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]
*******************************************************************************
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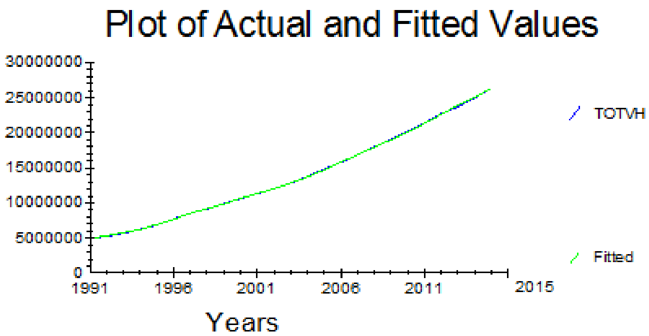


TOTVH: -843345.8 + 267283.4 * GDPC + 0.97362 * TOTVH (-1)

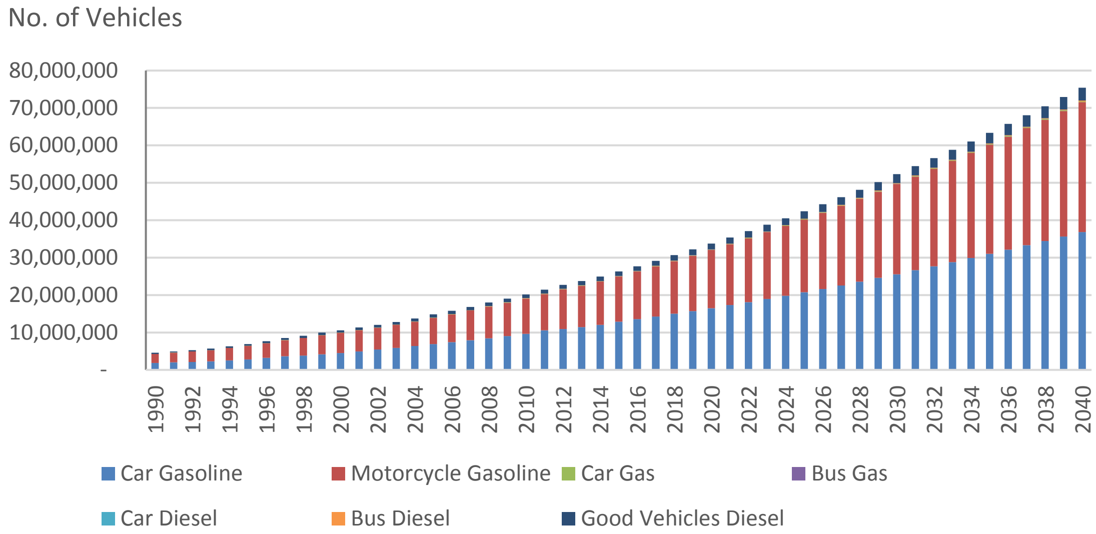
Where: TOTVH = Total Number of Vehicles

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*
*******************************************************************************
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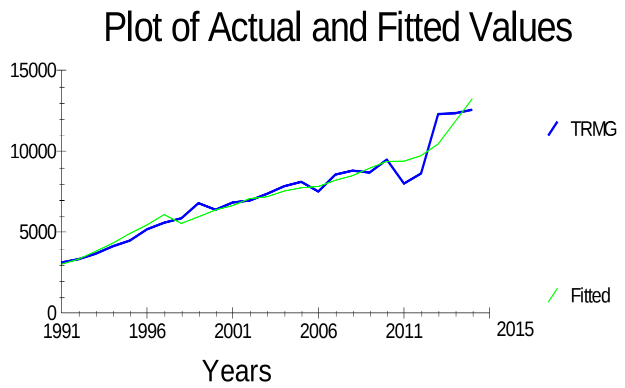

TRMG: 93.9696 + 33.0365 * GDP + (-1966.7) * RPOIL + 2.3211 * PDCAR + 0.15146 * TRMG (-1)

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*
*******************************************************************************
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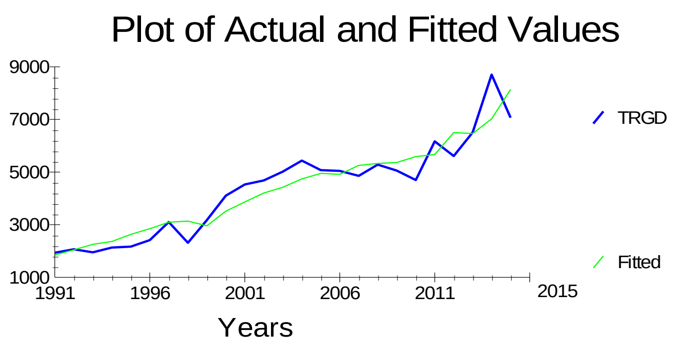

TRGD: -1.2873 + 15.3517 * GDP + (-6974.5) * RPRGD + 0.40778 * TRGD (-1)

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]
*******************************************************************************
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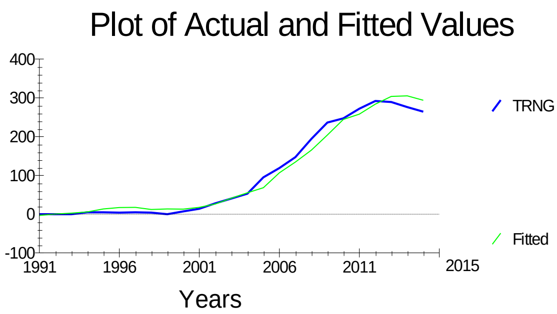


TRNG: -6.8176 + 0.22130 * GDP + (-244.5459) * RPRMG + 0.90196 * TRNG (-1)

Where;	TRNG	= Natural Gas Consumption in Land Transportation
	GDP	= Gross Domestic Product
	RPRMG	= Retail Prices of Motor Gasoline

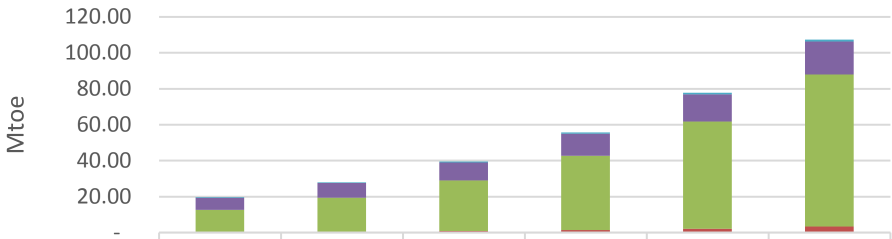
Source: Data calculated modelling results by Mr Zaharin, Energy Commission (2018).

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)

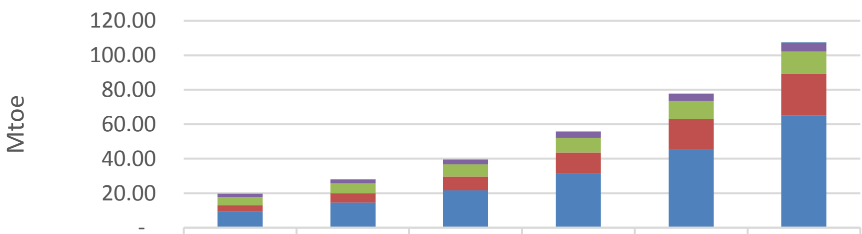


	2015	2020	2025	2030	2035	2040
Biofuel	0.39	0.47	0.58	0.71	0.87	1.06
Diesel	6.72	8.21	10.05	12.29	15.03	18.38
Gasoline	12.33	18.84	28.15	41.37	59.69	84.53
Natural Gas	0.26	0.46	0.77	1.29	2.10	3.36
Electricity	0.02	0.03	0.04	0.05	0.06	0.08

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)

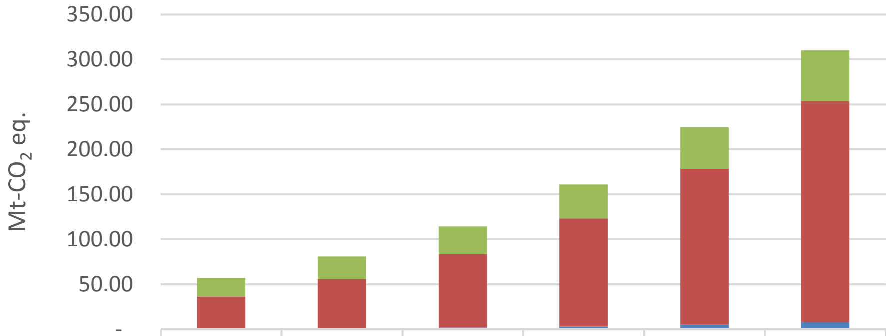


	2015	2020	2025	2030	2035	2040
Rail	0.02	0.03	0.04	0.05	0.06	0.08
Good Vehicles	1.87	2.28	2.79	3.42	4.18	5.11
Bus	4.72	5.77	7.07	8.67	10.63	13.04
Motorcycle	3.54	5.41	8.08	11.88	17.14	24.27
Car	9.57	14.51	21.60	31.68	45.73	64.90

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)



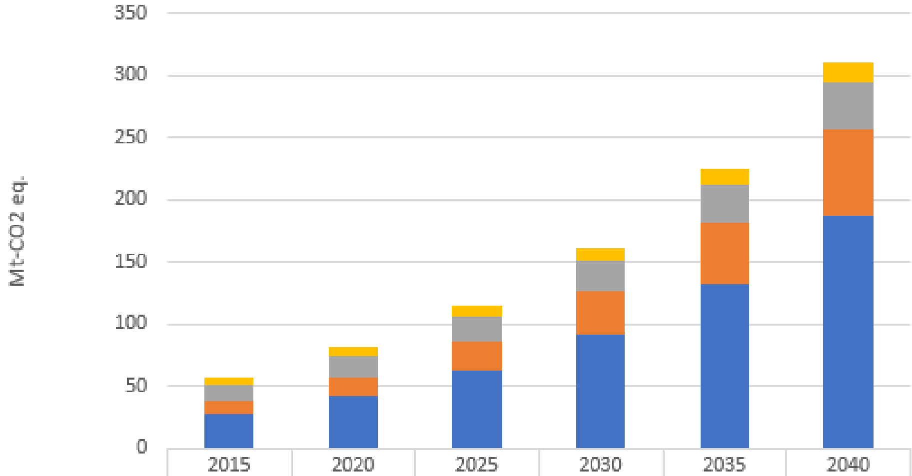
	2015	2020	2025	2030	2035	2040
Diesel	20.69	25.30	30.95	37.85	46.30	56.63
Gasoline	35.78	54.67	81.69	120.05	173.24	245.32
Natural Gas	0.63	1.10	1.85	3.08	5.04	8.07

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.

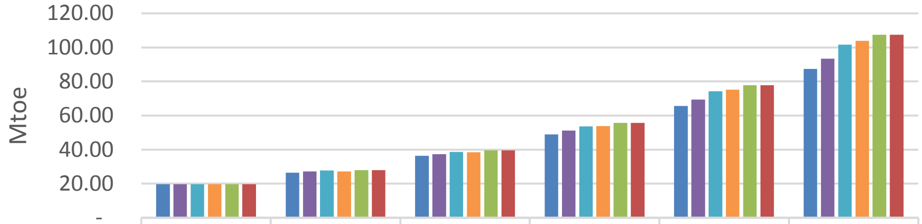
4.4 Results for Alternative Policy Scenario

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

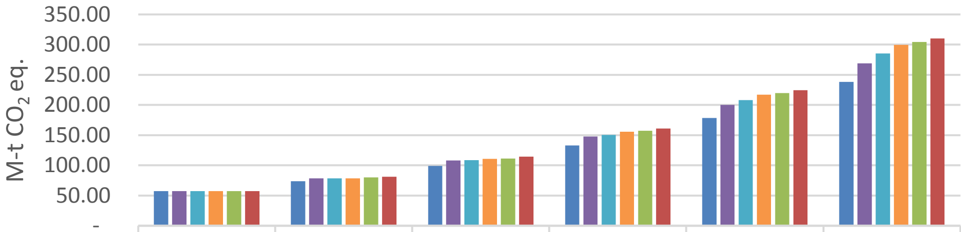


	2015	2020	2025	2030	2035	2040
APS	19.72	26.50	36.35	48.99	65.66	87.35
EEV	19.72	27.22	37.39	51.15	69.44	93.34
EV	19.72	27.70	38.64	53.71	74.18	101.60
PT	19.72	27.19	38.36	53.92	75.20	103.85
BIO	19.72	28.01	39.59	55.70	77.75	107.41
BAU	19.72	28.01	39.59	55.70	77.75	107.41

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



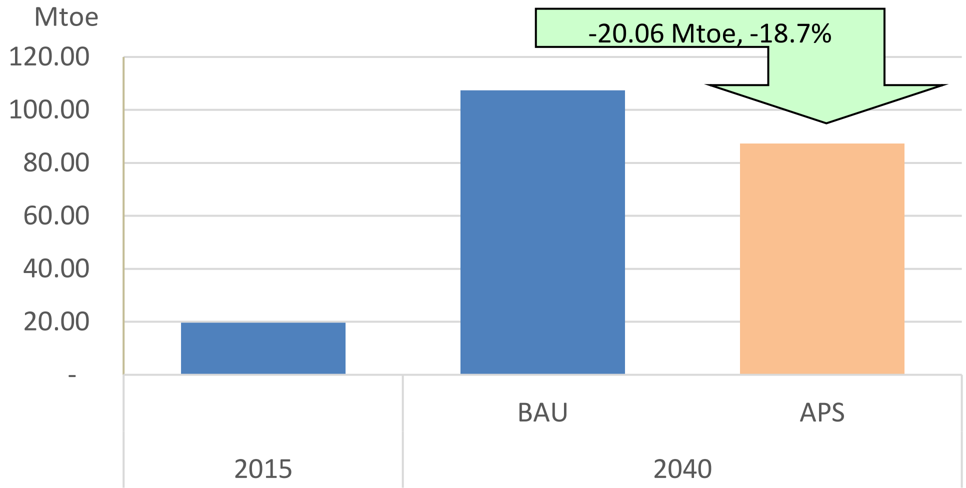
	2015	2020	2025	2030	2035	2040
APS	57.10	73.93	98.93	133.03	178.52	238.08
EEV	57.10	78.73	108.02	147.60	200.16	268.71
EV	57.10	78.63	108.68	150.61	208.08	285.48
PT	57.10	78.66	110.92	155.77	217.08	299.50
BIO	57.10	79.86	111.38	157.18	219.90	304.31
BAU	57.10	81.07	114.50	160.99	224.57	310.01

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

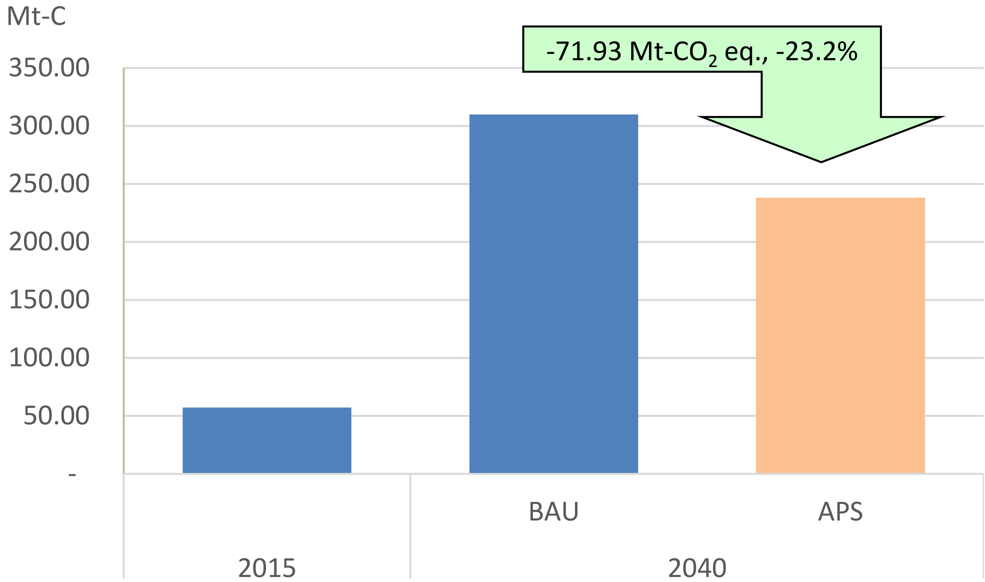


APS = alternative policy scenario, BAU = business-as-usual scenario, Mtoe = million tonnes of oil equivalent,

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

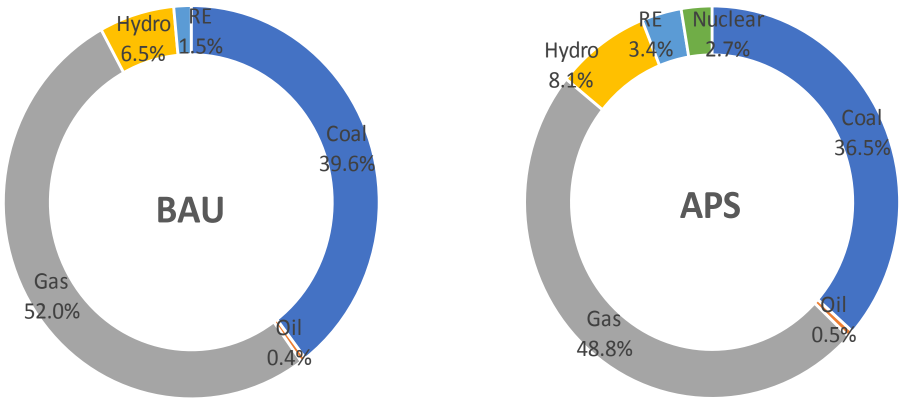


APS = alternative policy scenario, BAU = business-as-usual scenario, Mt-C = million tonnes of coal, Mt-CO_2eq = million tonnes of carbon dioxide equivalent.
Source: Study team.

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.

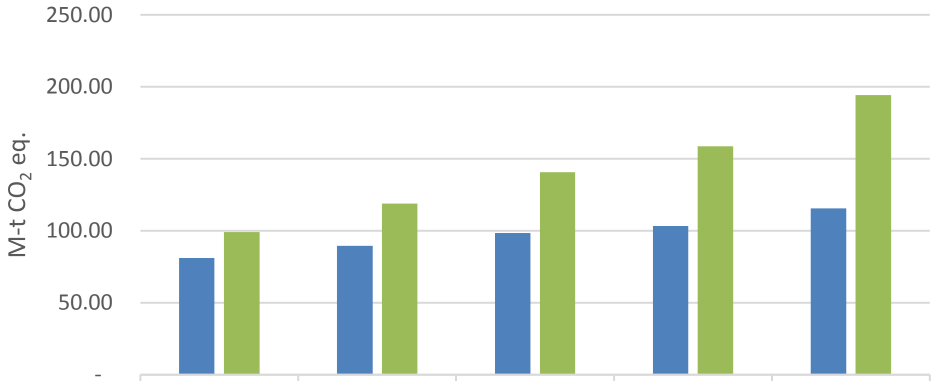
Figure 4.14 Power Generation Mix for BAU and APS, 2040



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.