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Sustainable Development of the Transport Sector: Malaysia

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Preface

No country can neglect the transport sector in its endeavours to reduce carbon dioxide (CO_2) emission as the sector emits a lot. The difficulty in this sector, particularly in road transport, is that there currently are no real practical alternatives to internal combustion engine (ICE) technology and fuel. As a mature technology, ICE provides great comfort and convenience for car owners.

We are observing rapid changes in energy, transportation, and information technologies. Renewable energy is gaining competitiveness in the energy field. More electric motor vehicles have become commercially available. New applications of information technologies, such as autonomous driving, are being tested. These phenomena seem to provide countries with unexpected opportunities to mitigate CO_2 emission in the transport sector.

Malaysia is not an exception in encountering challenges to reduce CO_2 emission in the transport sector; and it has an opportunity to take full advantage of such new technologies. I hope this study will serve as a reference for Malaysia to pave the way for a brighter future.

Ichiro Kutani

Working Group Leader

June 2018

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Ichiro Kutani

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June 2018

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List of Abbreviations

BAU	business-as-usual scenario
CO_2	carbon dioxide
EEV	energy-efficient vehicle
EV	electric vehicle
FCEV	fuel cell vehicle
GDP	gross domestic product
GHG	greenhouse gas emission
GKL	Greater Kuala Lumpur
ICE	internal combustion engine
ICT	information and communication technology
IEA	International Energy Agency
IEEJ	The Institute of Energy Economics, Japan
INDC	Intended Nationally Determined Contributions
ITS	Intelligent Transport Systems
JAMA	Japan Automobile Manufacturers Association, Inc.
JARI	Japan Automobile Research Institute
KeTTHA	Ministry of Energy, Green Technology and Water
km	kilometre
KV	Klang Valley
Ktoe	kilo tonnes of oil equivalent
KVMRT	Klang Valley mass rapid transit
LRT	light rail transit
METI	Ministry of Economy, Trade and Industry
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MPIC	Ministry of Plantation Industries and Commodities
MRT	mass rapid transit
Mtoe	million tonnes of oil equivalent
Mt-CO_2eq	million tonnes of carbon dioxide equivalent
NAP	National Automotive Policy

NLPTMP	National Land Public Transport Master Plan
PHV	plug-in hybrid vehicle
SAV	shared autonomous vehicle
SPAD	Land Public Transport Commission
toe	tonne of oil equivalent
ZEV	zero-emission vehicle

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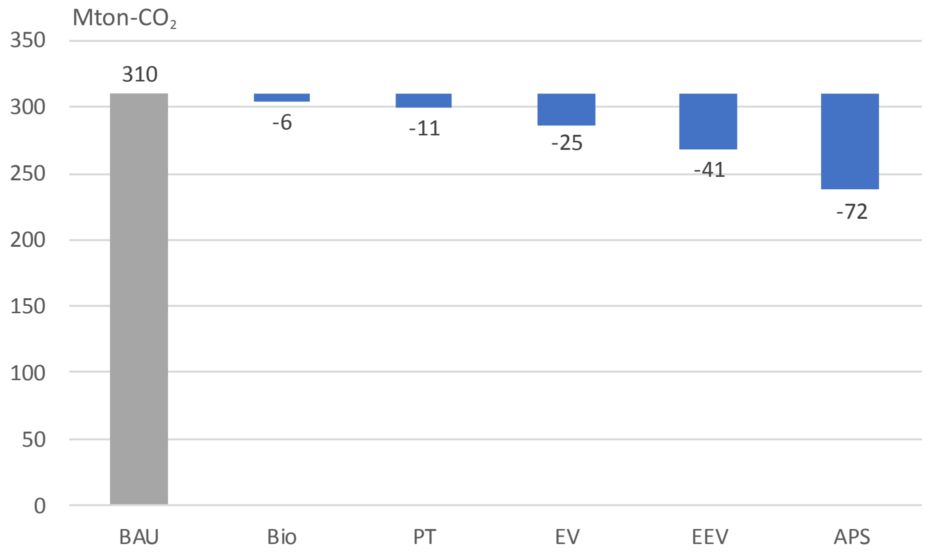
Executive Summary

Malaysia intends to reduce its greenhouse gas (GHG) emissions intensity of gross national product (GDP) by 35%, and an additional 10% under certain conditions by 2030 from 2005 figures. Since the transport sector is the second-largest CO_2 emitter in the country (28% of total), and since car ownership and thereby CO_2 emission due to gasoline/diesel combustion is expected to rise in a future, it is crucial to implement an appropriate policy to reduce CO_2 in this sector.

Referring to the result of scenario analysis, the deployment of energy-efficient vehicles (EEV scenario) has the largest potential to reduce CO_2 emissions, followed by electric vehicle (EV scenario), public transport (PT scenario), and biofuels (bio scenario).

Figure ES.1 Potential of Reducing CO_2, by Scenario (2040)



APS = combination of all the scenarios, BAU = business-as-usual scenario, bio = assumes more biofuel supply, EEV = assumes deployment of energy-efficient vehicles, EV = assume deployment of electric vehicles, Mt-CO_2eq = million tonnes of carbon dioxide equivalent, PT = assumes larger modal shift to public transport.

Source: Study team.

When classifying the options in two dimensions – reducing CO_2 and determining the time line of action – deployment of EEVs can be easily achieved. The next priority is public transport as it has a larger CO_2 reduction potential compared to biofuels, and lastly the EVs. Although Malaysia can expect large CO_2 reductions under the EV scenario, it needs to wait for reduced vehicle costs, spread of charging stations, and most importantly development of low-carbon electricity.

Table ES.1 Classification of CO_2 Reduction Scenarios in Two Dimensions

	CO_2 Reduction	Timeline of Action
Biofuel	Small	Short term
Public transport	Small	Short term
Electric vehicle	Medium	Long term
Energy efficient vehicle	Large	Immediate

Source: Study team.

Following the above classification, the study discusses two parts to reduce CO_2 emission in the transport sector.

Part 1 Maximise use of public transport

Part 2 Deploy low-emission vehicles

The first part is concerned with maximising the use of public transport, such as high-speed railways, underground lines, light railways, and buses, which have higher energy efficiency than vehicles. It suits large-city and inter-city passengers and cargo transport. Considering that landmark railway projects are under way in Malaysia, the priority of recommendation is on how to increase ridership of, rather than suggest developing, public transport.

Recommendation 1. Boost connectivity amongst various kinds of transportation

- To make the greatest use of upcoming railway projects, transport hubs are a key component to encourage people to use and shift to public transport

Recommendation 2. Provide last 1-mile mobility using innovative technology, shared autonomous vehicles (SAVs)

- SAVs can provide people with an ultimate access to transport hubs, such as railway stations or bus depots, which would accelerate modal shift.

Other recommendations to increase ridership of public transport

- Strictly implement parking regulations and conduct police patrols (park at lots or be fined)
- Restrict car driving within a certain zone.
- Implement load pricing for a certain zone.
- Provide public transport with sufficient capacity.
- Construct comfortable (safe and clean) bicycle and pedestrian ways.

The second part is concerned with deploying low-emission vehicles. Although costlier than conventional ICE vehicles, new vehicle technologies are emerging and becoming commercially available. Considering that the policy promoting EEVs was implemented in Malaysia after the National Transportation Plan 2014 and had resulted in EEVs sharing 52% of new car sales in 2017, the priority of recommendation goes to the difficult option of promoting EVs.

Recommendation 3. Take an integrated approach to increase low-emission vehicles

- Since all stakeholders, government, businesses, and the public have roles to play, they need to do their share in reducing CO_2 emissions.
  - Fuel-efficient vehicle by auto industry
  - Efficient vehicle usage by driver
  - Improving traffic flow by government
  - Diversified fuel supply by fuel supplier

Recommendation 4. Support zero-emission vehicles (ZEVs) to penetrate the market

- More diffusion of renewables is unavoidable.
- In the early stage of the ZEVs market, government support is indispensable.
- A governmental pilot project might bring a new perspective to the ZEVs market.

Recommendation 5. Set up smart power grids

- EV's batteries can play an important role in power grids, considering a massive introduction of renewables. Simultaneous development and integration of EVs and smart power grids can increase the value of EVs, thus improving their economic viability.

Chapter 1

Introduction

1.1 Background and Objective

Unprecedented sea change has been seen in the transport and energy sectors in a revolutionary way. Especially the automotive industry is facing a turning point that happens only once every 100 years. Major auto manufacturers worldwide are accelerating the development of clean vehicles, including electric vehicles, in the wake of tightening regulations on the environment. Furthermore, new advanced technologies such as artificial intelligence or the internet of things have made self-driving or connected vehicles available, which could solve traffic-related problems such as air pollution or traffic congestion.

In the energy field, the cost of renewable energy has drastically declined, and it has become a more powerful and competitive energy source compared to fossil fuels. Dozens of countries around the world are keen on introducing affordable renewable energies.

Tackling global warming is an urgent task for all countries. The energy and the transport sectors are the major sources of GHG emission. Combining zero-carbon energy supply with clean vehicle technology can make automobiles a carbon-free transport mode.

Although a lot of problems remain to be solved in renewables and clean vehicles, such as power intermittence or the price and quality of batteries, it is a good opportunity to tap into technology advancements and draw up a strategic policy for both the transport and energy sectors.

1.2 Work Stream

In this research, the study group held two workshops and discussed how to reduce CO_2 emissions in transport, especially in the road transport sector. In each workshop,[1] experts from Malaysia and Japan shared what is starting to happen.

In the first workshop, the team focused on next-generation vehicles, mainly EVs, FCEVs, and charging infrastructure based on Japan's Roadmap.[2] In the second workshop, the team exchanged information on the sustainable mobility aims for using Intelligence Transport Systems (ITS). At the end of the workshop, Malaysia's Energy Commission presented the country's scenario analysis for reducing CO_2 emissions in 2030.

[1] The workshops were held on 22 February 2018 and on 14 May 2018 in Putrajaya.

[2] http://www.meti.go.jp/press/2015/03/20160323002/20160323002-3.pdf

Malaysia's GHG is expected to increase as its economy grows. With an increasing number of automobiles, countermeasures against CO_2 emissions are impending issues. Innovative solutions are also expected to be developed in the years to come. Malaysia’s efforts could serve as a role model to member countries of the Association of Southeast Asian Nations.

We hope that this report will contribute to drawing up a strategic policy to address environmental issues in the transport sector.

Chapter 2

Energy and Transport Policy in Malaysia

2.1 Malaysia's Intended Nationally Determined Contributions

Malaysia's government submitted its Intended Nationally Determined Contributions (INDC) in January 2016. Malaysia intends to reduce its greenhouse gas (GHG) emissions intensity of gross domestic product (GDP) by 45% by 2030 relative to that of 2005. This consists of 35% on an unconditional basis and a further 10% is conditional upon receipt of climate finance, technology transfer, and capacity building from developed countries**.**

2.1.1 Overview on INDC

In the original INDC document submitted in January 2016, under the transport sector, only biofuel was meant to reduce GHG emissions. No specific target by each sector was listed. In Malaysia, the potential of reducing the energy and GHG emission was focused on renewables and energy efficiency in the power, industry, commercial, and residential sectors.

The Institute of Energy Economics, Japan (IEEJ) compared its outlook for Malaysia with the country's INDC. IEEJ's outlook has two scenarios. The reference scenario assumes changes based on the historical development of energy supply–demand and moderate policy prospect, whilst the advanced technology scenario assumes application of stronger and ambitious energy environment policies and corresponding technologies.[3]

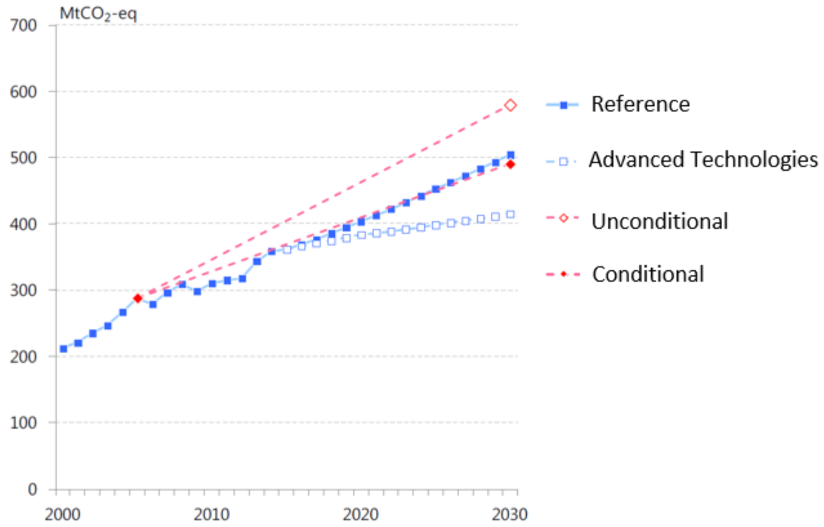
According to an analysis, Malaysia's unconditional INDC is almost the same as or slightly better than the IEEJ's reference scenario.

Since 2016, when Malaysia submitted the INDC, advanced technology such as artificial intelligence and the internet of things has been developing rapidly. For the transport sector, electric vehicles (EVs) are drawing much worldwide attention, and connected cars or autonomous vehicles are just becoming available.

Compared with the intensity of GDP, which is the INDC, the GDP growth rate exceeds the GHG emission growth rate, so the GHG/GDP ratio is expected to decline. However, the total amount of GHG emission will steadily increase. If Malaysia were willing to set itself even more ambitious targets, aggressive measures are required in the energy and the transport sectors that account for large proportions of GHG emissions.

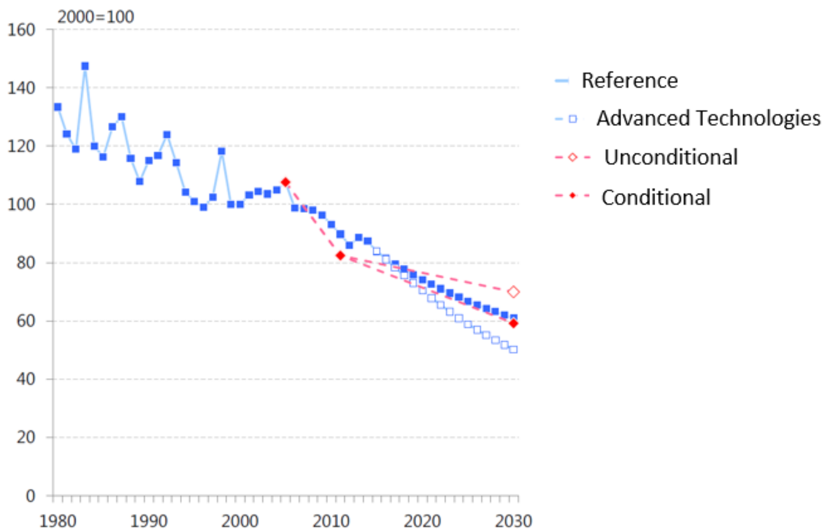
[3] Even applying an ambitious advanced technology scenario, the world cannot halve GHG emission by 2050.

Figure 2.1 GHG Projections Based on the INDC



IEEJ = Institute of Energy Economics, Japan; INDC = Intended Nationally Determined Contributions, Mt-CO_2eq = million tonnes of carbon dioxide equivalent.
*Reference case based on from past trends.
Source: IEEJ (2016).

Figure 2.2 GHG Intensity of GDP Projections Based on the INDC



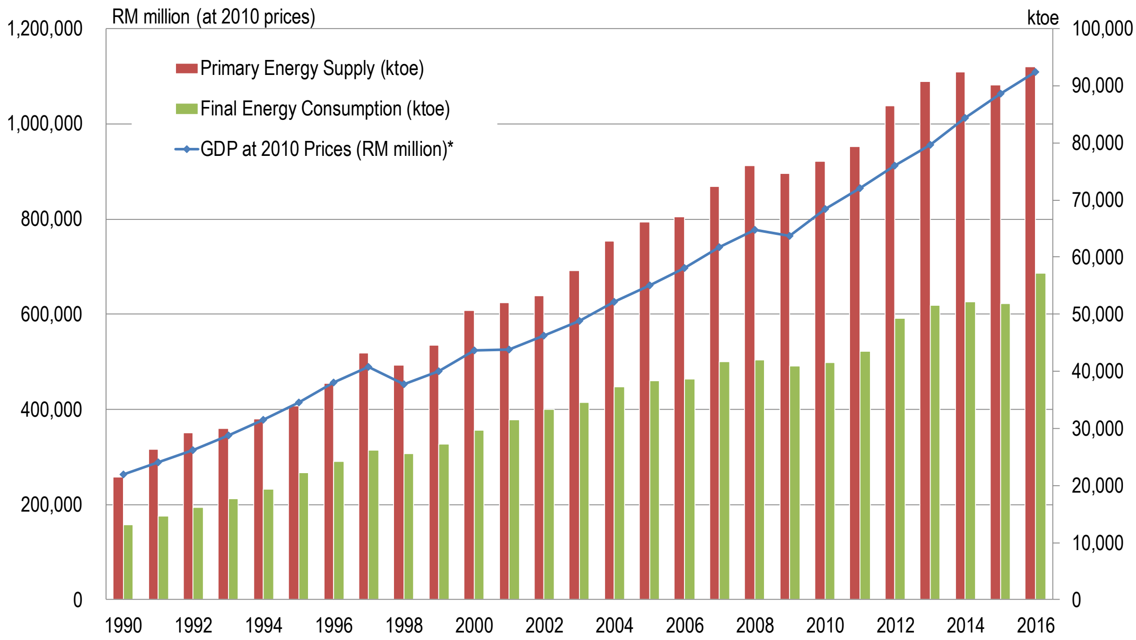
GDP = gross domestic product; GHG = greenhouse gas; IEEJ = The Institute of Energy Economics, Japan; INDC = Intended Nationally Determined Contributions.
*Reference case based on past trends
Source: IEEJ (2016).

2.1.2 Economic and energy background of Malaysia

In 2016, Malaysia's economy recorded growth of 4.2% (2015: 5%) despite considerable external and domestic headwinds. The global economic landscape was challenging, given subdued global demand and low commodity prices. In line with economic growth, performance of energy supply and demand for 2016 recorded a positive movement. Total primary energy supply increased by 3.6% to settle at 93,395 kilo tonnes of oil equivalent (ktoe). Final energy consumption in 2016 posted double-digit growth of 10.5%. The last recorded double-digit growth was in 2012 at 13.4%.

Figure 2.3 Trends in GDP, Primary Energy Supply,

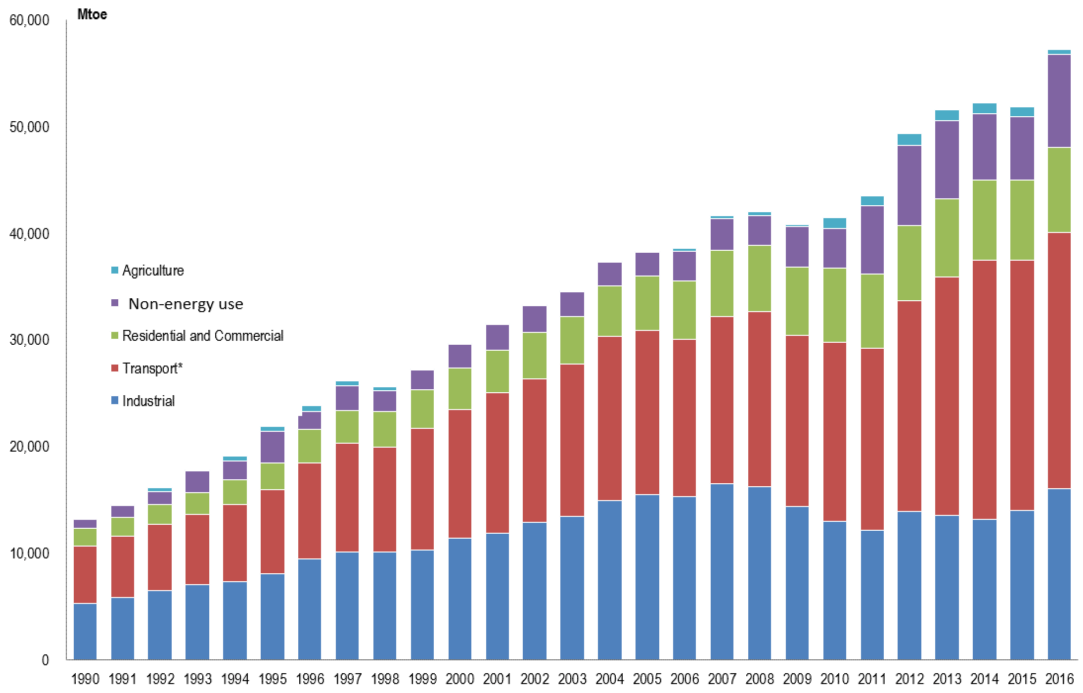
and Final Energy Consumption



GDP = gross domestic product, ktoe = kilo tonnes of oil equivalent, RM = Malaysian ringgit.
Source: Energy Commission (2018).

The major contributors of growth were the non-energy use and industry sectors. Final energy consumption for non-energy use increased by 47.3% to register at 8,729 ktoe. Higher demand for non-energy use was mainly contributed by natural gas use, which increased by 36.1% in 2016. Total final energy consumption in the industry sector increased by 14.5% to settle at 16,019 ktoe. The increase was mainly due to higher demand for natural gas in the industry sector, especially from Sabah and Sarawak. After a reduction in 2015, total energy consumption in the transport sector increased again by 2.4% to settle at 24,004 ktoe compared to the previous year's 23,435 ktoe. Consumption for petrol in the transport sector was the main contributor for growth as petrol recorded a positive trend of 6% in 2016. Total energy consumption for the residential sector recorded growth of 5.6% to settle at 3,284 ktoe in 2016. Final energy consumption of the commercial sector increased by 7.1% to register at 4,765 ktoe compared to the previous year's 4,449 ktoe. The agriculture and the fishery sectors recorded a downward trend of 37.7% and 59.1%, respectively.

Figure 2.4 Final Energy Consumption, by Sector



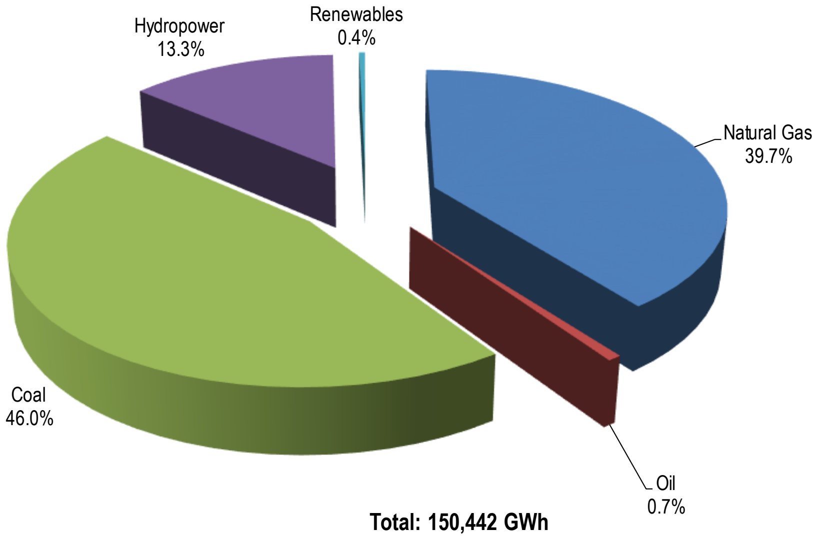
Mtoe = million tonnes of oil equivalent.
Source: Energy Commission (2018).

As of end-2016, Malaysia's total installed power generation capacity was 33,045 MW, an increase of 8.6% from 30,439 MW in 2015. The capacity increase was a result of the commissioning of new power stations – TNB Prai (1,071 MW), TNB Connaught Bridge (375 MW), and Tanjung Bin Energy (1,000 MW), which started operations on 20 February 2016, 27 February 2016, and 21 March 2016, respectively. Total gross electricity generation in 2016 was 156,665 GWh, an increase of 4.3% (2015: 150,190 GWh). Total electricity consumption was 144,024 GWh, an increase of 8.9% from the previous year (2015: 132,199 GWh). Peak demand for Peninsular Malaysia was recorded at 17,788 MW in the second quarter of 2016; Sarawak at 3,005 MW in the fourth quarter of 2016; and Sabah at 945 MW, also in the second quarter of 2016). The calculated reserve margin for Peninsular Malaysia in 2016 was 30.1% and 38.0% for Sarawak, with Sabah at 35.3%.

In Malaysia, the fuel to generate electricity consists of natural gas, coal, hydro, oil, and renewables. Total energy input in power stations increased by 6.7% in 2016 to register at 35,348 ktoe compared to the previous year's 33,133 ktoe. Coal and coke remained the main fuel source of electricity generation in the country, with a share of 48.4% of total fuel inputs or 17,101 ktoe. This was followed by natural gas at 37.5% or 13,260 ktoe; hydropower at 12.7% or

4,499 ktoe; diesel and fuel oil at 0.9% or 320 ktoe; and renewables at 0.5% or 168 ktoe. In terms of the generation mix, in 2016 the share of coal and coke constituted 44.9%, followed by natural gas at 40.7%, hydropower at 13.3%, oil at 0.7%, and the remaining 0.4% was from renewables.

Figure 2.5 Electricity Generation Mix, by Fuel Type, 2016

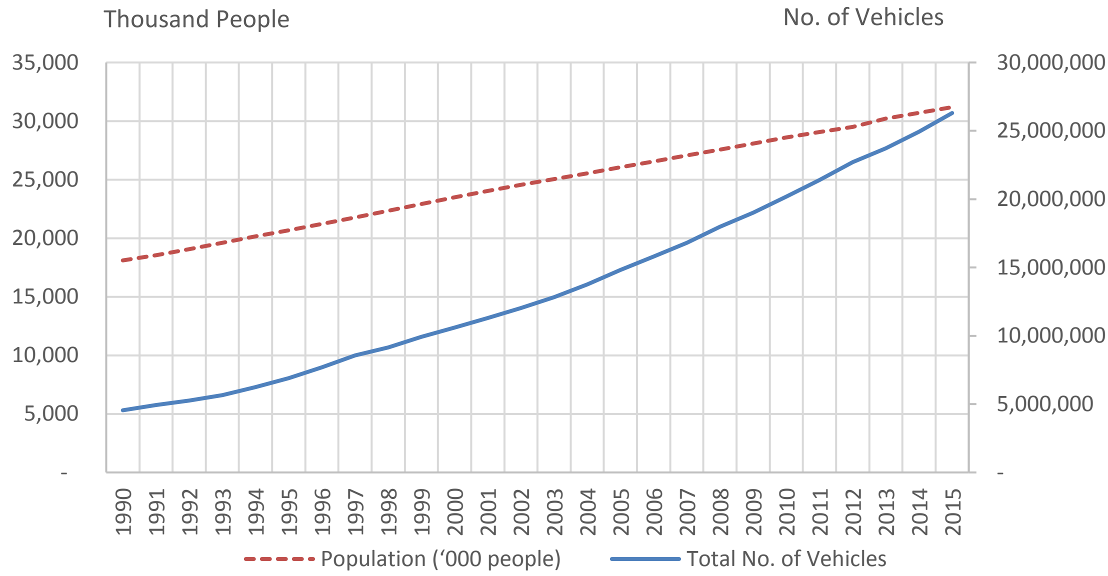


Source: Energy Commission (2018).

2.1.3 Features of Malaysia's transport sector

The number of motor vehicles in Malaysia increased by 7.3% per year on average from about 5 million in 1990 to 26.3 million in 2015. The insufficient public transport infrastructure contributed to the ever-increasing motor vehicle population. In 2015, cars and motorcycles together accounted for about 95% of the vehicles in the country. The increasing population and urbanisation also contributed to the rapid increase in vehicle numbers. Figure 2.6 shows that growth in the number of vehicles in the country has been much faster than population growth. Whilst the total population increased by 2.2% per year in 1990–2015, the number of vehicles in the country increased by 7.3% per year in the same period. As more than 90% of vehicles still run on petroleum fuels, this growth in vehicle population has significantly increased fuel demand and CO_2 emissions. The transport sector relies primarily on petroleum fuels. Presently, this sector accounts for about 45% of total final energy consumption, largely for road transportation modes. The heavy reliance of the transport sector on petroleum products, especially petrol and diesel, is a worrying trend for the future in terms of energy security and CO_2 emissions contribution.

Figure 2.6 Trends in Vehicle Numbers and Population Growth in Malaysia



Source: Ministry of Transport and Department of Statistics Malaysia (2016).

Data from Malaysia's Ministry of Transport showed that in 2015, the total number of vehicles in the country was 26,301,952, 48.9% or 12.9 million of which use gasoline. This was followed by motorcycles at 12,094,790 units or 46% of the total number of vehicles. These two types of vehicles mostly use gasoline or other petroleum products for fuel.

Table 2.1 Breakdown of Fuel Consumption and Number of Vehicles in Road Transport, 2015

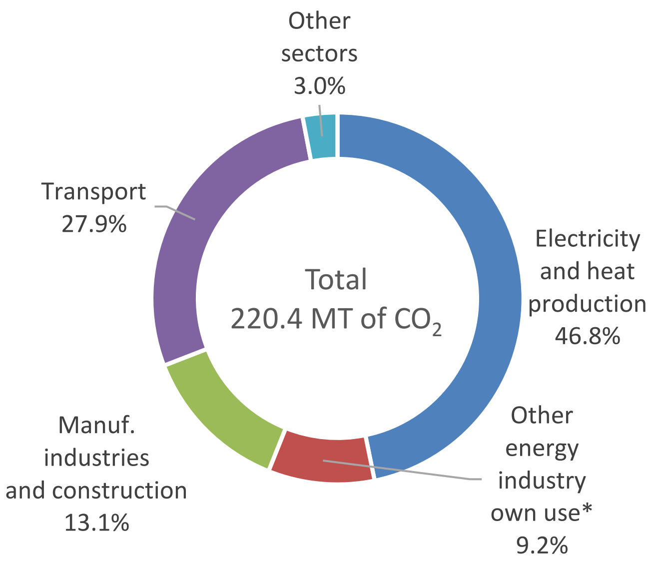
	Gasoline		Natural Gas		Diesel			Total
	Car	Motorcycle	Car	Bus	Car	Bus	Goods Vehicles	
No. of Vehicles	12,864,939	12,094,790	76,230	770	237	66,999	1,197,987	26,301,952
Share (%)	48.9	46.0	0.3	0.0	0.0	0.3	4.6	100.0
Fuel Demand (Mtoe)	8,788	3,766	251	13	504	4,445	1,766	19,533
Share (%)	45.0	19.3	1.3	0.1	2.6	22.8	9.0	100.0

Mtoe = million tonnes of oil equivalent.

Source: Ministry of Transport (2016) and Energy Commission (2018).

Data from the International Energy Agency (IEA) show that in 2015, 220.4 million tonnes of CO_2 equivalent (Mt-CO_2) were emitted from the energy sector (Figure 2.7). Major sectors contributing to CO_2 emissions in the country are electricity generation (46.8%), transport (27.9%), manufacturing (13.1%), and other (residential, commercial, and agriculture) (12.2%).

Figure 2.7 CO_2 Emissions from Fuel Combustion, 2015



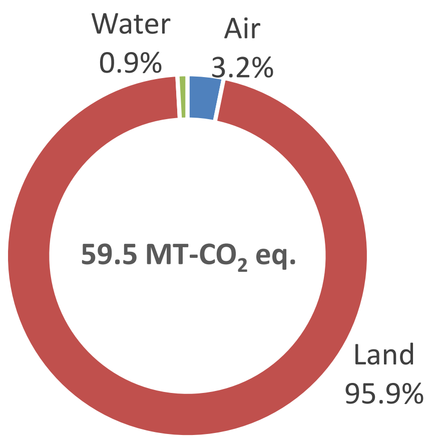
Source: IEA (2017).

Figure 2.8 shows the share of CO_2 emissions in the transport sector by transport mode. Land transportation accounts for the largest share (95.9% of total CO_2 emissions), followed by air and water. Figure 2.9 shows the contribution of different road vehicles in CO_2 emissions and demonstrates that private vehicles (car and motorcycles) represent the largest share of CO_2 emitters, with about 66.4% of the total road transportation sector. This was followed by bus and goods vehicles at 24.0% and 9.5%, respectively.

2.2 Green Technology Master Plan Malaysia 2017–2030

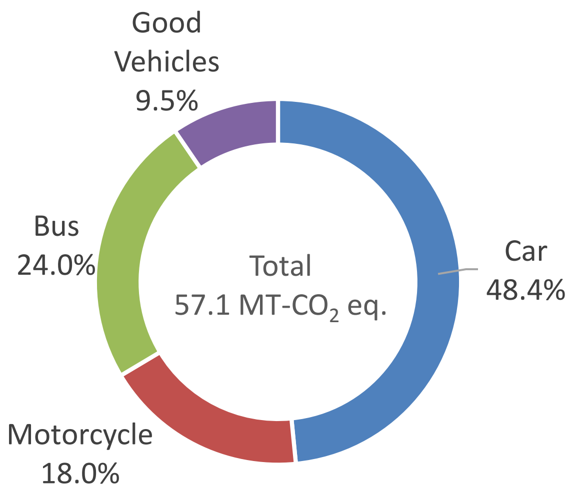
In June 2017, the government released the 'Green Technology Master Plan Malaysia 2017–2040', which outlines the strategic plans to develop green technology and create a low-carbon and resource-efficient economy. The document sets out the immediate course for the country's green growth journey. It lays the foundation for the cultivation of mindset and behavioural change to inculcate a green lifestyle amongst the people. This plan is essential to facilitate the Transformasi Nasional 2050, or TN50, an initiative to position Malaysia amongst the top countries in the world in economic development, citizen well-being, and innovation by the year 2050.

Figure 2.8 CO_2 Emissions, by Transport Mode, 2015



Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

Figure 2.9 CO_2 Emissions of Land Transport, by Mode



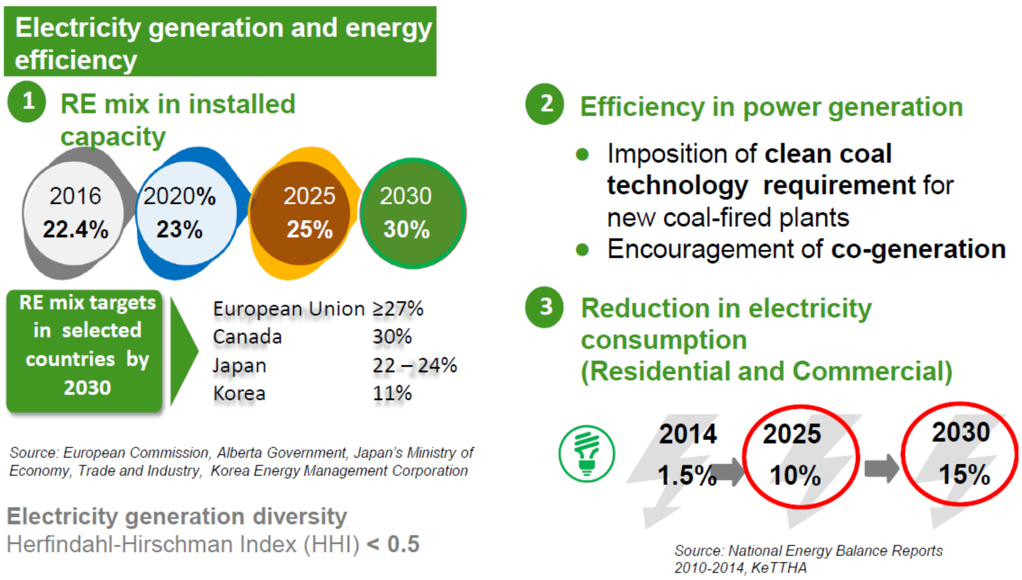
Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

Green technology also offers the capability of mitigating negative environmental impacts resulting from economic activities. There is a growing global need to deal with the dangers of climate change partly through the implementation of green technology. Malaysia's application of green technology provides the solution to realise the country's commitment to the world.

The master plan sets Malaysia's goals in the power and the transport sectors. The three goals of the power sector are as follows:

a) Expand renewable energy generation capacity to 25% in 2025 and 30% in 2030.
b) Introduce highly efficient coal-fired power and promote cogeneration for a more efficient power generation.
c) Reduce consumption of the residential and commercial sectors by 10% in 2025 and 15% by 2030.

Figure 2.10 Targets in the Power Sector



RE = renewable energy.

Source: Ministry of Energy, Green Technology and Water (2017).

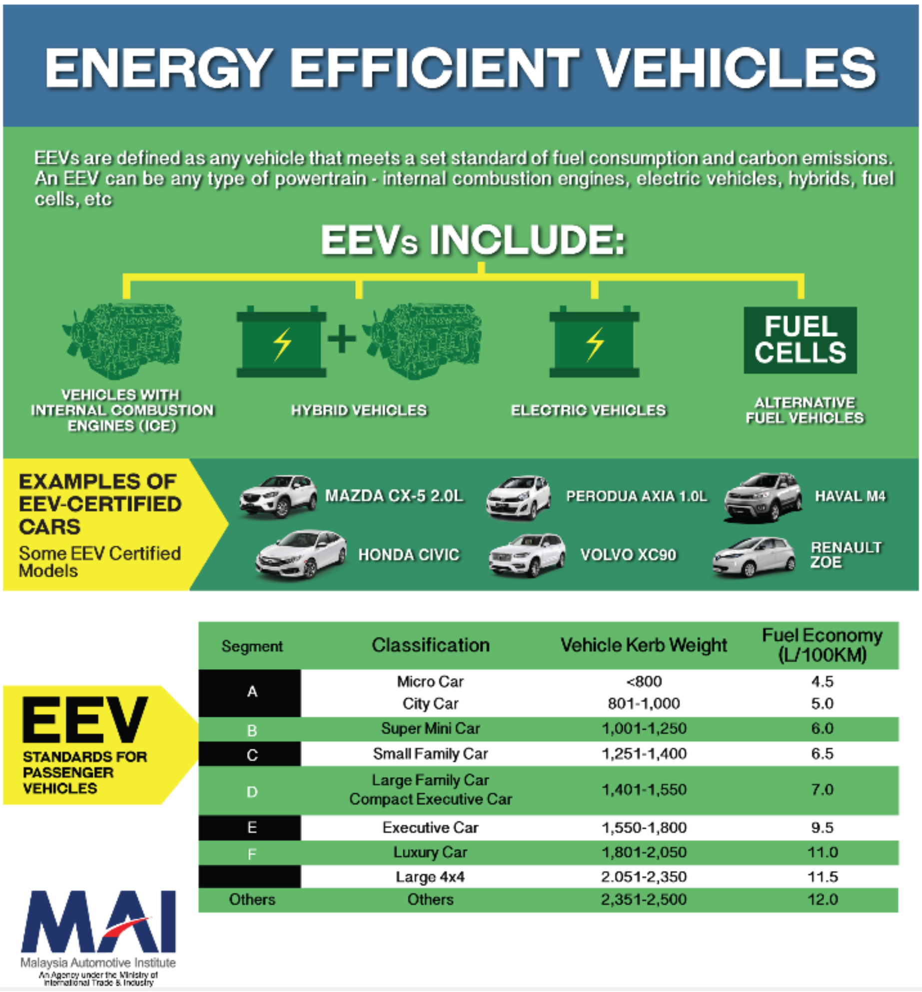
The transport sector's three-pronged approach to reducing CO_2 emission is as follows:

a) Double the modal share of public transport from 20.8% in 2018 to 40% in 2030.

b) Change the ratio of EEVs to private vehicles from 32.6% in 2015 to 100% in 2030.

c) Promote the introduction of eco-friendly fuels such as palm oil.

Figure 2.11 Energy-Efficient Vehicles



Segment	Classification	Vehicle Kerb Weight	Fuel Economy (L/100KM)
A	Micro Car	<800	4.5
	City Car	801-1,000	5.0
B	Super Mini Car	1,001-1,250	6.0
C	Small Family Car	1,251-1,400	6.5
D	Large Family Car Compact Executive Car	1,401-1,550	7.0
E	Executive Car	1,550-1,800	9.5
F	Luxury Car	1,801-2,050	11.0
	Large 4x4	2.051-2,350	11.5
Others	Others	2,351-2,500	12.0

Source: Malaysia Automotive Institute (2018).

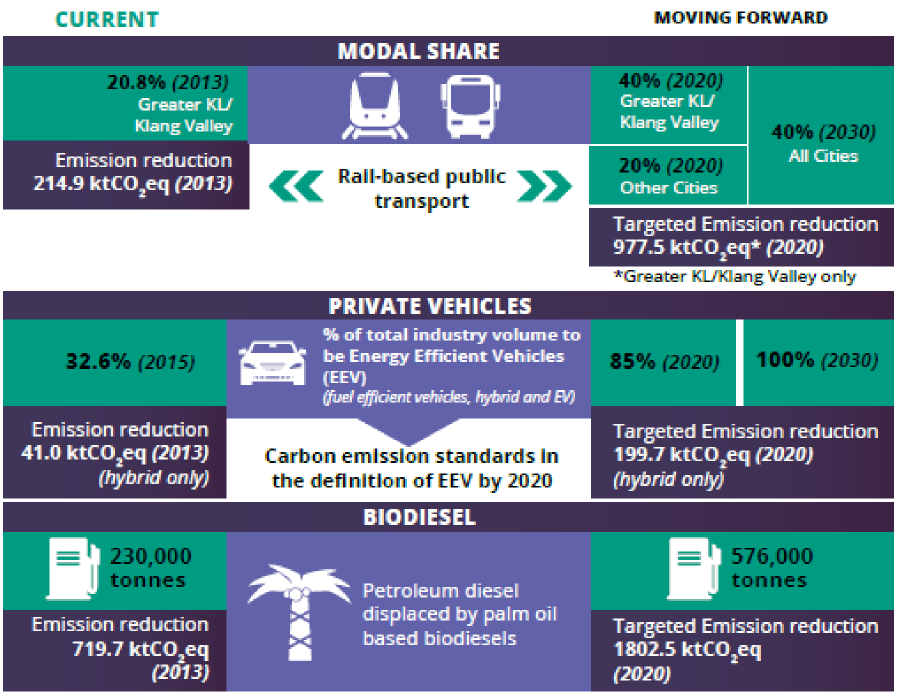
2.3 Transport Policy

The transport policy consists of five policy thrusts, 24 strategies, and 128 action items. It is in line with the Sustainable Development Goals 2030, particularly Goals 9 and 11[4] which emphasised sustainable transport system for all and resilient infrastructure to support socio-economic development. This thrust will ensure that the future enhanced, improved transport system will be efficient, clean, and resilient with minimal impact on the environment and natural resources, whilst providing the country with the necessary mobility. Main action items are as follows.[5]

[4] Goal 9 – Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation; Goal 11 – Make cities and human settlements inclusive, safe, resilient, and sustainable.

[5] Presented by the Ministry of Transport in the first workshop.

Figure 2.12 Main Targets in the Transport Sector



EV = electric vehicle, ktCO$_2$eq = kilo tonnes of carbon dioxide equivalent.
Source: Ministry of Energy, Green Technology and Water (2017).

1. Institutionalise green port, green airport, green transport terminals, and green logistics.
2. Develop sustainable and economically viable infrastructure for EEVs, for example, charging stations for EVs.
3. Provide incentives to EEV manufacturers and users and consider different models of EEVs.
4. Phase out two-stroke or non-fuel-efficient motorcycles.
5. Introduce carbon tax and increase tax on imported second-hand vehicles above a certain age.
6. Formulate and implement a fuel economy policy.
7. Facilitate green mobility through provision of necessary infrastructure (e.g. walking path, bicycle lane, covered pedestrian walkway) with safety features, and developing necessary regulatory framework.
8. Prioritise active and non-motorised modes in all urbanised areas and high-pedestrian areas (e.g. car-free zone, bicycle facilities, ban motorcycle in campuses, etc.)
9. Introduce congestion pricing and higher parking rate in city centres.
10. Implement a thorough consumer information and awareness programme by labelling all vehicles sold in the market by their energy efficiency rating.

2.3.1 National Land Public Transport Master Plan

The Land Public Transport Commission (SPAD) was established in 2010. As the central authority managing all aspects of public transport, the commission which is directly under the purview of the Prime Minister is responsible for drawing up public transport policies, plans, and regulations covering all aspects of land public transport.

SPAD launched the National Land Public Transport Master Plan (NLPTMP) in 2012. The master plan provides a high-level timeline to guide the transformation in the public transport service up to the year 2020. The NLPTMP aims to improve the land public transport system in relation to the increase in population, and the demand for accessibility, and quality and safety of public transport. It focuses on urban rail (i.e. mass rapid transit [MRT], light rail transport [LRT], and monorail), bus and other supporting infrastructure (i.e. bus rapid transit, park 'n ride bays, etc.), covering the five focus areas of improvement:

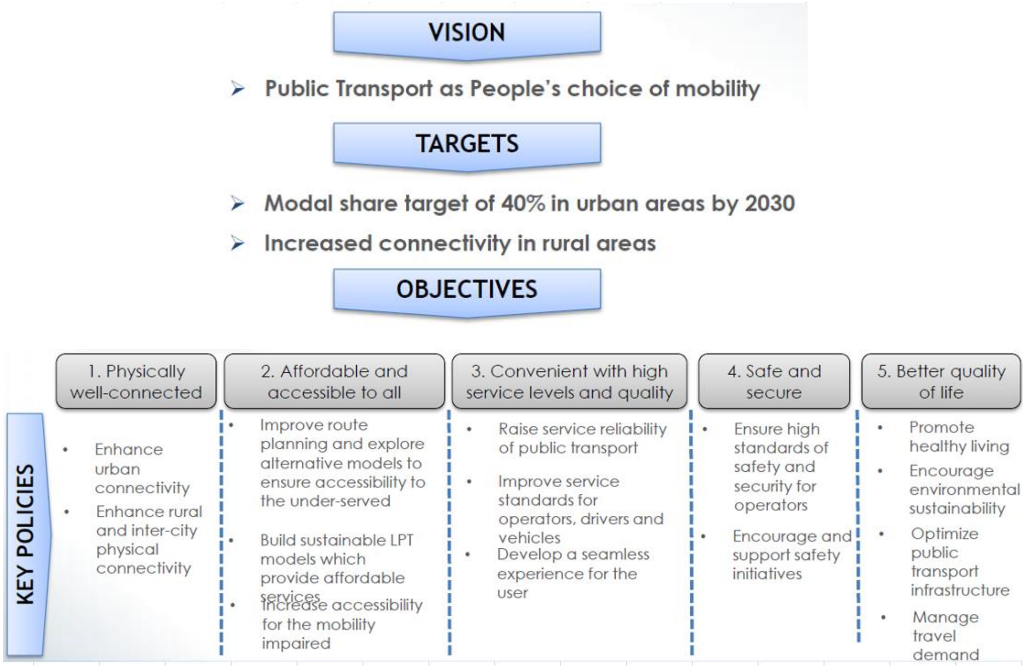
- Physical connectivity to encourage the use of public transport
- Affordability and accessibility so that public transport is available to people from all levels of society
- High service level, quality, and convenience to meet the public's expectations of service, reliability, and all-round user-friendliness
- Safety and security so that the public can be assured of their personal safety whilst using public transport
- Better quality of life by aspiring towards a clean and green environment

2.3.2 Greater Kuala Lumpur/Klang Valley Land Public Transport Master Plan

SPAD had formulated the Greater Kuala Lumpur (GKL)/Klang Valley (KV) Land Public Transport Master Plan for the metropolitan area of Malaysia where congestion is intense. A broad range of projects is under way; railway plans are strongly pushed forward. SPAD's statement published on 6 March 2018 is as follows (SPAD, 2018):

- Malaysians can now enjoy comfortable travelling in urban rail connectivity over the next 5 years with the completion of MRT Line 2 (Sungai–Buloh–Serdang–Putrajaya), the second line of the KVMRT project. The overall project is slated for opening in 2022.
- By 2021, commuters can benefit from the 37 km Bandar Utama–Klang LRT3 Line, construction of which started in the second quarter of 2017. LRT3 features 26 stations, 10 of them offering park and ride facilities for about 6,000 cars. Adding to this connectivity is the KTM SkyPark Link that will connect commuters from KL Sentral to Subang SkyPark Terminal (of the Sultan Abdul Aziz Shah Airport) in only 30 minutes. The 8 km line that connects Subang Jaya to the Subang SkyPark Terminal is under construction.

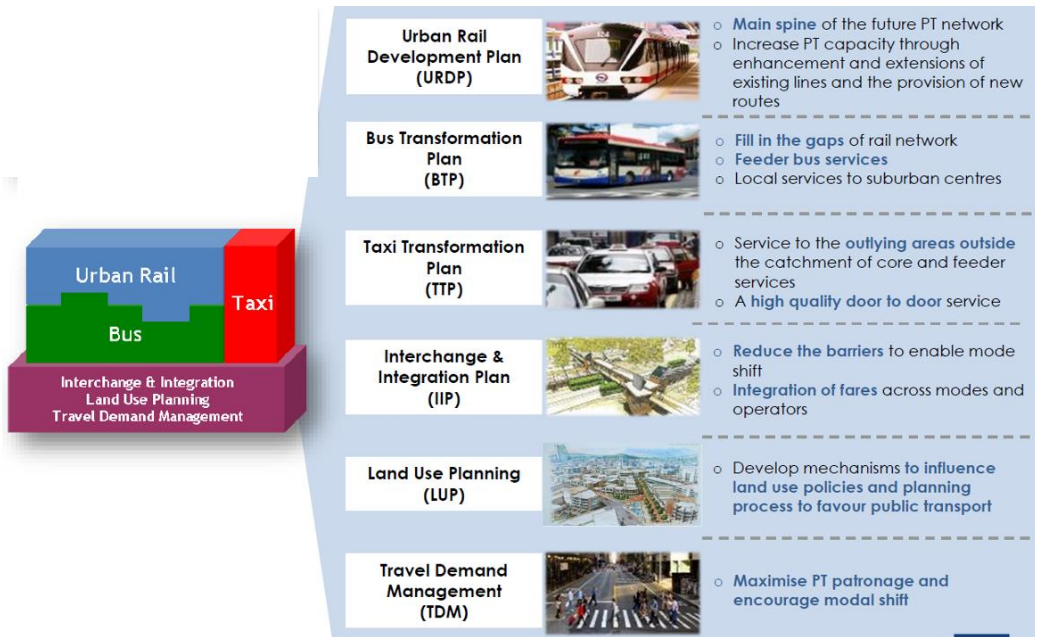
Figure 2.13 Outline of the National Land Public Transport Master Plan



LPT = land public transport.

Source: First workshop on 22 February 2018 presented by the Land Public Transport Commission (SPAD).

Figure 2.14 Outline of GKL/KV Land Public Transport Master Plan



GKL = Greater Kuala Lumpur, KV = Klang Valley, PT = public transport.

Source: First workshop on 22 February 2018 presented by Land Public Transport Commission (SPAD).

2.3.3 Intercity and cross-border connectivity gains momentum[6]

Landmark projects on intercity and cross-border connectivity are under way. SPAD's statement published on 6 March 2018 is as follows:

- Travelling to Singapore will be a hassle-free experience with the upcoming cross-border rail connections. The Kuala Lumpur–Singapore High Speed Rail project is slated to be completed by 2026. It called for a project delivery partner tender and a joint international tender for HSR AssetCo in 2017.
- In January 2018, the governments of Malaysia and Singapore signed the bilateral agreement for the Rapid Transit System (RTS) project at the Leaders' Retreat. Following this, rail operators Prasarana Malaysia Berhad and SMRT signed a letter of agreement to form a joint venture with OpCo to operate the RTS Link.
- By December 2024, commuters could board a train on the 4 km RTS from Bukit Chagar, Johor Bahru to Woodlands North station on the Thomson–East Coast Line. The RTS Link could carry 10,000 commuters an hour in each direction and would ease congestion in the causeway for thousands of commuters and tourists.

2.3.4 National Automotive Policy

The National Automotive Policy (NAP) was introduced in 2006 to transform the domestic automotive industry and integrate it into the increasingly competitive regional and global industry network. NAP was first revised in 2009 to enhance the capability and competitiveness of the automotive industry in Malaysia.

The latest revision, NAP 2014, was made to address the need to reduce carbon emission, and promote EEVs, and to position Malaysia as a EEV hub of the Association of Southeast Asian Nations by 2020. Under NAP 2014, EEVs are vehicles that meet a set of specifications in terms of carbon emission level (gram/kilometre [g/km]) and fuel consumption (l/100km). EEVs include fuel-efficient vehicles, hybrid, EVs, and alternatively fuelled vehicles such as those using compressed natural gas, liquefied petroleum gas, biodiesel, ethanol, hydrogen, and fuel cell.

A new version of NAP 2018 is being revised and is expected to be unveiled in late 2018 (JETRO, 2018).

[6] https://www.spad.gov.my/media-centre/media-releases/2018/land-public-transport-forefront-transformation

2.3.4 Land public transport issues and challenges

Below is a summary of the current land public transport issues and challenges:[7]

a) Different roles and responsibilities between the authorities

- SPAD's jurisdiction is limited to land public transport matters only
- Local authorities are responsible for the city's development inclusive of public transport infrastructure (i.e. bus stops, pedestrian walkways) and road/highways

b) The need for NAP and the NLPTMP to be mutually supportive

- NAP targets to accelerate technology development and allow market expansion for domestic players
- Meanwhile, SPAD targets to make public transport the people's choice for mobility

c) Lack of coordination between public transport planning and highway and land use planning

- Town/city development does not include provisional areas for public transport services

d) Limited funding support

- Currently rely on funding assistance from government

e) The need to improve service reliability and safety

- Rail system breakdown and derailment incidents
- Stage buses are not punctual due to congestion
- Accidents of express buses

2.4 Technology Advancement in the Transport Sector

Malaysia is entering a new era of a more efficient transportation network. A long-awaited Radio Frequency Identification Tag gateless gantry toll system started operation in January 2018. Other landmark projects – East Coast Rail Link, West Coast Expressway, Klang Valley Double Track, LRT3, MRT2, MRT3, and the Pan Borneo Highway – are also in the pipeline or under construction. These projects are expected to boost the country's infrastructure and utility services to keep up with growing public demand.

[7] Presented by SPAD in the first workshop.

2.4.1 Intelligence Transport Systems is set to propose various solutions to traffic problems

Intelligence Transport Systems (ITS) is the application of modern computer electronic and communications technology to transport. These technologies are already revolutionising the way people live, work, and travel.

Some ITS applications already exist in Malaysia. Kuala Lumpur has had a computer-controlled traffic signal system for many years and this is being enhanced and extended. Several expressways around the Klang Valley have computerised monitoring and control systems with variable message signs and traffic detectors. Several electronic toll collection systems are in operation and the 'Touch and Go' smart card is being used for toll collection and on public transport.

Furthermore, from 2020, motorists could access real-time traffic information when the ITS begins implementation of the multi-lane free flow system at toll plazas.

2.4.2 Malaysian Intelligent Transport System Blueprint 2017–2022

The Malaysian Intelligent Transport System Blueprint 2017–2022 identifies nine sectors. The challenge is funding and finding suitable, affordable, and sustainable technology. Also imperative are public–private partnerships to develop the system.

Figure 2.15 Nine Sectors in the Malaysian ITS Blueprint 2017–2022

1. Public Transport
2. Emergency Management
3. Electronic Payment
4. Commercial Vehicle Operations
5. Traveler Information
6. Advanced Traffic Management
7. Advanced Vehicle Control
8. Safety System
9. Information Warehouse

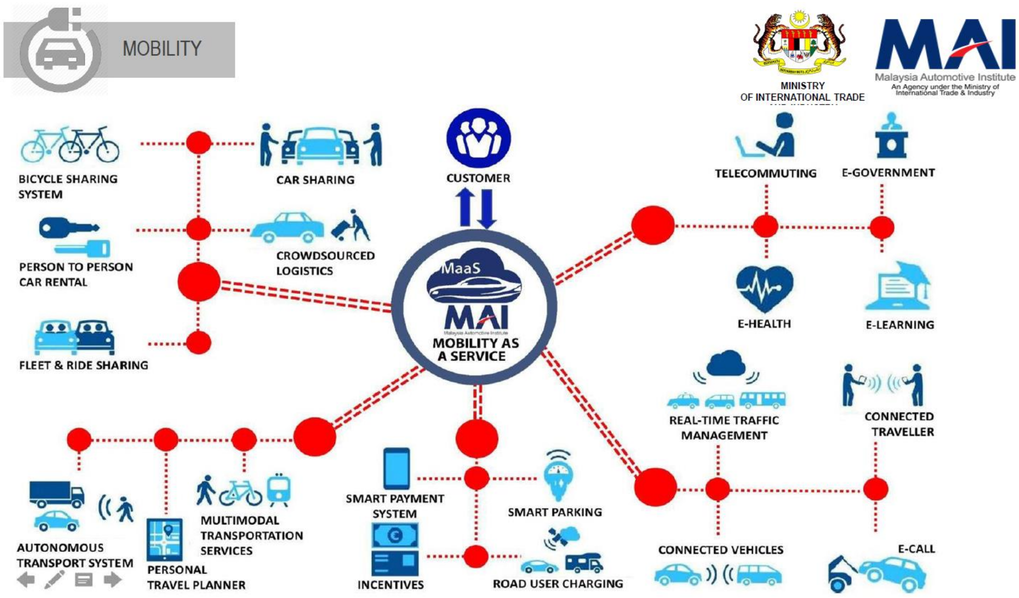
ITS = Intelligence Transport Systems.
Source: First workshop on 22 February 2018 presented by the Ministry of Transport.

In a bid to solve or improve transport problems, the planning and development of basic conventional land transportation infrastructures and facilities can benefit from the wealth of traffic data harvested through ITS implementation. Information mined from these traffic data will help support important transport policy decision-making and promote good governance.

The automobile industry itself faces new market challenges – improvements in technology, new entrants, shift to mobility as a service. Automobile manufacturers can exchange information directly with customers by collecting customers' driving situation or personal information such as travel, food and drink, music, etc.

In the wake of the trends, the Malaysia Automotive Institute takes mobility as a service and draws a mobility design of the future as follows.

Figure 2.16 Mobility Design for the Future



Source: Second workshop on 14 May 2018 presented by the Malaysia Automotive Institute.

Chapter 3

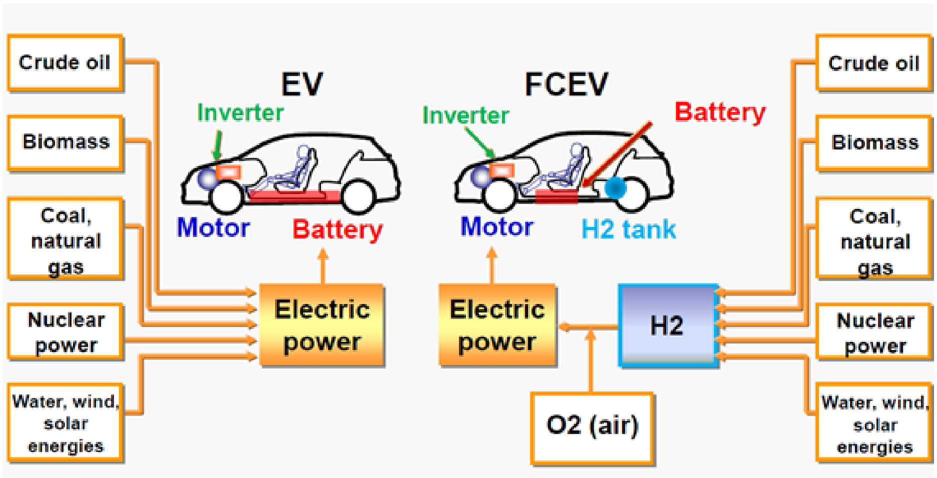
Promising Solutions for Reduced CO_2 Emissions from Automobiles

3.1 Next-Generation Vehicles

Since France and Britain in July 2017 announced their policy to end sales of petrol and diesel vehicles by 2040, similar movements of promoting clean automobiles have been spreading not only in the European Union but also in Asia, including India. In the wake of announcements from several governments, auto manufacturers around the world are pushing to develop environment-friendly vehicles.

In Japan, based on requests for emission reduction and contribution to a desirable energy mix in the future, Japanese automobile manufacturers are also developing so-called next-generation vehicles, such as hybrid vehicles, electric vehicles (EVs), plug-in hybrid vehicles (PHVs), fuel cell vehicles (FCEVs), and clean diesel vehicles.

Figure 3.1 Structure of EV and FCEV



EV = electric vehicle, FCEV = fuel cell vehicle, H2 = hydrogen.

Source: First workshop on 22 February 2018 presented by the Japan Automobile Manufacturers Association, Inc. (JAMA).

3.2 Japan's Roadmap for Next-Generation Vehicles

The Malaysian government is aiming for 100,000 EVs on the road by 2030. Japan has already authorised roadmaps for EVs and FCEVs, which may be a good reference for Malaysia in developing its own roadmap. The outline of Japan's roadmap is as follows.

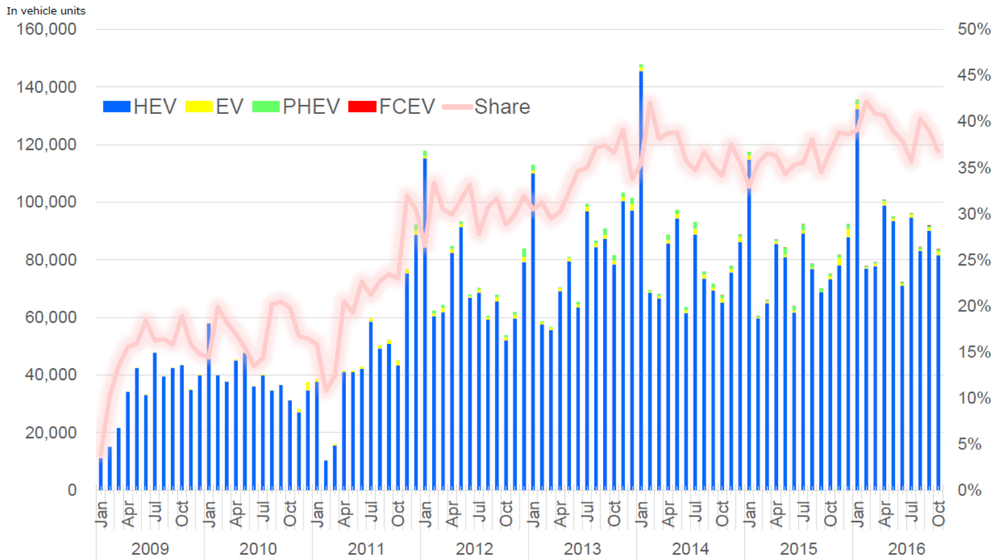
3.1.1 Japan's roadmap for next-generation vehicles

In terms of next-generation vehicles, the percentage of automobile sales have increased significantly since 2009 when promotion measures, such as government subsidies and preferential taxation, were launched. The proportion of next-generation vehicles in new car sales (passenger cars) in 2016 was about 35%. The holders of next-generation vehicles accounted for about 8% in 2015, and they have been growing sharply in recent years. Thanks to the government's continued incentive and subsidy programmes, next-generation vehicles have held a 25% share of the new car market in Japan. Almost all those vehicles are hybrid vehicles.

The trend is expected to contribute greatly to reducing CO_2 emissions in the future. Considering Japan's CO_2 reduction target of 80% in 2050, expansion of the EV market coupled with the use of renewable energy is a promising solution in well-to-wheel analyses. Thus, EVs have been getting a lot of attention in recent years.

Japan's government aims for next-generation vehicles to account for 50%–70% of new car sales by 2030.

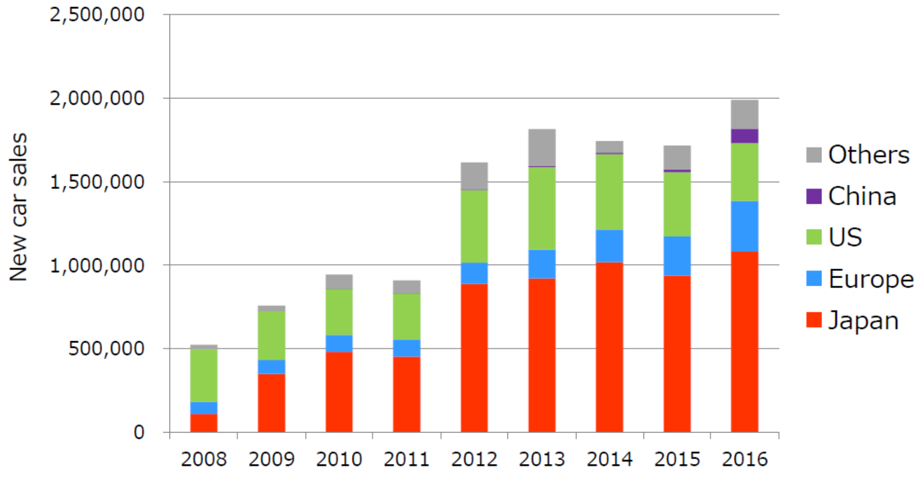
Figure 3.2 New Car Sales and Market Share of Next-Generation Vehicles in Japan



EV = electric vehicle, FCEV = fuel cell vehicle, HEV = hybrid vehicle, PHEV = plug-in hybrid vehicle.
Source: First workshop on 22 February 2018 presented by JAMA.

Regarding the trend in new car sales of hybrid vehicles around the world, the Japanese market is the largest, and the European market is expanding. On the other hand, the United States market is stagnant due to low fuel cost.

Figure 3.3 Trend in New Car Sales of Hybrid Vehicles Worldwide

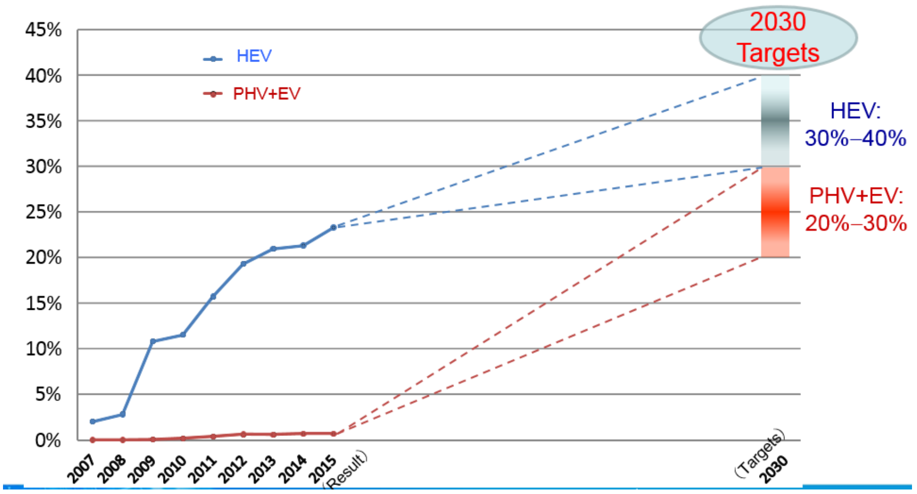


Source: First workshop on 22 February 2018 presented by JAMA.

(1) EV/PHV roadmap

On March 2016, Japan's Ministry of Economy, Trade and Industry (METI) announced the EV and PHV roadmap. This plan sets targets such as 1 million EVs and PHVs on the road in Japan by 2020 (the total number of sales of such cars at the end of 2016 was 140,000). It also calls for EVs and PHVs to account for 20%–30% of all new vehicles sold and 16% of all vehicles owned in 2030.

Figure 3.4 Japan's Roadmap for Electric Vehicles and Plug-in Hybrid Vehicles (Share amongst New Car Sales)

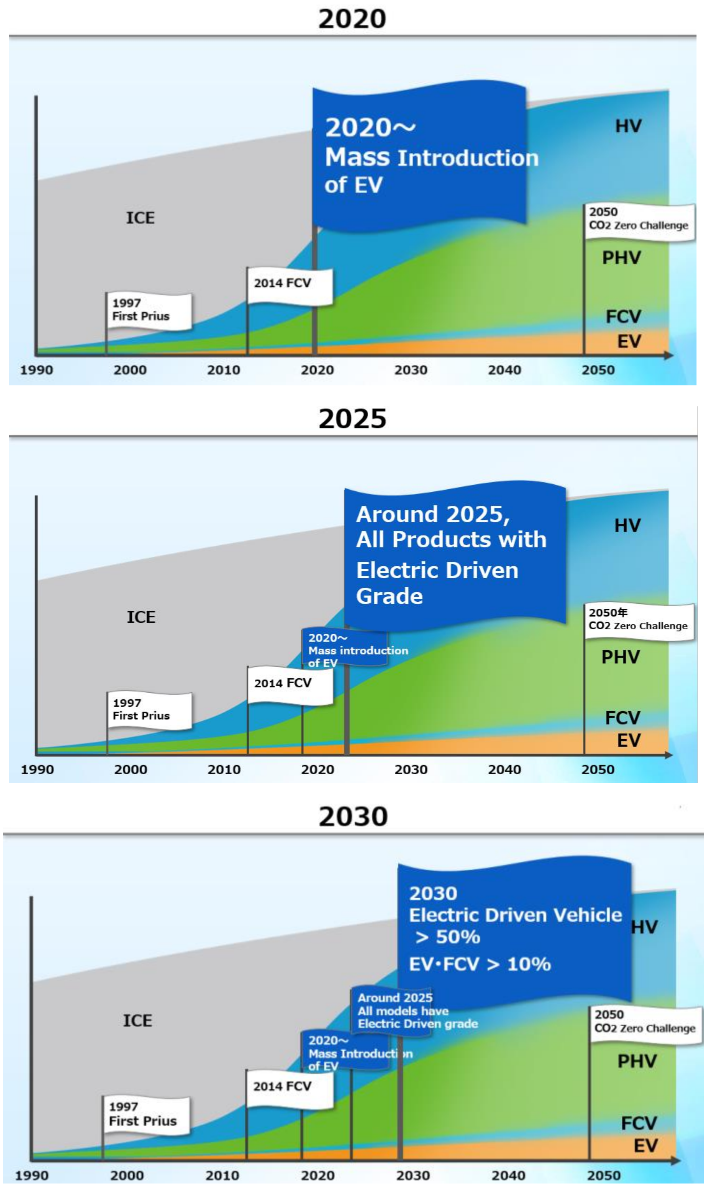


HEV = hybrid electric vehicle, PHV = plug-in hybrid vehicle.

Source: First workshop on 22 February 2018 presented by JAMA.

As for the development of electricity-driven vehicles, Toyota Motor Co. envisions acceleration of the current trend of internal combustion engine vehicles (ICE) shifting to all types of electricity-driven vehicles such as HEVs, PHVs, FCEVs, and EVs.

Figure 3.5 Deployment of Electricity-Driven Vehicles



Source: First workshop on 22 February 2018 presented by Toyota Motor Co.

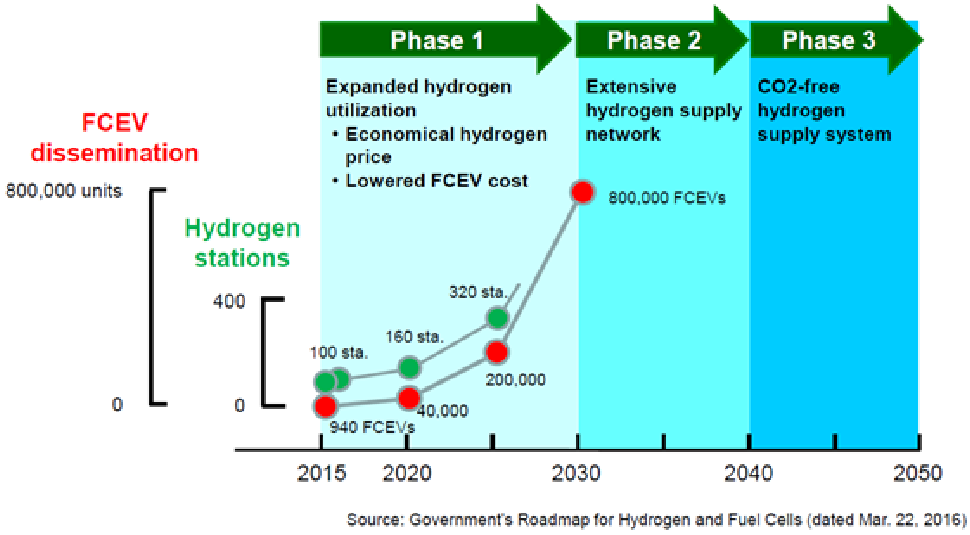
(2) FCEV roadmap

On December 2017, METI also released a revised version of its Strategic Roadmap for Hydrogen and Fuel Cells. It set targets for the dissemination and adoption of FCEVs in Japan – about 40,000 vehicles by 2020; about 200,000 vehicles by 2025; and about 800,000 vehicles by 2030.

The plan also included targets of about 160 hydrogen fuel stations by 2020 and 320 stations by 2025.

Instead of using a conventional ICE, FCEVs are equipped with a high-pressure hydrogen container that stores hydrogen fuel, and with a fuel cell stack that generates electric drive power. Consequently, like EVs, FCEVs are also considered zero-emission vehicles (ZEVs) because they do not directly emit carbon dioxide, nitrogen oxide, or other pollutants, leading to calls for the wider adoption of these vehicles.

Figure 3.6 Japan's Roadmap for Hydrogen and Fuel Cells



CO_2 = carbon dioxide, FCEV = fuel cell vehicle.

Source: First workshop on 22 February 2018 presented by JAMA.

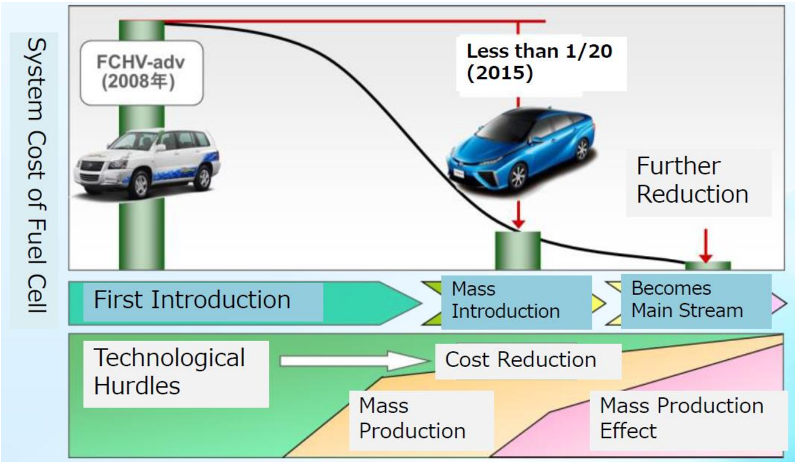
The price of FCEVs remains high. However, it is expected to decrease with reduced system costs in the future.

(3) EV charging structure

One big challenge in promoting EVs is in how to charge them. METI's compiled EV/PHV roadmap in 2016 shows the trajectory for the next 5 years. The policy on charging infrastructure is as follows:

- For public chargers, to eliminate the fear of car drivers for fuel (electricity) shortage, fill vacant areas (i.e. those with no charging stations), design them to optimise their placement, and set them up at easy-to-find nearby charging stations such as road stations and highway service areas/parking areas. In addition, the policy promotes large-scale installation, particularly at destinations with many customers.

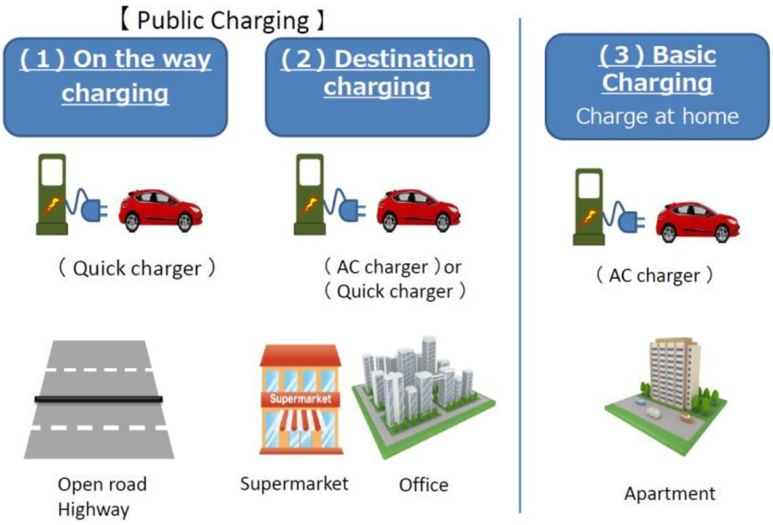
Figure 3.7 Cost Reduction of Fuel Cell Vehicles



FCHV = fuel cell vehicle.
Source: First workshop on 22 February 2018 presented by Toyota Motor Co.

- Setting up non-public chargers in apartments is extremely important because nearly 40% of the population lives in apartments or complex buildings.

Figure 3.8 Classification of Charging Infrastructure



Source: First workshop on 22 February 2018 presented by the Japan Automobile Research Institute (JARI).

Table 3.1 Charging Methods and Targets of Electric Vehicles

Methods		Targets
Public Charging	Quick chargers	By 2020 - Fill vacant areas where no charging station is installed, and thoroughly plan installation in common places such as road stations and highway service areas
	Normal chargers	By 2020 - Establish 20,000 units, especially in large-scale commercial facilities and accommodation facilities
Basic Charging	At apartments	By 2020 - Establish a new housing and large-scale repair in a joint housing (estimate: 2,000 units per year)
	At workplace	By 2020 - Establish workplace charging environment (estimate: about 9,000 units)

Source: METI, EV/PHV Roadmap (2016).

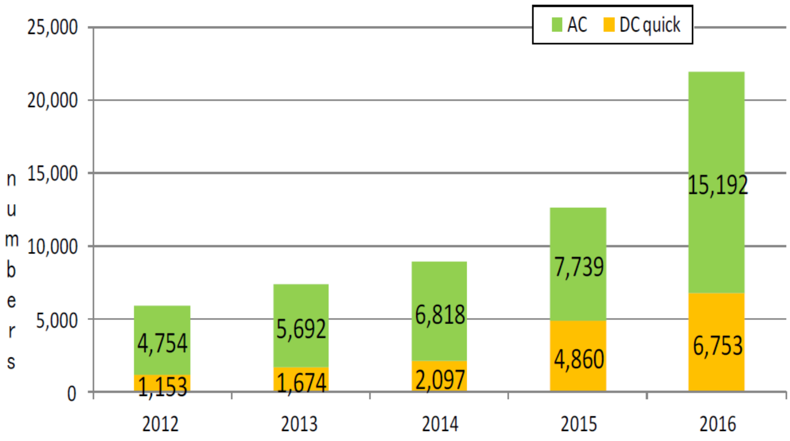
In December 2015, METI announced a deregulation to allow regular electricity chargers to be attached to fast chargers. This made it possible to use the same electric power receiving equipment and install regular chargers at locations such as roadside rest areas and highway service areas where fast chargers were already installed. This deregulation has promoted further installation of regular chargers.

As a result, the total number of regular and fast chargers in public has been increasing. In 2016, the number of public chargers was nearly 20,000 units, a 74% increase from that of the previous year.

In terms of the development of charging infrastructure, challenges to be currently faced are organised as follows:

- Elimination of blank service areas – in about 30 areas along expressways and major surface roads, chargers cannot be found over long distances
- Installation of chargers in condominiums – chargers remain unavailable at condominiums and apartments where 40% of Japanese live (less than 10% of EV owners are residents of collective housing)

Figure 3.9 Number of Public Chargers in Japan



Source: First workshop on 22 February 2018 presented by JARI.

- Shortening of waiting lines – waiting lines are now a common sight at some charging stations. This growing demand requires second and third chargers to be installed.
- Introduction of higher-output chargers – chargers with a higher output are needed to reduce the charging time and shorten the waiting line.[8]

3.3 EV Worldwide Trend[9]

(1) EV market

EV sales are on the rise in all major car markets worldwide. China is the largest electric car market globally, followed by Europe and the US. China has seen rapid growth in the last few years after the state set up ambitious EV targets. Norway is the global leader in terms of market share, with 40% in 2017.

The EV stock exceeded 3 million in 2017. However, EV still represents 0.3% of the global car fleet.

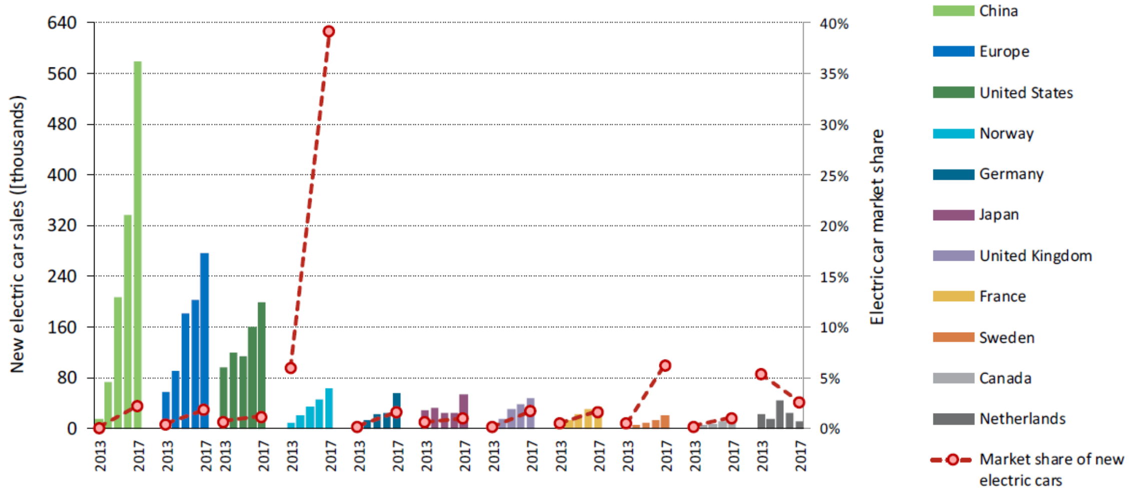
(2) Incentives/Regulations

EV uptake is still largely driven by the policy environment. Major leading countries in EV adoption have a range of policies in place to promote the uptake of EVs. Policies have been instrumental in making EVs more appealing to customers, reducing risks for investors, and encouraging manufacturers to scale up production.

[8] Source: First workshop on 22 February 2018 presented by JAMA.

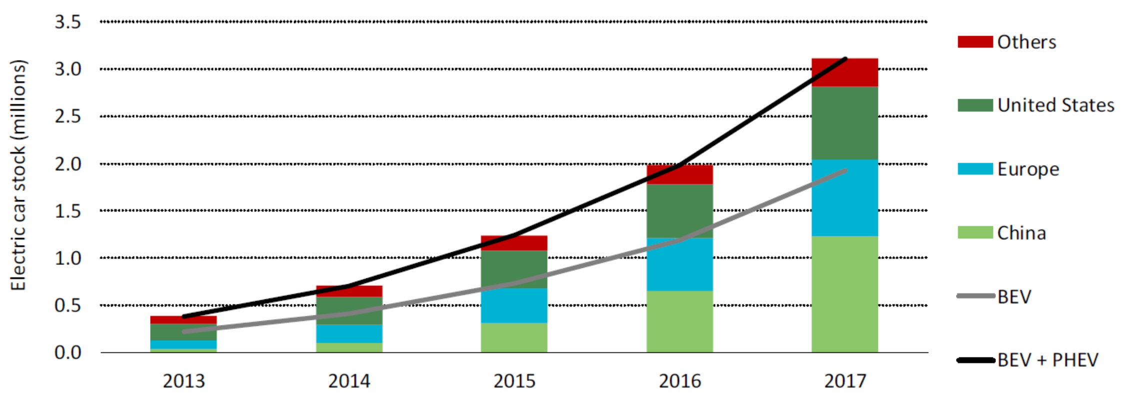
[9] IEA (2018).

Figure 3.10 Global Sales of Electric Vehicles



Source: International Energy Agency (2018).

Figure 3.11 Number of Electric Vehicles on the Road



BEV = battery electric vehicle, PHEV = plug-in hybrid vehicle.
Source: IEA (2018).

Key instruments adopted by local and national governments to support EV deployment are as follows:

- Public procurement
- Financial incentives facilitating acquisitions of EVs and reducing their usage cost (e.g. by offering free parking)
- Financial incentives and direct investment for the deployment of chargers
- Regulatory instruments, such as fuel economy standards and restrictions on the circulation of vehicles based on their tailpipe emissions performance

Figure 3.12 shows examples of financial support of government per EV purchaser (Nissan LEAF model) in major countries.

Figure 3.12 Examples of Financial Support from Government

Financial support per EV purchaser (LEAF model)

Good outlook   Uncertain outlook

	2017	2018	2019	2020
	Subsidy: ¥280k (¥400k max) Tax discount: ¥150.7k	Amounts undecided		
	$7,500 (approx. ¥810k)	←	←	
	RMB36k (approx. ¥610k)	←	RMB 27k (approx. ¥460k)	←
	€10,000 (approx. ¥1,230k)	←	←	←
	€11,500 (approx. ¥1,410k)	←	←	←
	£4,500 (approx. ¥680k)	←	Amounts undecided	
	€4,000 (approx. ¥490k)	←	←	

Source: First workshop on 22 February 2018 presented by JAMA.

(3) Charging infrastructure

Since EV owners mostly charge at home or at the workplace, private chargers far exceed public ones. However, publicly accessible chargers are important in ensuring expansion of the EV market; fast chargers are also essential for buses.

Regulatory policies on private chargers are also crucial. Building codes embedding requirements for 'EV-ready' parking is one key regulatory policy enabling greater EV deployment, with almost no incremental cost per square meter.

The agreement on the update of the European directive on the energy performance of buildings is the most significant development finalised in 2017.

One bottleneck of EVs is concerns about running short of power during driving. To solve this problem, in April 2018, the world's first electrified road that recharges the batteries of cars and trucks driving on it was opened in Sweden. About 2 km of electric rail was embedded in a public road near Stockholm, but the government's roads agency has already drafted a national map for future expansion.[10]

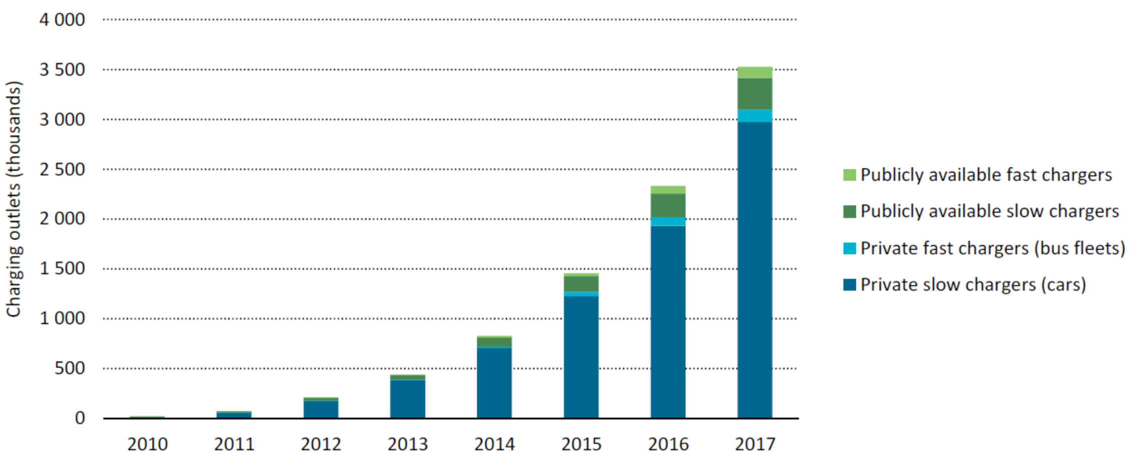
[10]https://www.theguardian.com/environment/2018/apr/12/worlds-first-electrified-road-for-charging-vehicles-opens-in-sweden

(4) EV batteries

Improving performance and reducing the price of EV batteries are indispensable for the spread of EVs. Because of technology progress and mass production, consumer electronics led to cost declines of Li-ion batteries. This benefited both EV packs, now set to deliver the next scale-up and stationary storage.

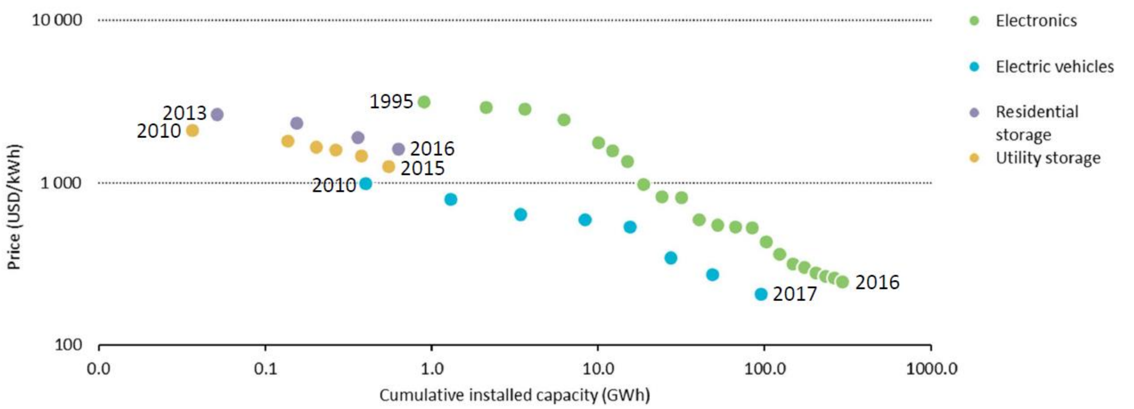
Battery size and manufacturing capacities have sizeable impacts on the cost of batteries per kilowatt-hour. Over time, both these factors will help in delivering significant cost reductions.

Figure 3.13 Number of Electric Vehicle Chargers



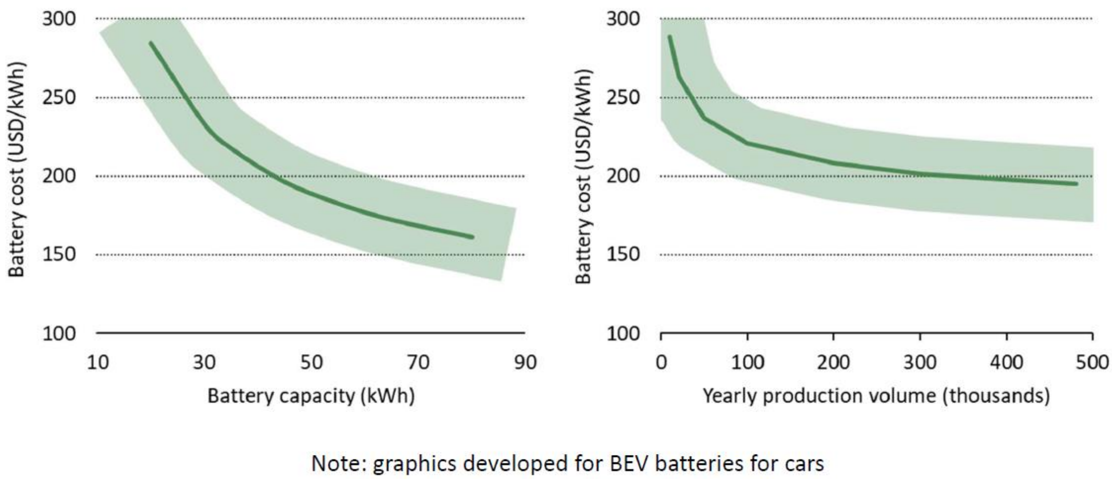
Source: IEA (2018).

Figure 3.14 Improvements on Li-ion Batteries



USD = United States dollars, GWh = gigawatt-hour, kWh = kilowatt-hour.
Source: IEA (2018).

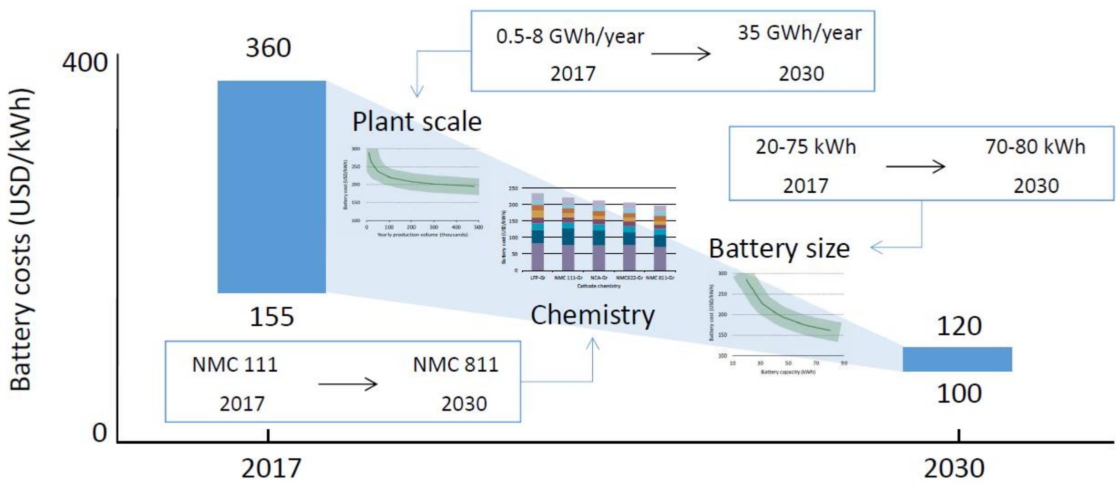
Figure 3.15 Improvements on Li-ion Batteries: Effects of Size and Production Volumes on Costs



USD = United States dollars, BEV = battery electric vehicle, GWh = gigawatt-hour, kWh = kilowatt-hour.
Source: IEA (2018).

The combined effect of manufacturing scale-up, improved chemistry, and increased battery size explain how battery cost can decline significantly in the next 10 to 15 years.

Figure 3.16 Li-ion Batteries: Further Cost Reductions

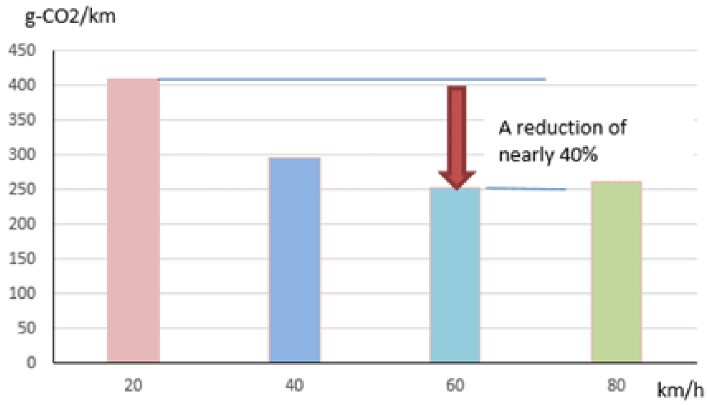


USD = United States dollars, GWh = gigawatt-hour, kWh = kilowatt-hour, NMC = nickel, manganese, cobalt.
Source: IEA (2018).

3.4 Traffic Flow Management Supported by Intelligent Transport Systems

CO_2 emissions from automobiles are influenced by their speed of travel. For example, if the driving speed improves from 20 km/h to 60 km/h, fuel efficiency will be improved; as a result, CO_2 emissions will be reduced by about 40%. Traffic congestion, especially in Kuala Lumpur's metropolitan area, is worsening. It is an important issue to facilitate reducing the traffic volume, smoothing traffic flow on the road, and increasing the driving speed.

Figure 3.17 Relationship between Vehicle Velocity and CO_2 Emissions

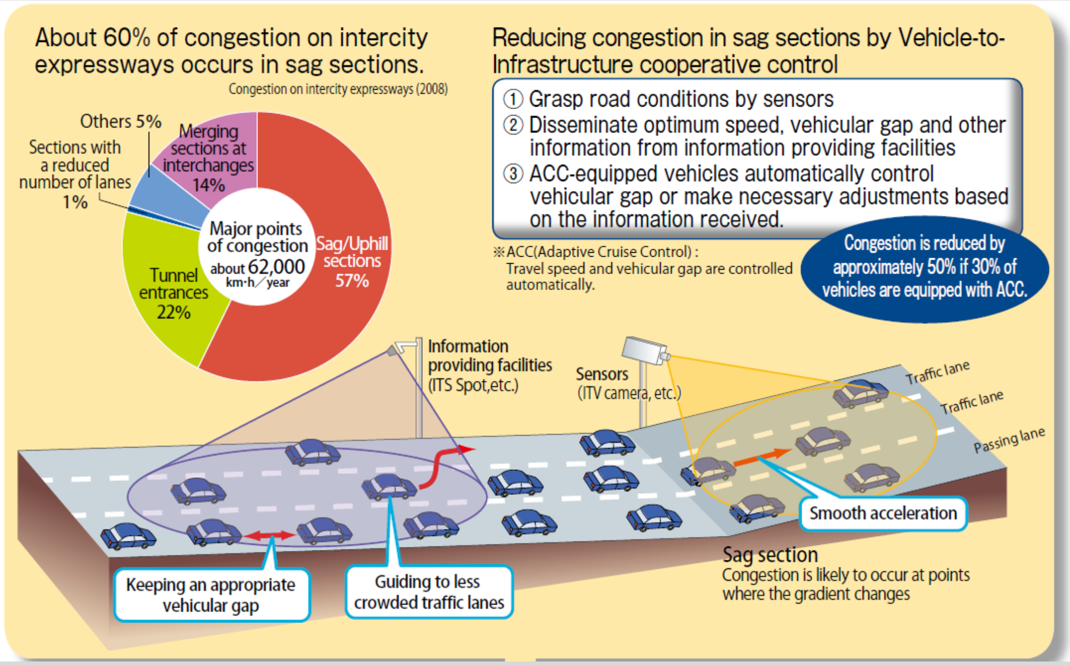


Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan (2010).[11]

[11] http://www.mlit.go.jp/hakusyo/mlit/hakusho/h20/html/j1211200.html

Box 3.1 ITS Spot Technology in Japan

As for an example of utilising Intelligent Transport Systems in Japan, vehicle-to-infrastructure cooperative control has been implemented to reduce congestion. On intercity expressways, nearly 60% of congestion occurs in sag section where the gradient changes. ITS spots have been set up along expressways to determine road conditions and provide information. Vehicles equipped with adaptive cruise control– (ACC) automatically control vehicular gap or make necessary adjustments based on the information received. A study shows that congestion is reduced by roughly 50% if 30% of vehicles are equipped with ACC.



Source: Ministry of Land, Infrastructure, Transport and Tourism (2012).

Chapter 4

Scenario Analysis towards Reduced CO_2 Emissions in Malaysia

4.1 Methodology

Using the econometric approach, the study team estimated energy demand projections up to 2040. The team took historical energy demand data from the National Energy Balance published by the Energy Commission of Malaysia. The economic indicators used in energy modelling such as gross domestic product (GDP) were taken from World Bank's World Development Indicators. Energy modelling involved the estimation of final energy consumption and the corresponding primary energy requirements or supply.

The study team applied the econometric approach in forecasting final energy demand. The team derived historical correlation between energy demand as well as macroeconomic and activity indicators through regression analysis using Microfit. Microfit is an interactive software package written for microcomputers and is designed especially for the econometric modelling of time series data. It has powerful features for data processing, file management, graphic display, estimation, hypothesis testing, and forecasting under various univariate and multivariate model specifications.

The future energy demand for various energy sources were estimated using assumed values of the macroeconomic and activity indicators. Future values of these indicators were also derived using historical data depending on the sufficiency of such analysis. In the model structure, energy demand is modelled as a function of activity such as income, industrial production, number of vehicles, number of households, number of appliances, floor area of buildings, etc. In the residential sector, for example, the demand for electricity could be a function of the number of households, disposable income, and penetration rate of electrical appliances. In the commercial sector, energy consumption could be driven by building floor arrears, private consumption, and other factors that encourage commercial activities. However, due to unavailable information on the activity indicators, macroeconomic data, which is GDP, was the best variable to search for the relationship with the energy demand trend. GDP information was broken down into industry GDP, commercial GDP, agriculture GDP, and manufacturing GDP. These macroeconomic indicators were mainly used to generate the model equations. In some cases, where regression analysis is not applicable due to insufficiency of data or there is failure to derive a statistically sound equation, other methods such as share of percentage approach are used.

4.2 Scenario Assumptions

One main driver of the modelling assumption is GDP growth rates. The GDP growth rates assumption forecast was based on IHS data from a study conducted by the Economic Planning Unit of Malaysia. Most of all, the energy demand equations for Malaysia were using GDP as the key factor to determine future projections. This was due to the high correlation between energy demand and GDP. Table 4.1 shoes the assumption of GDP growth rates.

Table 4.1 GDP Growth Assumptions for 2040, by Sector, % per Year

GDP Growth Rate, %	2016–2020	2021–2025	2026–2030	2031–2035	2036–2040
Agriculture	2.16	2.26	2.09	1.91	1.74
Mining & Quarrying	0.01	1.01	3.03	3.74	5.17
Manufacturing	3.55	3.16	2.77	2.47	2.30
Construction	3.44	3.01	2.54	2.26	2.09
Services	4.41	4.42	3.67	3.07	2.67
Total GDP	3.88	**3.77**	**3.19**	**2.74**	**2.43**

Source: IHS data from Economic Planning Unit (EPU) (2016).

Besides GDP future growth rates, the annual average population growth was also considered as one of the main key drivers for future energy growth. In 2015, Malaysia's population was 31 million and is projected to increase by 10.5 million (33.9%) to 41.5 million in 2040. However, the annual population growth rate would be decreasing from 1.15% in 2016–2020 to 1.02% in 2021–2025, 0.87% in 2026–2030, 0.74% in 2031–2035, and 0.63% in 2036–2040. This situation is in tandem with the targeted decline in fertility rate and international migration. The assumption of future growth rates of population was obtained from the Department of Statistics Malaysia (Table 4.2).

Table 4.2 Population Growth Assumptions for 2040

	2016–2020	2021–2025	2026–2030	2031–2035	2036–2040
Population (million)	33.80	36.00	38.10	39.90	41.50
Population growth (%)	1.15	1.02	0.87	0.74	0.63

Source: Department of Statistics (2016).

One key element contributing to GHG emissions in land transport is vehicle kilometre travelled (VKT). To obtain this information, data from the Malaysian Institute of Road Safety Research (MIROS) was used. A study was conducted by MIROS to obtain the data. This study aims to validate the VKT value for private vehicles. Questionnaire survey using face-to-face interview or self-completion survey was the method of data collection. This study used convenient sampling and involved only users of private vehicles (motorcycles, cars, multipurpose vehicles, sports utility vehicles, and vans) in Peninsular Malaysia. The findings show differences in distance travelled for motorcycles and cars. The average annual kilometre travelled for motorcycles is 21,495 km whilst that for cars is 28,184 km. Different demographic groups travel differently. On the validation part, results show that both methods (survey and secondary data) indicate that the relative standard error value is less than 25%, which means that the data is reliable.

Table 4.3 Average Annual Kilometre Travelled, by Mode of Transport

	Average Annual Kilometre Travelled	**Data Source**
Car	28,184	https://www.miros.gov.my/1/publications.php?id_page=19&id_event=580
Motorcycle	21,495	
Bus	77,112	Estimated by Mr Zaharin, Energy Commission
Goods Vehicles	48,598	

Source: Energy Commission (2018).

The other parameter that may contribute to energy demand in the transport sector is the fuel economy of vehicles, which can be presented as average fuel consumption (litre/100 km). Under this project, the assumption for the data was taken from the Energy Efficiency Office of the Electrical and Mechanical Services Department (EMSD) of Hong Kong. Realising the importance of energy efficiency and conservation, the EMSD has commissioned the development of energy utilisation indexes and benchmarking tools for selected energy-consuming groups in Hong Kong since 2001. Energy utilisation indexes and benchmarking tools are important to understand energy consumption levels and performance. The energy utilisation index primarily indicates the energy consumption level and energy use intensity of different operating entities. The energy consumption benchmark is based on the development of a benchmarking system for any energy consumption subgroup, which allows the user to benchmark his own energy consumption performance with others having similar operational and physical characteristics.

Table 4.4 Average Fuel Consumption, by Mode of Transport

	Average Fuel Consumption (litre/100 km)
Car Petrol	12.82
Car Diesel	10.80
Car Gas	15.77
Motorcycle Petrol	4.10
Bus Diesel	35.07
Bus Gas	29.30
Good Vehicle Diesel	22.10

Source: Electrical and Mechanical Services Department website, http://ecib.emsd.gov.hk/en/indicator_trp.htm

Since the transport sector is the second-largest emitter after power generation, there are several potential measures to reduce CO_2 emissions in this sector.

Table 4.5 List of Potential Scenarios

Scenarios	**Assumptions**
BAU	Business as Usual, extension of historic trend
EEV	Energy-efficient vehicle scenario: Lower growth rates of petrol demand in land transport compared to BAU scenario at 17%
EV	Electric vehicle scenario: The share of electric vehicles (car and motorcycles) amongst total vehicles will be 10% by 2040
BIO	Biofuel scenario: Increase blending of palm oil in diesel, B10[12] by 2020, and B15 by 2025
PT	Public transport scenario: Switching mode of transportation from car to rail
APS	Advanced policy scenario: Combination of all scenarios, EEV + EV + BIO + PT

Source: Assumptions by Mr Zaharin, Energy Commission (2018).

[12] Biofuel 10.

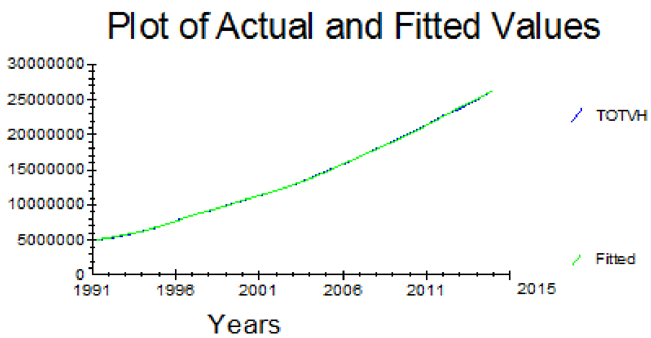
4.3 Results for Business-as-Usual Scenario

4.3.1 Total number of vehicles

The demand function for total number of vehicles can be developed through the Microfit software. Figure 4.1 shows that the total number of vehicles is highly correlated with GDP per capita – if national income increases, the total number of vehicles will also increase. Based on the results, the demand function for total number of vehicles is as below:

Figure 4.1 Microfit Result for Total Number of Vehicles

```
                              Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TOTVH
 25 observations used for estimation from 1991 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                   -843345.8            244546.1            -3.4486[.002]
 GDPC                     267283.4             55242.5             4.8384[.000]
 TOTVH(-1)                  .97362             .014363            67.7845[.000]
*******************************************************************************
 R-Squared                     .99984   R-Bar-Squared                    .99983
 S.E. of Regression           86475.1   F-stat.    F(  2,  22)   70789.4[.000]
 Mean of Dependent Variable  1.39E+07   S.D. of Dependent Variable      6642299
 Residual Sum of Squares     1.65E+11   Equation Log-likelihood       -318.0658
 Akaike Info. Criterion     -321.0658   Schwarz Bayesian Criterion    -322.8942
 DW-statistic                  1.8936   Durbin's h-statistic       .26676[.790]
*******************************************************************************
```



TOTVH: -843345.8 + 267283.4 * GDPC + 0.97362 * TOTVH (-1)

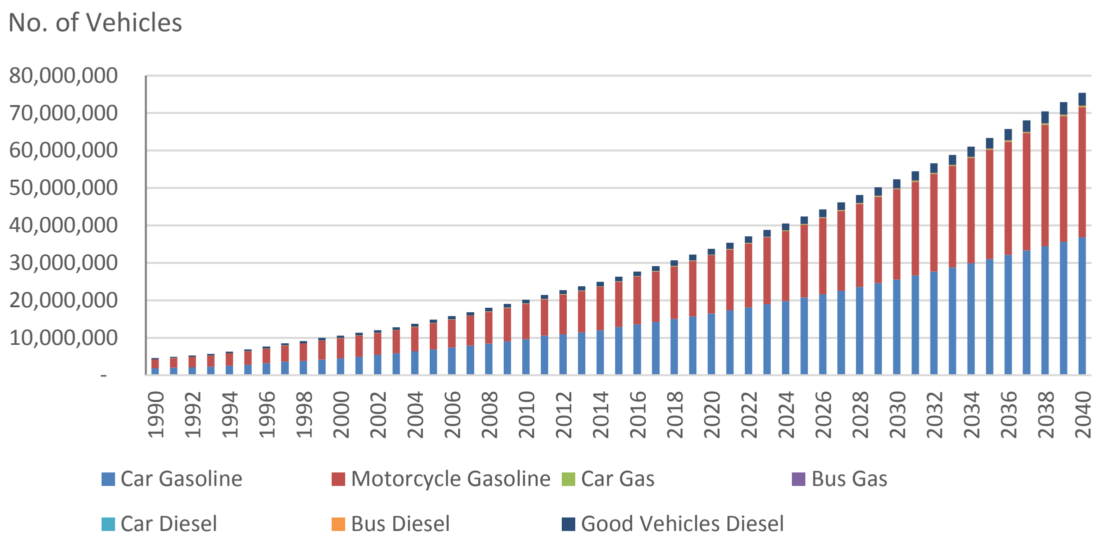
Where: TOTVH = Total Number of Vehicles

GDPC = Gross Domestic Product per capita

Source: Data calculated modelling results by Mr. Zaharin, Energy Commission (2018)

Figure 4.2 shows the number of vehicles from 2015 until 2040. This projection was based on the results obtained from Microfit. By using the above demand function, the equation then will be inputted into the LEAP software, which will generate the projection from the base year, 2015, until 2040, which is the end period. Based on the projection, the average annual growth rate for the total number of vehicles is expected to increase at 4.3% per year. We assume that by 2040, total vehicles in Malaysia will number 75 million. Most of these will be cars and motorcycles.

Figure 4.2 Projection of Total Number of Vehicles, 2015–2040



Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

4.3.2 Final energy consumption in land transport

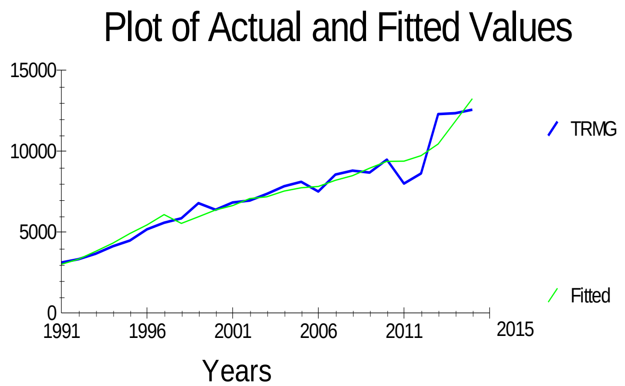
1) Motor gasoline

The demand function for final energy consumption of motor gasoline in land transportation can be developed by using the Microfit software. Figure 4.3 shows that final energy consumption of motor gasoline in land transportation is highly correlated with GDP, crude oil prices, and car production.

By using the above demand function, the equation will then be inputted into the LEAP software, which will generate the projection from the base year, 2015, until 2040, the end period. Based on the projection, the average annual growth rate for final energy consumption of motor gasoline in land transportation is expected to increase at 3.55% per year.

Figure 4.3 Microfit Result for Energy Consumption of Motor Gasoline in Land Transport

```
                        Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TRMG
 25 observations used for estimation from 1991 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                     93.9696             417.6461            .22500[.824]
 GDP                       33.0365              10.2585            3.2204[.004]
 RPOIL                     -1966.7             983.9401           -1.9988[.059]
 PDCAR                      2.3211               2.7906            .83176[.415]
 TRMG(-1)                   .15146               .20847            .72650[.476]
*******************************************************************************
 R-Squared                     .94379   R-Bar-Squared                    .93254
 S.E. of Regression          685.6980   F-stat.    F(  4,  20)    83.9463[.000]
 Mean of Dependent Variable    7290.3   S.D. of Dependent Variable       2640.1
 Residual Sum of Squares      9403635   Equation Log-likelihood       -195.9451
 Akaike Info. Criterion     -200.9451   Schwarz Bayesian Criterion    -203.9923
 DW-statistic                  1.8844   Durbin's h-statistic             *NONE*
*******************************************************************************
```



TRMG: 93.9696 + 33.0365 * GDP + (-1966.7) * RPOIL + 2.3211 * PDCAR + 0.15146 * TRMG (-1)

Where: TRMG = Motor Gasoline Consumption in Land Transportation

GDP = Gross Domestic Product

RPOIL = Crude Oil Prices

PDCAR = Production of Cars

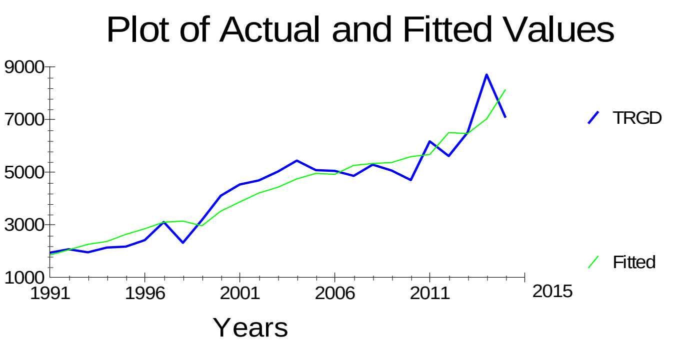
Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

2) Diesel

The demand function for final energy consumption of diesel in land transport can be developed by using Microfit software. Figure 4.4 shows that final energy consumption of diesel in land transport is highly correlated with GDP and retail prices of diesel.

Figure 4.4 Microfit Result for Energy Consumption of Diesel in Land Transport

```
                         Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TRGD
 25 observations used for estimation from 1991 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                     -1.2873           575.1317           -.0022383[.998]
 GDP                       15.3517             5.2173              2.9424[.008]
 RPRGD                     -6974.5            21191.9              -.32911[.745]
 TRGD(-1)                   .40778             .21744              1.8754[.075]
*******************************************************************************
 R-Squared                    .88111   R-Bar-Squared                    .86413
 S.E. of Regression         663.4684   F-stat.    F(  3,  21)   51.8778[.000]
 Mean of Dependent Variable   4365.0   S.D. of Dependent Variable       1799.9
 Residual Sum of Squares     9243998   Equation Log-likelihood       -195.7311
 Akaike Info. Criterion    -199.7311   Schwarz Bayesian Criterion    -202.1688
 DW-statistic                 2.0017   Durbin's h-statistic             *NONE*
*******************************************************************************
```



TRGD: -1.2873 + 15.3517 * GDP + (-6974.5) * RPRGD + 0.40778 * TRGD (-1)

Where:	TRGD	= Diesel Consumption in Land Transportation
	GDP	= Gross Domestic Product
	RPRGD	= Retail Prices of Diesel

Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

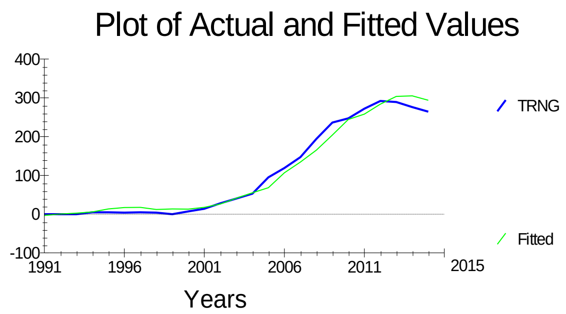
By using the above demand function, the equation will then be inputted into the LEAP software, which will generate the projection from the base year, 2015, until 2040, the end period. Based on the projection, the average annual growth rate for final energy consumption of diesel in land transport is expected to increase at 4.11% per year.

3) Natural gas

The demand function for final energy consumption of natural gas in land transportation can be developed by using the Microfit software. Figure 4.5 shows that the final energy consumption of natural gas in land transportation is highly correlated with GDP and retail prices of motor gasoline.

Figure 4.5 Microfit Result for Energy Consumption of Natural Gas in Land Transport

```
                              Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TRNG
 25 observations used for estimation from 1991 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONST                     -6.8176            28.9096            -.23583[.816]
 GDP                        .22130             .16385             1.3506[.191]
 RPRMG                   -244.5459           518.0731            -.47203[.642]
 TRNG(-1)                   .90196             .089560            10.0711[.000]
*******************************************************************************
 R-Squared                     .98209   R-Bar-Squared                   .97953
 S.E. of Regression           16.6169   F-stat.    F(  3,  21)  383.8341[.000]
 Mean of Dependent Variable  103.8400   S.D. of Dependent Variable    116.1453
 Residual Sum of Squares       5798.6   Equation Log-likelihood      -103.5546
 Akaike Info. Criterion     -107.5546   Schwarz Bayesian Criterion   -109.9923
 DW-statistic                  .57487   Durbin's h-statistic      3.9847[.000]
*******************************************************************************
```



TRNG: -6.8176 + 0.22130 * GDP + (-244.5459) * RPRMG + 0.90196 * TRNG (-1)

Where; TRNG = Natural Gas Consumption in Land Transportation

GDP = Gross Domestic Product

RPRMG = Retail Prices of Motor Gasoline

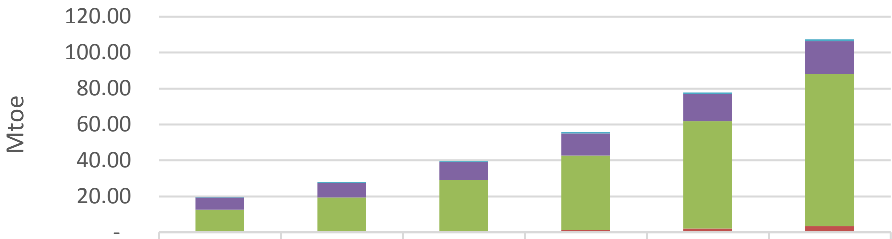
Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

By using the above demand function, the equation will then be inputted into the LEAP software, which will generate the projection from the base year, 2015, until 2040, the end period. Based on the projection, the average annual growth rate for final energy consumption of natural gas in land transportation is expected to increase by 6.1% per year.

4) Total final energy demand

Total final energy demand in BAU scenario will increase from 19.72 Mtoe in 2015 to 107.41 Mtoe in 2040, or at an average annual growth rate of 7% per year. Final demand of natural gas and gasoline will have the highest average annual growth rates of 10.7% and 8.0% per year from the 2015 level to 2040, respectively. Electricity demand will grow from 0.02 Mtoe in 2015 to 0.08 Mtoe in 2040, or by 5% per year. Diesel demand will increase 4.1% per year from 2015 until 2040 and biofuel will grow from 0.39 Mtoe in 2015 to 1.06 Mtoe in 2040, or an increase of 4.1% per year.

Figure 4.6 Final Energy Consumption in Land Transport, by Fuel (BAU Scenario)

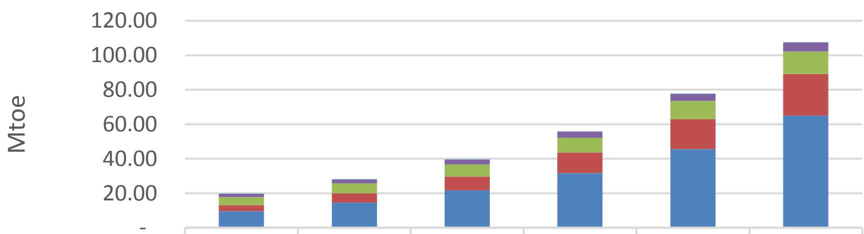


	2015	2020	2025	2030	2035	2040
Biofuel	0.39	0.47	0.58	0.71	0.87	1.06
Diesel	6.72	8.21	10.05	12.29	15.03	18.38
Gasoline	12.33	18.84	28.15	41.37	59.69	84.53
Natural Gas	0.26	0.46	0.77	1.29	2.10	3.36
Electricity	0.02	0.03	0.04	0.05	0.06	0.08

BAU = business-as-usual scenario, Mtoe = million tonnes of oil equivalent.
Source: Study team.

Final energy demand by mode of transport shows that cars and motorcycles will lead the growth with 8% per year from 2015 until 2040. Rail growth will follow, growing from 0.02 Mtoe in 2015 to 0.08 Mtoe in 2040, or by 5% per year. Buses are expected to increase from 4.72 Mtoe in 2015 to 13.04 Mtoe in 2040, or a growth rate of 4.2% per year. Goods vehicles will have average annual growth of 4.1% per year from 2015 until 2040.

Figure 4.7 Final Energy Consumption in Land Transport, by Mode (BAU Scenario)

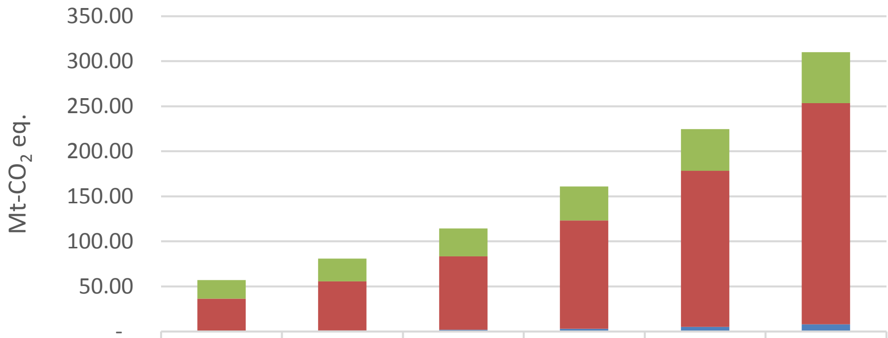


	2015	2020	2025	2030	2035	2040
Rail	0.02	0.03	0.04	0.05	0.06	0.08
Good Vehicles	1.87	2.28	2.79	3.42	4.18	5.11
Bus	4.72	5.77	7.07	8.67	10.63	13.04
Motorcycle	3.54	5.41	8.08	11.88	17.14	24.27
Car	9.57	14.51	21.60	31.68	45.73	64.90

BAU = business-as-usual scenario, Mtoe = million tonnes of oil equivalent.
Source: Study team.

In the BAU scenario, total CO_2 emission in land transportation is expected to grow around 7% per year from 2015 until 2040, reaching 310.01 Mtoe. CO_2 emission from natural gas will have the fastest growth at 10.7% per year in 2015–2040. As a result, CO2 emissions from natural gas are projected to increase to 8.07 million tonnes of CO2 eq. (Mt-CO_2) in 2040 from 0.63 Mt-CO_2 eq. in 2015. CO_2 emissions from gasoline will experience an annual growth rate of 8.0% per year in 2015–2040, from 35.78 Mt-CO_2 eq. in 2015 to 245.32 Mt-CO_2 eq. in 2040. CO_2 emissions from diesel will increase by 4.11% per year from 2015 until 2040.

Figure 4.8 CO2 Emissions in Land Transport, by Fuel (BAU Scenario)



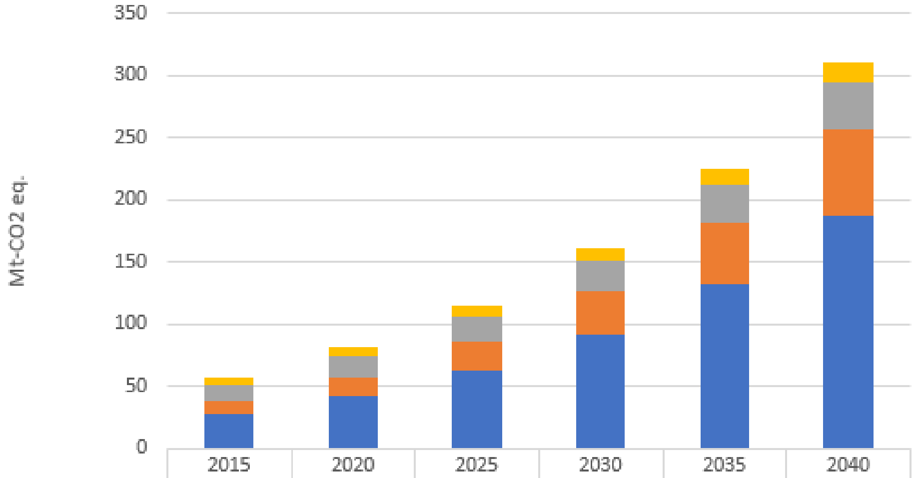
	2015	2020	2025	2030	2035	2040
Diesel	20.69	25.30	30.95	37.85	46.30	56.63
Gasoline	35.78	54.67	81.69	120.05	173.24	245.32
Natural Gas	0.63	1.10	1.85	3.08	5.04	8.07

BAU = business-as-usual scenario.
Source: Study team.

In the BAU scenario, CO_2 emissions from motorcycles are expected to increase by 8% per year from 2015 until 2040. This is followed by cars at 7.94% per year to reach 186.78 Mt-CO_2 eq. in 2040 compared with 27.66 Mt-CO_2 eq. in 2015. CO_2 emissions from buses are expected to increase by 4.15% per year from 13.73 Mt-CO_2 eq. in 2015 to 37.89 Mt-CO_2 eq. in 2040. CO_2 emissions from goods vehicles will experience an average annual growth rate of 4.11% per year from 2015 until 2040.

Figure 4.9 CO_2 Emissions in Land Transport, by Mode

(BAU Scenario)



	2015	2020	2025	2030	2035	2040
Good Vehicles	5.440755793	6.65459249	8.139237063	9.955106955	12.17609878	14.89259555
Buses	13.72550614	16.80478939	20.57978899	25.21223661	30.90073697	37.89089002
Motorcycles	10.2755205	15.70123296	23.46086675	34.47773861	49.75035296	70.45095576
Car	27.65983974	41.91296407	62.31637798	91.34699609	131.7419822	186.7781217

BAU = business-as-usual scenario, Mt-CO_2eq. = million tonnes of carbon dioxide equivalent.
Source: Study team.

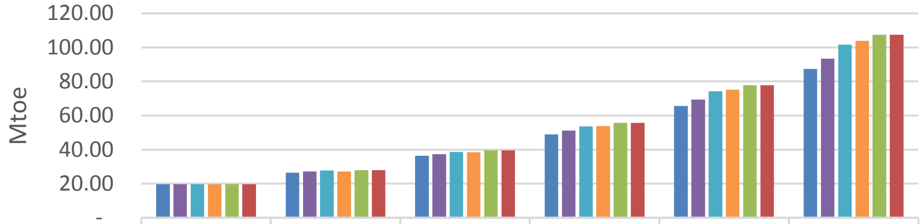
4.4 Results for Alternative Policy Scenario

Final energy consumption by scenario showed that BAU and bio scenarios will lead growth with 7.02% per year from 2015 until 2040. This will be followed by the PT scenario, growing from 19.72 Mtoe in 2015 until 103.85 Mtoe in 2040, or 6.87% growth per year. Final energy consumption in the EV scenario is expected to increase from 19.72 Mtoe in 2015 to 101.6 Mtoe in 2040, or a growth rate of 6.78% per year. Final energy consumption in the energy-efficient vehicles (EEV) scenario will have an average annual growth of 6.42% per year from 2015 until 2040, whilst the final energy consumption for the alternative policy scenario (APS) is expected to increase by 6.13% per year from 2015 until 2040.

Total CO_2 emissions in land transportation in the bio scenario will increase from 57.1 Mt-CO_2 eq. in 2015 to 304.31 Mt-CO_2 eq. in 2040, which amounts to an average annual growth rate of 6.92% per year. CO_2 emissions for land transportation under the PT scenario will have average annual growth rate of 6.85% from the 2015 level to 2040. The EV scenario is expected to increase around 6.65% per year. Total CO_2 emissions under the EEV scenario are expected to increase by 6.39% per year from 2015 until 2040, whilst under the APS scenario, total CO_2 emissions for land transportation will be 238.08 Mt-CO_2 eq. in 2040 compared with 57.10 Mt-CO_2 eq. in 2015.

Figure 4.10 Total Final Energy Consumption in Land Transport,

by Scenario

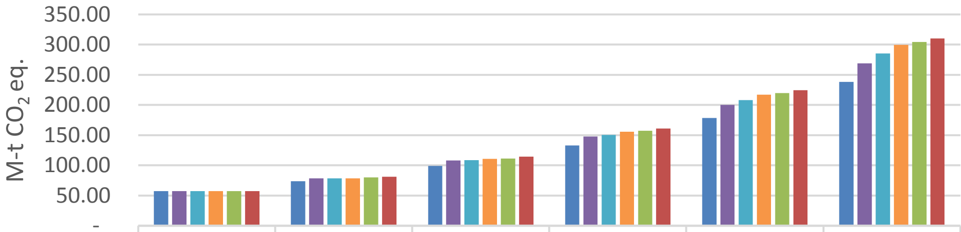


	2015	2020	2025	2030	2035	2040
APS	19.72	26.50	36.35	48.99	65.66	87.35
EEV	19.72	27.22	37.39	51.15	69.44	93.34
EV	19.72	27.70	38.64	53.71	74.18	101.60
PT	19.72	27.19	38.36	53.92	75.20	103.85
BIO	19.72	28.01	39.59	55.70	77.75	107.41
BAU	19.72	28.01	39.59	55.70	77.75	107.41

APS = alternative policy scenario, BAU = business-as-usual scenario, BIO = biofuel, EV = electric vehicle, EEV = energy-efficient vehicle, Mtoe = million tonnes of oil equivalent, PT = public transport.

Source: Study team.

Figure 4.11 Total CO_2 Emissions in Land Transport,
by Scenario



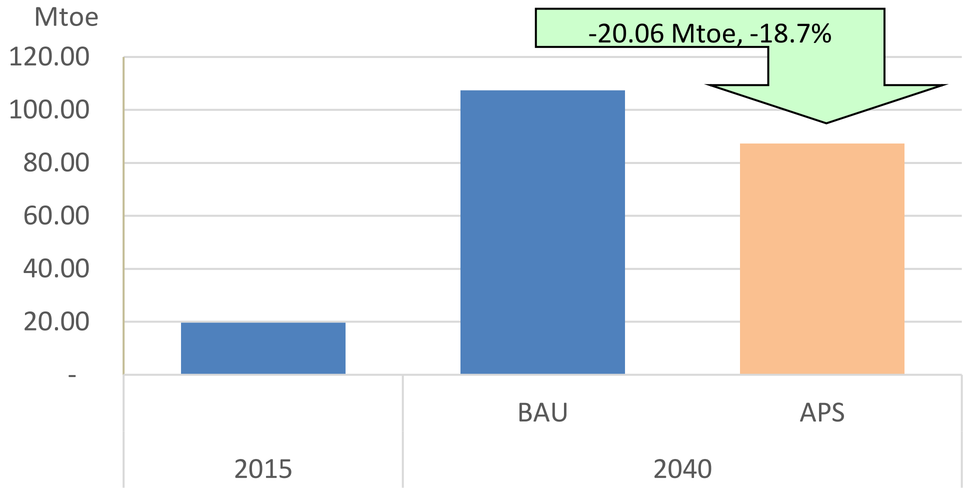
	2015	2020	2025	2030	2035	2040
APS	57.10	73.93	98.93	133.03	178.52	238.08
EEV	57.10	78.73	108.02	147.60	200.16	268.71
EV	57.10	78.63	108.68	150.61	208.08	285.48
PT	57.10	78.66	110.92	155.77	217.08	299.50
BIO	57.10	79.86	111.38	157.18	219.90	304.31
BAU	57.10	81.07	114.50	160.99	224.57	310.01

APS = alternative policy scenario, BAU = business-as-usual scenario, BIO = biofuel, EV = electric vehicle, EEV = energy-efficient vehicle, Mt-CO_2eq. = million tonnes of carbon dioxide equivalent, PT = public transport.

Source: Study team.

The energy savings that could be achieved under the APS, relative to the BAU scenario, because of EEVs and fuel-switching efforts are estimated at about 20.06 Mtoe in 2040, or 18.7%. In the APS, total final energy consumption is projected to increase at a slower rate than in the BAU scenario at 6.13% per year from 19.72 Mtoe in 2015 to 87.35 Mtoe in 2040. Motorcycles and cars will be growing fastest at average rates of 7.6% per year and 6.7% per year, respectively. Rail will also increase fast but at a slower rate of 5.1% per year between 2015 and 2040. Bus and goods vehicles will have slower growth rates of 3.9% per year from 2015 until 2040 from the BAU scenario.

Figure 4.12 Total Final Energy Consumption in Land Transport, BAU and APS

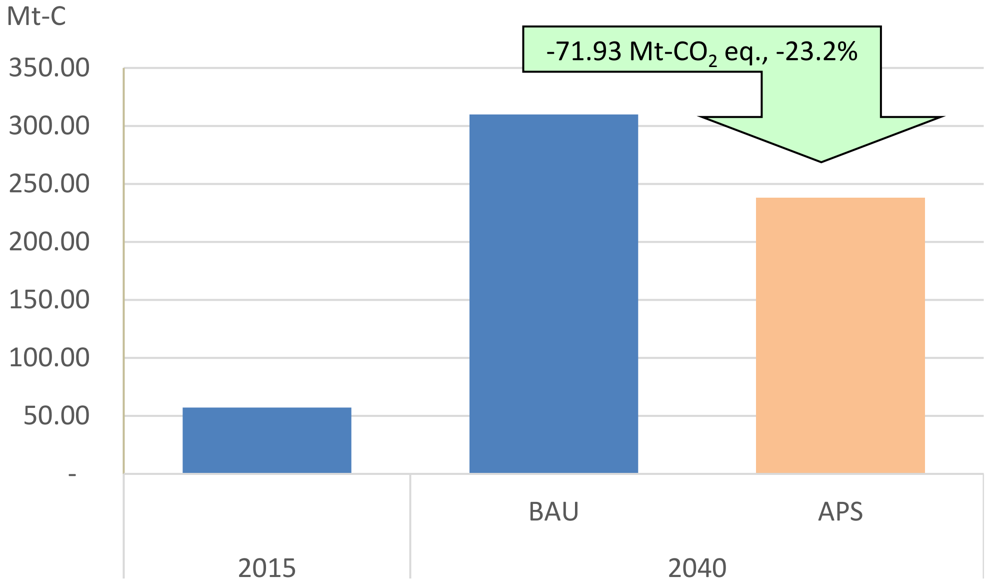


APS = alternative policy scenario, BAU = business-as-usual scenario, Mtoe = million tonnes of oil equivalent,

Source: Study team.

In the APS, the annual increase in CO_2 emissions from 2015 to 2040 will be lower than in the BAU scenario at 5.88% per year, which is consistent with the growth in final energy consumption. The reduction in CO_2 emissions in the APS scenario of 71.93 Mt-CO_2 eq. or 23.2% relative to the BAU scenario is also due to a significant decrease in gasoline and diesel consumption in all types of transport modes. The introduction of EEVs and EVs will significantly reduce CO_2 emissions in the land transport sector.

Figure 4.13 Total CO_2 Emissions in Land Transport, BAU and APS

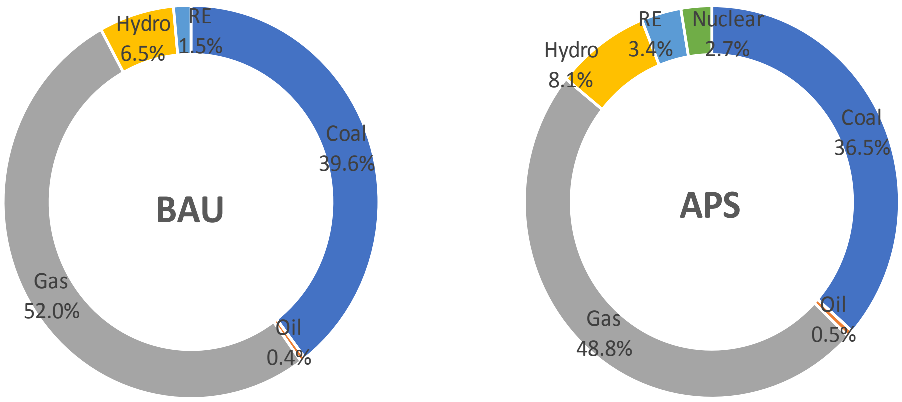


APS = alternative policy scenario, BAU = business-as-usual scenario, Mt-C = million tonnes of coal, Mt-CO_2eq = million tonnes of carbon dioxide equivalent.
Source: Study team.

Figure 4.14 shows the power generation mix for BAU and APS scenarios in 2040. In the BAU scenario, power generation mix will be dominated by natural gas and coal in 2040 with shares of 52.0% and 39.6%, respectively, followed by hydro with a share of 6.5% in 2040. The share of renewable energy will be 1.5% of the total power generation in 2040; oil share will be at 0.4% in 2040. By promoting more efforts in energy efficiency, renewable energy, and nuclear energy in power generation, the share of gas and coal is expected to be reduced to 48.8% and 36.5%, respectively, under the APS scenario. The share of hydro, including major and mini hydro, will increase to 8.1% in the APS scenario. More aggressive implementation of renewable energy through the feed-in tariff mechanism, net energy metering, and large-scale solar programme would have resulted in a higher share of renewable energy at 3.4% in 2040. The introduction of nuclear power after the year 2036 will contribute a share of 2.7% in 2040. The remaining share of 0.5% of oil is expected to remain low.

Based on results presented in Figure 4.15, in the BAU, total CO_2 emissions from power generation are projected to increase by 2.7% per year in 2015– 2040. By 2040, the CO_2 level is expected to increase to 194.32 Mt-CO_2 eq.

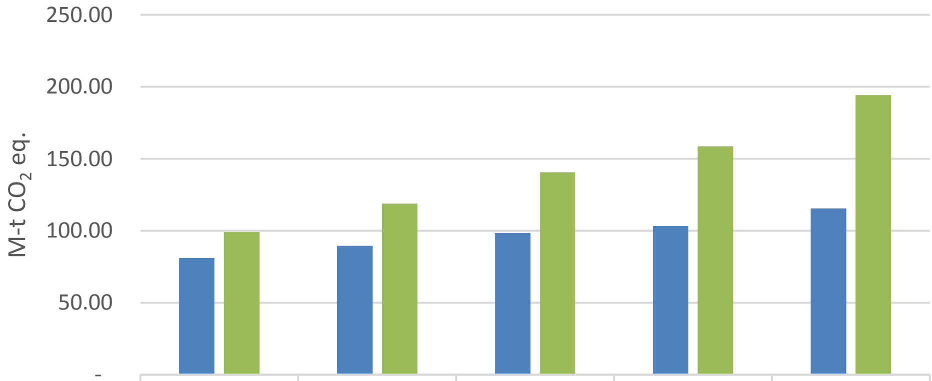
Figure 4.14 Power Generation Mix for BAU and APS, 2040



APS = alternative policy scenario, BAU = business-as-usual scenario, RE = renewable energy.
Source: Study team.

In the APS, the annual increase in CO_2 emissions from 2015 to 2040 will be lower than in the BAU scenario at 1.4% per year. Reduced CO_2 emissions in the APS of 78.7 Mt-CO_2 eq. or 40.5% relative to the BAU scenario is also due to a significant decrease in coal consumption for power generation in the APS as coal consumption is being replaced by natural gas and other clean energy sources such as nuclear and renewable energy. Furthermore, the lower energy usage in the industry and the 'others' sectors have also contributed to the reduction. This indicates that Malaysia's energy-saving effort and renewable energy action plan would be effective in reducing CO_2 emissions.

Figure 4.15 CO_2 Emissions in Power Generation, BAU and APS



	2020	2025	2030	2035	2040
APS	81.01	89.49	98.49	103.40	115.65
BAU	99.16	118.84	140.68	158.74	194.32

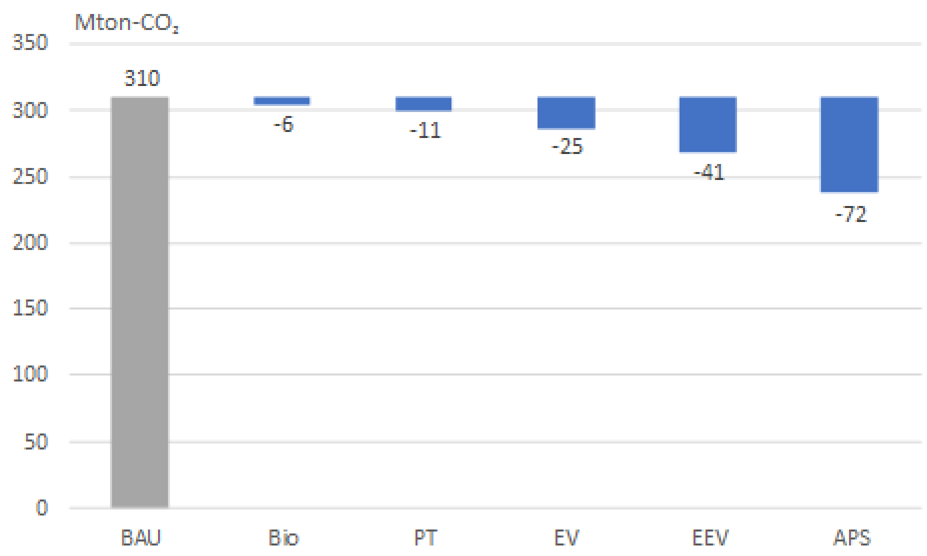
APS = alternative policy scenario, BAU = business-as-usual scenario, Mt-CO_2eq = million tonnes of carbon dioxide equivalent.
Source: Study team.

Chapter 5

Policy Recommendations

Referring to the result of the scenario analyses, the deployment of energy-efficient vehicles (EEV scenario) has the larger potential in reducing CO_2 emissions, followed by electric vehicles (EV scenario), public transport (PT scenario), and biofuels (bio scenario).

Figure 5.1 Potential of Reducing CO_2, by Scenario (2040)



APS = combination of all the scenarios, BAU = business-as-usual scenario, bio = assumes more biofuel supply; EEV = assumes energy-efficient vehicle deployment; EV = assumes EV deployment; Mt-CO_2eq = million tonnes of carbon dioxide equivalent, PT = assumes larger modal shift to public transport.

Source: Study team.

When classifying the options in two dimensions – reducing CO_2 and determining the time line of action – deployment of EEVs can be easily achieved. The next priority goes to public transport as it has a larger CO_2 reduction potential compared to biofuels, and lastly, the EVs. Although Malaysia can expect large CO_2 reductions, it needs to wait for reduced vehicle costs, spread of charging stations, and development of low-carbon electricity.

Table 5.1 Classification of CO_2 Reduction Scenarios in Two Dimensions

	CO_2 Reduction	Timeline of Action
Biofuel	Small	Short term
Public transport	Small	Short term
Electric vehicle	Medium	Long term
Energy-efficient vehicle	Large	Immediate

Source: Study team.

Following the above classification, this study discussed two parts to reduce CO_2 emission in the transport sector.

Part 1 Maximise use of public transport

Part 2 Deploy low emission vehicles

The first part is concerned with maximising use of public transport, such as high-speed railways, underground lines, light railways, and buses, which have higher energy efficiency than vehicles. It particularly suits large city and inter-city passenger and cargo transport. Considering that landmark railway projects are under way in Malaysia, the priority of recommendation is on how to increase ridership of, rather than suggest developing, public transport (recommendations 1 and 2 below).

Recommendation 1. Boost connectivity amongst various kinds of transportation

- To make the most use of upcoming railway projects, transport hubs are a key component to encourage people to use and shift to public transport

Recommendation 2. Provide last one mile mobility[13] using innovative technology, shared autonomous vehicles (SAVs)

- SAVs can provide people with ultimate access to transport hubs, such as railway stations or bus depots, which would accelerate modal shift.

Other recommendations to increase ridership of public transport

- Strictly implement parking regulations and conduct police patrols (park at lots or be fined)
- Restrict car driving within a certain zone.

[13] Last mile is a term used in transportation planning to describe the movement of people from a transportation hub to a final destination.

- Implement load pricing for a certain zone.
- Provide public transport with enough capacity.
- Construct comfortable (safe and clean) bicycle and pedestrian ways.

The second part is concerned with deploying low-emission vehicles. Although costlier than conventional internal combustion engine (ICE) vehicles, new vehicle technologies are emerging and becoming commercially available. Considering that the policy promoting EEVs was implemented in Malaysia after the National Transportation Plan 2014 and had resulted in EEVs accounting for 52% of new car sales in 2017,[14] the main recommendation is the difficult option of promoting EVs (recommendations 3, 4, and 5).

Recommendation 3. Take an integrated approach to increase low-emission vehicles

- Since all stakeholders, government, businesses, and the public have rules to deliver, they need to do their share in reducing CO_2 emissions.

Recommendation 4. Support zero-emission vehicles (ZEVs) to penetrate the market

- More diffusion of renewables is unavoidable.
- In the early stage of the ZEVs market, government support is indispensable.
- A governmental pilot project might bring a new perspective to the EV/FCEV market.

Recommendation 5. Set up smart power grids

- EV battery plays an important role in power grids, considering a massive introduction of renewables.

The following sections 5.1 to 5.5 discuss the details of recommendations 1 to 5.

5.1 Boosting connectivity amongst modes of land transport

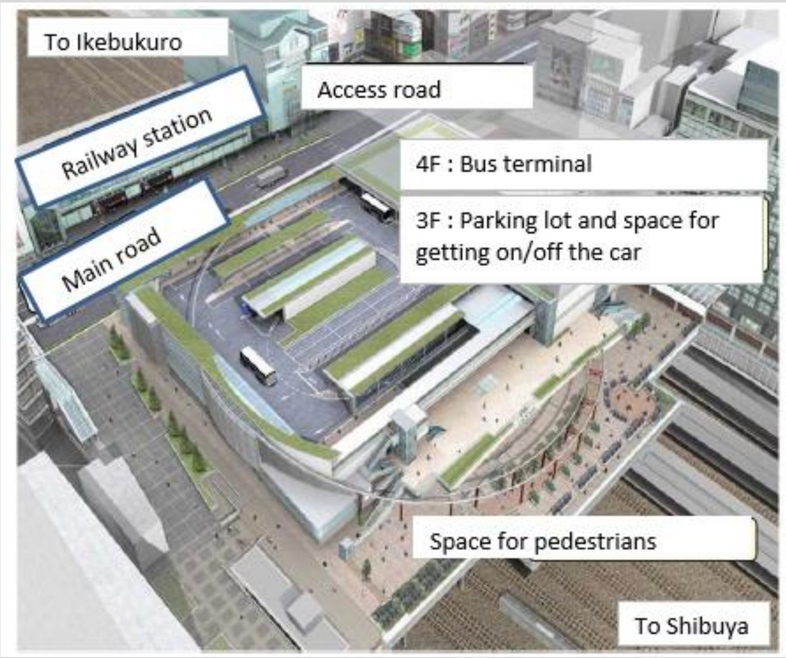
Connectivity is essential in encouraging people to use public transportation more. In these days, the transport hub plays an important role for people to move easily and comfortably, and to shift to other modes of transport. Specific facilities of the transport hub include a railway station, bus terminal, free passage and stairs, and square in front of the station. For example,

[14] Malaysia Automotive Institute, Technology Development in Transportation Sector, Malaysia, May 2018.

the station square is a facility connecting multiple transport modes. Recently, improvements have been made because of increased demand for more comfort and convenience. In addition, with urbanisation, required functions are also diversified. From the viewpoint of users, it is important to improve the transport hub to boost continuity of movement.

Box 5.1 Examples of Improving the Transport Hub in Japan

The biggest railway station in Japan, Shinjuku station, a large land transport system, which is convenient, comfortable, and user-friendly, is located in one place.



Easy to transit between LRT&Bus

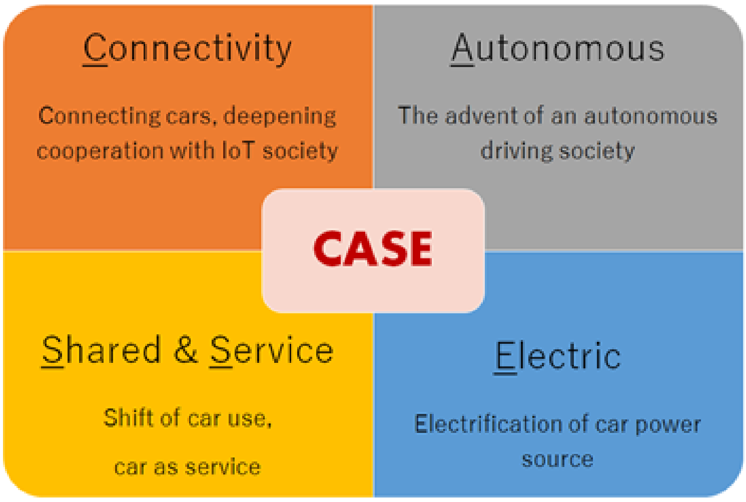
Development of bus location system

LRT = light rail transit.
Source: Ministry of Land, Infrastructure, Transport and Tourism (MLIT) website.

5.2 Improving Last 1-Mile Mobility to Promote Modal Shift

Drastic environment changes regarding automobiles, often referred to as 'CASE (connected, autonomous, shared, electric)', will lead to the transformation of the automobile- and mobility-related lifestyle as well as of the society. Autonomous, or self-driving or robotic, vehicles will affect future transportation. For a sustainable society, it is reasonable to make the most of SAVs.

Figure 5.2 Innovative Four Drives to Change Future Mobility



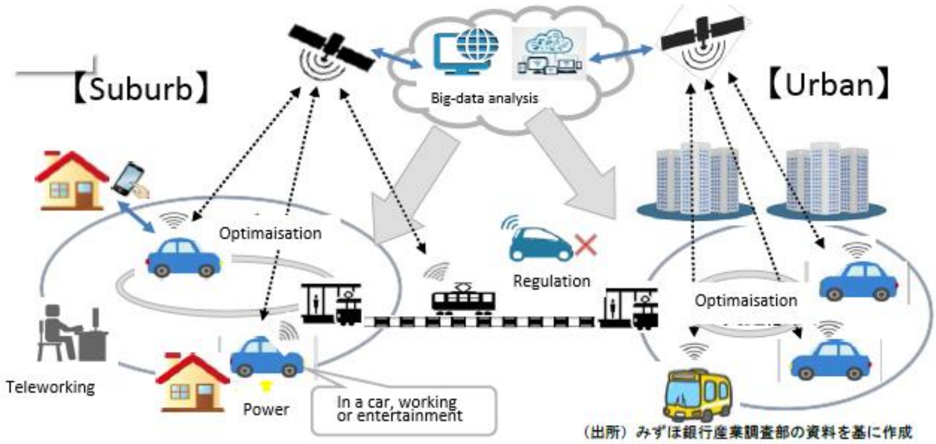
IoT = internet of things.
Source: IEEJ developed based on METI's Strategic Commission for the New Automotive Era on 18 April 2018.

In Malaysia, millions of people use their vehicles to commute, or they are obliged to do so because they do not have any other convenient and reasonable modes of transport. As for the-last-one-mile mobility to their home, workplace, school, or other places, SAVs, such as bus rapid transit, demand bases, robotic taxies, will provide access to the nearest transport and transit systems, which definitely encourages people to use public transportation more. As a result, road congestion will be mitigated, and the burden on the environment will be reduced.

SAVs are also expected to solve other administrative problems. Making the most of the existing infrastructure helps governments curb their investment in new infrastructure. SAVs are the vital piece that will not only save energy and reduce emissions but will also decongest highways, free up parking lots for other urban uses, cut transportation costs, and improve walkability and liveability. SAVs will also urge local businesses in Malaysia to enter the mobility service market and expand business opportunities.

In the automated driving society, robot taxies are constantly in operation, and people can move seamlessly without waiting (Figure 5.3). In Japan, for instance, car-sharing has been gaining popularity.

Figure 5.3 Autonomous Driving Society for the Future



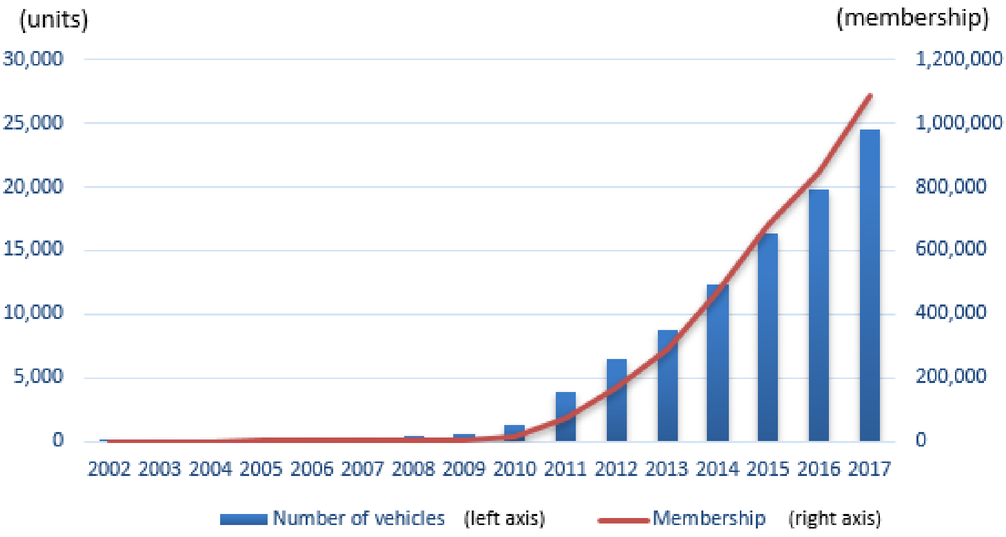
Source: IEEJ developed based on METI's Strategic Commission for the New Automotive Era on 18 April 2018.

The membership of car-sharing surpassed 1 million for the first time in 2017. The number has been growing by double digits for the past several years and is expected to continue to grow. The number of vehicles has reached 23,000 units, which means it doubled over the last 3 years. Especially in the urban areas, accessible cars near homes or workplaces are increasing, which helps car-sharing gain momentum. Even auto manufacturers are keen on entering the market.

As a worldwide trend, consumers' preference for cars has been shifting from ownership to convenience and ecological usage. The concept of sharing matches this trend. For example, Singapore's first electric car-sharing service was officially launched In December 2017, with 80 cars and 32 charging stations available for public use across the island (Aravindan, 2017). Not only in developed countries but in Thailand, Toyota launched a 2-year car-sharing project to study motorist behaviour in Bangkok in January 2018, using ultra-compact electric cars (Harman, 2018).

If Malaysia makes the most of 'CASE' trends, a huge reduction in CO_2 emissions might be achievable. What kind of sharing services is suitable or acceptable to people in Malaysia is dependent on various factors, such as accessibility to the public transport network, climate, or cultural and economic conditions. It is a good opportunity for Malaysia to latch on to the trend and technology related to it and formulate user-driven transport policies.

Figure 5.4 Car-Sharing: Number of Vehicles and Membership in Japan



Source: IEEJ developed based on the data from the Eco-Mobility Foundation, Japan.

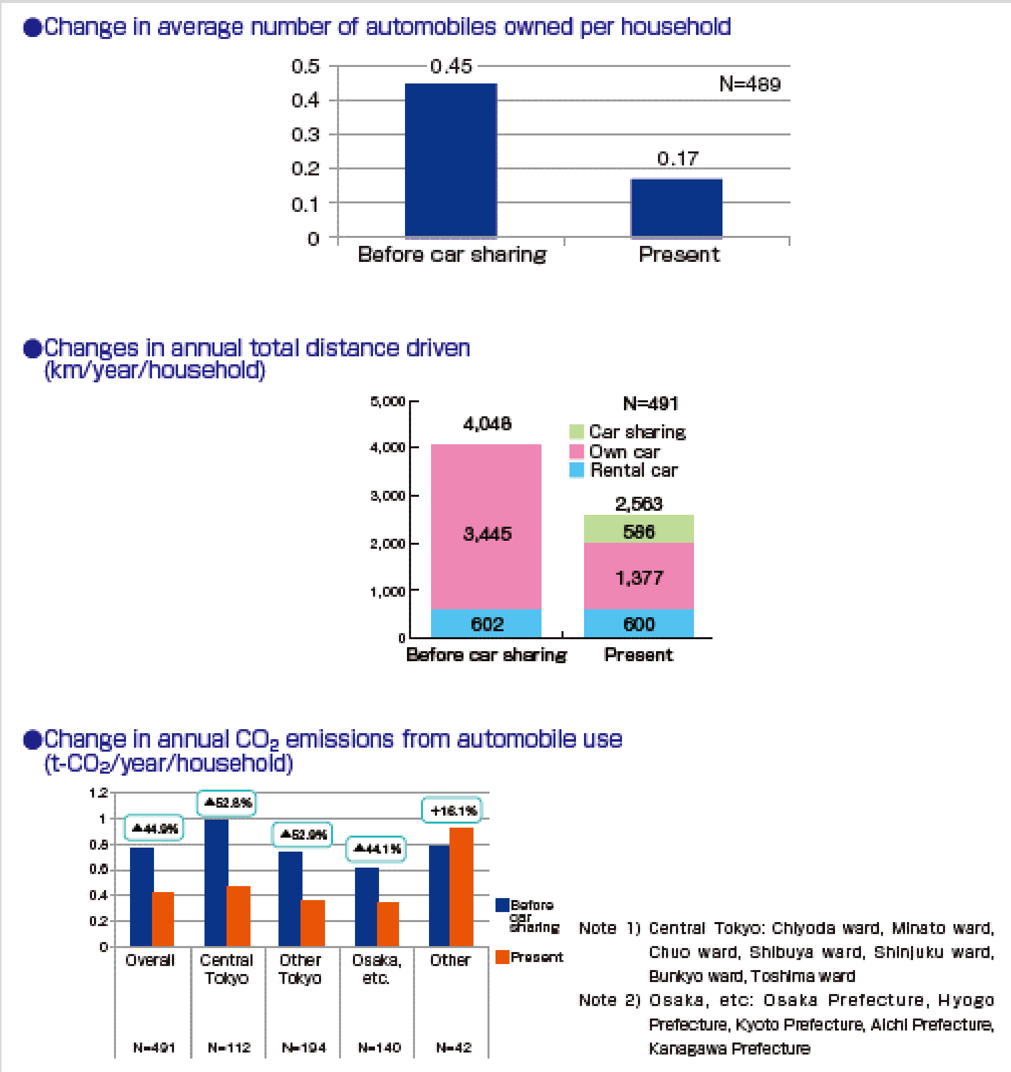
5.3 Suggestions to Take Integrated Approach with the Four Pillars

Since automobiles emit the most CO_2, fuel efficiency must be improved. In Japan, ZEVs such as EVs and FCEVs are already on sale but the costs are still very high. When thinking about the overall social cost, various initiatives, known as the 'integrated approach', could be most effective and realistic in reducing CO_2 emissions. The integrated approach consists of four pillars as follows. The bottom line is that not only auto industries but the other players including government, drivers, and fuel suppliers are required to do their part.

a) Fuel-efficient vehicles by auto industry
   - Improvement of fuel economy
   - Development of next-generation vehicles
b) Efficient vehicle usage by driver
   - Practice of eco-driving
   - Improvement of load efficiency in truck use
c) Improving traffic flow by government
   - Electric toll collection
   - Intelligent transport system (ITS)
d) Diversified fuel supply by fuel supplier
   - Biofuel
   - Hydrogen fuel
   - Electricity supply

Box 5.2 Effectiveness of Car-Sharing on the Environment

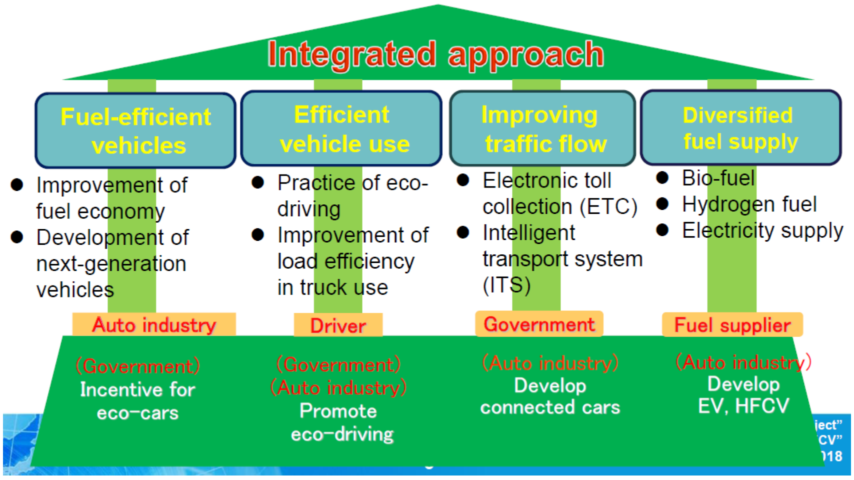
In 2012, the Eco-Mobility Foundation in Japan evaluated the effectiveness of car sharing at reducing environmental impact. A survey of car sharers was carried out with the cooperation of five major car-sharing operators. The survey found a decrease of over 60% in the number of cars owned per household after joining a car-sharing scheme, a decrease of just below 40% in average annual miles driven, and an average annual reduction in automobile CO_2 emissions of 0.34ton (45%).



CO_2 = carbon dioxide, t-CO_2 = ton of carbon dioxide.

Source: Eco-Mobility Foundation (2017).

Figure 5.5 Integrated Approach – Four Pillars



EV = electric vehicle, HFCV = hydrogen fuel cell vehicle.

Source: First workshop on 22 February 2018 presented by JAMA.

5.4 Support Zero-Emission Vehicles to Penetrate the Market

The reason EVs are drawing attention worldwide is that they help control CO_2 emissions since they do not emit CO_2 when running.

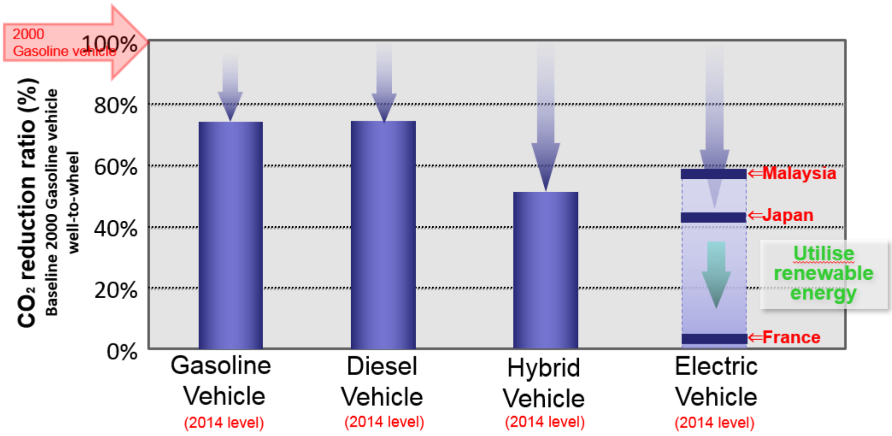
However, there are some points to be aware of. The impact on CO_2 emissions reduction will change widely, depending on how electricity is generated as an energy source for EVs. No matter how much emission while traveling is zero, there is no point if electricity is produced by burning fossil fuels.

On the other hand, if electricity for EVs can be generated only by zero-emission power supply, which does not emit CO_2, it will be possible to reduce emissions to zero even during car travel. For zero-emission power sources, renewable energy – such as hydroelectric, solar photovoltaic, and wind power generation – or fossil-fuelled power generation equipped with carbon capture and storage or nuclear power generation can be considered. Widespread use of EVs needs to be in conjunction with the transformation of power supply.

It is also important to prioritise the introduction of ZEVs. If vehicles with a high mileage such as buses or taxies are fuelled with renewable energy, CO_2 emission will be greatly reduced.

In Malaysia, renewable energy in power generation is expected to increase 2.3 times from 2015 to 2040. The promotion of automobiles that use renewable electricity can be a key driver in reducing CO_2 emissions.

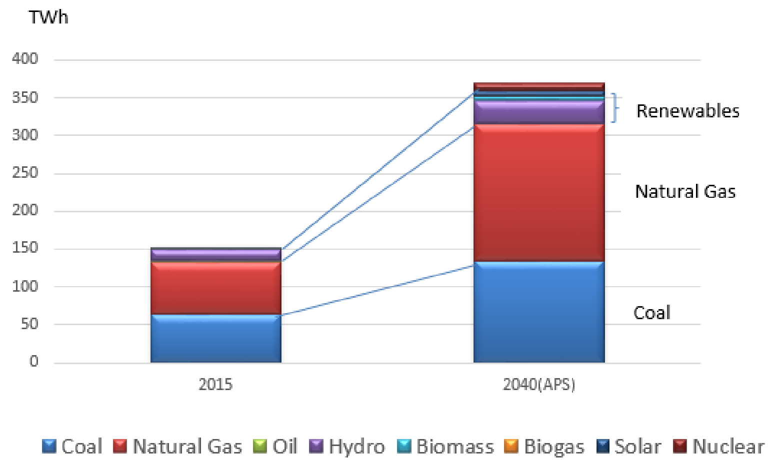
Figure 5.6 Well-to-Wheel CO_2 Emissions in Vehicle Type



CO_2 = carbon dioxide.

Source: First workshop on 22 February 2018 presented by JAMA.

Figure 5.7 Power Generation Mix Forecast for Malaysia



APS = alternative policy scenario, TWh = terawatt-hour.

Source: IEEJ developed based on the data proposed from the Energy Commission (ST).

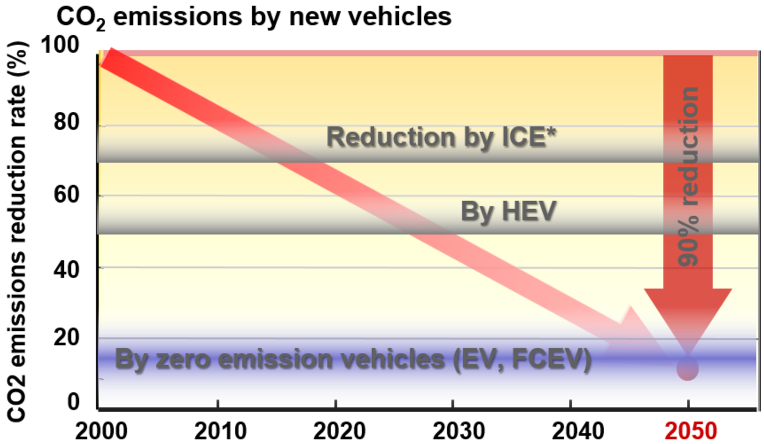
Figure 5.8 Illustration of EV Charging by Solar Power

Source: METI website.

On the other hand, it is not realistic to shift directly from ICEs to EVs or FCEVs in a short time. The price of EVs and FCEVs is still high compared to conventional ICEs, and it takes time and is costly to develop charging infrastructure. Therefore, gradually shifting from ICEs to EVs/FCEVs through fuel-efficiency improved ICE and hybrid (HEV) is desirable.

To popularise EVs and FCEVs and spread charging infrastructure, government should provide some incentives, such as tax exemptions or subsidies, especially during the initial stage.

Figure 5.9 Trajectory towards CO_2 Reduction



EV = electric vehicle, FCEV = fuel cell vehicle, HEV = hybrid vehicle, ICE = internal combustion engine.

Source: First workshop on 22 February 2018 presented by JAMA.

Figure 5.10 Examples of In-Use EV Incentive

Incentive for In-Use EV	Country, Region
Free parking	Norway, California, Amsterdam
Free charging	London, Amsterdam
Expressway toll (free, discount)	Norway, (Japan in the past)
Ferry fare (free)	Norway
HOV*/bus lanes *Open only to vehicles with designated numbers of occupants	Norway, California
Exemption from entry ban	London
Number plate (free)	China

HOV = high occupancy vehicle.

Source: First workshop on 22 February 2018 presented by JAMA.

5.5 Setting Up Smart Power Grids Incorporating EV batteries

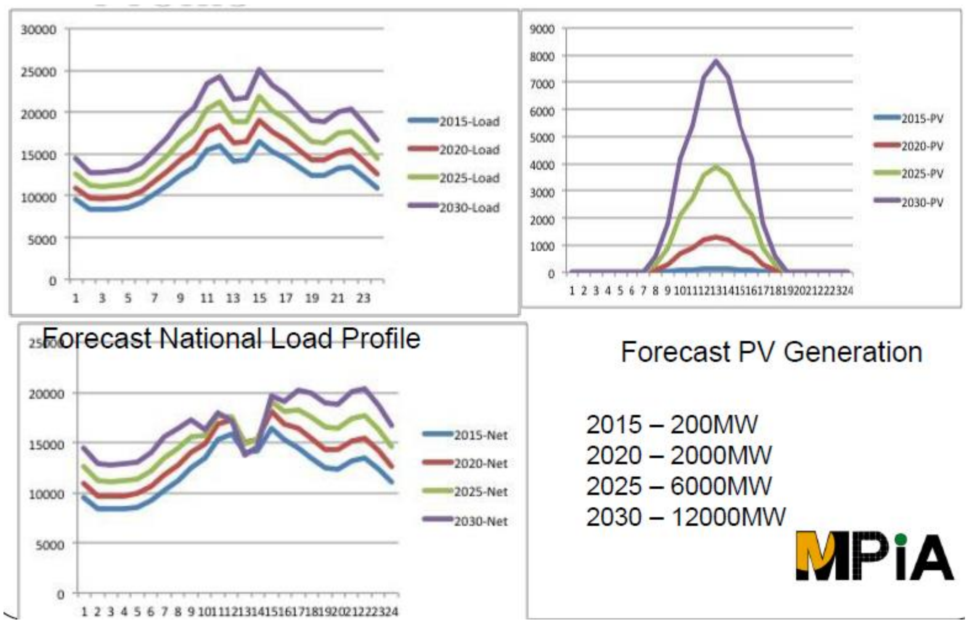
EVs are also one important component of the next-generation electricity network. The key is the storage battery installed in the EV. One idea is to use the storage battery to store 'surplus electricity' and extract electricity when power is insufficient.

Along with the introduction of large amounts of renewable energy, several problems could negatively influence power grid or distribution system stability – frequency, maintenance, voltage, and other issues. The influence of massive introduction of solar photovoltaic and wind power can be serious. Massive introduction of renewables often causes the timing imbalance between peak demand and renewable energy production.

The problem of what is known as the 'duck curve' has appeared to be a big challenge in several countries or regions worldwide. Malaysia also needs to prepare for such a problem in line with introducing massive renewables.

One solution to this is the power system in the storage battery in the EV, which has been drawing much attention these days, namely vehicle-to-grid (V2G). V2G technologies can contribute to limiting the need for grid upgrades. If the battery in the EV could somehow be priced (the grid operator would pay for using the battery in the EV to stabilise the grid), the real cost of EVs could be reduced and thereby incentivise people to buy EVs.

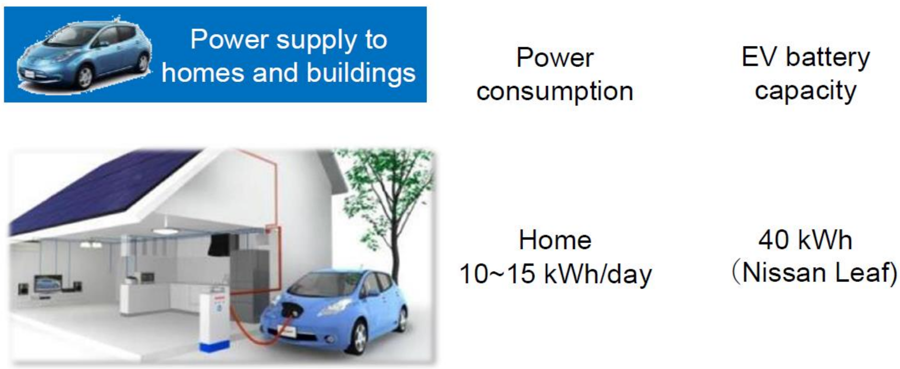
Figure 5.11 Malaysia's National Load Profile



MW = megawatt, PV = photovoltaic.

Source: Solar PV –The Game Changer in Malaysian Electricity Supply Industry, Malaysian Photovoltaic Industry Association (2015).

Figure 5.12 EV Battery Usable as Storage Battery



EV = electric vehicle, kWh = kilowatt-hour.

Source: First workshop on 22 February 2018 presented by JAMA.

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Agenda at Workshops

The 1st Workshop Meeting of ERIA Research Project FY2017

on 'Sustainable Development of Transport Sector: Malaysia'

Theme: Upcoming Green Automobiles towards CO_2 Reduction

Date: 22 February 2018

Venue: The Everly Hotel, Putrajaya, Malaysia

1. *Final Agenda*

09:00–09:35 *Registration*

09:35–10:00 Opening Session

Welcome Remarks

by ***YBhg Datuk Badriyah Binti Ab Malek****, Deputy Secretary General (Energy and Green Technology), Ministry of Energy, Green Technology and Water (KeTTHA), Malaysia*

Opening Remarks

by ***Mr Shigeru Kimura****, Special Advisor to President for Energy Affairs, Energy Unit, Research Department, Economic Research Institute for ASEAN and East Asia (ERIA)*

Photo Session

Adoption of Agenda

10:00–10:20 Session 1: Scene Setting Presentation

by ***Mr Ichiro Kutani****, Leader of the Working Group, Senior Economist, Manager of Global Energy Group 1, Strategy Research Unit, The Institute of Energy Economics, Japan (IEEJ), Japan*

10:20–10:40 *Coffee Break*

10:40–11:15 Session 2: The Current Public Transportation Policy and Upcoming Challenges, Malaysia

by ***Mr Na'el Kamil Bin Nor Hisham,*** *Manager of Policy, Planning and Research Division, Land Public Transport Commission (SPAD), Malaysia* (30 min. presentation)

11:15–11:40 Session 3: The Current Road Transport Policy and Upcoming Challenges, Malaysia

by ***Mr P. Jeevanath s/o Paliah****, Senior Principal Assistant Secretary, Logistic and Land Transport Division, Ministry of Transport (MOT), Malaysia*

(30 min. presentation)

11:40–11:55 Session 4: Scenario Setting of Model Analysis for the 2nd Workshop

by ***Mr Zaharin Zulkifli****, Senior Regulatory Officer, Energy Management and Service Quality Development Department, Energy Commission of Malaysia (ST), Malaysia* (20 min. presentation)

11:55–12:25 Discussion on Sessions 1 to 4

12:25–13:25 Lunch Break

13:25–13:30 Session 5:Trends and Targets of CO_2 Emissions in Japan

*by **Mr Hiroshi Kondo**, Senior Coordinator, Global Energy Group 1, Strategy Research Unit, IEEJ, Japan*

13:30–14:05 Session 6: Development of Environment-Friendly Vehicles in Japan

*by **Mr Noboru Oba**, Chairman of Climate Change Subcommittee, Japan Automobile Manufacturers Association, Inc. (JAMA)* (25 min. presentation)

14:05–14:35 Session 7: Development of FCV & EV at Toyota Motor Corp.

*by **Mr Takayuki Kusajima**, Project General Manager, Corporate Affairs Department, Toyota Motor Corporation, Japan* (25 min. presentation)

14:35–15:20 Discussion on Sessions 5 to 7

15:20–15:40 Coffee Break

15:40–16:05 Session 8: Prospects and Challenges of FCV & EV

*by **Prof Koichi Iwama**, Professor, Department of Economics, Wako University, Japan* (25 min. presentation)

16:05–16:30 Session 9: Challenges of EV Charging Infrastructure

*by **Mr Akihiko Kido**, Research Director, FC-EV Research Division, Japan Automobile Research Institute (JARI), Japan*

(25 min. presentation)

16:30–16:50 Whole Discussion, including Sessions 8 and 9

16:50– Wrap-up, Way Forward, and Closing

*by **Mr. Ichiro Kutani**, Leader of the WG, IEEJ, Japan*

*by **Mr. Shigeru Kimura**, Special Advisor, ERIA*

The 2nd Workshop of ERIA Research Project FY2017
on 'Sustainable Development of Transport Sector: Malaysia'
Theme: What sustainable mobility, led by
Intelligent Transport Systems (ITS), aims for
Date: 14 May 2018
Venue: The Everly Hotel, Putrajaya, Malaysia

2. *Final Agenda*

09:00–09:30 *Registration*

09:30–09:50 Opening Session

Welcome Remarks

*by **Mdm Inu Baizura binti Mohamad Zain**, Undersecretary, Strategic Planning & International Relation Division, Ministry of Energy Green Technology and Water (KeTTHA), Malaysia*

*by **Mr Shigeru Kimura**, Special Advisor to President for Energy Affairs, Energy Unit, Research Department, Economic Research Institute for ASEAN and East Asia (ERIA)*

Opening Remarks

*by **Mr Ichiro Kutani**, Leader of the Project, Assistant to Managing Director, Senior Economist, Manager of Global Energy Group 1, Strategy Research Unit, The Institute of Energy Economic, Japan (IEEJ), Japan*

Adoption of Agenda

09:50–09:55 Photo Session

09:55–11:10 Session 1: Sustainable Mobility that Contributes to CO_2 Reduction, taking Advantage of ITS

*by **Dr Takahiro Suzuki**, Professor, Planning Office for Development, New Industry Creation Hatchery Center (NICHe), Tohoku University, Japan*

(45 min. presentation)

11:10–11:35 Photo Session and Coffee Break

11:35–12:30 Session 2: Technology Development in Transport Sector, Malaysia

*by **Dr Ahmad Zainal Abidin**, Director of Innovation Centre, Malaysia Automotive Institute (MAI), Malaysia* (45 min. presentation)

Discussion

12:30–13:35 *Lunch Break*

13:35–13:45 Session 3: Key Approaches to a Reduction of CO_2 Emissions from Automobiles

*by **Mr Hiroshi Kondo**, Senior Coordinator, Global Energy Group 1, Strategy Research Unit, IEEJ, Japan*

13:45–14:45 Session 4: Digital Transformation of Transportation

*by **Mr Walter Lee**, Evangelist and Government Relations Leader, Global Safety Division, NEC Corporation, Singapore* (1 hour presentation)

Discussion

14:45–15:00 Coffee Break

15:00–16:10 Session 5: Results of Model Analysis and Malaysia's Strategies to a Reduction

of CO_2 Emissions

*by **Mr Zaharin Zulkifli**, Senior Regulatory Officer, Energy Management and Service Quality Development Department, Energy Commission of Malaysia (ST), Malaysia* (45 min. presentation)

Discussion

16:10–16:35 Wrap-up, Way Forward, and Closing

*by **Mr Shigeru Kimura**, ERIA*

*by **Mr Ichiro Kutani**, Leader of the Project, IEEJ, Japan*