Chapter 12

New Zealand Country Report

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

The Low Carbon Energy Transition (LCET) aims to reduce greenhouse gas emissions from energy and to find sustainable ways to remove the use of fossil fuels (primarily coal, oil and natural gas). This includes transformation of the energy structure (e.g. by replacing fossil fuels with renewable energy), decarbonisation of fossil fuel utilisation, and improvement in energy efficiency. The increasing penetration of renewable energy into the energy supply mix, the onset of electrification and improvements in energy storage are all key drivers of the energy transition.

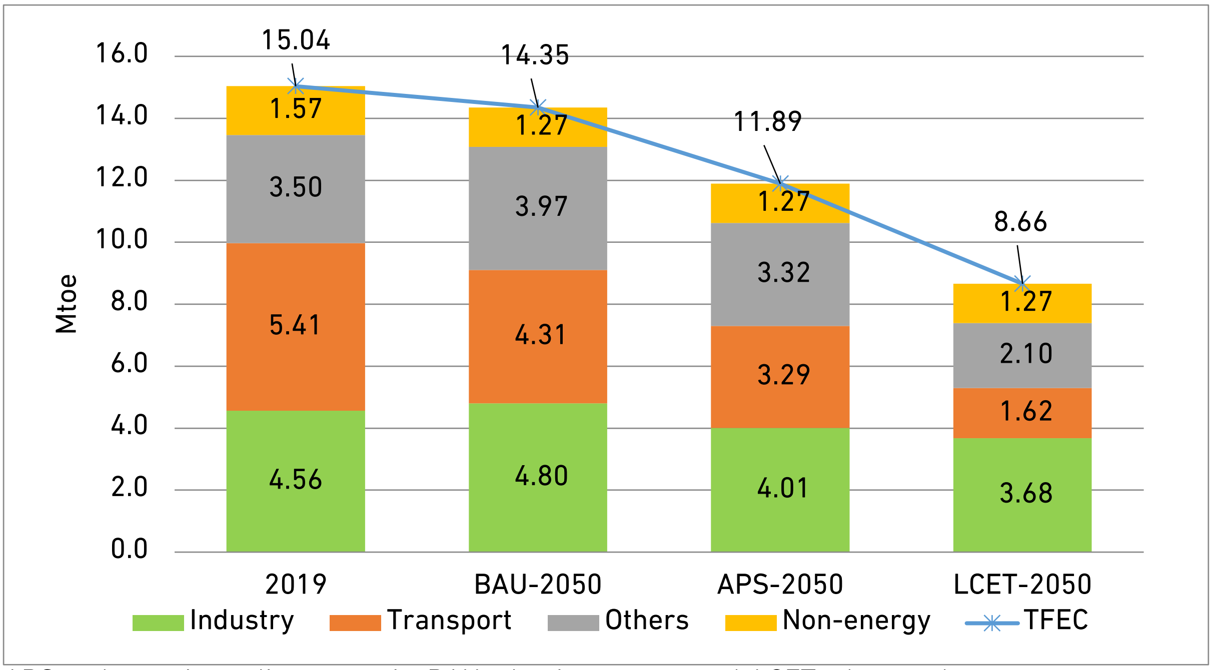
New Zealand enjoys many natural advantages for its energy transition, including an enviable renewable resource base. New Zealand already has a low-emissions electricity system, with significant production from both hydropower and geothermal power, and therefore has an attractive opportunity to leverage this clean electricity to decarbonise end-user sectors. The government has set ambitious targets for reducing greenhouse gas emissions, including achieving net-zero emissions by 2050. This chapter is a revised version of the LCET scenario developed for New Zealand in the Energy Outlook and Energy Saving Potential East Asia (EO&SP) 2023 report. The analysis also includes calculation of the investment costs and emissions reduction benefits of the LCET–CN scenario compared with the business as usual (BAU) scenario.

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

The low-carbon energy transition–carbon neutral (LCET–CN) scenario, will decrease New Zealand's total final energy consumption (TFEC) at an average rate of 1.8% per year from 15.0 million tonnes of oil equivalent (Mtoe) in 2019 to 8.7 Mtoe in 2050. Throughout this period, the TFEC in LCET–CN will always be lower than the BAU and alternative policy (AP)_ scenarios (40% lower compared with the BAU scenario and 27% lower compared AP scenario).

In 2050, the transport sector in the LCET–CN scenario is expected to decrease by 62% compared to BAU and 51% compared to the AP scenario. The 'others' category (agricultural, residential, and commercial) will decrease by 47% in the BAU scenario and 37% in AP scenario, whilst industry is projected to decrease by 23% in the BAU and 8% in AP scenarios. The LCET–CN's non-energy sector in TFEC is projected to remain unchanged, as shown in Figure 12.1.

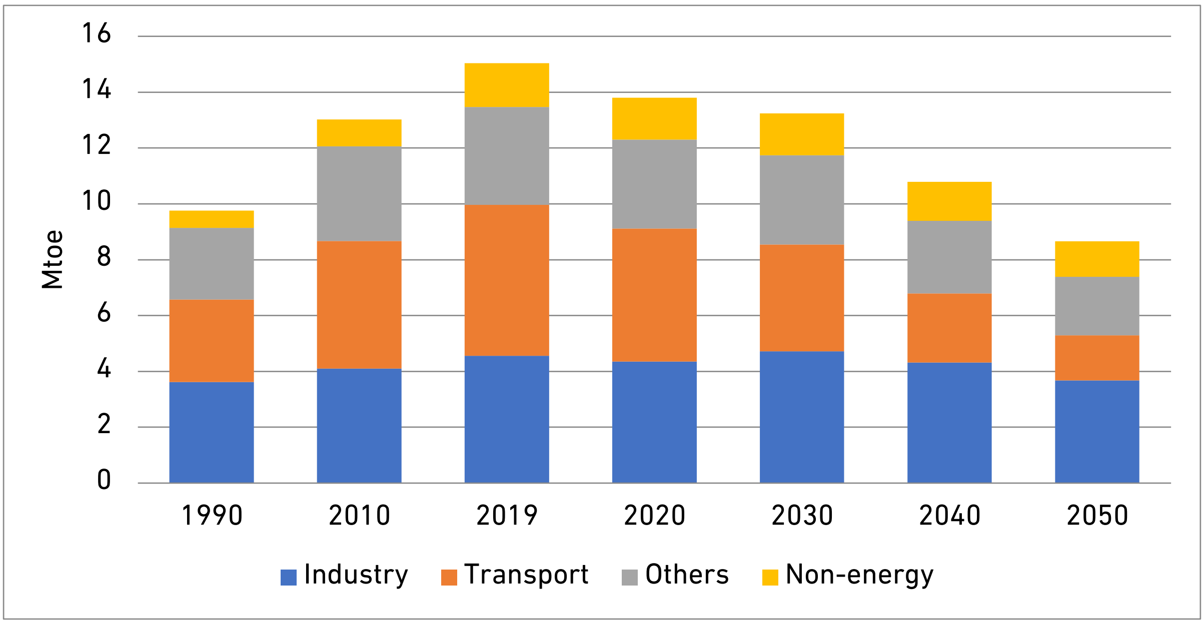
Figure 12.1. Total Final Energy Consumption, BAU, AP, and LCET-CN Scenarios



APS = alternative policy scenario, BAU = business-as-usual, LCET = low-carbon energy transition-carbon neutral, TFEC = total final energy consumption, Mtoe = million tonnes of oil equivalent, TFEC = total final energy consumption.
Note: 'Others' includes agricultural, residential, and commercial sectors.
Source: Authors' calculations.

Figure 12.2 shows the final energy consumption by sector under the LCET–CN scenario. The large reduction of energy consumption in the transport sector from 2019 to 2050 (70%) contributes to the rapid decrease of TFEC in the LCET–CN scenario. The transport sector TFEC decreases from 5.4 to 1.6 Mtoe. The second highest reduction in energy consumption (40% from 2019 to 2050) will be in the 'others' category. Both the industry and non-energy sector energy consumption will decrease only by 19% from 2019 to 2050.

Figure 12.2. Final Energy Consumption by Sector, LCET–CN Scenario (1990–2050)

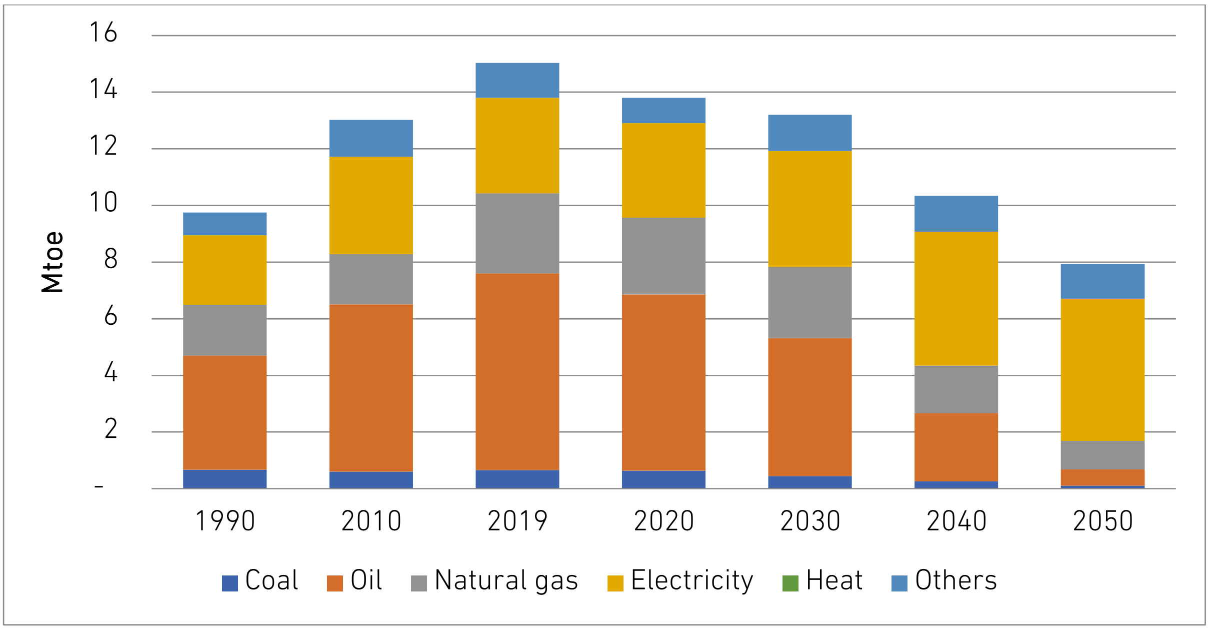


LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Note: 'Others' includes agricultural, residential, and commercial sectors.
Source: Authors' calculations.

The TFEC of the transport sector was the highest in 2019 with a share of around 36%. By 2050, the share of this sector will decline rapidly at an average rate per year of 3.8% compared with the rest of 'others' sector. The high reduction in the transport sector energy consumption is the result of a combined effect in fuel efficiency and substitution. Improved efficiency in the liquid-fuelled internal combustion engine and switching to highly efficient electric vehicles reduces liquid fuel consumption in the country. In addition, behaviour change in the distance travelled (vehicle kilometres travelled) as a result of urban intensification, people will live closer to their work place and choose public transport or other options such as walking and biking.

Considering that oil consumption was the main fuel consumed by the transport sector, oil consumption in the final sector will be reduce from around 6.9 Mtoe in 2019 to 0.6 Mtoe in 2050. This will be a reduction by around 6 Mtoe in 2050 (92% decrease). In case of coal, the reduction from 2019 to 2050 will be at 1 Mtoe (83% decrease), whilst natural gas will be at 2.0 Mtoe (65% decrease). Figure 12.3 shows the final energy consumption by sector under the LCET–CN scenario.

Figure 12.3. Final Energy Consumption by Fuel Type, LCET–CN Scenario (1990–2050)



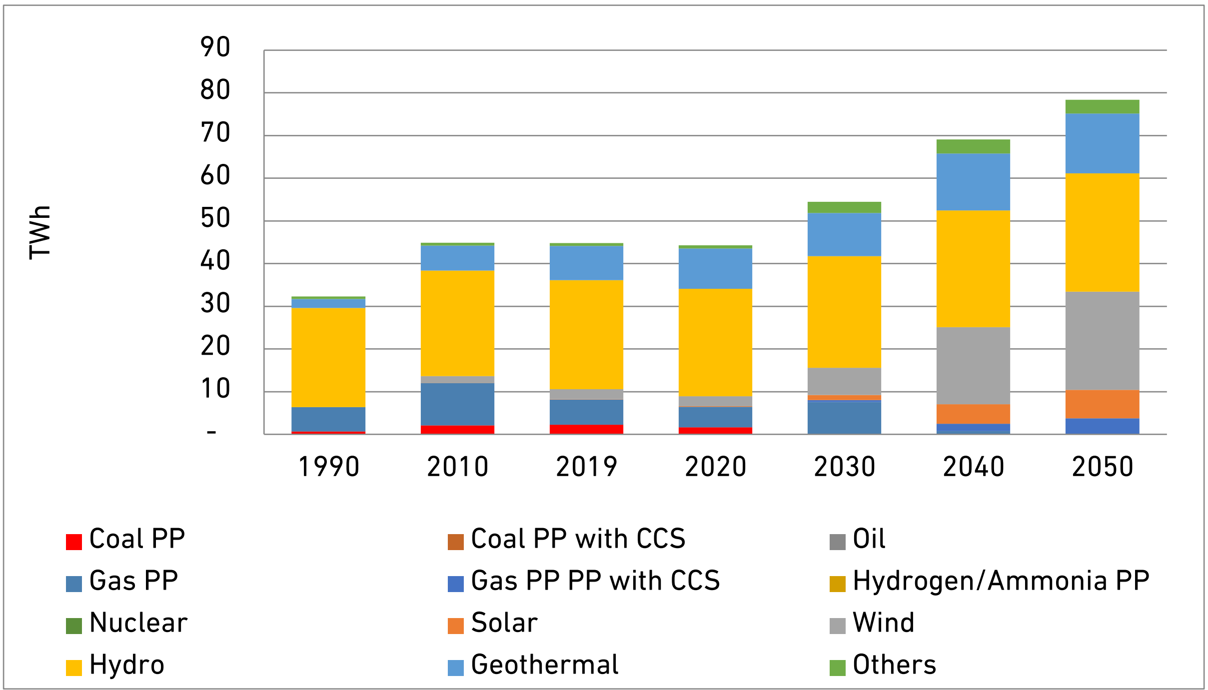
LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

These large reductions in fossil fuels consumption of the LCET–CN scenario underline the importance of having clean energy that can contribute to lowering carbon dioxide (CO_2) emissions. As fossil fuel consumption decreases, electricity demand will increase by 49%, from 3.4 Mtoe in 2019 to 5.0 Mtoe in 2050. Hydrogen will start to be consumed from 2030 and hydrogen demand will reach 0.7 Mtoe in 2050. Hydrogen used in the final sector will be in the industry and transport sectors.

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

Power generation in New Zealand is projected to increase over the projection period under the BAU, AP, and the LCET–CN scenarios (Figure 12.4). In the LCET scenario, power generation is projected to grow significantly at 75% in 2019–2050. In comparison to the LCET–CN scenario, power generation increases only by 39.4% in the BAU and by 37.0% in the AP scenario.

Figure.12.4. Electricity Generation by Fuel, 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: Authors' calculations.

Under the LCET–CN scenario, power generation will reach 78.4 terawatt hours (TWh) in 2050 from 44.8 TWh in 2019, increasing at an average rate of 1.8% per year. Hydropower generation will still be dominant, but the share is decreasing from around 57% in 2019 to 35% in 2050. The share of geothermal power generation remains the same in 2050 as it was in 2019 (18%). Solar photovoltaic (PV) cells, on the other hand, will have an increasing role in the country's power generation. The share of electricity produced by solar PV increased from 0.3% in 2019 to 8.5% in 2050. Similarly with solar PV, wind power generation will also be increasing. The share of wind power generation was 5% in 2019 and has increased to 29% in 2050. Overall, hydro, wind geothermal, and solar PV will constitute more than 90% of power generation in 2050, amounting to around 71 TWh.

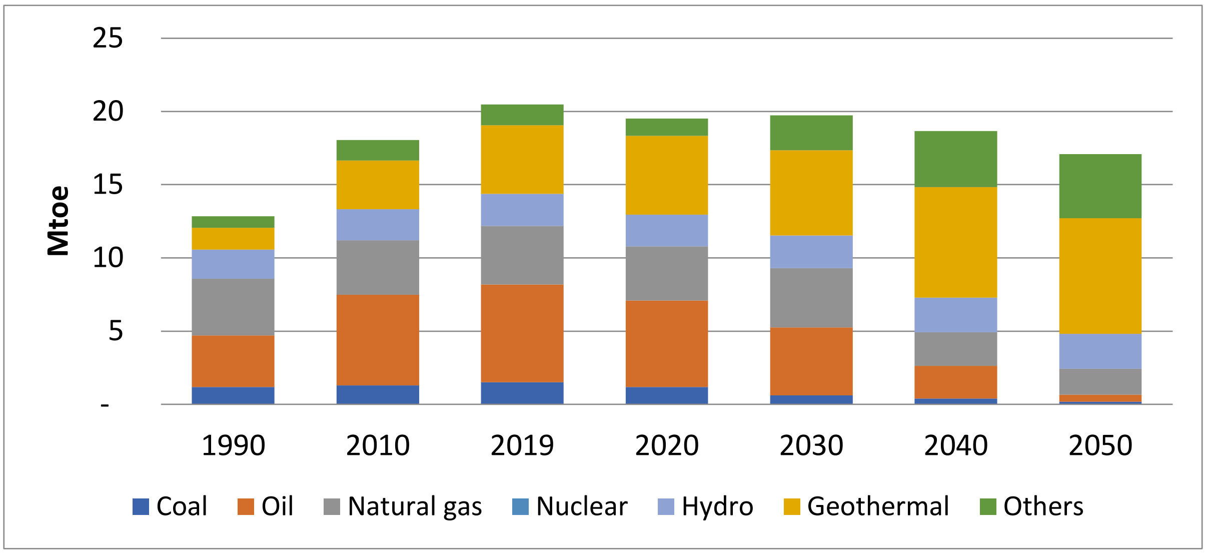
In the case of fossil-based power generation, the percentage of gas and coal will decrease significantly. Specifically, the share of gas, which was 13.1% in 2019, and the share of coal, which was 5.1% in 2019 are both expected to decline to 0.0% in 2050. The LCET–CN scenario projects power generation from natural gas (3.7 TWh in 2050) using carbon capture and storage (CCS). There is no power generated from coal using CCS. The share of total power generated from gas that will utilise CCS under the LCET–CN, accounts for 4.7% in 2050.

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

The total primary energy supply (TPES) under the LCET–CN scenario is expected to decrease at an average rate of 0.6% per year from 2019 to 2050. Fossil fuel supply will be declining sharply as more sustainable low-carbon fuel will be consumed in the LCET–CN scenario. Oil supply will decrease at an average rate of 8.2% per year, whilst coal supply will decline at an average rate of 6.6% per year. More efficient liquid-fuelled vehicles (including hybrid), switching to electric vehicles, biofuel vehicles, and fuel cell vehicles running on hydrogen will contribute significantly to the rapid decline of oil consumption in the TPES. Coal supply reduction will be both in the industry and power sectors. In the power sector, coal-fired power plants will cease to operate by 2050 and no coal-fired power plant will be operating using CCS.

Natural gas supply is projected to decrease by 2.6% per year, but not as rapidly as oil and coal. Although no gas-fired power plant will be operating in 2050, there will still be gas-fired power plants with CCS in operation from 2030. Other renewable sources, which include hydro, geothermal, wind, biomass, solar, liquid biofuels, and biogas, are projected to increase by an average rate of 1.9% per year in 2019–2050 (Figure 12.5).

Figure 12.5. Total Primary Energy Supply by Fuel Type, LCET–CN Scenario (1990–2050)



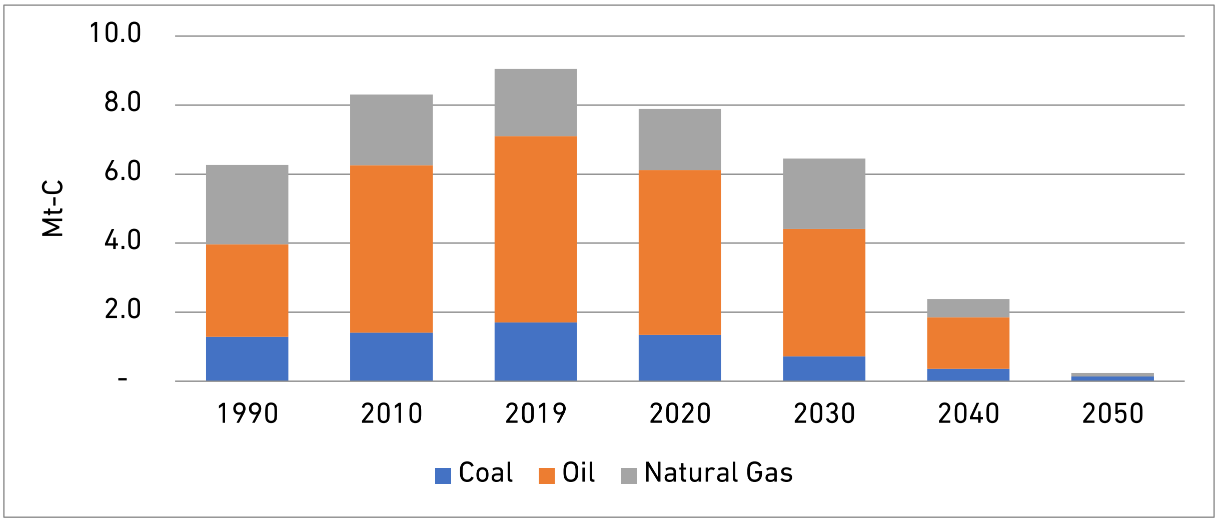
LCET–CN = low-carbon energy transition–carbon neutral, Mtoe = million tonnes of oil equivalent.
Source: Authors' calculations.

5. Carbon Dioxide Emissions

CO_2 emissions are expected to decline from 2019 to 2050 under the BAU, AP, and LCET–CN scenarios. The LCET–CN scenario projects a yearly reduction of 19.4% in CO_2 emissions from 33.2 million tons of carbon dioxide (Mt-CO_2) in 2019 to around 0.88 Mt-CO_2 in 2050

(Figure.12.6). Total reduction of CO_2 from 1990 to 2050 will almost be 100%, which is in line with the country's target of achieving net-zero emissions by 2050. The 2050 CO_2 emissions will be 0.49 Mt-CO_2 for coal and 0.38 Mt-CO_2 for natural gas.

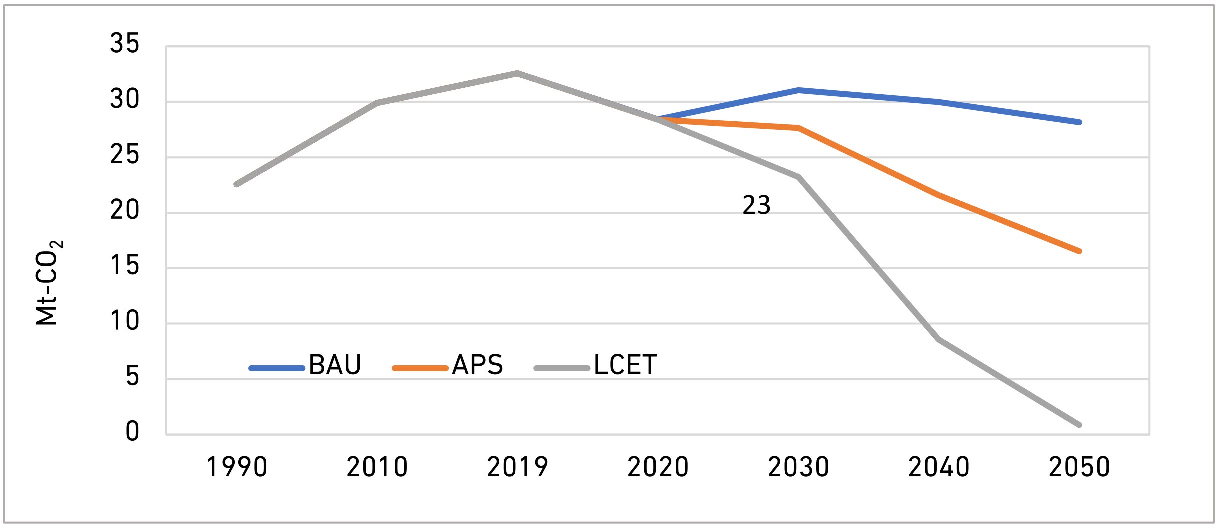
Figure 12.6. Total CO_2 Emissions by Fuel Type, LCET–CN Scenario (1990–2050)



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

Figure 12.7 shows the history of CO_2 emissions in the three scenarios, with a target to reduce CO_2 emissions by 30% in 2030 from 2005 levels.

Figure 12.7. CO_2 Reduction, BAU, AP, and LCET–CN Scenarios



APS = alternative policy scenario, BAU = business-as-usual, LCET–CN = low carbon energy transition–carbon neutral, Mt-CO_2 = million tonnes of carbon dioxide.
Source: Authors' calculations.

6. Hydrogen Demand Across the Sectors

Under the LCET–CN scenario assumptions, two sectors will be involved directly for hydrogen utilisation – the transport and industry sectors. In these sectors, hydrogen will replace oil consumption with hydrogen. The fuel switching will start in 2030. By 2050, hydrogen consumption will be 582 ktoe in the industry sector and 150 ktoe in the transport sector. Hydrogen consumption from these sectors represent 8.4% of total energy consumption of the final sector.

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

Implementing the LCET–CN scenario implies investing in low-carbon technologies covering energy saving technologies, renewable energy, hydrogen and CCS. An analysis on energy cost was carried out to estimate the total investment cost in implementing policies and programmes under the LCET–CN scenario in comparison with the BAU scenario. The basic assumption for this analysis covers fuel cost (Table 12.1), construction cost of power plants (Table 12.2), and capacity factor of power plants (Table 12.3).

Table 12.1. 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$/MMBtu
Hydrogen	0.80	0.30	US$/$Nm^3$
CCS	0	30	US$/$CO_2$ ton

bbl = barrel, CCS = carbon capture and storage, MMBtu = million British thermal unit, Nm3 = normal cubic metre.
Source: Authors' calculations

Table 12.2. 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: Authors' calculations.

Table 12.3. Capacity Factor of Power Plants Assumptions
(%)

	2019	by 2050
Coal	75	0
Oil	9	9
Gas	30	10
Hydrogen	0	80
Nuclear	100	80
Hydro	55	40
Geothermal	92.5	97
Solar	23	23
Wind	42	40
Biomass	50	70

Source: Authors' calculations.

7.1. Fuel Cost

The fuel cost comparison will be analysed based on the primary energy consumption of the BAU and LCET–CN scenarios. Under the LCET–CN scenario, the primary energy consumption in 2050 will be 2.4 Mtoe, whilst under BAU it will be 10.8 Mtoe. Consequently, the total investment fuel cost in 2050 under the LCET–CN scenario will be lower than that under the BAU scenario, US$863 million compared to US$5,035 million, (Table 12.4).

Table 12.4. Total Investment Fuel Cost Comparison, BAU and LCET–CN Scenarios in 2050

	Primary Energy Consumption (Mtoe), BAU in 2019	Primary Energy Consumption (Mtoe), BAU in 2050	Primary 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	1.50	0.87	0.18	138	29
Oil	6.67	5.07	0.47	3,490	322
Gas	4.00	4.87	1.78	1,407	513
Hydrogen	0.00	0.00	0.00	0	0
Total	**12.18**	**10.82**	**2.43**	**5,035**	**863**

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

7.2. Power Generation Investment

The construction cost and capacity factor assumptions in Table 12.2 and Table 12.3 will be the basis for calculating the total investment cost for power plants in 2050 for the BAU and LCET–CN scenarios. The capacity factor for each power plant in both scenarios will determine the additional capacity of the power plants to produce the electricity in 2050. The total investment cost to construct these new plants in each scenario is shown in Table 12.5.

Table 12.5. 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	2	0	0	0	0	0	0
Oil	0.004	0.008	0.004	5	0	0	0
Gas	6	15	4	9,977	-2466	6,984	0
Hydrogen	0	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0	0
Hydro	26	23	28	-710	619	0	1,376
Geothermal	8	14	14	712	703	3,030	2,990
Solar	0	3	7	1412	3247	433	997
Wind	2	6	23	1,038	5,927	1,283	7,320
Biomass	1	2	3	229	411	692	1,242
Total	**45**	**63**	**78**	**12,662**	**8,441**	**12,422**	**13,925**

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

As discussed in Section 5 on power generation, electricity generated in 2050 for the LCET–CN scenario will be higher than under BAU, 78 TWh compared to 63 TWh. The type of plants to produce the needed electricity will be gas and renewable energy under BAU. In the LCET–CN scenario, electricity generation from renewable energy power plants will increase significantly since the target of this scenario is to achieve net-zero CO_2 emissions. Based on the capacity factor assumption of each plant, the total additional capacity requirement of BAU will be 12,662 megawatts MW with gas plants being the majority to be constructed (9,977 MW). In the LCET–CN scenario, the total additional capacity requirement will be 8,441 MW, where 5,927 MW will be that from wind power plant and 3,247 MW from solar power plants.

Based on the construction cost assumptions, the renewable energy power plants construction cost is assumed to be higher than the fossil plants (except solar power plants), As a result, the total investment cost for power plants in 2050 for the BAU scenario will be US$12,422 million, lower than in the LCET–CN scenario (US$13,925 million).

7.3. Carbon Capture and Storage Cost

In New Zealand, carbon capture and storage (CCS) technology has been assumed to be introduced under the LCET–CN scenario starting from 2030 onwards. The investment cost for CCS was calculated only for natural gas-fired power plants equipped with CCS since coal-based power plants will not be operating by 2050. If CCS devices can capture up to 90% of CO_2 emissions and the average cost of capture is about US$30/$CO_2$ ton, the total investment for CCS is estimated to be US$37million (Table 12.6).

Table 12.6. Total Investment Cost of CCS 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-fired Power Plant with CCS	0	0	0	0
Natural Gas-fired Plant with CCS	0.635	0.37	1.35	37
Total	0.635	0.37	1.35	37

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, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

7.4. Overall Cost

Based on the result from the calculations above, the overall total cost comparison between the BAU and LCET–CN scenarios is shown in Table 12.7. The overall investment cost for the BAU scenario in 2050 is projected to be US$5,436 million, whilst in the LCET–CN scenario it will be US$1,349 million. The differences in the total investment of both the BAU and LCET–CN scenarios indicate that there will be a saving in investment of 75% if the LCET–CN scenario is implemented. Fuel costs contribute more than 100% to the cost savings in the LCET–CN scenario.

Table 12.7. Overall Total Investment Cost for BAU and LCET–CN Scenarios in 2050

	BAU	LCET–CN	LCET–CN vs BAU
Total Fuel Cost Investment (US$ million)	5,035	863	–4,172
Total Power Capital Cost Investment (US$ million)	401	449	48
Total CCS Cost Investment (US$ million)	0	37	37
Total (US$ million)	**5,436**	**1,349**	**–4,087**

BAU = business as usual, LCET–CN = low-carbon energy transition – carbon neutral.
Source: Authors' calculations.

8. Conclusions and Recommendations

The total investment cost of the LCET–CN scenario is estimated to be US$1,349 million, which is lower than in the BAU scenario, US$5,436 million. This result indicates that implementing all the measures assumed in the LCET–CN scenario will enable New Zealand to attain net-zero emissions by 2050. This is in line with the government energy strategies being developed to achieve net-zero carbon emissions by 2050. The total investment reduction of the energy sector by implementing LCET–CN scenario will be US$4,087 million compared to implementation of the BAU scenario.

The main reduction in total investment will be that of fuel cost (US$4,172 million) since fuel cost is the major portion of the total investment (93% in BAU and 64% in LCET–CN). Increasing renewable power generation in the LCET–CN scenario and introducing CCS with gas-fired power generation will require additional investment of US$ 85 million in 2050 as compared to the BAU scenario.

Introduction of CCS is assumed to be from 2030, and the investment in CCS will reach US$37 million in 2050. This amount is 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.

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