Chapter 2

Economic and Energy Outlook up to 2040

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Chapter 2

Economic and Energy Outlook up to 2040

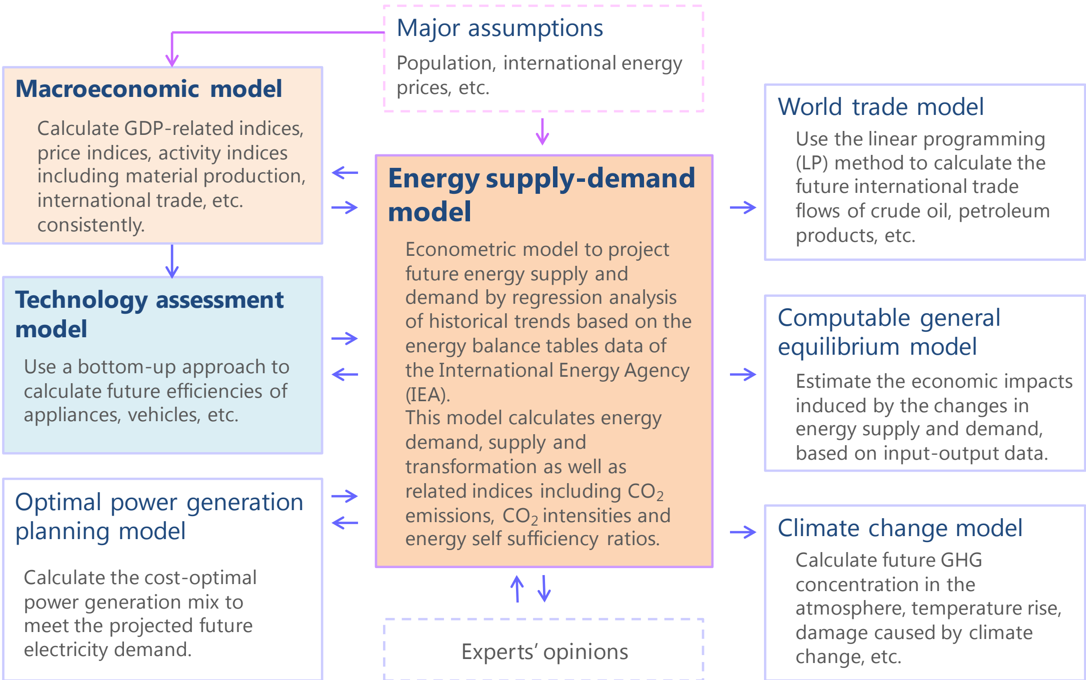
1. Modelling Framework

This study develops some scenarios focusing on xEV penetration and examines how each scenario might influence the 3Es. To quantitatively assess the influences, we build economic and energy models for Indonesia, Thailand, Malaysia, and Viet Nam.

1.1. Economic and Energy Analysis Model

We use the energy analysis model of The Institute of Energy Economics, Japan (IEEJ) (Figure 2.1). The energy supply–demand model is central to various models, allowing the projection of future energy supply and demand by regression analysis of historical trends. The energy demand and supply structure relies on the energy balance tables of the International Energy Agency (IEA). The model can calculate energy demand, supply, and transformation, as well as related indices, including CO_2 emissions and energy self-sufficiency rate.

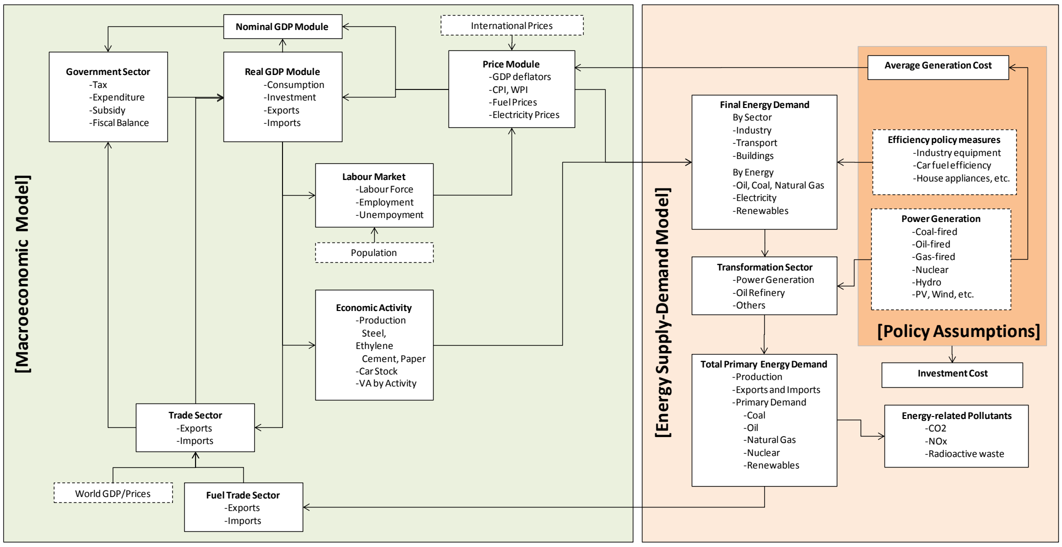
Figure 2.1: The Institute of Energy Economics, Japan's Energy Modelling Framework



Source: IEEJ (2018).

Changes in energy demand rest heavily on macroeconomic trends. To forecast the future energy supply and demand structure, therefore, we must reflect estimates through a macroeconomic model in an energy supply and demand analysis model. Changes in energy supply and demand structure, however, influence the macroeconomy through energy trade and costs. In other words, the macroeconomy and energy structure depend on each other. We can use an econometric model integrating a macroeconomic model and an energy supply–demand model to coherently project future macroeconomic and energy supply and demand structures (Figure 2.2).

Figure 2.2: Economic and Energy Model



Source: ERIA (2017).

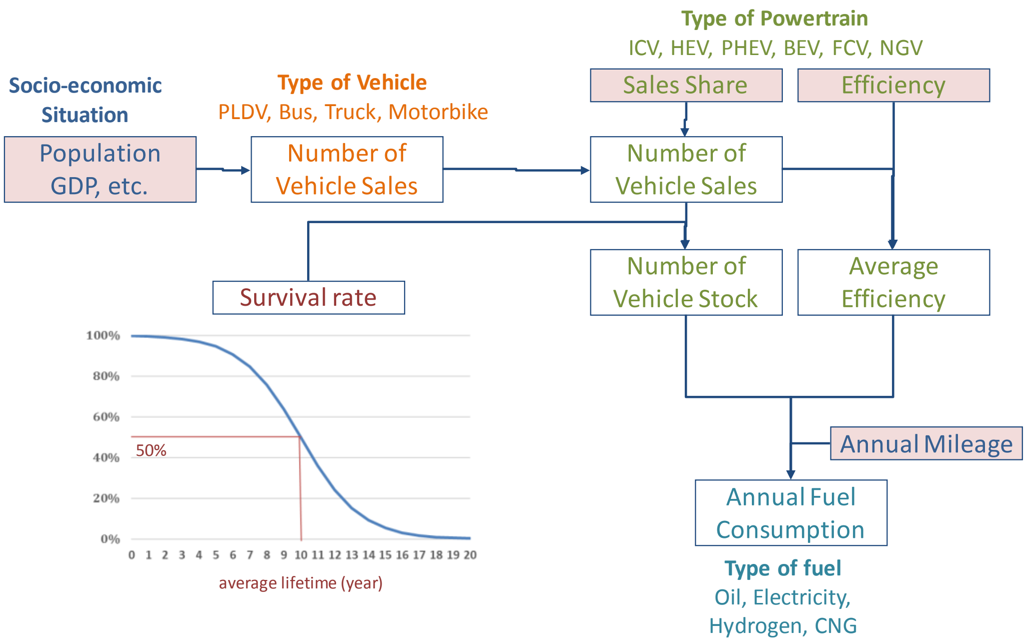
The macroeconomic model projects a commensurately balanced economic structure, including consumption, investment, trade, government, and general prices, and calculates economic activity indicators (including production and vehicle ownership) that directly and indirectly influence energy demand. The model is an econometric one that includes interdependent variables and allows prices and other variables to serve as coordinators amid a widening supply–demand gap to achieve partial supply–demand equilibrium.

Assumptions for more energy-efficient household appliances and automobiles are needed for the energy supply–demand model. These assumptions are calculated in the technology assessment model, which uses the bottom-up approach to calculate future efficiencies of appliances, vehicles, etc.

1.1 Technology Assessment Model for Automobiles

The technology assessment model for automobiles employs the turnover model, which deals with four vehicle types: passenger light-duty vehicle (PLDV), bus, truck, and motorbike (Figure 2.3). To analyse how powertrain mix, especially electrification, could affect fuel demand in the road sector, this model considers six types of powertrain: ICEV, HEV, PHEV, BEV, fuel-cell vehicle, and natural-gas vehicle.

Figure 2.3: Technology Assessment Model (Vehicle Turnover Model)



BEV = battery electric vehicle, FCV = fuel-cell vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, NGV = natural gas vehicle, PHEV = plug-in hybrid vehicle.
Source: ERIA(2017)

After estimating future vehicle sales and shares of powertrain types (see the next section), the model estimates future vehicle stock by powertrain type, based on the survival rate. The survival rate describes how many vehicles are on the road in a certain year after being sold. A logistic curve is utilised to shape survival rates and set 50% of the rate as the average lifetime. When assuming fuel efficiency by powertrain type for each year's sales, the model can estimate average fuel efficiency on the road.

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

1.2 Multinomial Logit Model for Powertrain Choice

Powertrain sales shares are estimated using the multinomial logit model. We set utilities for using each powertrain and then calculate the ratio of the exponential function of its utility using the Napier's number (e). This ratio is considered selection probability: sales share.

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

i (type of powertrain) = ICV, HEV, PHEV, BEV, FCV, NGV

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

The utility is estimated by initial cost, running cost, income level, cruising distance, charging time, population, average mileage and fuelling time. When the initial and running cost is lower, the utility is higher. The utility for EVs depends on cruising distance. Higher income is assumed for users to afford to purchase more expensive cars.

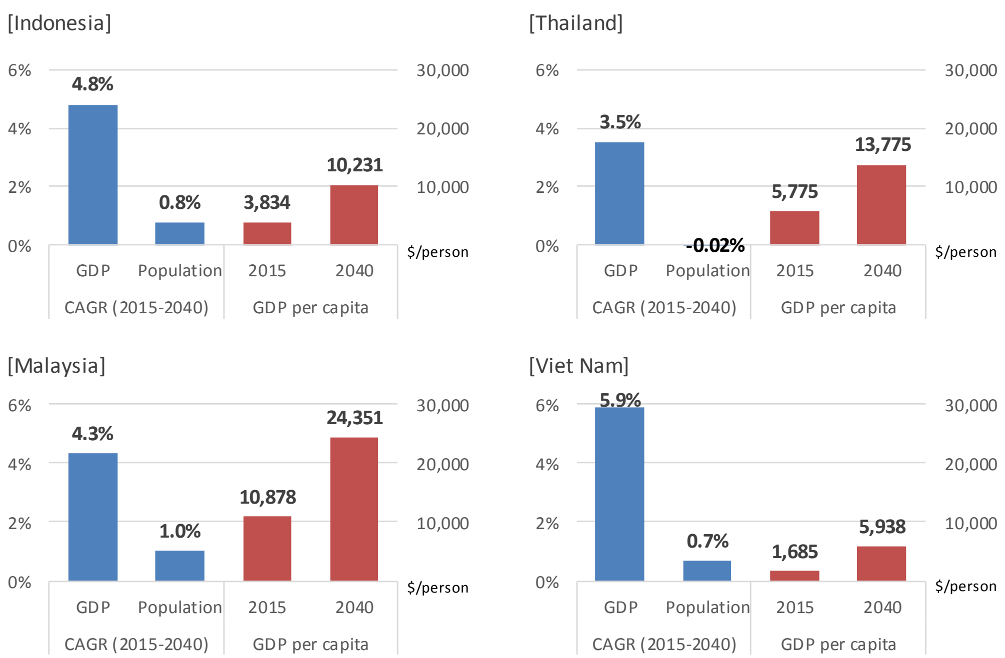
2. Main Assumptions for the Study

2.1. Demographic Assumptions

Population assumptions are from the United Nations' World Population Prospects (Figure 2.4). Population will grow at about 1% annually until 2040 in Indonesia, Malaysia, and Viet Nam. In Thailand, population will peak by 2030 then decline almost to today's level due to ageing.

Average GDP growth will be higher in Viet Nam (5.9%) and Indonesia (4.8%). Both countries have a young demographic structure and the potential to increase their low GDP per capita. Malaysia, a richer country, is also growing steadily at about 4%. In Thailand, economic growth will be more moderate than in other countries due to demographic factors.

Figure 2.4: Assumptions for GDP and Population



GDP = gross domestic product, CAGR = compound annual growth rate
Sources: World Bank (2018), United Nations (2017), and author's analysis.

2.2. Automobile Assumptions

When using the automobile model, various data such as number of vehicles owned, number of sales, fuel consumption, and travel distance are required for each vehicle and engine type. However, it is not easy to obtain these statistical data in ASEAN countries.

Data such as fuel consumption and mileage have to be estimated based on the literature survey Table 2.1 to Table 2.4 estimate average fuel efficiency and travel mileage by vehicle type. When calibrating them, we considered fuel consumption (IEA data) in the road sector as a control total.

Table 2.1: Calibration for Indonesia, 2015

	Actual	Calibration			Estimation	Actual
	No. of Stock*1 (1000unit)	Average Fuel Efficiency (km/L-gsl)	Average Mileage (km/yr)	Average Lifetime (Years)	Fuel Consumption (ktoe)	Fuel Consumption *2 (ktoe)
PLDV	13,481	11.8	10,000	10	9,073	
Bus	2,421	6.0	19,000	10	6,108	
Truck	6,611	5.6	14,000	15	13,167	
Motorbike	98,881	30.3	4,200	5	10,897	
Total					39,245	39,084

PLDV = passenger light duty vehicle.
Sources: Authors' analysis; *1: Badan Pusat Statistik (2018);
*2: International Energy Agency (2017).

Table 2.2: Calibration for Thailand, 2015

	Actual	Calibration			Estimation	Actual
	No. of Stock*1 (1000unit)	Average Fuel Efficiency (km/L-gsl)	Average Mileage (km/yr)	Average Lifetime (Years)	Fuel Consumption (ktoe)	Fuel Consumption *2 (ktoe)
PLDV	7,857	11.8	11,000	15	6,628	
Bus	582	5.8	15,000	15	1,565	
Truck	7,166	6.2	12,500	15	12,368	
Motorbike	20,519	39.0	5,000	10	2,087	
Total					22,648	22,691

PLDV = passenger light duty vehicle
Sources: Author's analysis; *1: Department of Land Transport (2018);
*2: International Energy Agency (2017).

Table 2.3: Calibration for Malaysia, 2015

	Actual	Calibration			Estimation	Actual
	No. of Stock*1 (1000unit)	Average Fuel Efficiency (km/L-gsl)	Average Mileage (km/yr)	Average Lifetime (Years)	Fuel Consumption (ktoe)	Fuel Consumption *2 (ktoe)
PLDV	13,167	12.3	15,000	20	14,426	
Bus	65	4.6	20,000	15	248	
Truck	1,198	5.1	18,000	15	3,712	
Motorbike	11,872	32.2	6,500	10	1,901	
Total					20,287	20,274

PLDV = passenger light duty vehicle
Sources: Author's analysis; *1: Malaysia Informative Data Centre (MysIDC) (2018); *2: International Energy Agency (2017).

Table 2.4: Calibration for Viet Nam, 2015

	Actual	Calibration			Estimation	Actual
	No. of Stock*1 (1000unit)	Average Fuel Efficiency (km/L-gsl)	Average Mileage (km/yr)	Average Lifetime (Years)	Fuel Consumption (ktoe)	Fuel Consumption *2 (ktoe)
PLDV	1,033	11.7	15,000	10	1,049	
Bus	118	4.6	18,000	10	365	
Truck	950	4.9	25,000	15	3,846	
Motorbike	45,398	35.1	5,000	5	5,135	
Total					10,395	10,390

PLDV = passenger light duty vehicle
Sources: Author's analysis; *1: Ministry of Transport (2018) and authors' estimation; *2: International Energy Agency (2017).

Whilst assuming constant average mileage during the outlook period, we also assumed that automobile fuel efficiency would gradually improve along with the technology (Table 2.5 to Table 2.8). Annual efficiency improvement rates are set based on historical trends: 0.5%–0.9% for ICEVs, 0.6%–0.7% for HEVs, 0.4%–0.5% for PHEVs,[1] and 0.2%–0.4% for BEVs.

[1] For PHEVs, efficiency is calculated by weighted-averaging HEV efficiency and BEV efficiency, assuming that 60%–70% of travel mileage is driven by electric motor.

Table 2.5: Fuel Economy in 2017 and 2040 (km/L-gasoline eq.), Indonesia

	ICV	HEV	PHEV	BEV
PLDV	12.3	24.6	39.2	49.0
Bus	6.4	9.5	19.5	25.3
Truck	6.0	9.0	19.6	23.9
Motorbike	30.8	-	-	115.0

	ICV	HEV	PHEV	BEV
PLDV	15.2	28.8	44.2	54.5
Bus	7.6	10.9	21.5	27.7
Truck	7.2	10.3	21.6	26.1
Motorbike	34.7	-	-	120.6

BEV = battery electric vehicle, ICV = internal combustion engine vehicle, PHEV = plug-in hybrid vehicle, PLDV = passenger light duty vehicle
Source: GFEI (2016), GFEI and IEA (2014), and authors' analyses.

Table 2.6: Fuel Economy in 2017 and 2040 (km/L-gasoline eq.), Thailand

	ICV	HEV	PHEV	BEV
PLDV	12.7	25.2	38.9	50.3
Bus	6.2	9.4	21.8	24.9
Truck	6.7	10.0	23.2	26.5
Motorbike	40.2	-	-	150.2

	ICV	HEV	PHEV	BEV
PLDV	17.1	31.7	46.3	58.5
Bus	7.5	10.7	23.9	27.2
Truck	8.0	11.4	25.5	29.0
Motorbike	45.3	-	-	157.6

BEV = battery electric vehicle, ICV = internal combustion engine vehicle, PHEV = plug-in hybrid vehicle, PLDV = passenger light duty vehicle
Source: GFEI (2016), GFEI and IEA (2014), and authors' analyses.

Table 2.7: Fuel Economy in 2017 and 2040 (km/L-gasoline eq.), Malaysia

	ICV	HEV	PHEV	BEV
PLDV	13.6	27.2	38.1	54.3
Bus	5.0	7.5	15.1	20.1
Truck	5.5	8.3	16.0	22.1
Motorbike	33.2	-	-	124.0

	ICV	HEV	PHEV	BEV
PLDV	17.3	32.5	43.9	61.1
Bus	6.0	8.6	16.6	22.0
Truck	6.6	9.5	17.6	24.2
Motorbike	37.4	-	-	130.0

BEV = battery electric vehicle, ICV = internal combustion engine vehicle, PHEV = plug-in hybrid vehicle, PLDV = passenger light duty vehicle
Source: GFEI (2016), GFEI and IEA (2014), and authors' analyses.

Table 2.8: Fuel Economy in 2017 and 2040 (km/L-gasoline eq.), Viet Nam

	ICV	HEV	PHEV	BEV
PLDV	12.7	25.2	35.3	50.3
Bus	5.1	7.6	16.0	20.3
Truck	5.6	8.4	13.9	22.3
Motorbike	35.7	-	-	133.3

	ICV	HEV	PHEV	BEV
PLDV	17.1	31.7	42.4	58.5
Bus	6.9	9.6	19.0	23.6
Truck	7.6	10.6	16.7	26.0
Motorbike	40.2	-	-	139.9

BEV = battery electric vehicle, ICV = internal combustion engine vehicle, PHEV = plug-in hybrid vehicle, PLDV = passenger light duty vehicle
Source: GFEI (2016), GFEI and IEA(2014), and authors' analyses.

Automobile sale prices are an important element of the multinomial logit model. The prices are common in the four countries and assumed to gradually decline (but rise only for ICEVs) along the learning curve (Table 2.9). Learning rates are set as 101% for the base component and 80% for the battery system. For other components of specific powertrains, the rates are set as 90%–95% for HEVs, 85% for PHEVs, and 80%–85% for BEVs.

Table 2.9: Assumptions for List Price in 2017 and 2040 (US$ in 2010 / unit)

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

	ICV	HEV	PHEV	BEV
PLDV	22,169	25,347	27,564	24,401
Bus	67,547	74,052	91,378	77,398
Truck	47,384	54,913	54,743	50,238
Motorbike	1,498	-	-	1,837

BEV = battery electric vehicle, ICV = internal combustion engine vehicle, PHEV = plug-in hybrid vehicle, PLDV = passenger light duty vehicle
Source: Mitsubishi Fuso, Toyota, Nissan, Hino, and authors' analyses.

2.3. Reference Scenario

A reference scenario is used as the baseline to evaluate quantitative effects of alternative scenarios. The reference scenario is assumed to continue historical trends without strengthening policy measures.

2.3.1. Automobile Penetration

Assuming the above, car (PLDV, bus, truck) stock[2] in the four countries is projected to increase 2.5 times to 136 million units by 2040, from 122 per 1,000 people in 2015 to 258 in 2040, which is still much lower than the OECD average of 589 per 1,000 people in 2015. Cars in Viet Nam increase about eight times and in Indonesia three times. Growth in

[2] We do not consider the effects of carsharing, the future of which is challenging to estimate.

Thailand and Malaysia is less than two times because ownership rates are already relatively high.

Motorbikes, which are more than three times the number of cars today, increase 1.7 times. Growth is more moderate than for cars in all countries. Each country except Malaysia has higher motorbike than car ownership. In Viet Nam, especially, nearly 500 per 1,000 people own motorbikes and that number could increase to about 700.

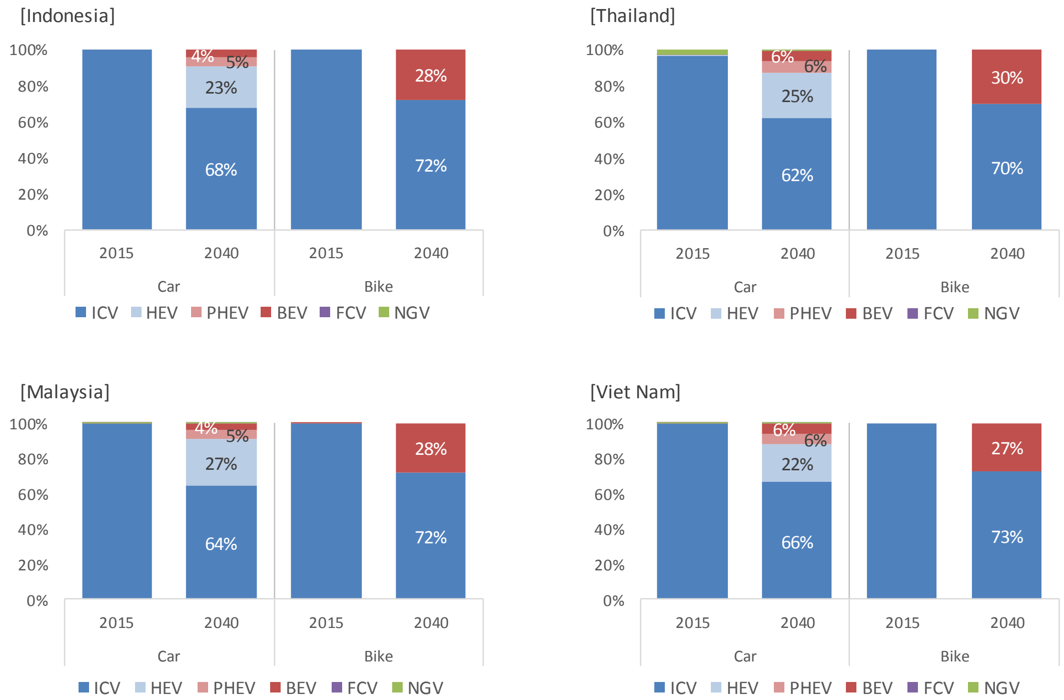
Figure 2.5: Outlook for Vehicle Stock

Sources: Indonesia: BPS – Statistics Indonesia (2018); Viet Nam: Ministry of Transport (2018); Thailand: Department of Land Transport (2018); Malaysia: Malaysia Informative Data Centre (MysIDC) (2018); authors' analyses.

For the mix by powertrain, conventional ICEVs keep dominant up to 2040 and hybrid electric vehicles gradually increase their sales share to around 25% in the reference scenario. Sales of PHEVs increase to 5%–6% of total car sales by 2040, and EV sales account for only 4%–6% due to higher cost and shorter cruising distance than that of other powertrains.

Electric bikes will make up around 30% of the motorbike market due to the small price gap between ICEVs and BEVs.

Figure 2.6: Sales Share by Powertrain



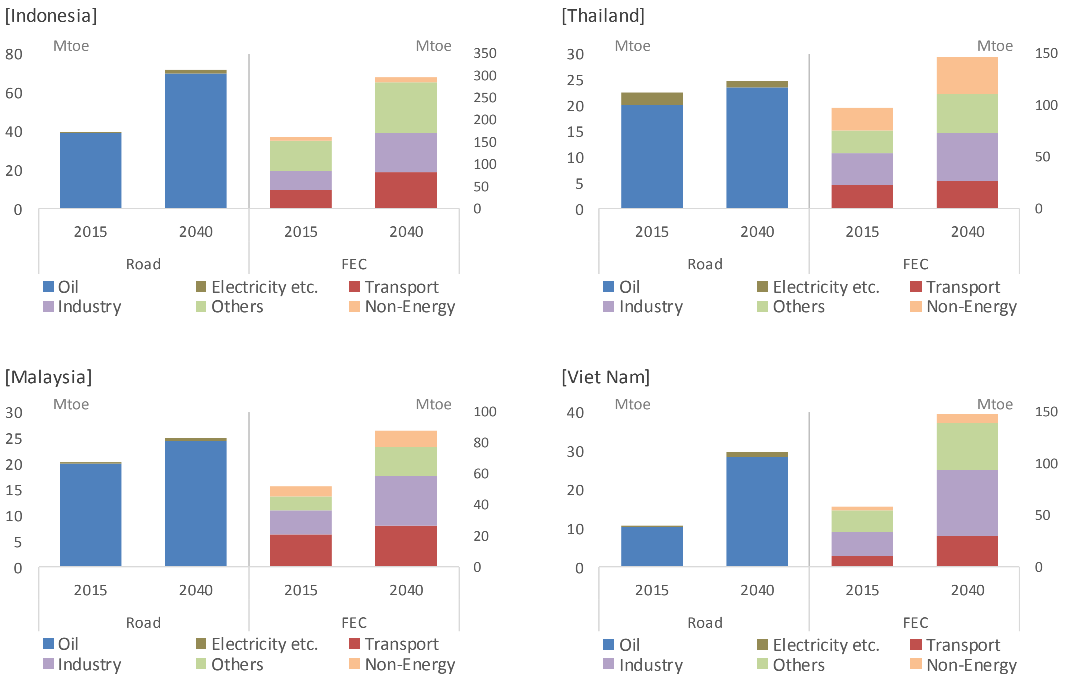
BEV = battery electric vehicle, FCV = fuel-cell vehicle, HEV = hybrid electric vehicle, ICEV = internal combustion engine vehicle, NG.V = natural gas vehicle, PHEV = plug-in hybrid vehicle
Source: Authors' analysis.

2.3.2. Fuel Consumption in the Road Sector

Fuel consumption, mostly oil, in the road sector increases 1.6 times by 2040 in the four countries. Growth is slow relative to stocks due to efficiency improvement, including the shift to HEVs from ICEVs. Consumption in Viet Nam rapidly increases, almost triples by 2040, whilst in Thailand and Malaysia, oil consumption for automobiles peaks and then declines before 2040.

Energy demand in the transport sector, including the road sector, rapidly increases but shares in final energy consumption stay at today's level in Indonesia and Viet Nam. For Thailand and Malaysia, transport sector shares in final energy consumption decline by 6 and 10 percentage points in 2040 from today, respectively.

Figure 2.7: Energy for the Road Sector and Total Final Consumption



Mtoe= million ton of oil equivalent, FEC=final energy consumption
Source: IEA (2017), authors' analysis.

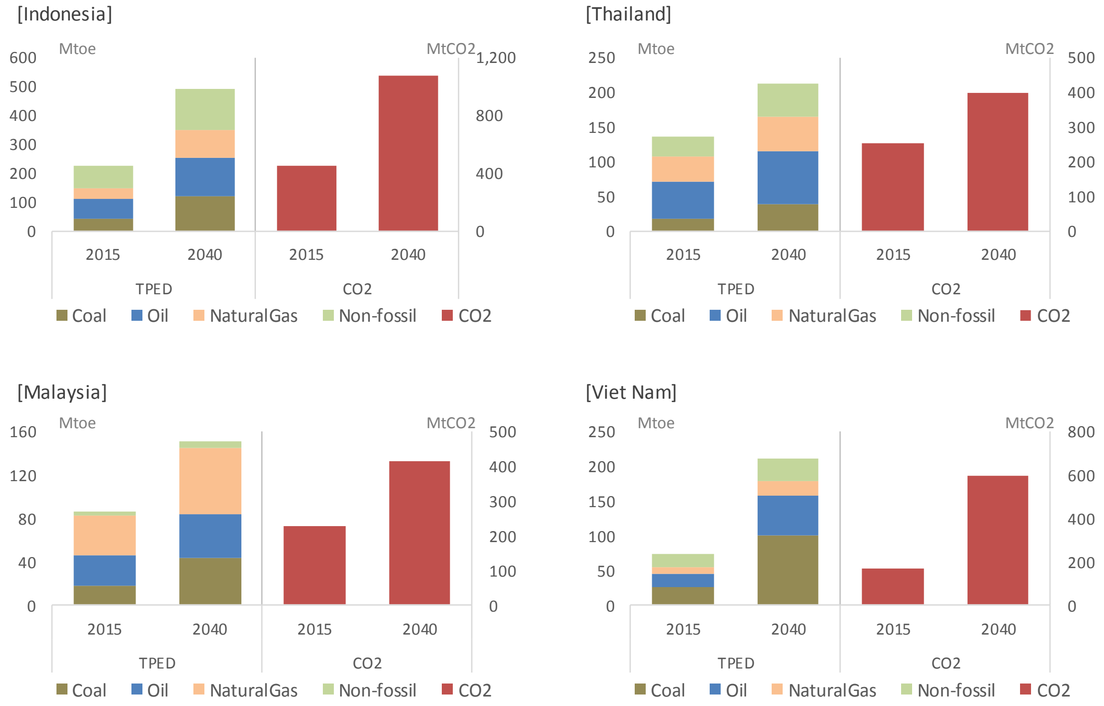
2.3.3. Primary Energy Demand and CO_2 Emissions

Total primary energy demand, which combines final energy consumption and the transformation sector, including power generation, increase annually by 3.2% in Indonesia, 4.3% in Viet Nam, 1.8% in Thailand, and 2.3% in Malaysia. These growth rates are much lower than their economic growth rates, which means that energy efficiency is rapidly improving.

Coal demand grows at higher rates than other fuels in each country, especially in power generation, to meet rapidly growing electricity demand. Gas demand also grows rapidly due mainly to its use in the generation sector. Oil demand, mainly for transport and building, and chemical feedstock grows more slowly than other fossil fuels. Fossil-fuel dependence ratios are still high, at 70%–90% in 2040, similar to levels today.

Maintaining high fossil-fuel dependency leads to increasing CO_2 emissions. CO_2 emissions increase annually by 3.5% in Indonesia and 5.2% in Viet Nam, higher than energy-demand growth, meaning that their energy mix becomes more carbon intensive. In Thailand and Malaysia, CO_2 emissions grow at almost the same rate as energy demand.

Figure 2.8: Primary Energy Demand and CO_2 Emissions



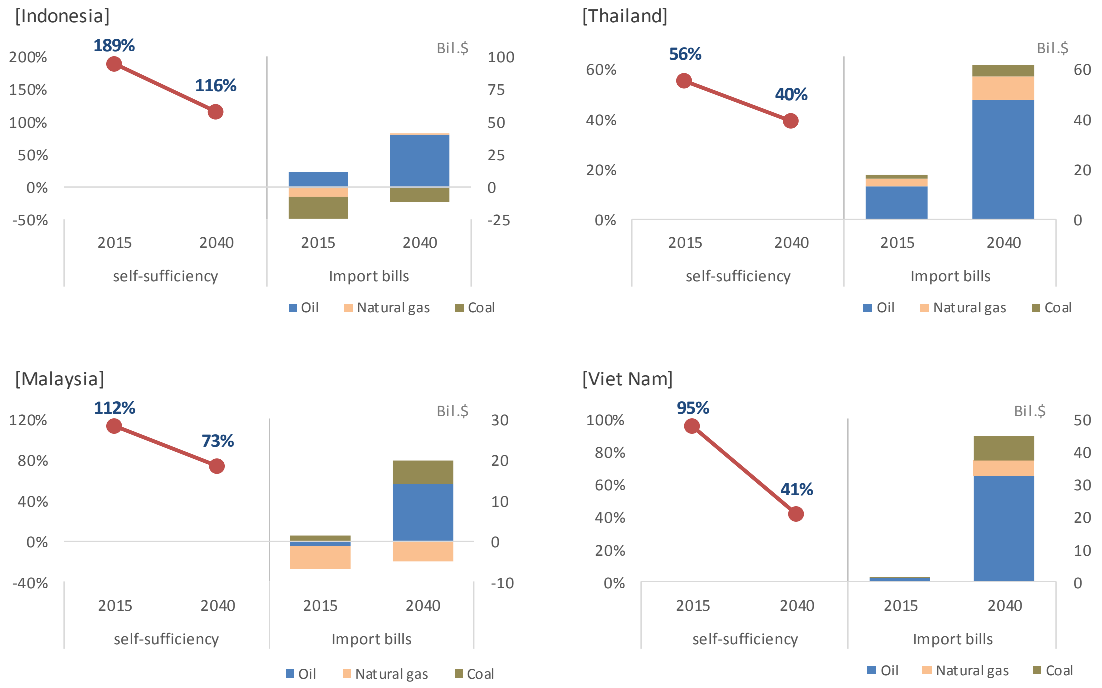
CO2 = carbon dioxide, MtCO2=million ton of carbon dioxide, Mtoe= million ton of oil equivalent, TPED = total primary energy demand.
Source: IEA (2017), authors' analysis.

2.3.4. Energy Self-sufficiency

High fossil-fuel dependency results in lower energy self-sufficiency. One of the largest coal exporters, Indonesia maintains its self-sufficiency at over 100% but it drops significantly from today's level. Malaysia is a net energy export country today but will become a net energy importer within 10 years. Thailand and Viet Nam are already net importers and their self-sufficiency rates decrease further.

Net import bills (imports less exports) dramatically increase in the four countries as their oil self-sufficiency declines, even though Indonesia and Malaysia export coal and gas, because oil import prices on a calorific basis are much higher than coal and gas export prices.

Figure 2.9: Energy Self-sufficiency and Net Import Bills



Bil.$ = US billion dollars.
Source: IEA (2017), authors' analysis.