Chapter 2

Brunei Darussalam Report

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1. Background

A low-carbon energy transition refers to the shift from high-carbon or fossil fuel-based energy sources to low-carbon or renewable energy sources. The transition involves adopting technologies and practices that produce fewer emissions per unit of energy generated. This can include renewable energy sources such as solar, wind, hydroelectric, geothermal, and biomass, as well as nuclear power, which produces minimal emissions during electricity generation. Additionally, energy efficiency measures and improvements in energy storage technologies play a crucial role in this transition.

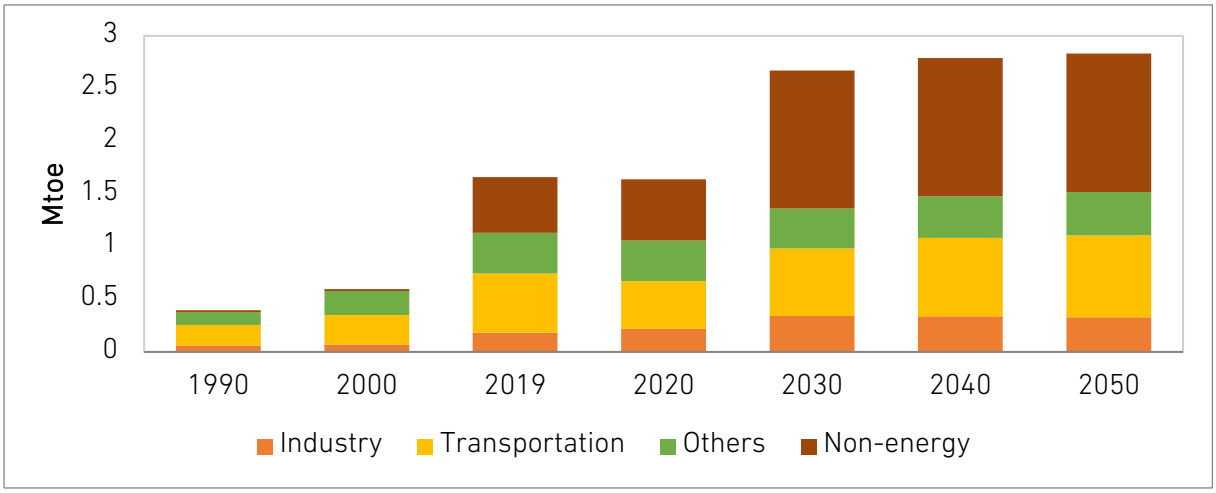
Carbon neutrality or achieving a net-zero carbon footprint means balancing emissions with carbon removal or offsetting measures. It involves reducing emissions as much as possible and then offsetting any remaining emissions through activities that remove carbon dioxide from the atmosphere or prevent additional emissions. In the *Energy Outlook and Energy-Saving Potential in East Asia 2023,* Brunei Darussalam includes carbon capture and storage (CCS) technologies under its low-carbon energy transition–carbon neutral (LCET-CN) scenario in addition to an increased share of solar in the power mix by 2050. This transition requires coordinated efforts from the government, businesses, and individuals to invest in renewable energy infrastructure, adopt energy-efficient technologies, and implement policies that incentivise low-carbon practices. This study analyses the cost requirements for an energy transition towards carbon neutrality for Brunei Darussalam.

2. Final Energy Consumption (historical trend: 2019, 2030, 2040, 2050)

Under the LCET-CN scenario, the total final energy consumption (TFEC) for Brunei Darussalam is expected to reach 3 million tonnes of oil equivalent (Mtoe) in 2050, increasing at an average rate of 1.7% per year over 2019–2050 (Figure 2.1). This rate is lower than that of the business-as-usual (BAU) scenario at 2.1% per year. The lower growth rate under the LCET-CN scenario is expected to occur primarily in the transport sector (22%) as a result of stricter fuel efficiency regulations and the introduction of electric vehicles (EVs). Further reductions of 20% would occur as stringent energy efficiency and conservation measures for buildings are implemented in the 'others' sector.

Figure 2.1. Final Energy Consumption by Sector, LCET-CN Scenario, 1990–2050

(Mtoe)

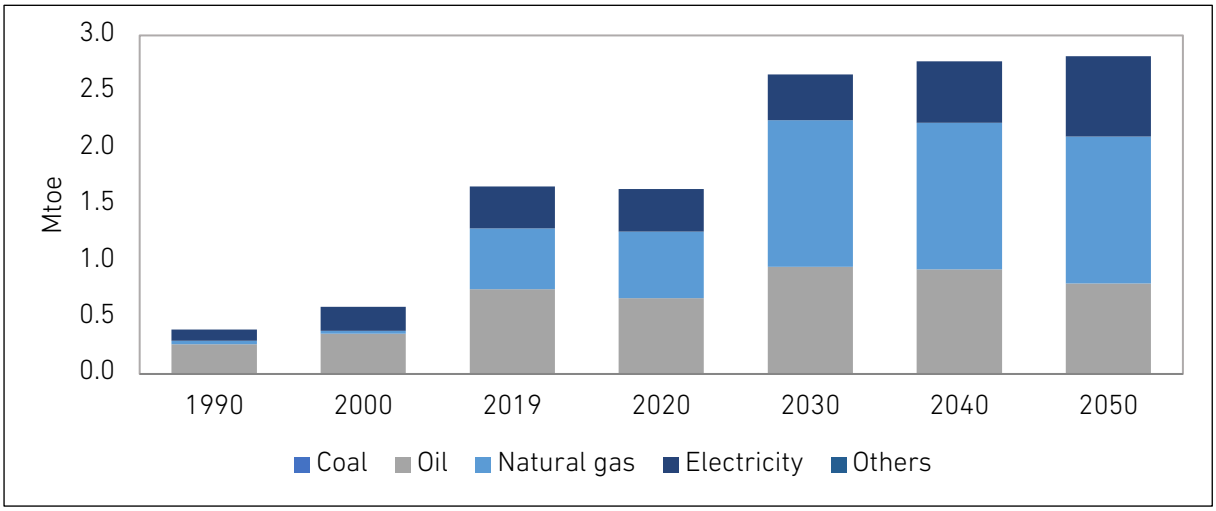


LCET-CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

In 2050 under the LCET-CN scenario, the share of electricity at 25.3% would be higher in the TFEC than the 14.4% share under the BAU scenario, in line with the anticipated electricity demand for EVs. Whilst the share of oil will decline to 28.5%, the share of natural gas in the TFEC is expected to increase to 46.2% under the LCET-CN scenario as demand for natural gas continues to surge with the expansion of the downstream industry. Figure 2.2 shows the final energy consumption by fuel under the LCET-CN scenario.

Figure 2.2. Final Energy Consumption by Fuel, LCET-CN Scenario, 1990–2050

(Mtoe)



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

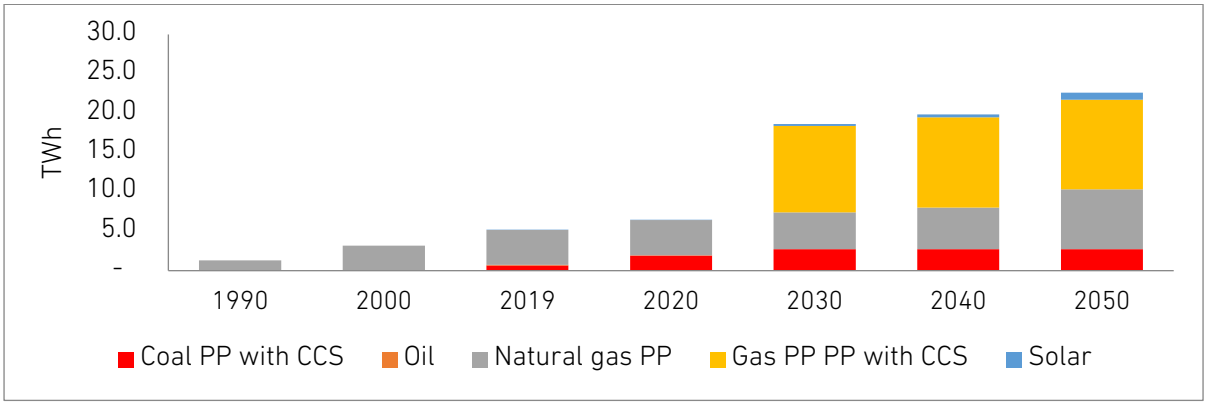
3. Power Generation (historical trend: 2019, 2030, 2040, 2050)

Total electricity generation under the LCET-CN scenario is projected to increase at 4.9% per year from 2019 until 2050, reaching 22.6 terawatt-hours (TWh). Total power generation includes the own-use generation of coal to operate the Hengyi Phase I and Hengyi Phase II petrochemical complex projects. Under the LCET-CN scenario, coal would still be used in generating electricity for Hengyi Phase 1. Yet during Hengyi Phase II, there would be a transition from coal to gas-fired power generation, including carbon capture, use, and storage (CCUS). The transition would result in a moderate reduction in electricity generation to 22.6 TWh in 2050 from 25.0 TWh under the BAU scenario.

Overall, the share of generation under the LCET-CN scenario is expected to remain unchanged from fossil fuels, with an increased natural gas share (including with CCUS) to 84% in 2050 compared with 25% under the BAU scenario, whilst the share of coal would drop to 12% from 75% in the BAU scenario. Renewable energy in Brunei Darussalam is only solar; this share would be 4% in the total electricity generation mix in 2050 under the LCET-CN scenario.

Figure 2.3. Electricity Generation by Fuel, LCET-CN Scenario, 1990–2050

(TWh)



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 4.9% per year from 2019 until 2050 (Figure 2.3).

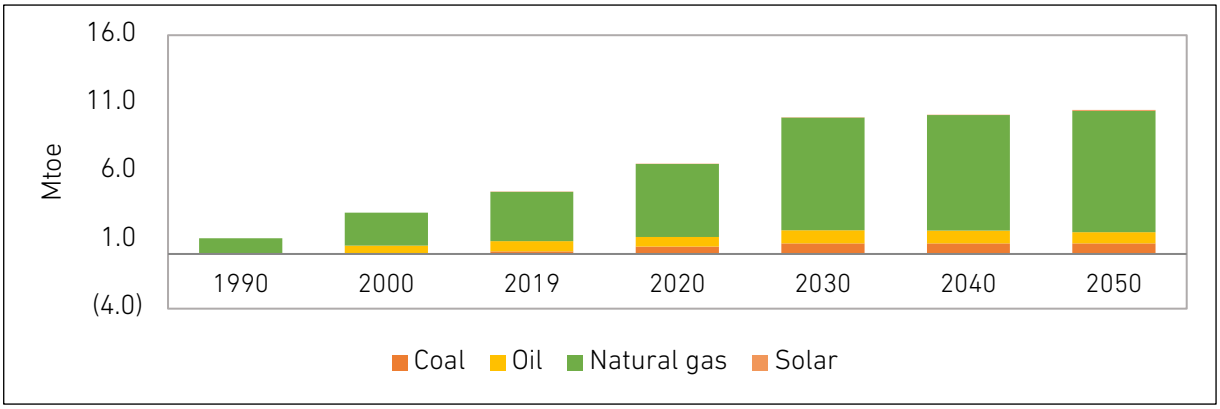
4. Primary Energy Supply (historical trend: 2019, 2030, 2040, and 2050)

The total primary energy supply (TPES) under the LCET-CN scenario is expected to reach 10.4 Mtoe in 2050, increasing at an average rate of 2.8% per year from 2019 (Figure 2.4). The TPES under the LCET-CN scenario would decline by 24.3% compared to the BAU

scenario. The share of natural gas in the TPES is projected to increase to 84.3% in 2050, and the shares of coal and oil would decline to 7.4% and 7.6%, respectively. The trend would be due to the switch from natural gas to coal during Hengyi Phase II.

Figure 2.4. Total Primary Energy Supply by Fuel Type, LCET-CN Scenario, 1990–2050

(Mtoe)



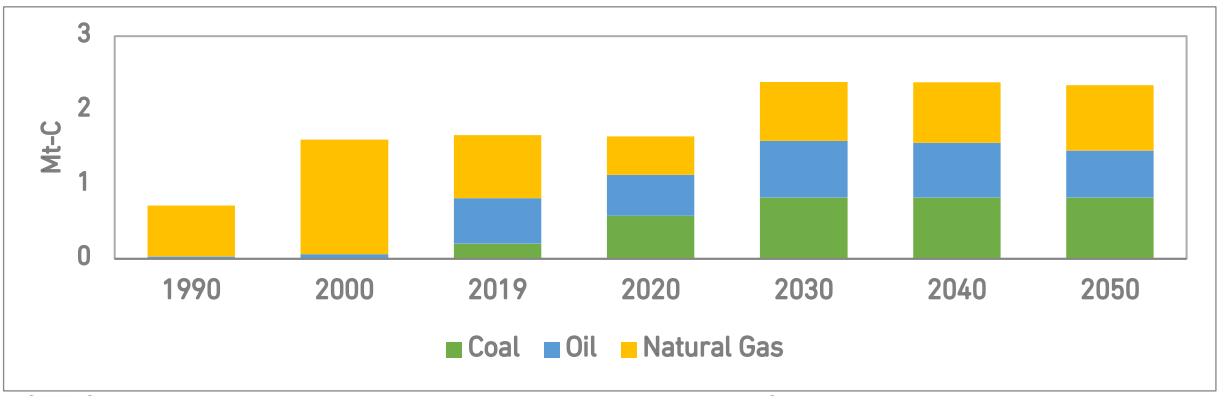
LCET-CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

5. Emissions

Total emissions will peak in 2030 and show a declining trend of about 0.17% per year to reach 2.3 million tonnes of carbon (MtC) in 2050, as less demand for oil is expected. Natural gas will become the major source of emissions, with a 37.6% share in 2050, followed by coal with 35.2%. Oil is projected to emit the least, at 27.2%. Using a CCUS unit in natural gas power plants would reduce emissions by 67.6% under the LCET-CN scenario compared with the alternative policy scenario (APS).

Figure 2.5. Total Emissions by Fuel Type, LCET-CN Scenario, 1990–2050

(MtC)



LCET-CN = low-carbon energy transition–carbon neutral, Mt-C = metric tonne of carbon.
Source: Author's calculations.

6. Hydrogen Demand across the Sector

Hydrogen demand was not assumed under the Brunei Darussalam LCET-CN scenario.

7. Energy Cost Comparison

7.1. Assumptions

An analysis of energy costs was carried out to compare the BAU and LCET-CN scenarios. The objective of this analysis to see the total energy costs needed to implement all assumptions under the LCET-CN scenario. The basic assumptions for this analysis are stated in Tables 2.1–2.3.

Table 2.1. Assumed Fuel Costs

Fuel	2019/2020	2050 (2019 constant price)	Unit
Coal	80.03	98.00	US$/tonne
Oil	41.00	100.00	US$/bbl
Gas	7.77	7.50	US$/mmbtu
Hydrogen	0.80	0.30	US$/$Nm^3$
CCS	0	30.00	US$/$tCO_2$

bbl = barrel, CCS = carbon capture and storage, CO_2 = carbon dioxide, mmbtu = million British thermal units, Nm^3 = normal cubic metre, tCO_2 = tonne of carbon dioxide.
Source: Author's calculations.

Table 2.2. Assumed Construction Costs of Power Plants
(US$/kilowatt)

Fuel	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

Source: Author's calculations.

Table 2.3. Assumed Capacity Factors of Power Plants

(%)

Fuel	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.

7.2. Fuel Costs

Based on fuel cost assumptions in Table 2.1, fuel costs are shown in Table 2.4.

Table 2.4. Fuel Cost Comparison, BAU and LCET-CN Scenarios, 2050

Fuel	Primary Energy Consumption, BAU, 2019 (Mtoe)	Primary Energy Consumption, BAU, 2050 (Mtoe)	Primary Energy Consumption, LCET-CN, 2050 (Mtoe)	Total Investment Cost, BAU, 2050 (US$ million)	Total Investment Cost, LCET-CN, 2050 (US$ million)
Coal	0.19	5.38	0.78	820	93
Oil	0.74	1.38	0.80	440	41
Gas	3.60	7.16	8.89	1,028	1,527
Hydrogen	0	0	0	0	0
Total	**4.53**	**13.92**	**10.47**	**2,288**	**1,662**

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 above, the total investment fuel cost in 2050 for the BAU scenario is expected to be US$2,288 million, higher than that of the LCET-CN scenario at US$1,662 million.

7.3. Power Generation Investment

Based on power generation investment assumptions in Tables 2–3, the total investment costs for power plants in 2050 under the BAU and LCET-CN scenarios are in Table 2.5.

From Table 2.5, the total additional capacity needed for the BAU scenario would be 2,850 megawatts (MW) from the 2019 level. The additional capacity under the LCET-CN scenario would be slightly higher at 2,955 MW. As explained previously, own-use of coal for operating the Hengyi Phase I is assumed to not be affected under the LCET-CN scenario; only in the Hengyi Phase II would coal be replaced with gas-fired power generation, including CCUS. This transition would result in a in a moderate reduction in electricity generation in 2050. Thus, the total additional capacity from coal and gas under the LCET-CN scenario (2,368 MW) would be lower than that under the BAU scenario (2,829 MW). In addition, Brunei Darussalam would increase its solar capacity under the LCET-CN scenario (an additional 586 MW compared to 21 MW under the BAU scenario) to reduce emissions. The total investment for power plants in 2050 under the BAU scenario would therefore be around US$4,115 million, while under the LCET-CN scenario, it would be US$2,079 million.

Table 2.5. Power Plant Cost Comparisons, BAU and LCET-CN Scenarios, 2050

	Electricity Generation, BAU, 2019 (TWh)	Electricity Generation, BAU, 2050 (TWh)	Electricity Generation, LCET-CN, 2050 (TWh)	Additional Capacity, BAU, (MW)	Additional Capacity, LCET-CN (MW)	Total Investment Cost, BAU, 2050 (US$ million)	Total Investment Cost, LCET-CN, 2050 (US$ million)
Coal	0.67	18.75	2.72	2,580	292	3,934	446
Oil	0.05	0.00	0.00	0			
Gas	4.45	6.20	19.74	249	2,076	174	1,453
Hydrogen	0.00	0.00	0.00	0	0	0	0
Hydro	0.00	0.00	0.00	0	0	0	0
Solar	0.00	0.03	0.87	21	586	7	180
Wind	0.00	0.00	0.00	0	0	0	0
Biomass	0.00	0.00	0.87	0	0	0	0
Total	**5.17**	**24.98**	**23.34**	**2,850**	**2,955**	**4,115**	**2,079**

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

7.4. Carbon Capture and Storage Costs

The introduction of CCS for natural gas power plants would be implemented under the LCET-CN scenario starting in 2041. Based on Table 2.1, the CCS costs are around US$30 per tonne of carbon dioxide (Table 2.6).

Table 2.6. Total Investment Cost of CCS for LCET-CN Scenario in 2050

	Consumption for LCET-CN in 2050 (Mtoe)	Emissions for LCET-CN ($MtCO_2$)	Emissions for LCET-CN (MtC)	Total Investment Cost of CCS for LCET-CN (US$ million)
Coal Power Plant with CCS	0.00	0.000	0.000	0
Natural Gas Plant with CCS	0.07	0.142	0.039	4
Total	**0.07**	**0.142**	**0.039**	**4**

CCS = carbon capture and storage, LCET-CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent, MtC = million tonnes of carbon, $MtCO_2$ = million tonnes of carbon dioxide.
Source: Author's calculations.

Table 2.6 indicates that the total investment costs of CCS under the LCET-CN scenario would be around US$4 million.

7.5. Overall Costs

The breakdown of the total investment costs is shown in Table 2.7.

Table 2.7. Overall Total Investment Costs for BAU and LCET-CN Scenarios in 2050

	BAU	LCET–CN	LCET–CN vs. BAU
Total Fuel Cost Investment (US$ million)	2,288	1,662	–626
Total Power Capital Cost Investment (US$ million)	133	67	–66
Total CCS Cost Investment (US$ million)	0	4	4
Total (US$ million)	**2,421**	**1,733**	**–688**

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

Overall investment costs under the BAU scenario in 2050 are projected to be US$2,421 million, while under the LCET-CN scenario, they are US$1,733 million.

8. Conclusions and Recommendations

Brunei Darussalam will remain reliant on fossil fuels to meet growing energy demand, even under the LCET-CN scenario. The non-energy sector will drive energy demand, as a significant volume of natural gas is needed to expand downstream industries as the economy diversifies. Transport would offer the greatest savings in the LCET-CN scenario, with improved vehicle efficiency and greater use of EVs. The power sector under the LCET-CN scenario would be decarbonised through CCS and increasing shares of renewable energy (mainly solar) as well.

Overall, the energy-related emissions of Brunei Darussalam would decrease significantly in the LCET-CN scenario by 2050 (i.e., 70%) compared to the BAU scenario. Projected carbon removal of about 3.8 MtC and emissions of 2.3 MtC in 2050 would result in a net sink of –1.5 MtC. Hence, the NDC and net-zero emissions target are assumed to be achieved under the LCET scenario, which means that ambitious measures are required to put the economy on a sustainable energy pathway to achieve net-zero emissions by 2050.

The total investment cost of the LCET–CN scenario is estimated to be US$1,733 million, which is lower than that in the BAU scenario, US$2,421 million. This result indicates that implementing all measures assumed under the LCET–CN scenario would enable Brunei Darussalam to attain net-zero emissions by 2050. This is in line with the government energy strategies being developed to achieve net-zero emissions by 2050. The total investment reduction of the energy sector by implementing the LCET–CN scenario would be US$688 million compared to implementation of the BAU scenario.

The main reduction in total investment would be due to lower fuel costs (US$626 million), as fuel costs are the largest portion of the total investment (95% in the BAU and 96% in the LCET–CN scenarios). Introduction of CCS is assumed to be from 2030 in the LCET-CN scenario, and the investment in CCS would reach US$4 million in 2050, around 1% of the total investment. If the cost of CCS technology is reduced by 2050, the investment cost of CCS is expected to be reduced significantly.