Chapter 10
Malaysia Country Report

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1. Basic Concept of Low-carbon Energy Transition – Carbon Neutrality

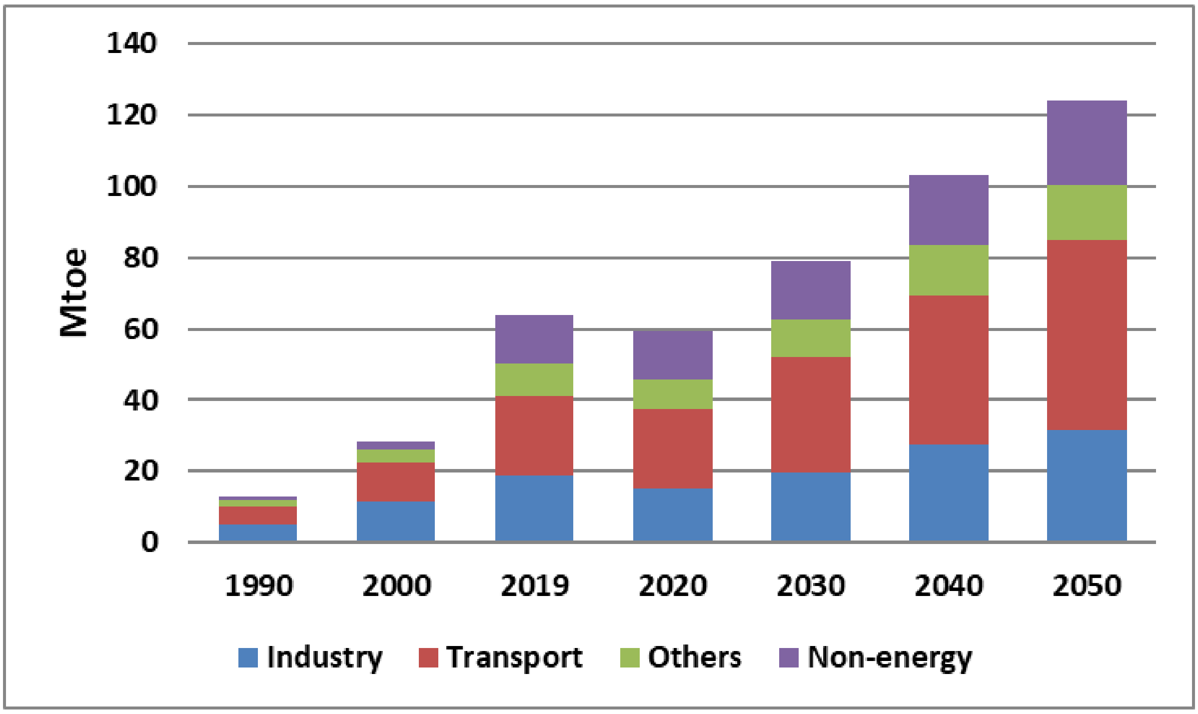
The concept 'low-carbon transition' refers to a shift from an economy that depends heavily on fossil fuels to a sustainable, low-carbon economy. A fundamental change in the way an economy organises energy services is necessary to reduce the risks of catastrophic climate change. Furthermore, a sustainable energy system is likely to offer other significant benefits such as lower resource dependence, technology spillovers associated with the development of alternative energy sources, global access to energy services, and secure and reliable low-carbon energy supplies (Earth System Governance, n.d.).

Carbon neutrality means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon dioxide (CO_2) from the atmosphere and then storing it is known as carbon sequestration. To achieve net-zero emissions, all worldwide greenhouse gas (GHG) emissions will have to be counterbalanced by carbon sequestration. A carbon sink is any system that absorbs more carbon than it emits. The main natural carbon sinks are soil, forests, and oceans. To date, no artificial carbon sinks can remove carbon from the atmosphere on a scale needed to fight global warming. The carbon stored in natural sinks such as forests is released into the atmosphere through forest fires, changes in land use, and logging. This is why it is essential to reduce carbon emissions to reach climate neutrality (New European Parliament, 2019).

2. Final Energy Consumption (Historical Trends: 2019, 2030, 2040, 2050)

Under the low-carbon energy transition–carbon neutral (LCET–CN) scenario, the total final energy consumption for Malaysia is expected to increase by 2.2% per year by 2050 from the 2019 level. This rate is much lower compared to the business as usual (BAU) scenario at 2.5% per year and the alternative policy (AP) scenario at 2.4% per year. The lower growth rate per year under the LCET–CN scenario is due to higher potential of savings of energy efficiency that can be obtained from the industry, residential, and commercial sectors. The potential savings of energy efficiency under the LCET–CN scenario is assumed at 16% from 2041 until 2050, whilst only 8% for the AP scenario. The projection of final energy consumption for the BAU scenario until 2050 is based on gross domestic product (GDP) and population growth assumptions.

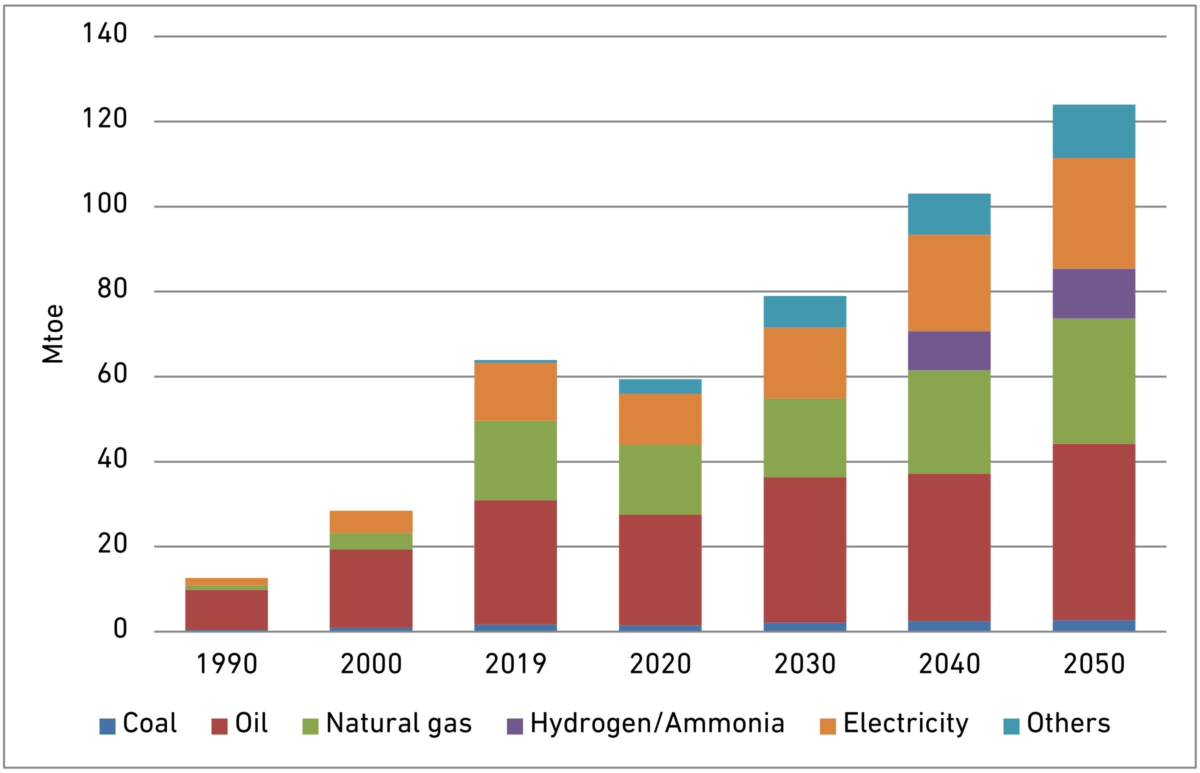
Figure 10.1. Final Energy Consumption by Sector, LCET–CN Scenario (1990–2050)



LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

Figure 10.1 shows the final energy consumption by sector under the LCET–CN scenario. In 2050, the total final energy consumption is expected to register at 124 million tonnes of oil equivalent (Mtoe). The transport sector will be expected to remain as the leading sector in 2050 with 43.3% of the total share. Moreover, the transport sector will be assumed to increase at the highest rate per year at 2.9% compared with the other sectors. The industry sector, which is the second largest of final energy consumed will be expected to settle at 31.42 Mtoe or 25.3% from the total share in 2050. Due to measures to combat energy efficiency in the industry sector, the increment per year is only at 1.6% from 2019 until 2050. Non-energy sector performance will be assumed to increase at 1.8% per year from 2019 until 2050. However, the share of the non-energy sector dropped to 18.9% in 2050 from 21.3% in 2019. Lastly, the 'others' sector (residential, commercial, and agriculture) constituted about 12.4% share from the total final energy consumption in 2050. The 'others' sector posted a positive trend from 2019 until 2050 at a rate of 1.8% per year.

Figure 10.2. Final Energy Consumption by Fuel Type, LCET–CN Scenario (1990–2050)



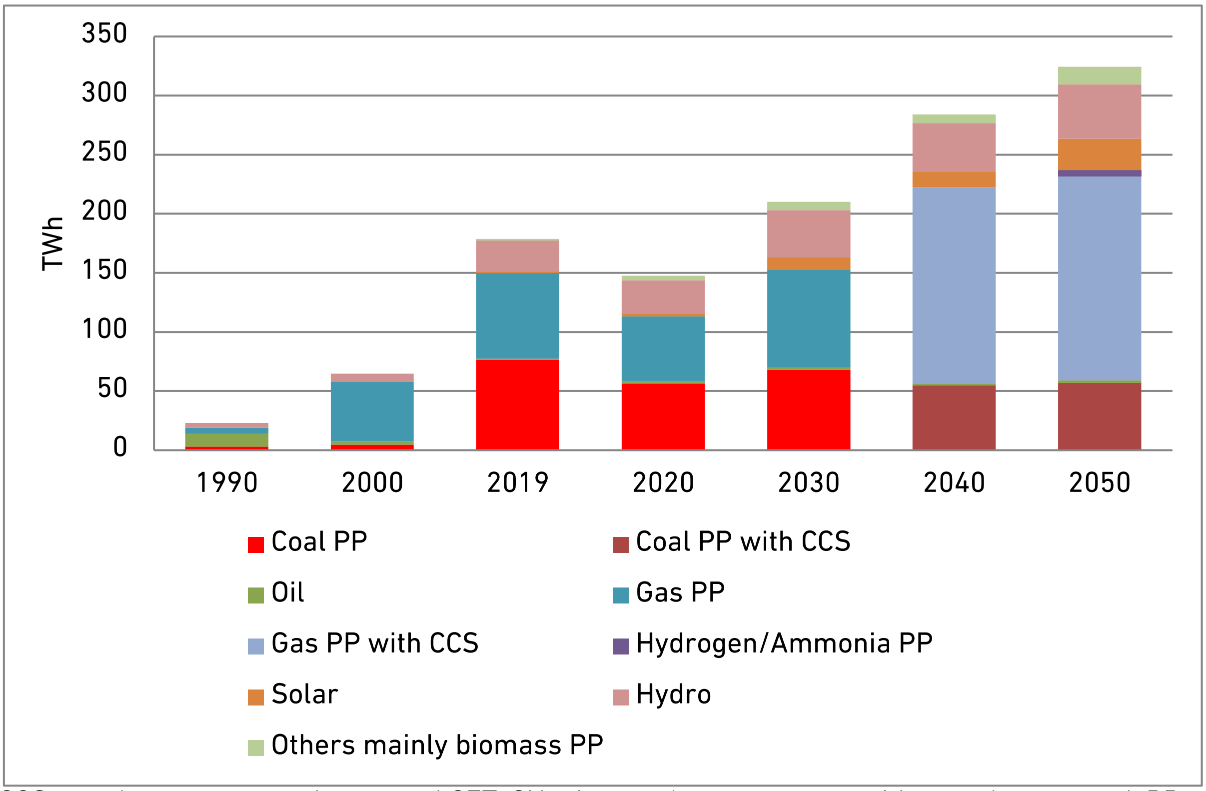
LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

The LCET–CN scenario underlines the importance of having clean energy that can contribute to lowering CO_2 emissions. The introduction of hydrogen and biofuel for fuelling vehicles will result in a change in the mix of final energy consumption in 2050. Non-fossil fuels contribute about 19.6% of share from the total final energy consumption in 2050. These contributions come from biofuel at 10.2% and hydrogen at 9.4%. The oil share will be expected to reduce at 33.5% share in 2050 compared to 45.8% share in 2019. The natural gas share also copied the same trend with oil with 23.8% share in 2050 from 2019 level at 29.2% share in 2019. The electricity share remains at same level in 2019 and 2050 with 21.4% and 21.0%, respectively.

3. Power Generation (Historical Trend: 2019, 2030, 2040, 2050)

In 2050, the total power generation is expected to register at 324.29 terawatts per hour (TWh) under the LCET–CN scenario. This figure is lower than in the business as usual (BAU) and alternative policy (AP) scenarios at 412.77 TWh and 379.80 TWh, respectively. The savings generated from electricity consumption in the industry, commercial, and residential sectors has required the power sector to produce less electricity.

Figure 10.3. Electricity Generation by Fuel Type, LCET-CN Scenario (1990–2050)



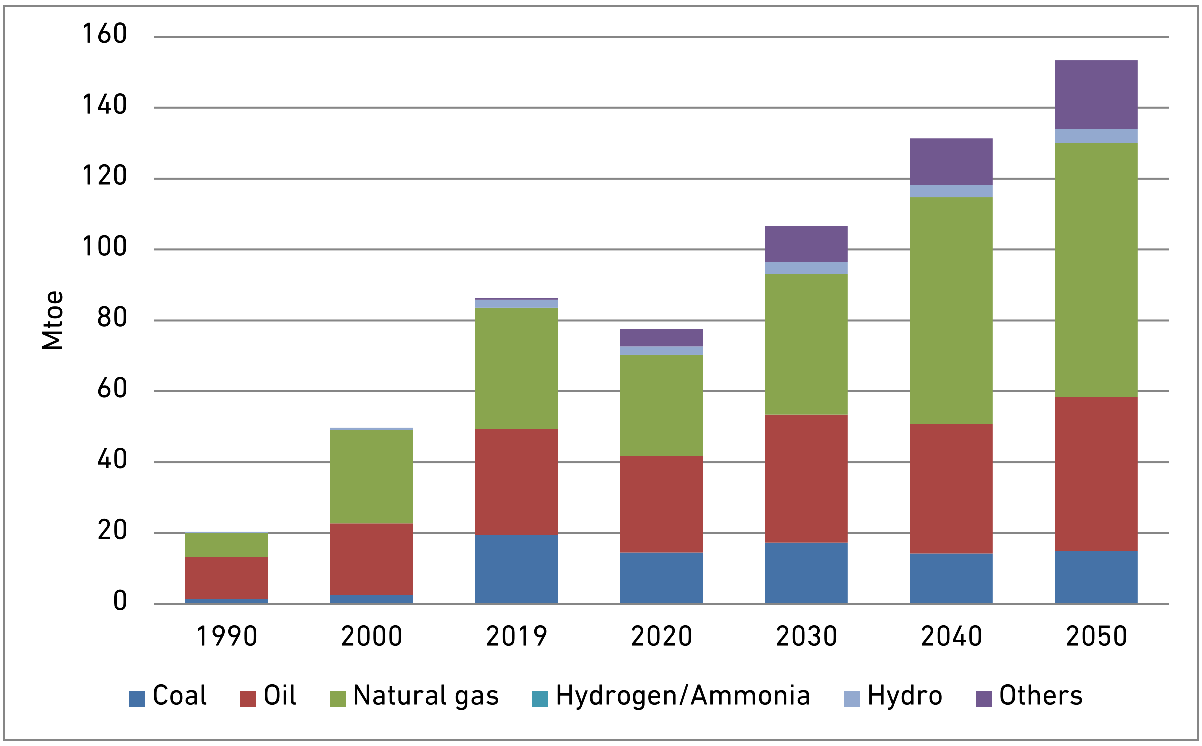
CCS = carbon capture and storage, LCET–CN = low-carbon energy transition–carbon neutral, PP = power plant, TWh = terawatt-hour.
Source: Author's calculations.

Total electricity generation under the LCET–CN scenario is projected to increase at 1.9% per year from 2019 until 2050. Based on Figure 10.3, gas-fired power plants with carbon capture and storage (CCS) register the highest share with 53.3% from the total electricity generation in 2050. This is followed by coal-fired power plants with CCS at 17.5% share. The total renewable energy (RE) share that consist of hydro, solar, and biomass contributes about 27.0% share of total electricity generation in 2050. The higher share of RE generation in 2050 was due to adjusted assumption of RE installed capacity compare with the AP scenario. Under the AP scenario, the RE generation share is 15.7%, whilst in the BAU scenario the share is 9.9%.

4. Primary Energy Supply (Historical Trend: 2019, 2030, 2040, 2050)

The total primary energy supply under the LCET–CN scenario is expected to increase at 1.9% per year from 2019 until 2050. The incremental rate is lower when comparing with the BAU and AP scenarios at 2.6% and 2.1% per year, respectively. This was due to greater assumption of energy savings being inserted into the LCET–CN scenario. Figure 10.4 shows the total primary energy supply by fuel type.

Figure 10.4. Total Primary Energy Supply by Fuel Type, LCET–CN Scenario (1990–2050)



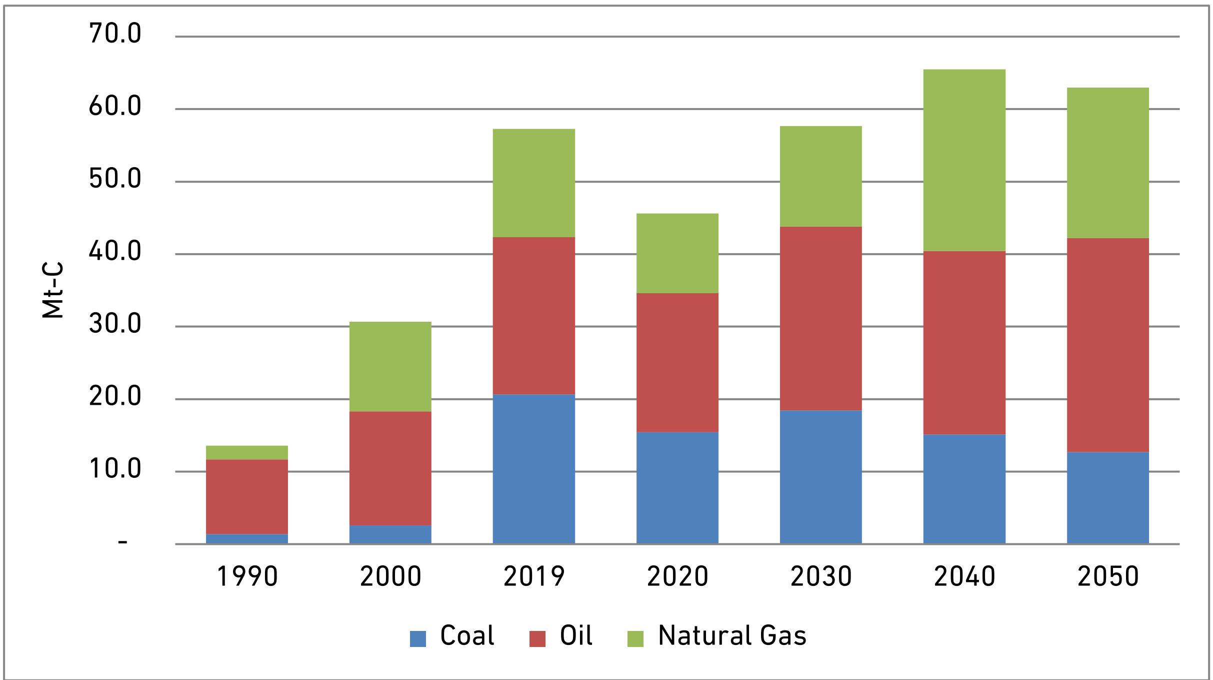
LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

'Others' fuel recorded the highest increase amongst fossil fuels at 12.3% per year from 2019 until 2050. This was contributed by biofuel at 10.0% per year in a similar time horizon. The introduction of the National Biofuel Policy and the target of the implementation of biodiesel blending with conventional diesel up by 30% by 2030 in the transport sector have given a significant impact. The assumption of doubling the capacity of RE in the power sector by 2050 has created a bright prospect of RE especially for biomass, biogas, and solar. Solar alone is expected to increase at 9.8% per year from 2019 until 2050 whilst biomass, biogas, and municipal solid waste will grow at 8.7% per year. Natural gas and oil will have minimal growth throughout the projection period at 2.4% per year and 1.2% per year, respectively. Nevertheless, natural gas and oil will still have a significant role for the future energy landscape in the country as they will contribute around 46.8% share and 28.3% share, respectively. This is followed by 'others' at 12.6% share and coal at 9.7% share. The government decision in 2021 that no new coal-fired power plants will be commissioned in the country has contributed to the impact. Overall, the total primary energy supply is expected to register at 153.39 million tonnes of oil equivalent (Mtoe) in 2050.

5. Carbon Dioxide Emissions

Overall, for 2050, the total CO_2 emissions for the LCET–CN scenario is stated at 63.0 million tonnes of carbon (Mt-C), an increase of 0.3% per year from the 2019 level. The total emissions for the LCET–CN scenario in 2050 is much lower compared with the BAU and AP scenarios. In the BAU scenario for 2050, the total CO_2 emissions is registered at 117.9 Mt-C ,whilst in the AP scenario it is 94.1 Mt-C. Between the BAU and LCET–CN scenarios, the highest contribution of CO_2 emissions potential savings will be expected to come from natural gas. Only CO_2 emissions for coal will be expected to have a decreasing trend from 2019 until 2050 with –1.6% per year. This was due to the new policy by the government to stop developing new coal power plants in the future. CO_2 emissions from natural gas will be expected to increase by 1.1% per year from 2019 until 2050 since switching from coal. Natural gas will always be the best option compared to coal, especially in the power sector in generating electricity, because of the stability of supply and the affordability factor. The total emissions from oil will be expected to increase at 1.0% per year to register at 29.5 Mt-C (Figure 10.5).

Figure 10.5. Total CO_2 Emissions by Fuel Type, LCET–CN Scenario (1990–2050)



CO_2 = carbon dioxide, LCET–CN = low-carbon energy transition–carbon neutral, Mt-C = million tonnes of carbon.
Source: Author's calculations.

Overall, analysis by share shows that oil will still dominate the total emissions at 46.9% in 2050 followed by natural gas at 33.0%, and lastly coal at 20.1%

6. Hydrogen Demand across the Sectors

Under the LCET–CN scenario assumptions, two sectors will be involved directly for hydrogen utilisation: transport and power. In the transport sector, the assumption was made that gasoline will be replaced with hydrogen. Based on this assumption, the fuel switching between them will start in 2041 until 2050 with a utilisation rate of 50%. This utilisation rate can only be achieved with the proper infrastructure of hydrogen fuelling stations available and affordable hydrogen vehicles in the market. As a result, in 2050, hydrogen consumption will be 11.64 kilotons of oil equivalent (ktoe) coming from road transport. This hydrogen consumption will represent 9.4% of share from the total final energy consumption in 2050.

Hydrogen as a fuel will also be introduced in the power sector beginning in 2041 with total capacity of 720 megawatts (MW). This assumption was made to fully utilise the local supply of hydrogen. In 2050, the total power generation from hydrogen power plants will be expected to generate 5.05 TWh of electricity. This electricity generation will constitute about 1.6% share from the total electricity generation in 2050. In terms of fuel input, the hydrogen share will represent 2.0% from the total fuel input in power generation in 2050.

7. Energy Cost Comparison between BAU and LCET–CN Scenarios

An analysis on energy cost was carried out to see the comparison between the BAU and LCET–CN scenarios. The objective of this analysis is to see the total investment cost needed to implement all assumptions under the LCET–CN scenario and compare with the BAU scenario. The basic assumption for this analysis is stated in Table 10.1.

Table 10.1. Fuel Cost Assumptions

	2019/2020	2050 (2019 constant price)	Unit
Coal	80.03	98.00	US$/ton
Oil	41	100	US$/bbl
Gas	7.77	7.50	US$/MMBtu
Hydrogen	0.8	0.3	US$/$Nm^3$
CCS	0	30	US$/$CO_2$ ton

bbl = barrel, CCS = carbon-capture and storage, MMBtu = metric million British thermal unit, Nm^3 = normal cubic metre.
Source: Author's calculations.

Table 10.2. Construction Cost of Power Plants Assumptions
(US$/KW)

	2019	by 2050
Coal	1,500	1,525
Oil	0	0
Gas	700	700
Hydrogen	0	700
Nuclear	4,500	3,575
Hydro	2,000	2,223
Geothermal	4,000	4,256
Solar	1,600	307
Wind	1,600	1,235
Biomass	2,000	3,019

KW = kilowatt.
Source: Author's calculations.

Table 10.3. Capacity Factor of Power Plants Assumptions
(%)

	2019	by 2050
Coal	75	80
Oil	75	80
Gas	75	80
Hydrogen	0	80
Nuclear	100	80
Hydro	50	40
Geothermal	50	50
Solar	17	17
Wind	40	40
Biomass	50	70

Source: Author's calculations.

7.1. Fuel Cost

Based on fuel cost assumptions that are stated in Table 10.1, the overall result of total investment fuel cost is shown in Table 10.4.

Table 10.4. Total Investment Fuel Cost Comparison, BAU and LCET–CN Scenarios in 2050

	Final Energy Consumption (Mtoe), BAU in 2019	Final Energy Consumption (Mtoe), BAU in 2050	Final Energy Consumption (Mtoe), LCET–CN in 2050	Total Investment Cost, BAU in 2050 (US$ million)	Total Investment Cost, LCET–CN in 2050 (US$ million)
Coal	192.23	505.12	184.85	49,444	–1,166
Oil	218.49	563.95	262.12	237,609	30,009
Gas	134.83	387.22	269.4	72,878	38,857
Hydrogen	0	0	155.1	0	180,723
Total	**545.55**	**1,456.29**	**871.47**	**359,931**	**248,422**

BAU = business as usual, LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

From the results in Table 10.4, the total investment fuel cost in 2050 for the BAU scenario is expected to be US$359,931 million. This total is higher from the total investment fuel cost under the LCET–CN scenario at US$248,422 million.

7.2. Power Generation Investment

Based on power generation investment assumptions stated in Table 10.2 and Table 10.3, analysis on the total investment cost for power plants in 2050 for the BAU and LCET–CN scenarios are shown in Table 10.5.

Table 10.5. Total Investment Power Plants Cost Comparison, BAU and LCET–CN Scenarios in 2050

	Electricity Generation in BAU for 2019 (TWh)	Electricity Generation in BAU for 2050 (TWh)	Electricity Generation in LCET–CN for 2050 (TWh)	Additional Capacity for BAU (MW)	Additional Capacity for LCET–CN (MW)	Total Investment Cost, BAU in 2050 (US$ million)	Total Investment Cost, LCET–CN in 2050 (US$ million)
Coal	76	49	57	–3,871	–2,785	–5,904	–4,248
Oil	1	2	2	124	0	0	0
Gas	72	321	173	35,455	14,332	24,819	10,033
Hydrogen	0	0	5	0	721	0	504
Hydro	26	36	46	2,763	5,659	6,141	12,581
Solar	1	2	27	195	16,821	60	5,164
Wind	0	0	0	0	0	0	0
Biomass	1	3	15	320	2,223	965	6,711
Total	**179**	**413**	**324**	**34,985**	**36,971**	**26,081**	**30,744**

BAU = business as usual, LCET–CN = low-carbon energy transition–carbon neutral, MW = megawatt, TWh = terawatt-hour.
Source: Author's calculations.

From Table 10.5, the total additional capacity needed for the BAU scenario is 34,985 MW from the 2019 level. However, the additional capacity for the LCET–CN scenario in 2050 is much greater from the BAU scenario at 36,971 MW. This was due to more aggressive assumptions put RE for power plants in 2050 for the LCET–CN scenario to reduce CO_2 emissions. As a result, the total investment for power plants in 2050 for the BAU scenario is assumed to be US$26,081 million, whilst under the LCET–CN scenario at US$30,744 million.

7.3. Carbon Capture and Storage Cost

The introduction of carbon capture and storage (CCS) is projected to be implemented under the LCET–CN scenario starting from 2041 onwards. The CCS projects will be assumed to be implemented for coal-fired and natural gas-fired power plants. Based on the assumption stated in Table 10.1, the CCS cost is around US$30/$CO_2$ tonne, the total investment for CCS can be calculated. The total investment cost of CCS is shown in Table 10.6.

Table 10.6. Total Investment Cost of Carbon Capture and Storage for LCET–CN Scenario in 2050

	Consumption for LCET–CN in 2050 (Mtoe)	CO_2 Emissions for LCET–CN (Mt-CO_2)	CO_2 Emissions for LCET–CN (Mt-C)	Total Investment Cost of CCS for LCET–CN (US$ million)
Coal Power Plant with CCS	12.31	12.52	45.94	1,240
Natural Gas Plant with CCS	28.9	16.77	61.55	1,662
Total	**41.21**	**29.29**	**107.50**	**2,902**

CCS = carbon capture and storage, LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent, Mt-CO_2 = million tonnes of carbon dioxide, Mt-C = million tonnes of carbon.
Source: Author's calculations.

Table 10.6 indicates that the total needed investment cost of CCS will be around US$2,902 million. The total consists of CCS projects for coal-fired power plants at US$1,240 million and US$1,662 million for natural gas-fired power plants with CCS.

7.4. Overall Cost

Based on analysis on the overall calculation from section 1 until section 3, the breakdown of the total investment cost is shown in Table 10.7.

Table 10.7. Overall Total Investment Cost for BAU and LCET–CN Scenarios in 2050

	BAU	LCET–CN
Total Fuel Cost Investment (US$ million)	359,931	248,422
Total Power Capital Cost Investment (US$ million)	26,081	30,744
Total CCS Cost Investment (US$ million)	0	2,902
Total (US$ million)	**386,012**	**282,069**

BAU = business as usual, CCS = carbon capture and storage, LCET–CN = low-carbon energy transition–carbon neutral.
Source: Author's calculations.

The overall investment cost for the BAU scenario in 2050 is projected to be US$386,012 million, whilst in the LCET–CN scenario the cost is projected to be US$282,069 million.

8. Conclusions and Recommendations

From the overall calculation of the total investment cost, the LCET–CN scenario required less investment cost compared with the BAU scenario. This indicates that by implementing all measures under the LCET–CN assumption, Malaysia is not only able to achieve net zero by 2050 but can make a saving of US$103,943 million of investment in the energy sector.

Efforts need to be in place to achieve net-zero emissions by 2050. The government should focus on the availability of new technologies and opportunity of investment. Some other parameters such as legal frameworks, an expert work force, and public awareness also need to be prioritised.

Regional cooperation and understanding between economies in the Asian region need to be strengthened through dialogue, seminars, and workshops so that the target of achieving net zero by 2050 will succeed, not only by country but as a whole region.

References

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