electric vehicle, PHEV = plug-in hybrid electric vehicle, VAT = value-added tax.
Source: Authors.

5. Case Studies

5.1. India

India aspires to promote EVs to support industrial development, improve the air quality, and reduce CO_2 emissions. EVs are seen as an effective tool to curb excessive dependence on oil imports.[8]

On 16 February 2018, the Government of India think tank, the National Institute for Transforming India, announced its target that EVs will account for 30% of all vehicle sales by 2030 (a change from its previous direction that EVs should account for 100% of vehicle sales by 2030).

India's market is currently dominated by e-rickshaws and two-wheeled vehicles. However, there is substantial potential for the share of EVs to increase due to rising personal incomes, the formulation of necessary policy frameworks, and the development of infrastructure.

In April 2015, the central government launched an incentive scheme known as the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME). The scheme's targets includes (i) technology platforms, (ii) demand incentives, (iii) charging infrastructure, (iv) pilot projects, and (v) electronical operations. As shown in Table 4.3, the FAME scheme has been implemented in two phases: fiscal year (FY) 2015–FY2016 and FY2016–FY2017. The scheme has been extended through September 2018.

Table 4.3: Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles Scheme Incentives

Component under FAME scheme	FY2015–FY2016 ₹ million ($ million)	FY 2016–FY2017 ₹ million ($ million)
Technology platforms	700 (10.5)	1,200 (18)
Demand incentives	1,550 (23.25)	3,400 (51)
Charging infrastructure	100 (1.5)	200 (3)
Pilot projects	200 (3)	500 (7.5)
Electronical operations	50 (0.75)	50 (0.75)
Total	2,600 (39)	5,350 (80.25)

Note: 'FY' before a calendar year denotes the year in which the fiscal year ends, e.g., FY2017 ends on 31 March 2017.

Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*. Washington, DC.

As shown in Table 4.4, demand side incentives under the FAME scheme cover five types of vehicles (two-wheeled vehicles, three-wheeled vehicles, passenger cars, light-commercial vehicles, and buses); and the level of incentives differs by type of technology, with higher incentives for BEVs.

[8] Young, E. (2018), 'Electrifying India – Building Blocks for a Sustainable EV Ecosystem'.

Table 4.4: Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles Scheme Demand Incentives

Vehicle segment	Mild hybrid ₹ ($)	Strong hybrid ₹ ($)	Plug-in hybrid ₹ ($)	Battery-operated electric ₹ ($)
Two-wheeled vehicles	1,800–6,200 (27–93)	-	13,000–18,000 (195–270)	7,500–29,000 (112.5–435)
Three-wheeled vehicles	3,300–7,800 (49.5–117)	-	25,000–46,000 (195–270)	11,000–61,000 (165–915)
Passenger cars	11,000–24,000 (165–360)	59,000–71,000 (885–1,065)	98,000–118,000 (1,470–1,770)	76,000–138,000 (1,140–2,070)
Light commercial vehicles	17,000–23,000 (255–345)	52,000–62,000 (780–930)	73,000–125,000 (1,095–1,875)	102,000–187,000 (1,530–2,805)
Buses	3,000,000–4,100,000 (45,000–61,500)	5,100,000–6,600,000 (76,500–99,000)		

Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*. Washington, DC.

In addition to the FAME scheme, the Government of India provides tax incentives in the form of a preferential rate for EVs and HEVs. The central excise duty, which is levied on all goods produced in India, is 12.5% for hybrid cars, close to half the rate for ICVs. The central excise duty for EVs (including passenger vehicles, buses, two-wheeled vehicles, and three-wheeled vehicles) would be even lower at 6% (Table 4.5).

Table 4.5: Central Government Excise Duty Rate

Vehicle category	Central excise duty
Length < 4m, gasoline/LPG/CNG, and engine capacity 1,200 cc	12.5%
Length < 4m, diesel, and engine capacity < 1,500 cc	12.5%
Length < 4m, gasoline/LPG/CNG, and engine capacity > 1,200 cc but <1,500 cc	24%
Length > 4m, and engine capacity < 1,500 cc	24%
Length > 4m, and engine capacity > 1,500 cc	27%
Length > 4m, engine capacity > 1,500 cc, and ground clearance > 170 mm (SUVs and MUVs)	30%
Buses	12.5%
Trucks	12.5%
Three-wheeled vehicles	12.5%
Two-wheeled vehicles	12.5%
Hybrid cars	12.5%
Electric cars, buses, two-wheeled vehicles, three-wheeled vehicles	6%

cc = cubic centimetres, CNG = compressed natural gas, LPG = liquified petroleum gas, m = metres, mm = millimetres, MUV = multi utility vehicle, SUV = sport utility vehicle.

Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*, Washington, DC.

Table 4.6: Central Infrastructure Cess on Motor Vehicles

Vehicle Category	Infrastructure Cess
Ambulances	0%
Taxis	0%
Battery-powered electric vehicles	0%
Hybrid motor vehicles	0%
Three-wheeled vehicles	0%
Cars for physically handicapped persons	0%
Hydrogen vehicles based on fuel-cell technology	0%
Petroleum, LPG, CNG vehicles, length < 4,000 mm, engine capacity < 1,200 cc	1%
Diesel vehicles, length < 4,000 mm, engine capacity < 1,500 cc	2.5%
All other categories	4%

cc = cubic centimetres, CNG = compressed natural gas, LPG = liquified petroleum gas, m = metres, mm = millimetres, MUV = multi utility vehicle, SUV = sport utility vehicle.
Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*. Washington, DC.

Infrastructure cess is a government tax on the production of vehicles and is used to finance infrastructure projects.[9] The cess levy rate on the production of vehicles is 1% for small ICEVs, 2.5% for diesel engine vehicles, and 4% for higher engine capacity vehicles.

In addition to the economic incentives provided by the central government, state governments also offer incentives for the purchase of EVs. For example, in Delhi, owners of EVs pay a lower value-added tax at the time of purchase. The value-added tax rate for ICVs is 12.5%, while that of EVs in Delhi is 5.0%.

Table 4.7: Subsidy for Battery-Powered Electric Vehicles from the Delhi Pollution Control Committee

Type of Vehicle	Vehicle Base Price	Subsidy Amount
Four-wheeled	< ₹500,000 (< $7,500)	₹30,000 ($450)
Four-wheeled	> ₹500,000 (> $7,500)	₹150,000 ($2,250)
Two-wheeled	< ₹20,000 (> $300)	₹1,000 ($15)
Two-wheeled	> ₹20,000 < ₹25,000 (> $300 < $375)	₹2,000 ($30)
Two-wheeled	> ₹25,000 (> $375)	₹5,500 ($82.5)
Three-wheeled (e-rickshaws)		₹15,000 ($225)

Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*. Washington, DC.

[9] Arthapedia, *Infrastructure Cess*. http://arthapedia.in/index.php?title=Infrastructure_Cess24.43%

In the National Capital Territory (NCT) of Delhi, the Air Ambience Fund, which was created in 2008, levies a fee on the sale of diesel at a rate of ₹0.25 per liter.[10] As Table 4.7 shows, in FY2014–FY2015 cumulative fund collections reached $57.85 million, 12.86% of which is used to subsidise BEVs. Delhi's air quality is marred by high levels of suspended particulate matter, sulfur dioxide, nitric oxide, and lead, and the fund is used to promote clean technologies. The fund has also been used for the treatment of hazardous waste and development of disposal facilities.

The fund collections increased substantially in 2014–2015 (120%) compared to 22% year-on-year in 2013–2014. The substantial increase in the fund collections indicate that diesel consumption for the transport sector has risen due to the decline in the international price of crude oil. As the share of the fund used to incentivise BEVs is relatively low (12.86%), the NCT of Delhi has room to increase its utilisation.

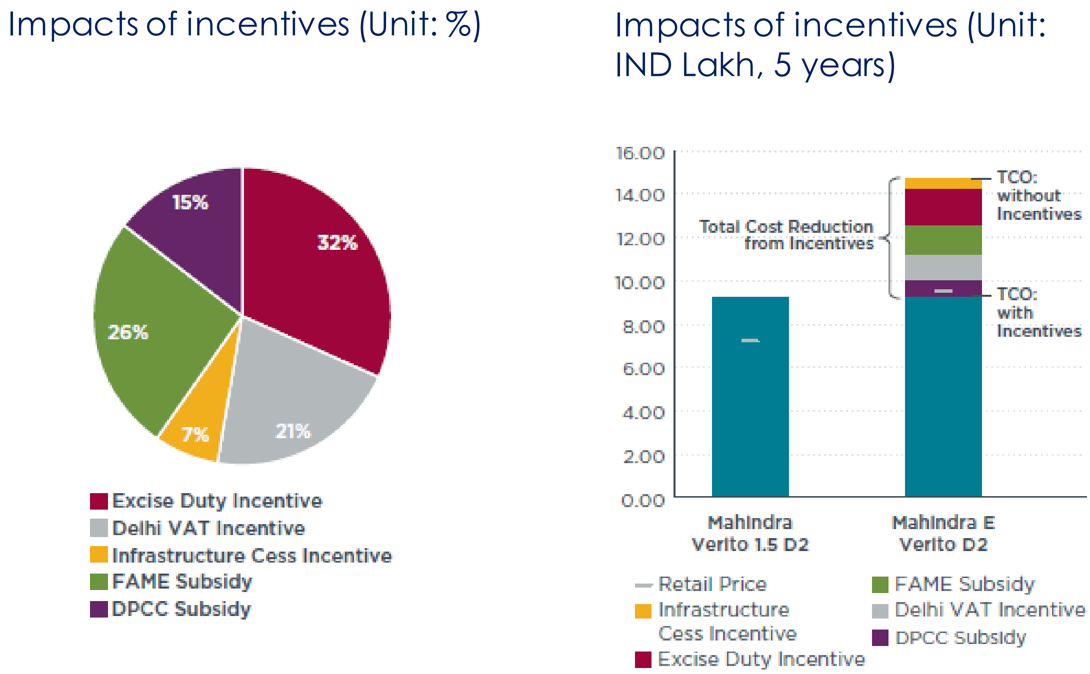
Table 4.8: Collections and the Utilisation of the Air Ambience Fund for Incentivising Electric Vehicles

Year (up to)	**Cumulative fund collections** ₹ million ($ million)	**Cumulative utilisation towards battery-powered electric vehicle subsidy** ₹ million ($ million)	**Utilisation on a cumulative basis** (%)
FY2008–FY2009	383.2 (5.75)	-	-
FY2009–FY2010	688.8 (10.33)	41.2 (0.62)	5.98
FY2010–FY2011	893.5 (13.4)	181.2 (2.72)	20.28
FY2011–FY2012	1,160.4 (17.41)	307.0 (4.61)	26.46
FY2012–FY2013	1,442.0 (21.63)	395.8 (5.94)	27.45
FY2013–FY2014	1,754.5 (26.32)	428.6 (6.43)	24.43
FY2014–FY2015	3,856.5 (57.85)	495.7(7.44)	12.86

Note: 'FY' before a calendar year denotes the year in which the fiscal year ends, e.g., FY2017 ends on 31 March 2017.
Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*. Washington, DC.

[10] Department of Environment, Government of NCT of Delhi. http://www.delhi.gov.in/wps/wcm/connect/environment/Environment/Home/Environmental+Issues/Ambient+Air+Quality

Figure 4.4: Impacts of Incentives on Electric Passenger Vehicle Price



DPCC = Delhi Pollution Control Committee, FAME = Scheme for the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME), TCO = total cost of operation, VAT = value-added tax.
Source: International Council on Clean Transportation (2016), *Hybrid and Electric Vehicles in India – Current Scenario and Market Incentives*. Washington, DC.

Figure 4.4 shows the analysis results of the TCO of EVs. The analysis was made to estimate the impacts of these incentives on the utilisation of vehicles for 5 years, assuming that the EVs are purchased and used in the NCT. These impacts are compared with those of the non-electric, non-hybrid model to understand the approximate magnitude of their impact on the TCO.

As shown in Figure 4.4, the TCO of EVs (exemplified by the Mahindra E Verito D2) would be 1% higher than that of the base model (Mahindra Verito 1.5 D2), and 51% higher without any incentives. Of the incentives' total impacts, the excise duty incentive is the most significant, accounting for 32%, followed by the FAME subsidy and Delhi VAT incentive.

5.2 Singapore

Singapore views EVs as an important means of controlling CO_2 emissions and reducing vehicle-related impacts on air quality. Oil savings resulting from the shift to EVs could help ease Singapore's energy security concerns as well.

A research body from Nanyang Technological University has projected that EVs could make up as much as 30%–50% of Singapore's vehicle stocks by 2050. The study found that increasing the use of EVs to half of all cars on the road by 2050 would reduce greenhouse gas emissions by 20%–30% compared to a business as usual scenario.

In view of these benefits, Singapore is implementing incentives to promote EVs, focusing on both purchase and use. Vehicle owners in Singapore are required to provide several items at the time of registration, making the cost of ownership higher than in neighbouring countries. The required items are (i) the registration fee, (ii) the additional registration fee, (iii) the Certificate of Entitlement (COE), and (iv) the excise duty. The registration fee of S$220 involves the costs of registering a vehicle. The additional registration fee is collected based on the unit price, known as the open market value (OMV). Of the total OMV, the first S$20,000 is charged at 100%, the next S$30,000 is charged at 140%, and more than S$50,000 is charged at 180%. The Government of Singapore uses the COE system to control the number of vehicles on the road to avoid congestion and handle road transport efficiently for both passenger and freight usage. The COE is the quota that entitles owners to use their purchased vehicles in Singapore for 10 years. To obtain the COE, vehicle owners must bid in categories corresponding to the size of their vehicle. The excise duty is collected at the time of purchase and calculated based on the vehicle's OMV.

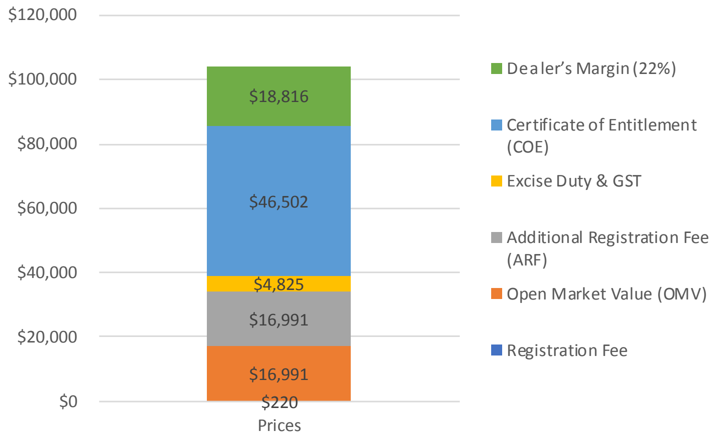
Table 4.9: Required Items with an Example of Vehicle Prices in Singapore

Items required at registration	Classification
Registration fee	S$220
Additional registration fee	First S$20,000 OMV: 100% Next S$30,000 OMV: 140% Above S$50,000 OMV: 180%
Certificate of Entitlement	Bid in Category A, B, or E
Excise duty	20% of OMV

cc = cubic centimetres, kW = kilowatt, OMV = open market value.
Note: Category A = small cars up to 1,600 cc and 97 kW, Category B = large cars exceeding 1,600 cc and 97 kW, Category C = buses and goods vehicles, Category D = motorcycles, and Category E = any kind of vehicle.
Source: Land and Transport Authority.
https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/costs-of-owning-a-vehicle/tax-structure-for-cars.html (accessed May 2018)

Figure 4.5: True Cost of Vehicle Price in Singapore

	Prices
Registration Fee	$220
Open Market Value (OMV)	$16,991
Additional Registration Fee (ARF)	$16,991
Excise Duty & GST	$4,825
Certificate of Entitlement (COE)	$46,502
Sub Total	$85,529
Dealer's Margin (22%)	$18,816
Final Price	**$104,345**



GST = goods and services tax.
Source: Estimated by the Institute of Energy Economics, Japan (2018).

For example, to purchase a S$16,991 Mitsubishi ASX in Singapore, the owners would have to pay a final price of S$104.345. As the above figure shows, COE accounts for the largest share (nearly half) of the total cost.

The Government of Singapore provides incentives for zero-emission vehicles (including EVs and HEVs) through the Vehicular Emissions Scheme (VES), which it implemented in January 2018. The VES accounts for emissions of four pollutants (hydrocarbons, carbon monoxide, nitrogen oxide, and CO_2) from 1 January 2018 to 30 June 2018; and five pollutants (hydrocarbons, carbon, nitrogen oxide, particulate matter, and CO_2) from 1 July 2018. Based on the worst performing emissions, the owners' rebate or surcharge will be determined. For example, vehicles whose emissions fall under A1 or A2 qualify for a rebate, while those under C1 or C2 incur a surcharge.

Table 4.10: Rebates and Surcharges for Vehicles Based on Emissions

Band	CO_2 (g/km)	HC (g/km)	CO (g/km)	NO_x (g/km)	PM* (mg/km)	Rebate**	Surcharge
A1	**A1**≤90	**A1**≤0.020	**A1**≤0.150	**A1**≤0.007	**A1**=0.0	S$20,000	
A2	90<**A2**≤125	0.020<**A2**≤0.036	0.150<**A2**≤0.190	0.007<**A2**≤0.013	0.0<**A2**≤0.3	S$10,000	
B	125<**B**≤160	0.036<**B**≤0.052	0.190<**B**≤0.270	0.013<**B**≤0.024	0.3<**B**≤0.5	S$0	S$0
C1	160<**C1**≤185	0.052<**C1**≤0.075	0.270<**C1**≤0.350	0.024<**C1**≤0.030	0.5<**C1**≤2.0		S$10,000
C2	**C2**>185	**C2**>0.075	**C2**>0.350	**C2**>0.030	**C2**>2.0		S$20,000

CO = carbon monoxide, CO_2 = carbon dioxide, g/km = grams per kilometre, HC = hydrocarbon, mg/km = milligrams per kilometre, NO_x = nitrogen oxide, PM = particulate matter.
Source: Land and Transport Authority.
https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/costs-of-owning-a-vehicle/tax-structure-for-cars.html

Table 4.11: Road Tax on Electric Vehicles

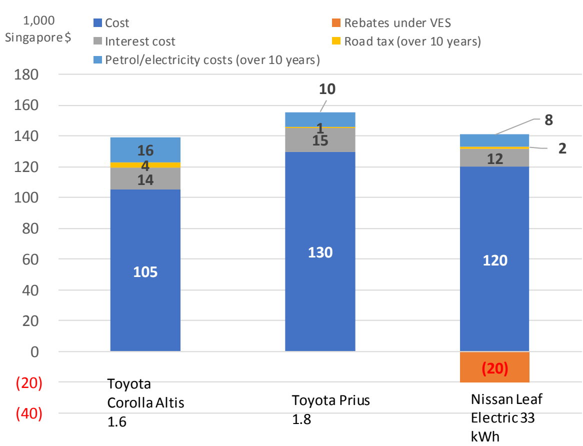
Power rating (kW)	**6-monthly road tax formula (from 1 August 2016)**
PR < 7.5	S$200×0.782
7.5 < PR < 32.5	[S$200+S2(PR-7.5)]×0.782
32.5 < PR < 70	[S$250+S6(PR-32.5)]×0.782
70 < PR < 157.5	[S$475+S12(PR-70)]×0.782
PR > 157.5	[S$1,525+S16(PR-157.5)]×0.782

kW = kilowatt, PR = power rating.
Source: Land and Transport Authority.
https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/costs-of-owning-a-vehicle/tax-structure-for-cars.html (accessed May 2018)

In addition to the fee paid at the time of registration, vehicle owners in Singapore must pay road tax, the rate of which is determined based on the vehicle type (PHEV, EV, or powered by gasoline, compressed natural gas, or diesel). Table 4.5 shows the formula for calculating the rate for EVs based on the maximum power rating. For example, over a 6-month period, a petroleum-powered vehicle with a 1,600 cubic centimetre engine would incur tax of S$372, while an EV with a 33-kilowatt power rating would incur S$198.

Figure 4.6: Analysis Framework

	Toyota Corolla Altis 1.6	Toyota Prius 1.8	Nissan Leaf Electric 33 kWh
Cost	$104,988	$129,988	$119,900
Rebates under VES	$0	$0	($20,000)
Interest cost	$14,302	$15,177	$11,559
Road tax (over 10 years)	$372 x 10 years	($340+$198) x 10 years	$198 x 10 years
Petrol/electricity costs (over 10 years)	$1,639.26 x 10 years	$989.62 x 10 years	$750 x 10 years
Total Net Cost	$139,403	$160,441	$120,939



kWh = kilowatt-hour, VES = Vehicle Emissions Scheme.
Source: Authors.

Figure 4.6 shows a cost comparison for passenger vehicles owned for a span of 10 years in Singapore. The analysis compares a gasoline-powered vehicle (Toyota Corolla Altis), a HEV (Toyota Prius), and an EV (Nissan Leaf). The analysis reveals that, despite the higher vehicle cost, the net cost of the EV is the lowest of the analysed vehicles due to rebates, lower interest costs, lower road tax, and lower energy costs derived from its higher fuel efficiency.

5.3 Malaysia

Malaysia has pledged a voluntary target to reduce greenhouse gas emissions at a level equal to 40% of its GDP by 2020 compared to the 2005 level. In line with this, Malaysia launched a national green technology policy in July 2009, in which it focuses on EVs as a means to support industrial development.

The government formulated the National Automotive Policy (NAP) in 2006 to facilitate the transformation of the local automotive industry and encourage its integration in global networks. The NAP was amended in 2009 and 2014 to strengthen its objectives with regard to the creation of a competitive local automotive industry and to benefit consumers. The 2014 NAP includes the following key concepts.

(i) Develop a competitive and capable domestic automotive industry;

(ii) Develop Malaysia as the regional automotive hub for energy-efficient vehicles (EEVs) by 2020;

(iii) Increase value-added activities in a sustainable way while continuously developing domestic capabilities;

(iv) Increase exports of vehicles, automotive components, spare parts, and related products in the manufacturing and aftermarket sectors;

(v) Increase the participation of competitive Malaysian companies in the domestic automotive industry, including the aftermarket sector;

(vi) Enhance the ecosystem of the manufacturing and aftermarket sectors of the domestic automotive industry; and

(vii) Safeguard consumer interests by offering safer and better quality products at competitive prices.

Malaysia Automotive Institute defines an EEV as a vehicle that meets a certain level of carbon emissions (grams per kilometre) and fuel consumption (litre/100 kilometres).[11] According to this definition, EEVs include fuel-efficient vehicles, HEVs, EVs, and alternatively fuelled vehicles (e.g., compressed natural gas, liquefied petroleum gas, biodiesel, ethanol, hydrogen, and fuel cells).

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[11] Malaysia Automotive Institute. http://mai.org.my/energy-efficient-vehicles-eevs/;
Ahmad, D.A. (2014), 'Evolution of Auto Policy – the Malaysian Experience', Presentation at Auto Trade Dialogue. 4 February. Delhi.

The NAP 2014 provides economic incentives for manufacturers to promote the production of EEVs. Malaysia aims to increase annual production of motor vehicles from 601,407 units in 2013 to 1.35 million by 2020, with EEVs accounting for 1.15 million units. With regard to motorcycles, in the same timeframe, Malaysia aims to increase production from 430,000 units to 800,000 units, 650,000 of which would be EEVs.

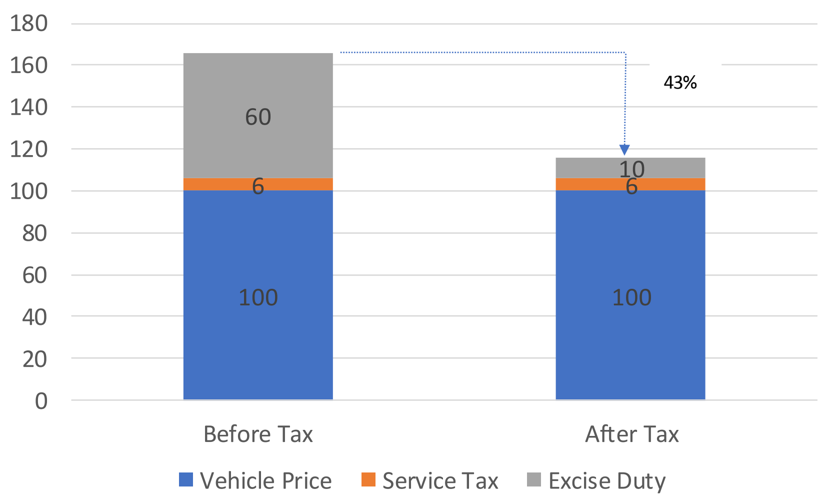
Economic incentives being prepared for both foreign direct investment and domestic investment include (i) pioneer status; (ii) investment tax allowance; (iii) grants (research and development, training); (iv) infrastructure facilitation; (v) lower taxes; and (vi) expatriates. The Government of Malaysia announced that the 2014 NAP includes RM2 billion in soft loans and grants for human capital purposes related to automotive infrastructure.

Table 4.12: Economic Incentives for Energy-Efficient Vehicles

Sector	Incentives
Incentives for local assembly and manufacturing of EEVs	• 100% tax break for 10 years for FDIs • 100% tax break for 10 years for corporate tax • Subsidy provision for training and R&D • Tax breaks (maximum 10%) for import duties • Tax breaks (maximum 10%) for import duties • Tax breaks (maximum 10%) for excise duties
Incentives for locally assembled and/or manufactured EEVs	• Tax breaks (50%) for excise duties • Subsidy provision from the Industrial Adjustment Fund
Incentives for promoting EEV-related parts	• Electric motors, HEV and EV batteries, battery management systems, inverters, ACs, air compressors • 100% tax break for 10 years for corporate tax • 100% tax break for 10 years for FDIs

AC = air conditioning unit, EEV = energy-efficient vehicle, EV = electric vehicle, FDI = foreign direct investment, HEV = hybrid electric vehicle, R&D = research and development.
Source: National Automotive Policy 2014.

Figure 4.7: Impacts of Incentives on Electric Passenger Vehicle Price



Source: Malaysian Green Technology Corporation.

The Government of Malaysia initially introduced tax exemption for imported EVs and HEVs to encourage manufacturers to invest and assemble in Malaysia. However, the significant results of the incentive met the initial objectives, and the government determined to end the tax incentives.[12]

The 2018 NAP emphasises next-generation vehicles, mobility, the Industrial Revolution 4.0, and artificial intelligence.

6. Conclusions

The biggest hurdle for the introduction of EVs is currently the upfront costs; thus, it is important for the Government of Indonesia to provide incentives for EVs to ensure the realisation of their potential benefits for drivers and consumers. Mechanisms should be in place to secure necessary funds for the provision of incentives. The case of the state of Delhi in India offers a good lesson in this regard as it charges diesel consumers an additional fee that it uses as the basis for incentive funds.

Another illustrative case is that of Malaysia, where EEVs (including HEVs and EVs) are considered an effective tool for supporting the development of the manufacturing industry. The country provides incentives to the manufacturing industry, specifically to assembly and manufacturing companies that produce parts, including electric motors, HEV and EV batteries, battery management systems, inverters, air conditioning units, and air compressors. This is an important point with regard to the stepwise development of the manufacturing industry in Indonesia.

[12] Expat Go (2014), 'Malaysia Ends Tax Breaks for Hybrid and Electric Cars'. http://www.expatgo.com/my/2014/01/25/tax-breaks-hybrid-cars-stopped-malaysian-government/

Chapter 5

Policy Implications

As shown by the results of the analyses in Chapters 2–4, introducing alternative vehicles, particularly EVs, in Indonesia would be an effective tool for various policy purposes. For example, shifting to EVs would enhance energy security in Indonesia by increasing oil savings to 1.2 million barrels per day, comparable to the primary oil demand in 2015 (1.5 million barrels per day). In recognition of such benefits from the introduction of EVs, this chapter presents policy implications to realise these expected benefits.

1. Need for a Clear Vision and Prioritised Approach to Electric Vehicle Deployment

The use of EVs in Indonesia would help meet various policy goals, including energy security enhancement, climate change mitigation, air quality improvement, and manufacturing industry development. However, it is important to make clear the country's long-term vision for the wider utilisation of EVs, and which policy objectives EVs would meet. For example, a prioritised approach could be coupled with economic and financial incentives, which should be dedicated effectively to the targeted sectors.

2. Integration of Demand- and Supply-Side Planning for Carbon Dioxide Emissions Reduction

EVs could serve as an effective tool for reducing CO_2 emissions under conditions where the decarbonisation of the electricity generation mix takes effect. Assuming the continued dependence on fossil fuels for power generation (accounting for 90% of the total generation mix), this analysis found that, by 2040, the massive deployment of EVs would only reduce CO_2 emissions by 2% compared with the reference scenario. By contrast, assuming that renewable sources would account for 26% of the electricity generation mix by 2040, EVs could reduce CO_2 emissions by 17% by 2040.

This finding suggests that it is important to integrate demand-side policy in the deployment of EVs, as well as supply-side policy to plan the decarbonisation of the electricity sector. For example, Indonesia should integrate planning for EVs into its national electricity plan (*Rencana Umum Ketenagalistrikan Nasional*) and consider the necessary infrastructure for EV charging systems.

It is important to note that Indonesia's current feed-in-tariff regulation does not ensure enough incentives for renewable energy sources. In January 2017, The Ministry of Energy and Mineral Resources issued MEMR Regulation No. 12/2017 capping the feed-in-tariff for renewable sources at 85% of the average cost of generation in the respective grid. This provides insufficient incentives for renewables at locations where electricity generation relies on relatively low-cost options such as coal, placing the potential for CO_2 emissions reduction at stake. It is thus critically important to coordinate the various policy goals in view of the substantial introduction of EVs in the future.

a. Coordination amongst Stakeholders to Realise the Full Benefits of Electric Vehicles

In addition to the benefits of reduced CO_2 emissions, concerted efforts by stakeholders are required to realise the potential benefits of EVs. This includes the coordination of various plans and policies related to EVs. In particular, coordinating planning for transport, electricity, environment, and industry will be critical.

b. Stepwise Approach to Introduce Incentives for Electric Vehicles

The biggest hurdle for the introduction of EVs is currently the upfront cost. Thus, it is important for the Government of Indonesia to provide incentives for EVs to ensure that their potential benefits for drivers and consumers are realised. Mechanisms should be in place to secure necessary funds for the provision of incentives. A good lesson has been provided by the state of Delhi in India, where diesel consumers charged an additional fee that is used as the basis for incentive funds.

Another illustrative case is that of Malaysia, where EEVs (including HEVs and EVs) are considered an effective tool for supporting the development of the manufacturing industry. The country provides incentives to the manufacturing industry, and takes a stepwise approach. These incentives are provided specifically to assembly and manufacturing companies that produce parts, including electric motors, HEV and EV batteries, battery management systems, inverters, air conditioning units, and air compressors.

3. Creation of Conditions for Electric Vehicle-Related Business

As shown by the results of the cost–benefit analysis, substantial funds would be required to develop the necessary infrastructure to meet the increased electricity demand from the diffusion of EVs in Indonesia. To meet the 2040 target of banning sales of ICEVs following the massive introduction of EVs, $187 billion in additional investment will be needed through 2040. Securing funding will be critically important to realise these requirements.

It is also necessary to create a policy environment conducive to private investment for infrastructure development. For example, promoting distributed energy systems (not necessarily grid-connected) would enhance the integration of EVs with renewable electricity generation. In other words, incentives could promote renewable generators with charging systems to support EV owners (passenger vehicles or motorcycles) and operators (buses and motorcycles).