Chapter 3

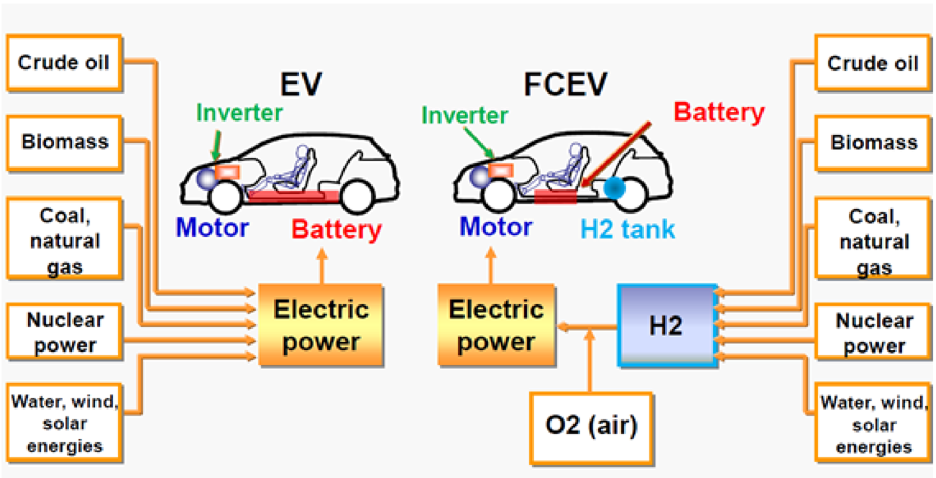
Promising Solutions for Reduced CO_2 Emissions from Automobiles

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.

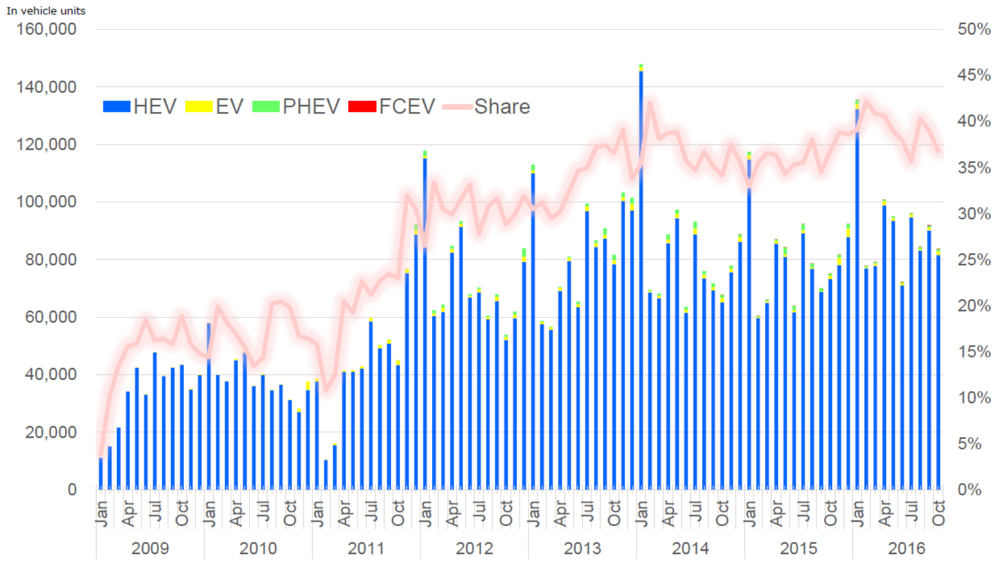
3.1.1 Japan's roadmap for next-generation vehicles

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.

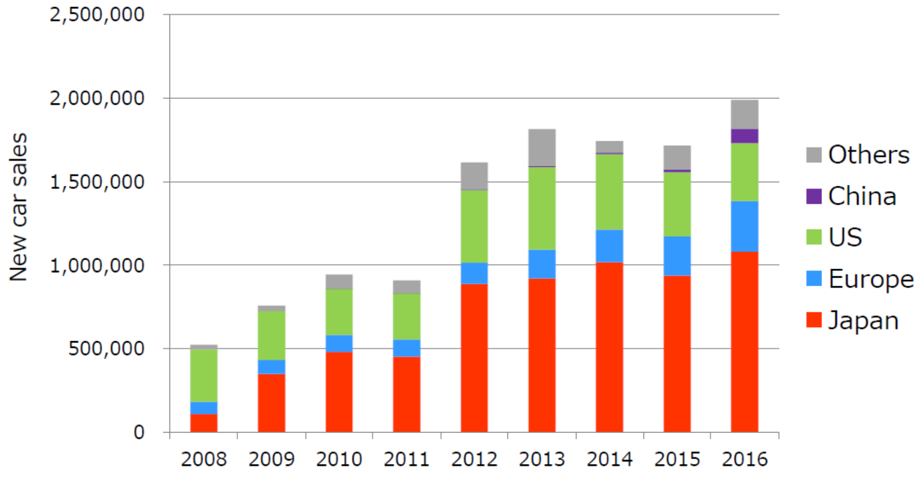
Figure 3.2 New Car Sales and Market Share of Next-Generation Vehicles in Japan



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

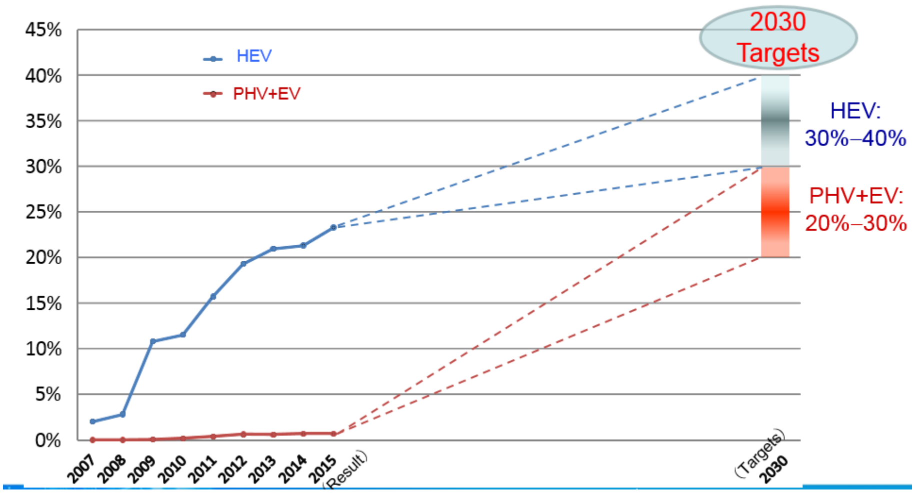


Source: First workshop on 22 February 2018 presented by JAMA.

(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)

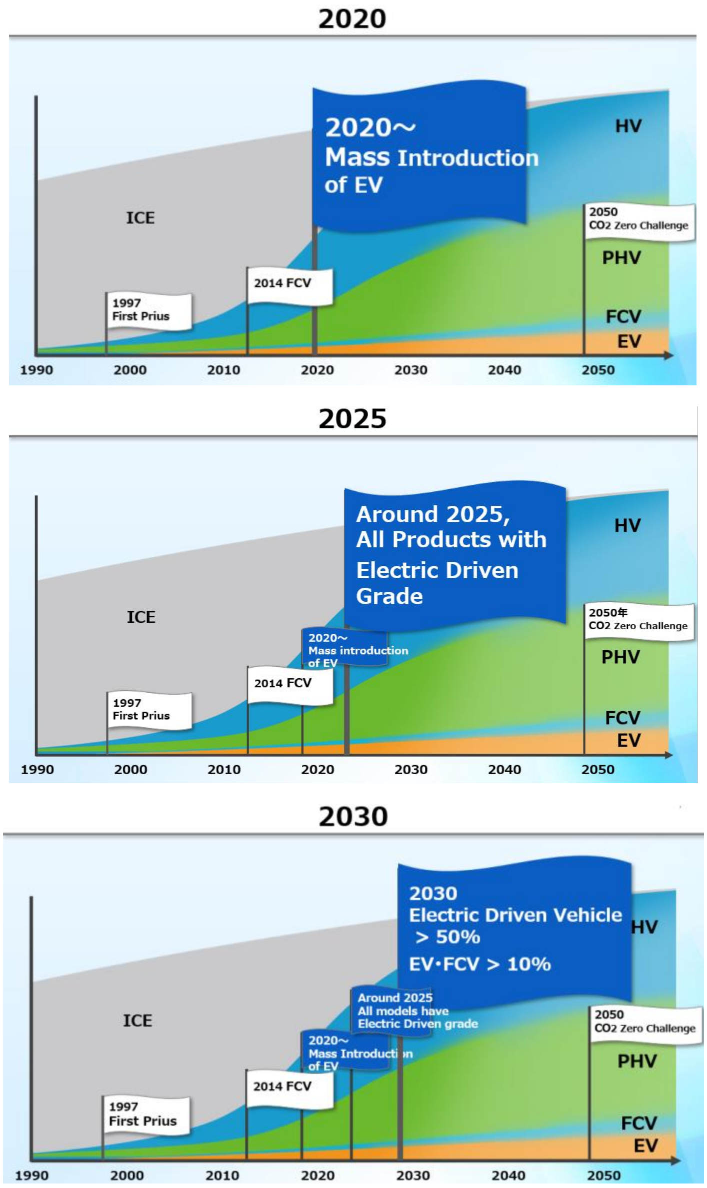


HEV = hybrid electric vehicle, PHV = plug-in hybrid vehicle.

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.

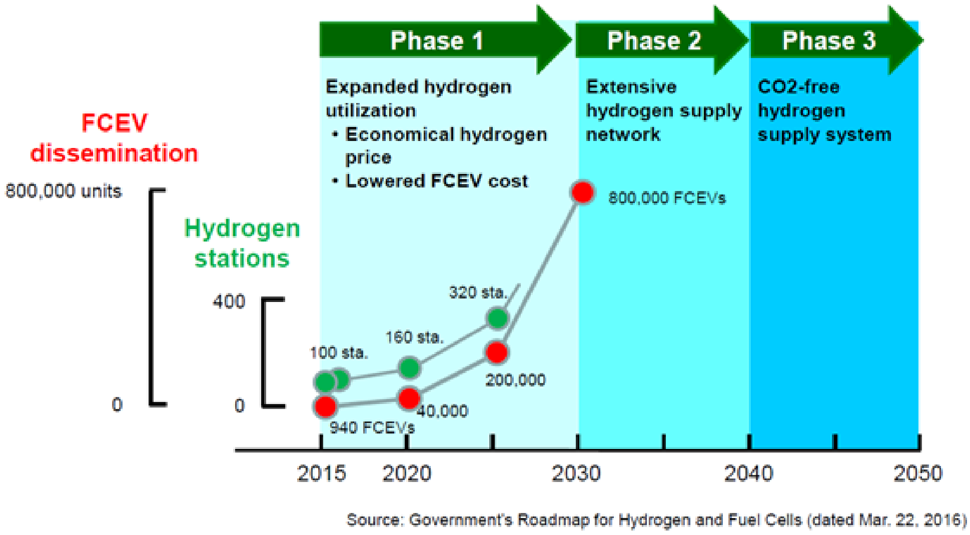
(2) FCEV roadmap

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.

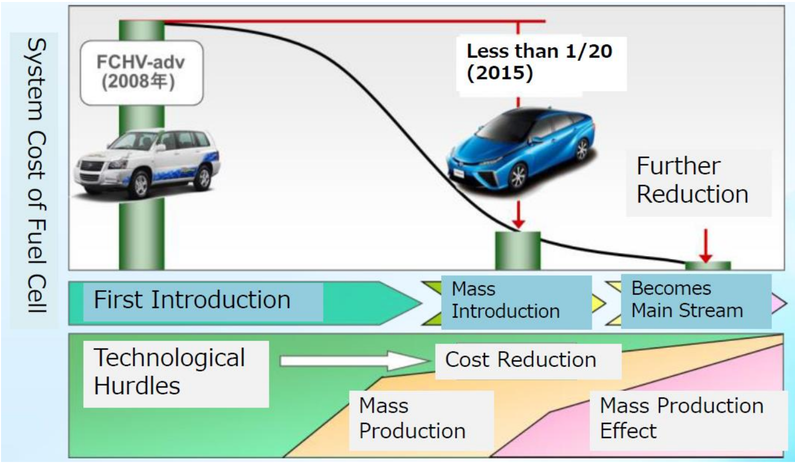
The price of FCEVs remains high. However, it is expected to decrease with reduced system costs in the future.

(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

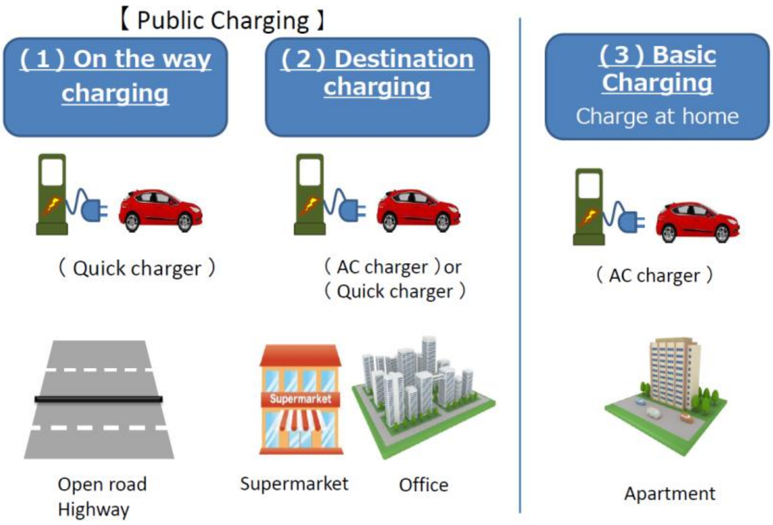


FCHV = fuel cell vehicle.

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).

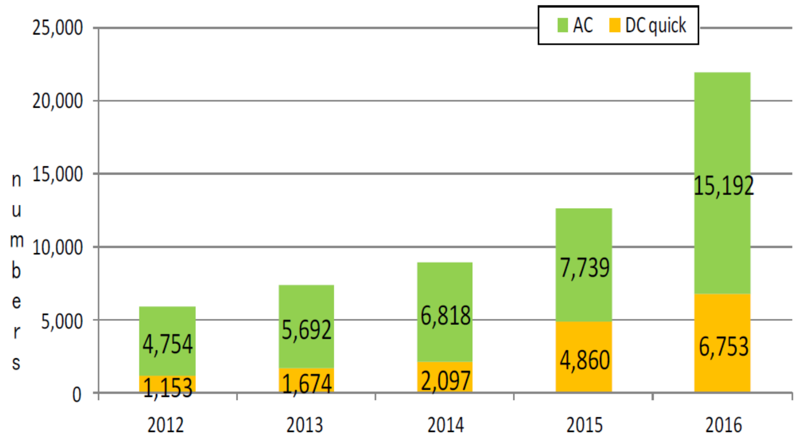
In December 2015, METI announced a deregulation to allow regular electricity chargers to be attached to fast chargers. This made it possible to use the same electric power receiving equipment and install regular chargers at locations such as roadside rest areas and highway service areas where fast chargers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

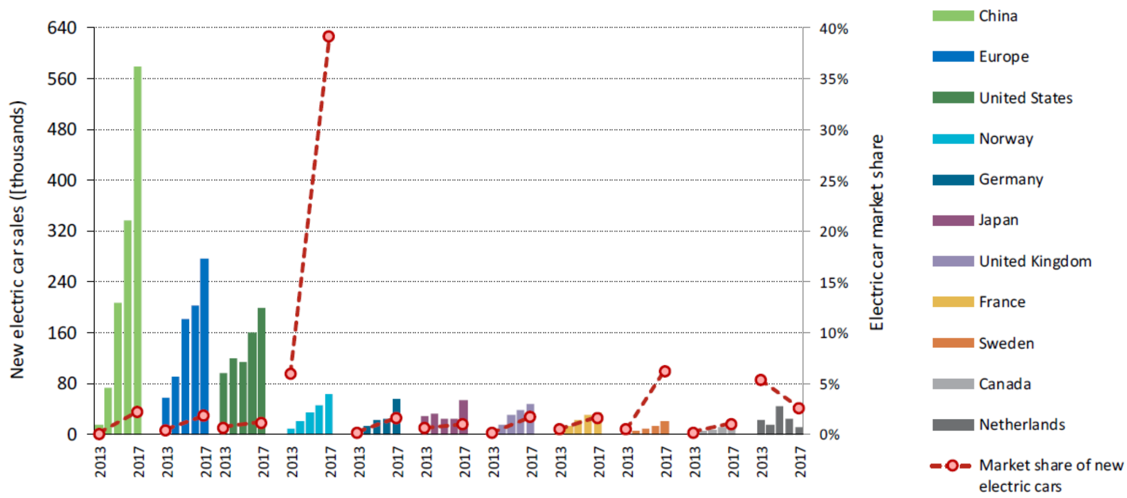
The EV stock exceeded 3 million in 2017. However, EV still represents 0.3% of the global car fleet.

(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.

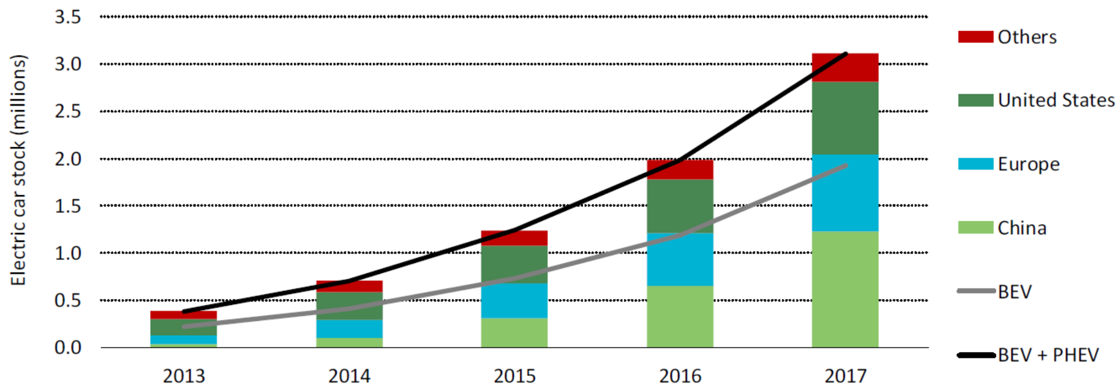
[8] Source: First workshop on 22 February 2018 presented by JAMA.
[9] IEA (2018).

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]

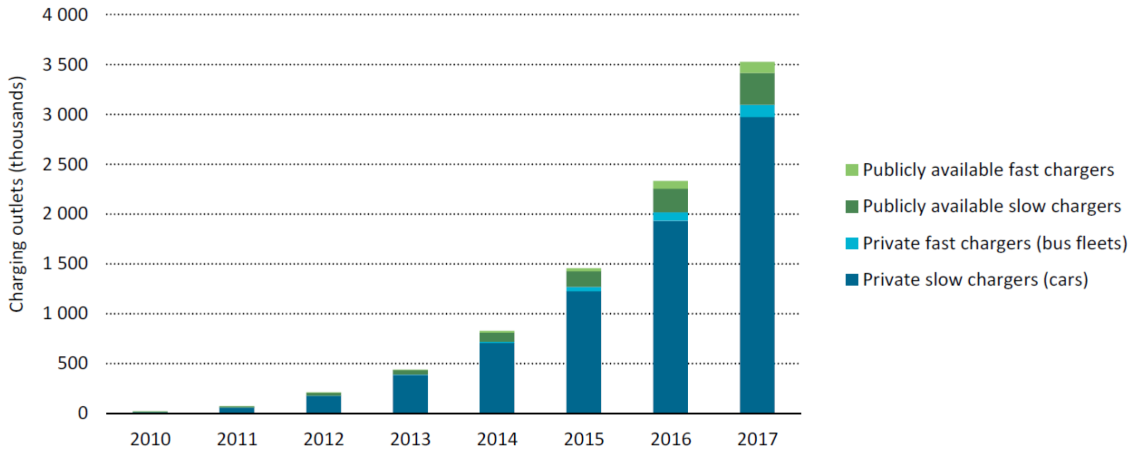
[10]https://www.theguardian.com/environment/2018/apr/12/worlds-first-electrified-road-for-charging-vehicles-opens-in-sweden

(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.

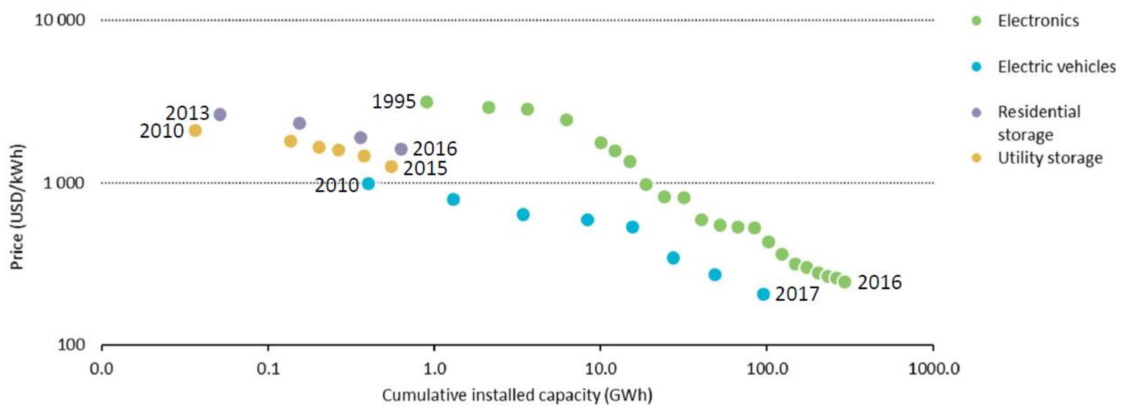
Battery size and manufacturing capacities have sizeable impacts on the cost of batteries per kilowatt-hour. Over time, both these factors will help in delivering significant cost reductions.

Figure 3.13 Number of Electric Vehicle Chargers



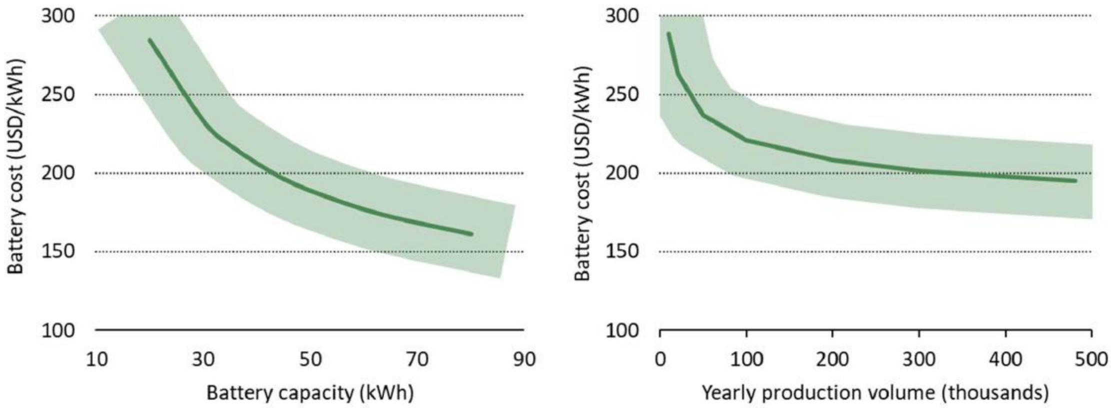
Source: IEA (2018).

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

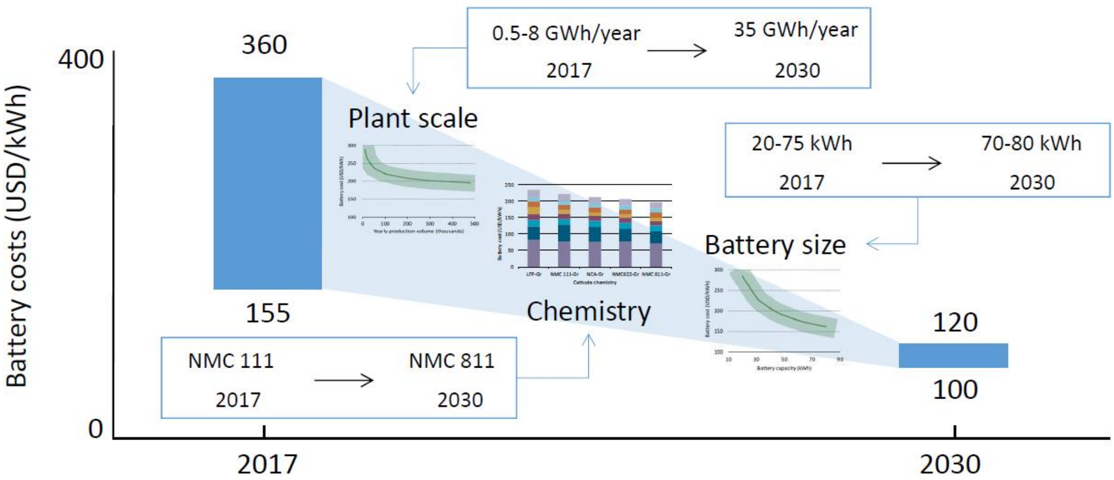


Note: graphics developed for BEV batteries for cars

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

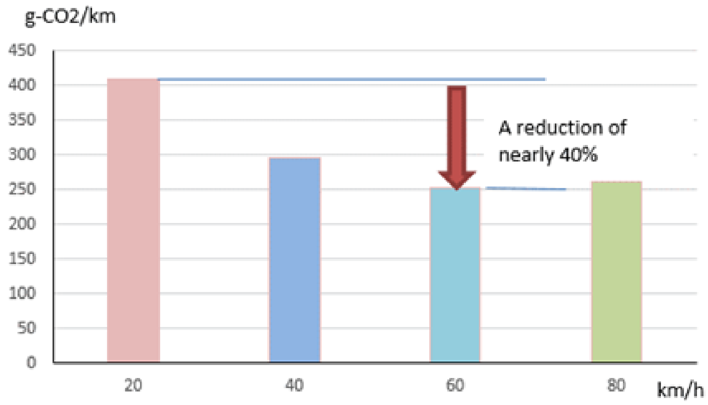


USD = United States dollars, GWh = gigawatt-hour, kWh = kilowatt-hour, NMC = nickel, manganese, cobalt.
Source: IEA (2018).

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

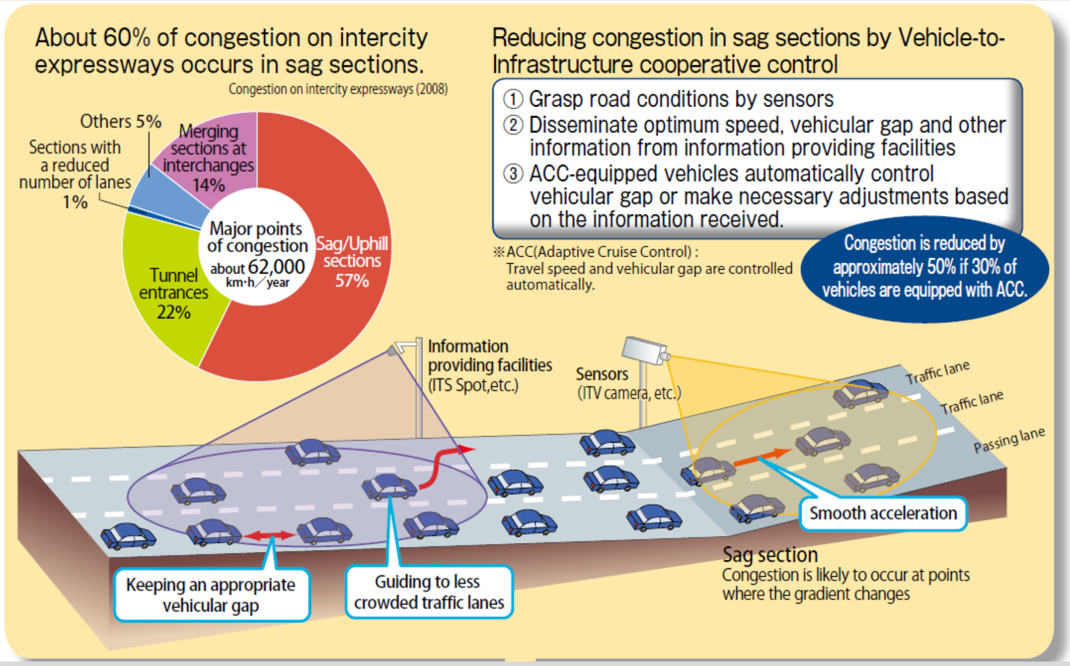


Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan (2010).[11]

[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).