Chapter 3
Cambodia Country Report

Heang Theangseng

Department of Energy Development, Ministry of Mines and Energy, Cambodia

1. Background

Cambodia's nationally determined contribution (NDC) targets the country's emissions rising by up to 90 million tonnes of carbon dioxide equivalent (tCO_2e) per year by 2030, whilst emissions are expected to increase to 155 million tCO_2e per year (MtCO2e) in a business-as-usual (BAU) scenario (Table 3.1).

Table 3.1. Emissions, BAU Scenario, 2030

Sector	Sectoral Share (%)	Emissions ($MtCO_2e$)
FOLU	49.2	76.3
Energy	22.2	34.4
Agriculture	17.5	27.1
IPPU	9.0	13.9
Waste	2.1	3.3

BAU = business as usual, FOLU = forestry and other land use, IPPU = industrial processes and product use, $MtCO_2e$ = million tonne of carbon dioxide equivalent.
Source: Government of Cambodia, National Council for Sustainable Development and Ministry of Environment (2020).

Forestry and other land use (FOLU) would mark the highest emissions under the BAU scenario in 2030, at 49.2% of total emissions, followed by energy at 22.2%, agriculture at 17.5%, and industrial processes and product use at 9.0%. The estimated emissions reduction under the NDC in 2030 would be about 64.5 $MtCO_2e$ per year, or a 41.7% reduction, of which 59.1% would be from FOLU (Table 3.2). About 38 $MtCO_2e$ are assumed as carbon sink by forests to 2050.

Table 3.2. BAU Scenario Emissions and NDC Emissions Reductions

Sector	BAU 2016 Emissions ($MtCO_2e$)	BAU 2030 Emissions ($MtCO_2e$)	NDC 2030 Scenario ($MtCO_2e$)	NDC 2030 Reduction ($MtCO_2e$)	NDC 2030 Reduction (%)
FOLU	76.3	76.3	38.2	–38.1	–50
Energy	15.1	34.4	20.7	–13.7	–40
Agriculture	21.2	27.1	20.9	–6.2	–23
IPPU	9.9	13.9	8.0	–5.9	–42
Waste	2.7	3.3	2.7	–0.6	–18
Total	**125.2**	**155.0**	**90.5**	**–64.5**	**–42**

BAU = business as usual, FOLU = forestry and other land use, IPPU = industrial processes and product use, $MtCO_2e$ = million tonnes of carbon dioxide equivalent, NDC = nationally determined contribution.
Source: Government of Cambodia, National Council for Sustainable Development and Ministry of Environment (2020).

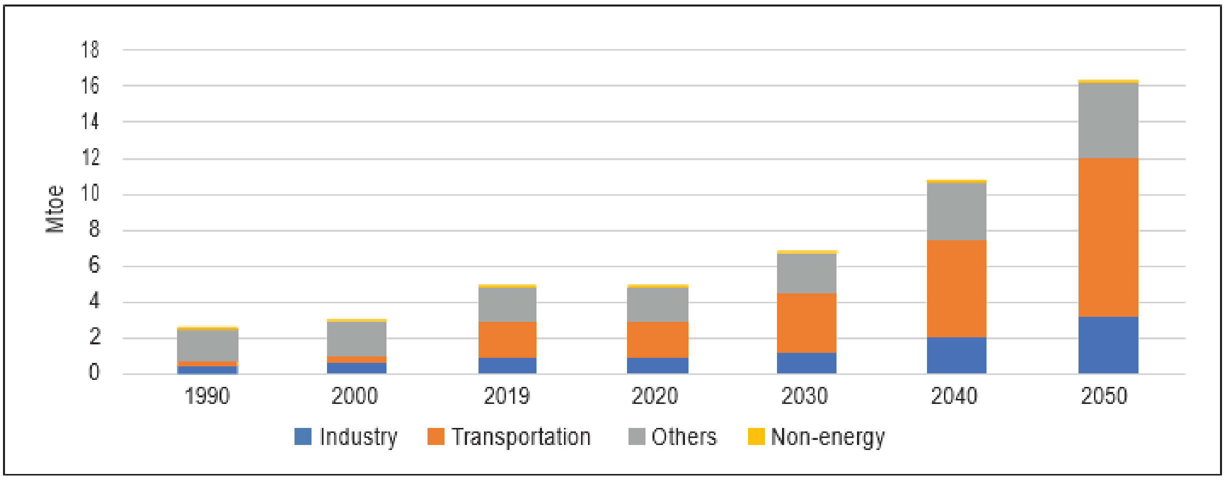
To ensure that the low-carbon energy transition–carbon neutral (LCET-CN) scenario is in line with Cambodia's NDC emissions reduction target, in addition to assuming carbon sink by forests to 2050, decreased oil demand is projected at 9.4% per year in the industrial sector and at 18.6% per year in the transport sector during 2040–2050 due to electrification. New technologies would also be applied, such as coal power plants using clean coal technologies with carbon capture and storage (CCS) and natural gas power plants using CCS in 2040–2050.

2. Final Energy Consumption

Figure 3.1 illustrates final energy consumption by sector during 1990–2050 under the LCET-CN scenario. The average annual growth rate (AAGR) would be 3.9% per year, which is the same as the AAGR of final energy consumption in alternative policy scenario (APS) 5.

Demand is projected to be strongest in the transport sector with an AAGR of 4.73% during 2019–2050, from 2.09 million tonnes of oil equivalent (Mtoe) to 8.74 Mtoe. The industrial sector is projected to follow, with an AAGR of 4.20% from 0.95 Mtoe in 2019 to 3.35 Mtoe in 2050. The 'others' sector would be next, at 2.60%, from 1.91 Mtoe in 2019 to 4.19 Mtoe in 2050.

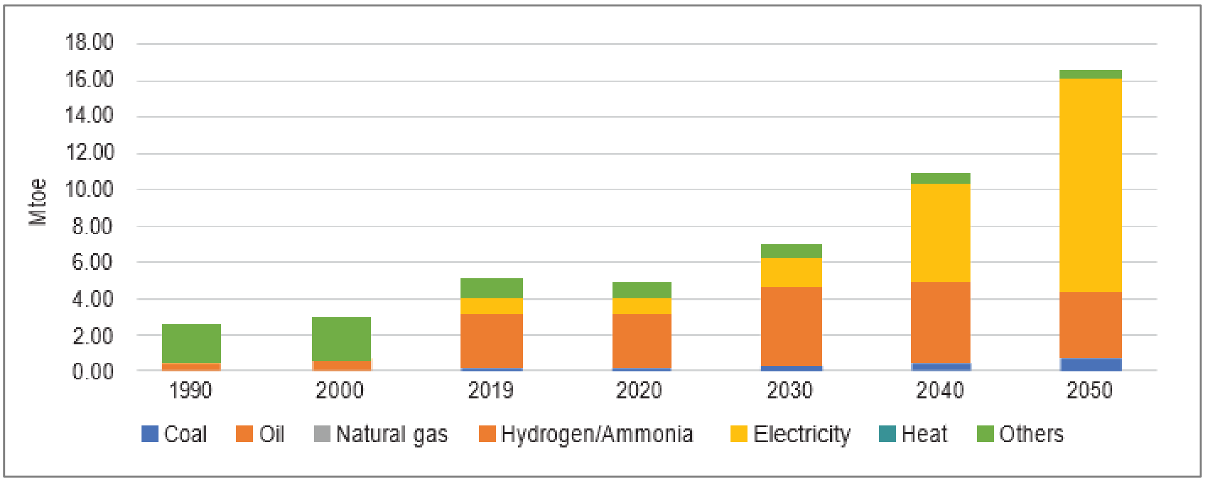
Figure 3.1. Total Final Energy Consumption by Sector, LCET-CN Scenario



Mtoe = million tonnes of oil
equivalent. Source: Author.

Figure 3.2 reveals that the highest shares of electricity demand would be during 2040–2050 under the LCET-CN scenario, the result of reducing oil demand in the transport sector. The AAGR of total final energy consumption (TFEC) under the LCET-CN scenario is projected to increase by 3.9% during 2019–2050. Electricity would dominate at 50.4% of TFEC in 2040 and 71.2% in 2050, followed by oil at 41.5% in 2040, before dropping to 22.8% in 2050.

Figure 3.2. Total Final Energy Consumption by Fuel, LCET-CN Scenario

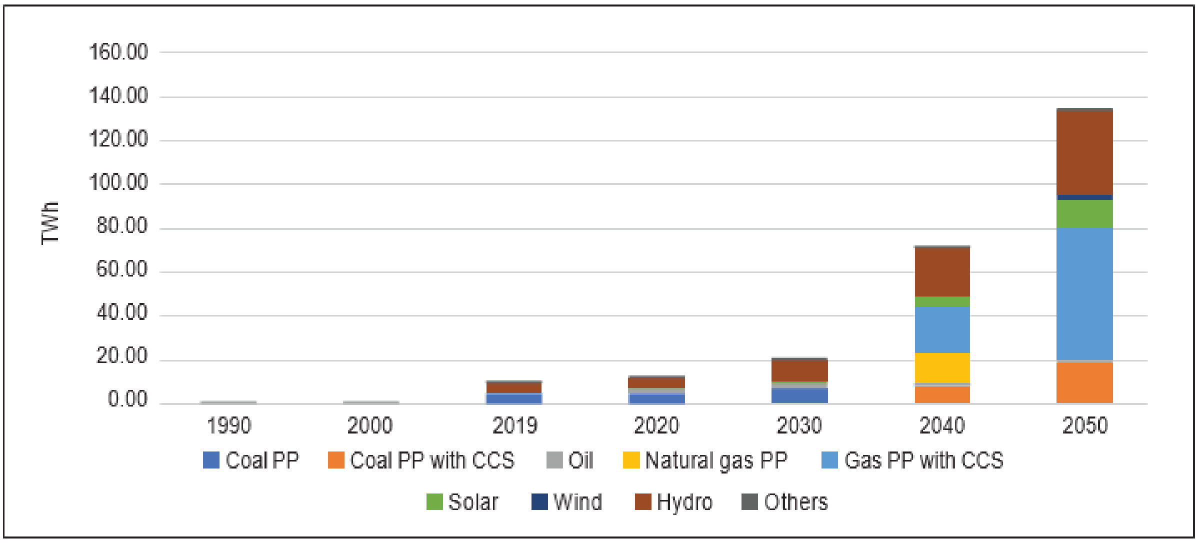


Mtoe = million tonnes of oil equivalent.
Source: Author.

3. Power Generation

Figure 3.3 shows that Cambodia's total electricity generation in 2050 would be 134.02 terawatt-hours (TWh) under the LCET-CN scenario, much higher than in the APS5 at 65.82 TWh due to the projected huge decrease in oil demand during 2040–2050. Emissions would be reduced as natural gas power plants become the main contributor to electricity generation during 2032–2040; natural gas with CCS and coal with CCS would then be the highest contributors during 2040–2050. Electricity generation is projected to have an AAGR of 9.1%, with solar energy having the highest share at 16.9% during 2019–2050.

Figure 3.3. Total Electricity Generation, LCET-CN Scenario

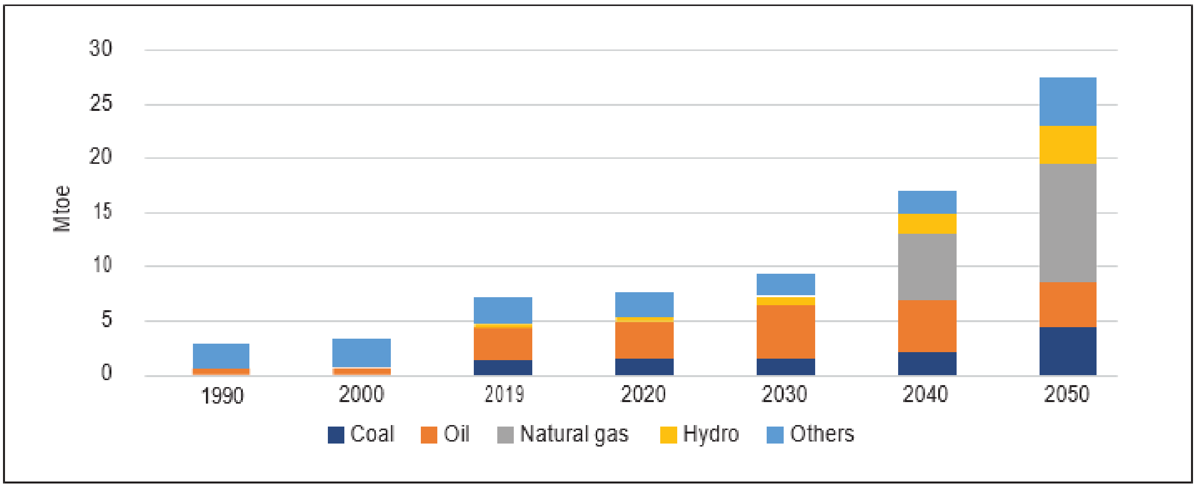


CCS = carbon capture and storage, PP = power plant, TWh =terawatt-hour.
Source: Author.

4. Primary Energy Supply

In 2050, the total primary energy supply (TPES) under the LCET-CN scenario would be 27.35 Mtoe, much higher than in the APS5 at 21.76 Mtoe (Figure 3.4). The TPES would record an AAGR of 4.4% during 2019–2050 under the LCET-CN scenario and 3.6% under the APS5. Biomass would be the only fuel to register a negative AAGR at –1.05%, due to people replacing firewood with liquefied petroleum gas (LPG) as cooking fuel in both urban and rural areas.

Figure 3.4. Total Primary Energy Supply by Fuel, LCET-CN Scenario

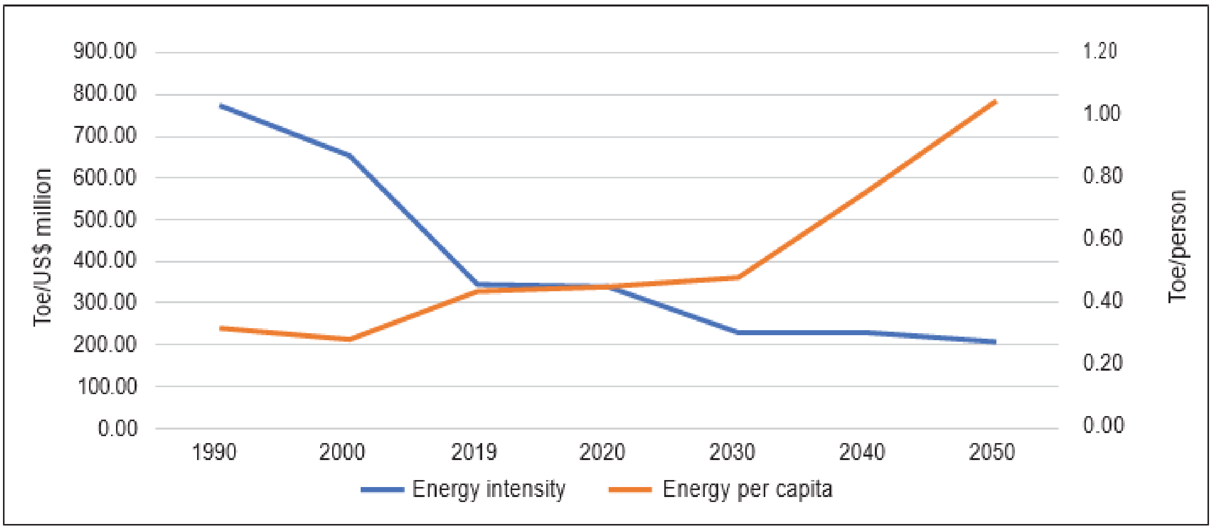


Mtoe = million tonnes of oil equivalent.
Source: Author.

Figure 3.5 shows that primary energy intensity decreased from 775 tonnes of oil equivalent (toe)/US$1 million in 1990 to 343 toe/US$1 million in 2019 and would further decrease to 204 toe/US$1 million in 2050 under the LCET-CN scenario. The trend indicates that energy would be used more efficiently due to implementation of an energy efficiency and conservation programme and use of new technologies.

Primary energy per capita increased from 0.32 toe/person in 1990 to 0.43 toe/person in 2019 and would further increase to 1.05 toe/person in 2050 under the LCET-CN scenario, indicating that living standards are improving, resulting in increasing energy demand per capita.

Figure 3.5. Energy Indicators, LCET-CN Scenario

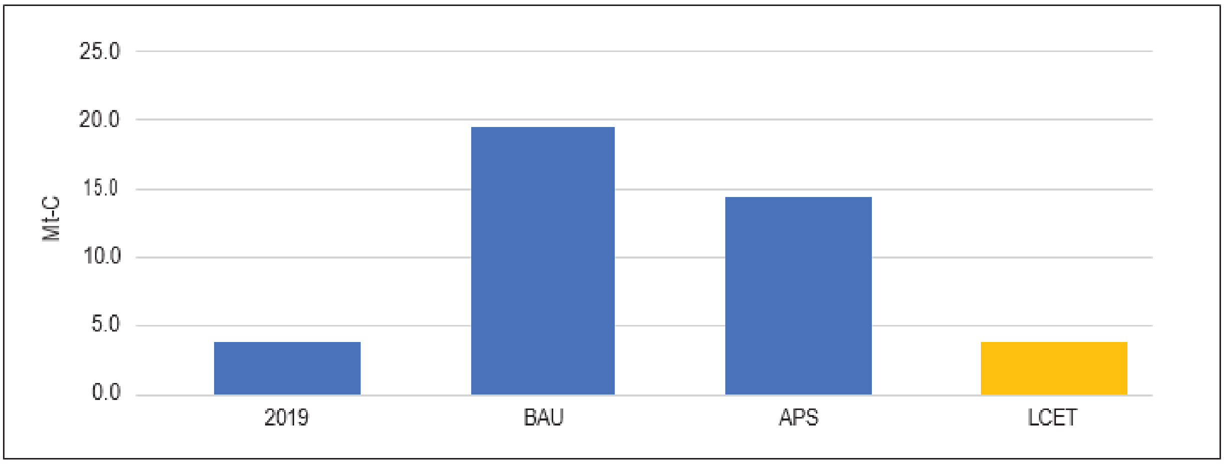


Source: Author.

5. Emissions

Emissions from energy consumption are projected to decrease by 3.7% per year during 2040–2050, from 5.64 million tonnes of carbon (MtC) to 3.85 MtC under the LCET-CN scenario. Under the APS5, the AAGR of emissions are projected to increase by 4.3% during 2019–2050. Emissions under the LCET-CN scenario would decrease by 10.5 MtC or about 73.2% by 2050 compared to the APS5 (Figure 5). Carbon sink by forests is assumed to be about 38 $MtCO_2e$ or about 10 MtC. Through applying CCS technologies, Cambodia could achieve carbon neutrality by 2050.

Figure 3.6. Emissions Reduction under the BAU, APS5, and LCET-CN Scenarios



APS = alternative policy scenario, BAU = business as usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.
Source: Author.

6. Cost Comparison

6.1. Assumptions

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 costs in implementing such policies and programmes under the LCET-CN scenario. The basic assumptions for this analysis cover fuel costs (Table 3.3), construction costs of power plants (Table 3.4), and capacity factors of power plants (Table 3.5).

Table 3.3. Assumed Fuel Costs

Scenario	Coal	Oil	Gas	Total Cost (US$ million)
BAU	4.27	12.69	7.12	9,126.70
LCET-CN	4.49	4.03	11.02	4,332.31

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

Table 3.4. Assumed Construction Costs of Power Plants

Scenario	Coal	Oil	Gas	Hydro	Solar	Wind	Biomass	Total (TWh)	Total Cost (US$ million)
BAU	12.49	1.16	43.03	15.66	5.92	0.00	0.10	78.36	14,672.31
LCET-CN	17.95	1.16	61.54	38.46	11.86	2.96	0.10	134.02	34,459.20

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

Table 3.5. Assumed Capacity Factors of Power Plants

(%)

Fuel	2019	by 2050
Coal	75	80
Oil	75	80
Gas	75	80
Hydro	50	40
Solar	17	17
Wind	40	40
Biomass	50	70

Source: Author's calculations.

6.2. Fuel Costs

Under the LCET-CN scenario, the primary energy consumption in 2050 would be 19.54 Mtoe, while under the BAU scenario, it would be 24.08 Mtoe. Consequently, the total investment fuel costs in 2050 under the LCET-CN scenario would be lower than those under the BAU scenario, US$4,332 million compared to US$9,127 million (Table 3.6).

Table 3.6. Fuel Cost Comparison, BAU and LCET-CN Scenarios

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	1.23	4.27	4.49	480	514
Oil	3.11	12.69	4.03	6,592	635
Gas	0	7.12	11.02	2,055	3,183
Hydrogen					
Total	**4.33**	**24.08**	**19.54**	**9,127**	**4,332**

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

6.3. Power Generation Investment

The construction cost and capacity factor assumptions in Tables 3.3 and 3.4 are the basis of calculating the total investment cost for power plants in 2050 under the BAU and LCET-CN scenarios. The capacity factor for each power plant in both scenarios determines the additional capacity of the power plants to produce electricity in 2050. The total investment cost to construct these new plants in each scenario is shown in Table 3.7.

Table 3.7. Power Plant Cost Comparison, BAU and LCET-CN Scenarios, 2050

Fuel	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	3.92	12.49	17.9	1,223	2,002	1,865	3,053
Oil	0.75	1.16	1.2	57			
Gas	0.00	43.03	61.5	6,140	8,781	4,298	6,147
Hydrogen	0.00	0.00	0.0	0	0		0
Nuclear	0.00	0.00	0.0	0	0		0
Hydro	4.15	15.66	38.5	3,286	9,793	7,305	21,770
Geothermal	0.00	0.00	0.0	0	0	0	0
Solar	0.09	5.92	11.9	3,911	7,963	1,201	2,445
Wind	0.00	0.00	3.0	0	844	0	1,042
Biomass	0.09	0.10	0.1	1	1	3	3
Total	9.01	78.00	134.0	14,677	29,384	14,672	34,459

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

The amount of electricity generated in 2050 under the LCET-CN scenario would be greater than that under the BAU scenario, 134 TWh versus 78 TWh. The types of plants would be gas and renewable energy under the BAU scenario. Under the LCET-CN scenario, electricity generation from renewable energy power plants would increase significantly since the target of this scenario is to achieve net-zero emissions. Based on the capacity factor assumption of each plant, the total additional capacity requirement under the BAU scenario would be 14,677 MW, with gas plants comprising the majority constructed (6,140 MW). Under the LCET-CN scenario, the total additional capacity requirement would be 29,384 MW, where 9,793 MW would be from hydropower plants, 8,781 MW from liquefied natural gas (LNG) power plants, and 7,963 MW from solar power plants. Based on the construction cost assumptions, the renewable energy power plant construction costs would be higher than those of the fossil fuel plants (except solar power plants). As a result, the total investment cost for power plants in 2050 under the BAU scenario would be US$14,672 million, lower than that under the LCET-CN scenario at US$34,459 million.

6.4. Carbon Capture and Storage Costs

The introduction of CCS would be implemented under the LCET-CN scenario starting from 2040 for coal and natural gas power plants. Based on assumptions in Table 3.4, the CCS cost is around US$30/t$CO_2$ (Table 3.8).

Table 3.8. Total Investment Cost of Carbon Capture and Storage for the LCET-CN Scenario, 2050

	Fuel Consumption for LCET-CN, 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	3.86	14.40	3.92	388.80
Natural Gas Plant with CCS	11.02	23.47	6.39	633.91
Total	**14.88**	**37.87**	**10.32**	**1,022.72**

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

Table 3.8 indicates that the total investment cost of CCS under the LCET-CN scenario would be US$1,022.72 million. The total consists of CCS projects for coal power plants at US$388.80 million and US$633.91 million for natural gas power plants with CCS.

6.5. Overall Cost

Based on analysis, the breakdown of the total investment costs for both scenarios is in Table 3.9.

Table 3.9. Total Investment Cost
(US$ million)

No.	Cost	BAU	LCET-CN
A	Fuel Cost in 2050	9,126.70	4,332.31
	CCS in 2050	0.00	1,022.72
	Total	9,126.70	5,355.03
B	Power capital cost	14,672.31	34,459.20
	Total	**23,799.01**	**39,814.23**

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 under the BAU scenario in 2050 is projected to be US$23,799.01 million, while under the LCET-CN scenario, it is US$39,814.23 million.

7. Conclusions

From the calculation of total investment costs, the LCET-CN scenario would cost more compared to the BAU scenario due to applying CCS technologies for gas and coal power plants.

However, efforts need to be in place to achieve net-zero emissions in Cambodia by 2050. It cannot only depend on the availability of new technologies and investment; the government must also create a legal framework, encourage the development of an expert workforce, and raise public awareness. Moreover, regional cooperation and understanding between economies in the region need to be strengthened through dialogues, seminars, and workshops so that net-zero emissions can be achieved by the whole region.

Key findings are as follows:

(i) Energy demand is expected to continue to grow significantly, driven by robust economic growth, industrialisation, urbanisation, and population growth. Energy efficiency and conservation are reflected in the APS and LCET-CN scenarios.

(ii) Energy intensity will further decrease until 2050 due to more efficient use of energy.

(iii) The AAGR of energy demand in the transport sector is projected to be the highest at 5.3% from 2.09 Mtoe in 2019 to 10.46 Mtoe in 2050 under the BAU scenario. Under the LCET-CN scenario, this AAGR is projected to be lower at 4.7%, reaching only 8.74 Mtoe in 2050.

(iv) Coal demand is increasing and would witness the highest AAGR of 5.8% under the BAU scenario. It is projected to be slightly lower at 5.0% under the APS5 and LCET-CN scenarios.

(v) LNG power plants will become the major power generation source. The LNG share in total power generation output is increasing continually, from 6.4% in 2032 to 55.0% in 2050 under the BAU scenario. Under the LCET-CN scenario, natural gas power plants would be the main power-generating source during 2032–2040. Natural gas with CCS and coal with CCS would then contribute the highest generation during 2040–2050, thereby reducing emissions. The projected AAGR in power generation under the LCET-CN scenario is 9.1%. Solar energy would have the highest AAGR at 16.9% during 2019–2050. Hydropower plants would be the second major source of power generation, with their share in total power generation output increasing to 46% by 2019 but dropping to 20% in 2050 due to LNG's huge contribution.

To implement energy efficiency and conservation measures, the following actions are recommended:

(i) Establish appropriate policies, including targets and road maps, to promote these measures. Targets should be for the short, medium, and long term, and focussed on the construction and industrial sectors. The long-term plan should be based on an assessment of energy-saving potential of all energy sectors, including residential and commercial sectors, which have large energy-saving potential up to 2050. Some activities can promote these measures, such as (a) support for the development of professionals in the energy conservation field, who can be responsible for energy management and operation; verification and monitoring; consultancy and engineering services provision; and the planning, supervision, and promotion of the implementation of energy conservation measures; (b) support for the development of the institutional capability of agencies and organisations in the public and private sectors to be responsible for planning, supervision, and promotion of the implementation of energy conservation measures; (c) support for the operation of energy service companies to alleviate technical and financial risks of entrepreneurs who wish to implement energy conservation measures; and (d) energy conservation public relations and knowledge provision through educational institutions and fostering of awareness amongst youth.

(ii) Establish a compulsory energy standard and labelling system for electrical appliances, as the annual growth of electricity demand in the residential and commercial sectors is projected to be substantial.

(iii) Prioritise the development of advanced hydro and thermal power technologies, including coal and natural gas. Hydropower and thermal power plants will be the major source of power generation up to 2050. Therefore, advanced technologies for both types of resources should be prioritised for development from project design onwards.

(iv) Prioritise renewable energy development policies. Renewable energy is an important resource for energy independence, energy security, and emissions abatement. The strategy and mechanisms to support renewable energy development must be built up.

(v) Keep in touch with international and regional CCUS frameworks, such as the Asia CCUS Network, and monitor the development and deployment of CCUS under appropriate carbon-pricing mechanisms in Asia as conducted by Organisation for Economic Co-operation and Development countries and the network. CCS and CCUS will be important innovations in decarbonisation technologies.

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