Chapter 4
China Country Report

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1. Introduction

In an effort to promote low-carbon development and further China's 'dual-carbon' objective, which was formally declared in 2020, the central and local administrations of China have enacted a variety of measures. As a consequence, China has made significant progress in its transition towards low-carbon energy sources. According to the National Development and Reform Commission (NDRC, 2023), the entire annual energy consumption in 2022 was 5.41 billion tonnes of standard coal, representing a 2.9% rise compared to the previous year. The consumption of crude oil declined by 3.1%, whilst natural gas consumption decreased by 1.2%. Conversely, there was a 3.6% increase in electricity use. Coal utilisation represents 56.2% of the overall energy consumption. Renewable energy sources, such as natural gas, hydropower, nuclear power, wind power, and solar power, constituted 25.9% of the overall energy consumption, marking a 0.4% increase. The average coal use per kilowatt-hour (kWh) of thermal power generation in major energy-consuming industrial businesses decreased by 0.2%. China's carbon dioxide emissions (CO_2) intensity, measured as the amount of carbon dioxide emitted per unit of gross domestic product (GDP), decreased by 0.8%.

Advancements have been made in the process of transitioning towards environmentally sustainable practices and promoting growth. According to the National Bureau of Statistics (NBS, 2023a), the energy intensity of GDP in 2022 declined by 0.1% compared to the previous year, for every CNY10,000 of GDP. The total capacity for clean energy generation, including hydropower, nuclear power, wind power, solar power, and other sources, reached 2,959.9 billion kilowatt-hours (kWh), representing an 8.5% increase compared to the previous year. Out of the 339 cities that were observed at the prefecture level and higher, 62.8% complied with the yearly air quality regulations. The mean annual concentration of particulate matter ($PM_{2.5}$) was 29 μg/m^3, representing a decrease of 3.3% compared to the preceding year.

This report provides projections for future energy demand, energy production, and carbon emissions based on low-carbon energy transition LCET scenarios, and offers policy suggestions.

2. Macro Assumptions

China's GDP in 2023 reached CNY12,6058.2 billion, an increase of 5.2% over the previous year at constant prices. Table 4.1 shows the assumptions of the average annual growth rate (AAGR) of GDP and population. Based on the estimation of the Economic Research Institute for ASEAN and East Asia (ERIA), the average AAGR of GDP is projected to be 5.7% in 2020–2030, 4.5% in 2030–2040, and 3.4% in 2040–2050.

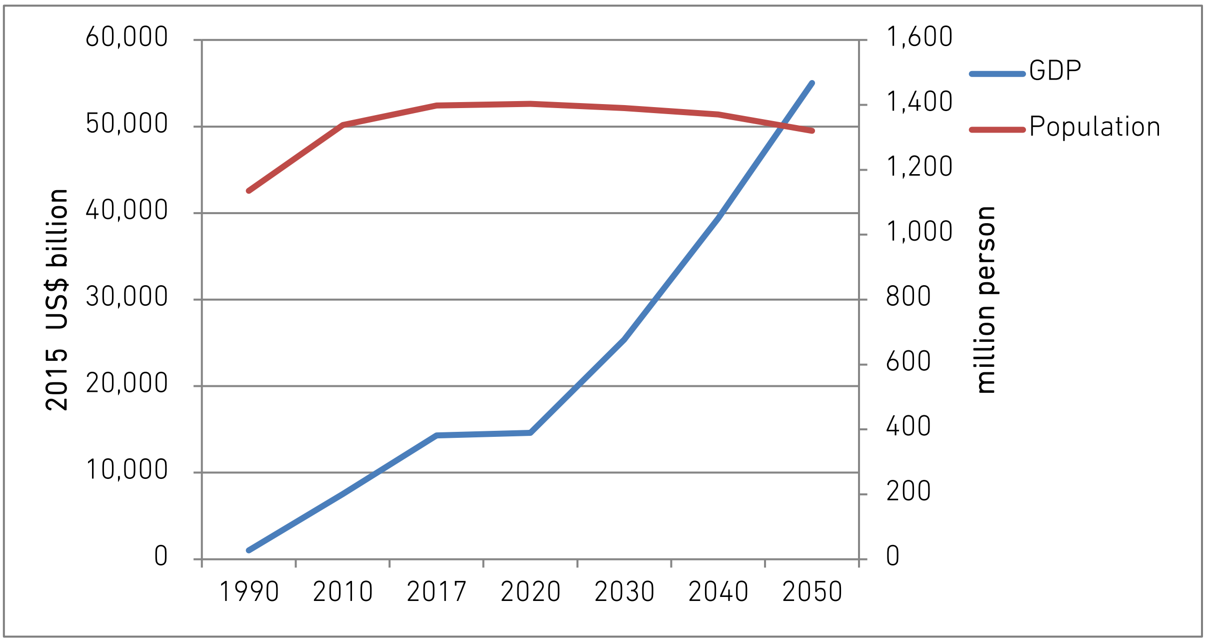
Table 4.1. Annual Growth Rates of Gross Domestic Product and Population

	2019–2020	2020–2030	2030–2040	2040–2050
GDP	2.1%	5.7%	4.5%	3.4%
Population	0.4%	–0.1%	–0.1%	–0.4%

GDP = gross domestic product.
Source: Economic Research Institute for ASEAN and East Asia.

Figure 4.1 shows China's GDP and population assumptions. The population growth rate is projected to decline by 0.1%, 0.1%, and 0.4% throughout the periods of 2020–2030, 2030–2040, and 2040–2050, respectively. The projected population for the year 2050 will be 1.320 billion. The population of China was 1,411.175 million at the end of 2022, which is a decrease of 850,000 from the previous year. This marked the first negative rise in population in over 60 years, and the natural growth rate was –0.60%. Simultaneously, the proportion of the population that is 60 and older has been steadily increasing, reaching 280.04 million, or 19.8% of the total. There were 875.56 million people in the nation who were of working age, making up 62.0% of the total population. The demographic dividend is dwindling for China, and the country will need to make significant adjustments to its growth model to accommodate its ageing population for the foreseeable future.

Figure 4.1. Assumptions of the Average Annual Growth Rate of Gross Domestic Product and Population



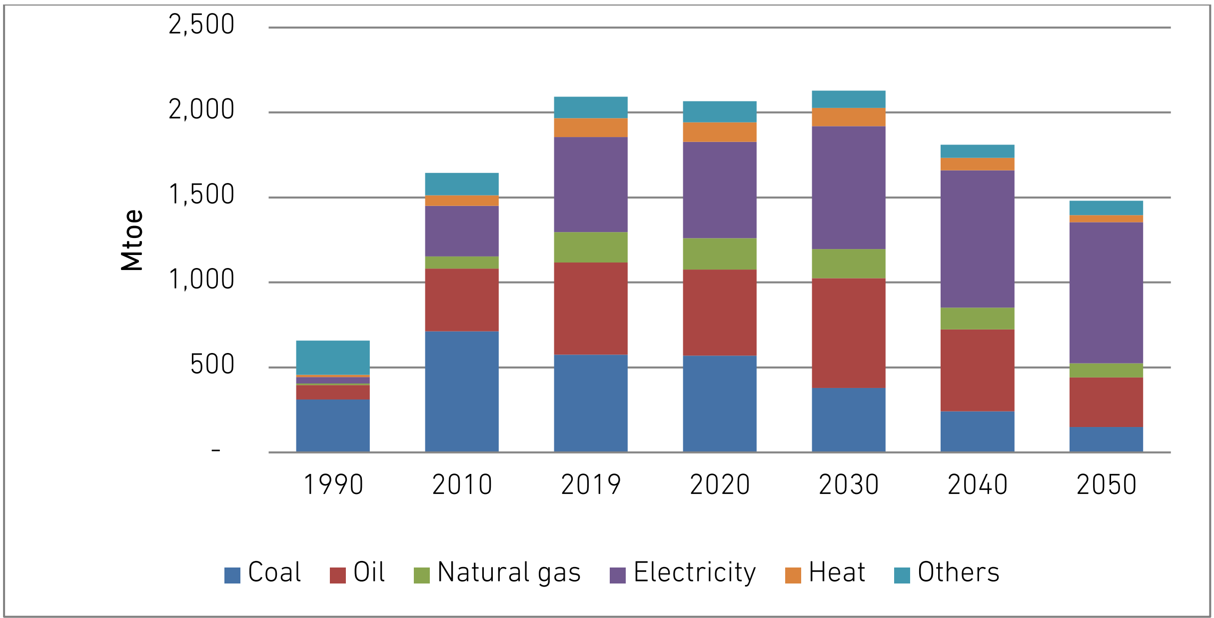
GDP = gross domestic product.
Source: Economic Research Institute for ASEAN and East Asia.

3. Outlook Results

3.1. Total Final Energy Consumption

Figure 4.2 shows total energy consumption by fuel in 1990–2050 under a low-carbon energy transition (LCET) scenario. According to ERIA, China's total final energy consumption (TFEC) has experienced a significant increase, from 658 million tonnes of oil equivalent (Mtoe) in 1990 to 2,067 Mtoe in 2020. Projections indicate that the TFEC will continue to climb, reaching 2,128 Mtoe by 2030. However, it is predicted to gradually fall thereafter, reaching 1,837 Mtoe by 2040 and 1,529 Mtoe by 2050. As for energy type, China is the biggest coal user in the world (BP, 2022). The development of low-carbon energy transition in China has led to a decrease in the share of final coal consumption. Between 1990 and 2020, the proportion of coal in final energy consumption was projected to decrease from 47% to 28%. This will drop to 18% in 2030 and 10% in 2050. The use of coal at terminals increased from 311 Mtoe to 574 Mtoe between 1990 and 2019, and then is expected to decrease to 150 Mtoe in 2050. The consumption of oil and gas is expected to decrease from 646 Mtoe and 173 Mtoe to 292 Mtoe and 82 Mtoe, respectively, from 2030 to 2050. China's electric power infrastructure has experienced rapid growth, bolstered by government laws, positioning it as an exemplar of clean energy and a hallmark of an advanced civilisation. The utilisation of electricity as a final energy source has experienced a significant increase, escalating from 39 Mtoe in 1990 to 568 Mtoe in 2020. Consequently, the level of domestic electricity consumption has been steadily increasing. According to the National Bureau of Statistics (NBS, 2023b), China's whole electricity consumption was projected to reach 8.6 trillion kWh in 2022, with total power generation expected to reach 8.7 trillion kWh. By 2050, it is expected that final electricity consumption will reach 830 Mtoe, or 54% of total final energy, representing electricity as the predominant energy source for final consumption.

Figure 4.2. Final Energy Consumption by Fuel Type, LCET Scenario (1990–2050)

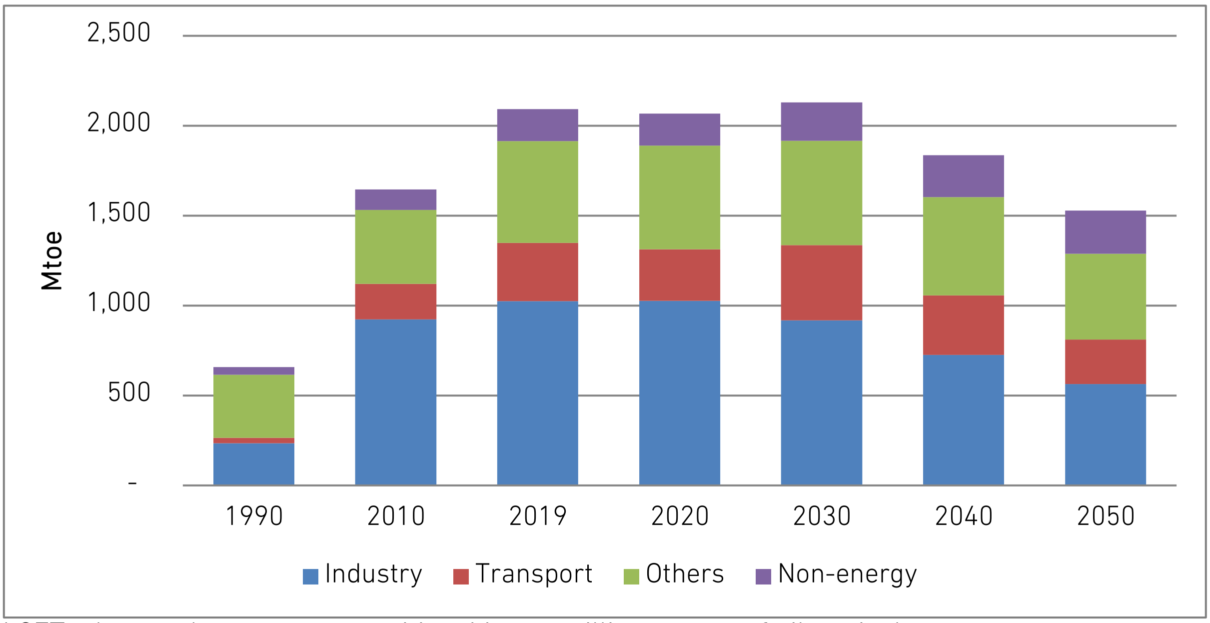


LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.
Source: Economic Research Institute for ASEAN and East Asia.

Figure 4.3 shows the TFEC by sector in 1990–2050 under the LCET scenario. The majority of current energy use is attributed to industry and transportation. Between 1990 and 2020, the proportion of energy consumed by the industrial sector rose from 36% to 50%. China has achieved an average yearly reduction of over 4% in energy consumption per unit of GDP during the past 40 years, resulting in a cumulative decrease of approximately 84% (NBS, 2023b). Significant advancements have been made in the realm of energy conservation and reduction of energy consumption, leading to a rapid improvement in energy efficiency. However, when considering the global context, China's energy consumption per unit of GDP remains 1.5 times higher than the average worldwide. Currently, a sizable share of China's economic structure is devoted to energy-intensive and secondary industries. As part of efforts to expedite the establishment of an energy-efficient society, the 14th Five-Year Plan (2021–2025) in China has incorporated the objective of 'achieving a 13.5% reduction in energy consumption per unit of GDP' as a key benchmark for economic and social progress, which would expedite the process of enhancing the efficiency of traditional energy-intensive sectors and contribute to the growth of low-energy businesses. Projections indicate that the future share of industrial energy consumption will decline to 43% by 2030 and further decrease to 37% by 2050.

China is currently experiencing a period of rapid industrialisation and urbanisation, resulting in an increasing demand for energy in the transport sector. China's transport sector was projected to consume 287 Mtoe in 2020, representing approximately 14% of the total energy consumption. The infrastructure in China is expanding dramatically in terms of both scope and capacity, whilst the use of private vehicles is growing as a result of the social economy's quick expansion. Due to that, energy use in the realm of transport in China has progressively escalated, with an anticipated surge to 417 Mtoe by 2030, constituting 20% of the total. Conversely, the Chinese government has released the China's Green Transport 14th Five-Year Development Plan and other official papers to advance energy preservation, effectiveness, and sustainable growth in the transport industry. According to ERIA, it is anticipated that the share of energy consumption attributed to transportation will diminish to 16% by the year 2050.

Figure 4.3. Final Energy Consumption by Sector, LCET Scenario (2000–2050)

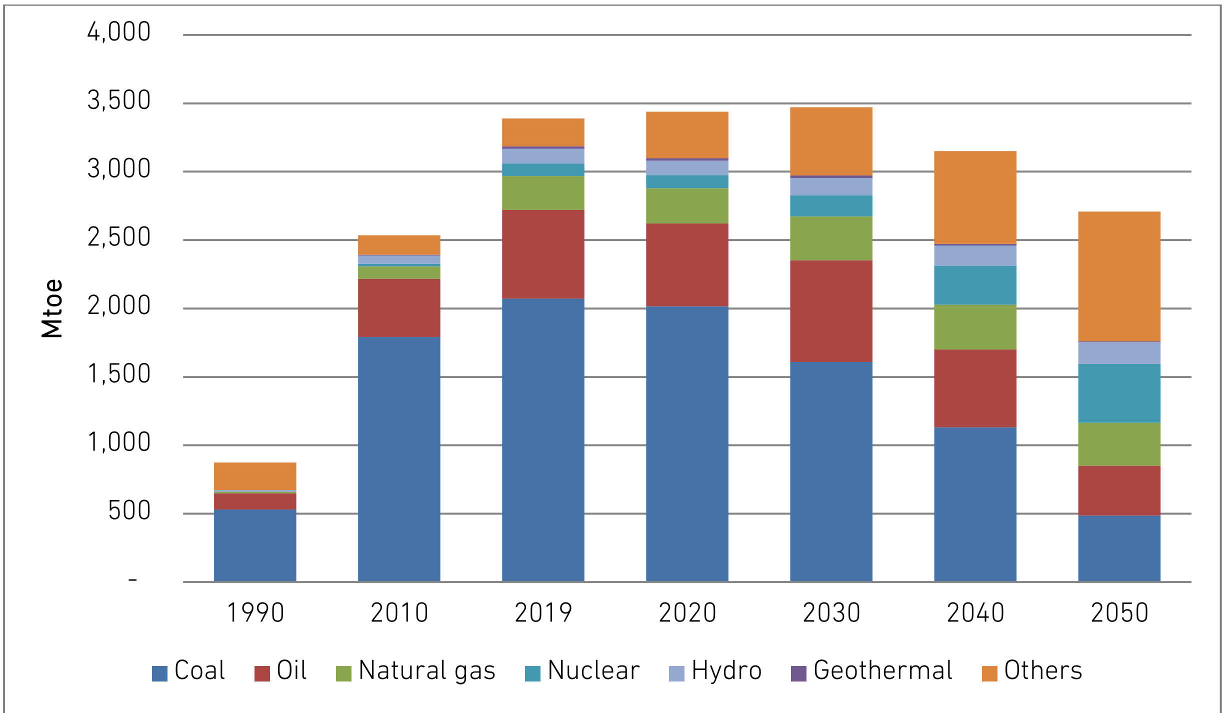


LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.
Source: Economic Research Institute for ASEAN and East Asia.

3.2. Total Primary Energy Supply

Figure 4.4 shows total primary energy supply (TPES) by source in 1990–2050 in the LCET scenario. China possesses abundant coal resources, limited oil reserves, and scarce natural gas. Coal continued to be the predominant source of China's primary energy supply in 2020, representing 59%. Oil is the second largest contributor to primary energy supply, making up 18%, whilst natural gas accounts for 8%. China is heavily dependent on oil and gas imports due to its comparatively limited natural gas and oil resources. According to NBS (2022), China's reliance on imported crude oil stands at 71.2% and its dependence on imported natural gas is 40.5%. Global energy security uncertainties persist due to the impact of geopolitical conflicts, climate change, exchange rate volatility, and other causes. To guarantee energy security, the Chinese government will prioritise the fundamental national coal conditions and encourage the environmentally-friendly utilisation of coal. Simultaneously, the government is actively engaged in the development of renewable energy and enhancing the diverse energy supply. Hydropower is the dominant source of clean electricity, generating 105 Mtoe in 2020 and projected to increase to 159 Mtoe by 2050. Nuclear production, which was 95 Mtoe in 2020, is predicted to more than quadruple to 431 Mtoe in 2050. China has abundant solar and wind energy resources in its northeast, north, and northwest regions. Recent years have seen a rise in the use of solar and wind power by the Chinese government; the share of photovoltaic power generation, wind power, and other energy sources has reached 10% and is predicted to rise to 14% in 2030 and 35% in 2050.

Figure 4.4. Total Primary Energy Supply by Fuel Type, LCET Scenario (1990–2050)



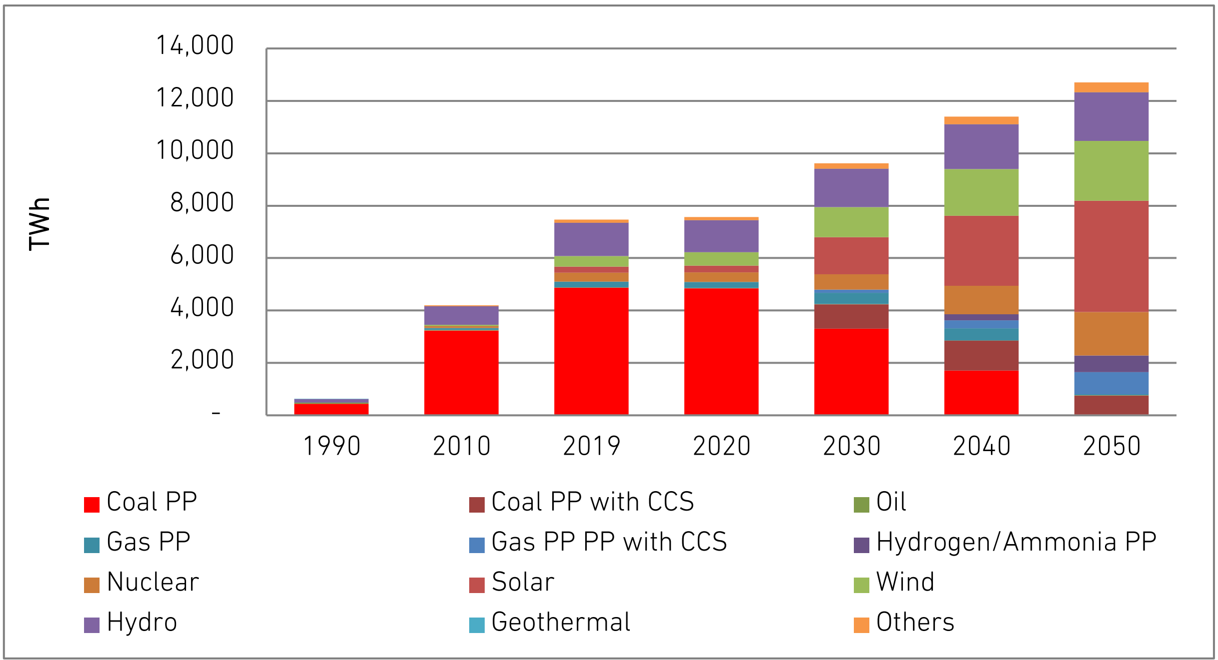
LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.
Source: Economic Research Institute for ASEAN and East Asia.

3.3. Electricity Generation

Figure 4.5 shows historical and future power generation in the LCET scenario. China's power generation has been steadily increasing alongside its economic development. From 1990 to 2020, power generation rose from 621 terawatt-hours (TWh) to 7567 TWh, reflecting an average yearly growth rate of approximately 8.69%. China's reliance on coal as a power source has made it the primary producer of electricity for an extended duration.

By 2020, coal-fired power plants contributed 64% of the overall electricity generation. Nevertheless, as the transition towards clean electricity gains momentum, the proportion of coal-fired power plants in the electricity generation mix is projected to decrease significantly. It is anticipated to decline to 34% by 2030, 15% by 2040, and a mere 0.3% by 2050. However, this does not imply that China will completely forsake coal. Conversely, the Chinese government is actively advocating for the adoption of carbon capture and storage (CCS) technology to facilitate the environmentally-friendly utilisation of coal. By 2030, it is projected that coal-fired power plants incorporating CCS technology will contribute around 10% to the overall electricity supply. Natural gas is considered a comparatively environmentally-friendly energy source. The utilisation of natural gas as a power source is expected to rise to 458 TWh by 2040 and then decline to 44 TWh by 2050. Electricity generation from gas-fired power plants equipped with CCS technology is projected to rise to 842 TWh by 2050, representing approximately 7% of the total. The utilisation of oil and geothermal energy for power generation in China is minimal and ignorable. By 2050, it is projected that nuclear power generation will account for 13% of the total energy produced. Hydropower has historically been the primary source of renewable energy production in China. It generated 711 TWh in 2010, 1216 TWh in 2020, and is projected to reach 1849 TWh in 2050. The progress of hydropower has been largely stable over time. By contrast, the expansion of solar and wind power generation has been swift in recent years. Solar power's share of the energy market was a mere 0.02% in 2010. By 2020, it had increased to 3.4%. Projections indicate that it will reach 14.7% by 2030 and 33.4% by 2050. In 2010, wind power made up only 1.1% of the total energy production. However, it is projected to increase significantly and reach 18% by 2050. Renewable energy generation is projected to become the primary source of electricity generating in the future.

Figure 4.5. Power Generation by Source, LCET Scenario (1990–2050)

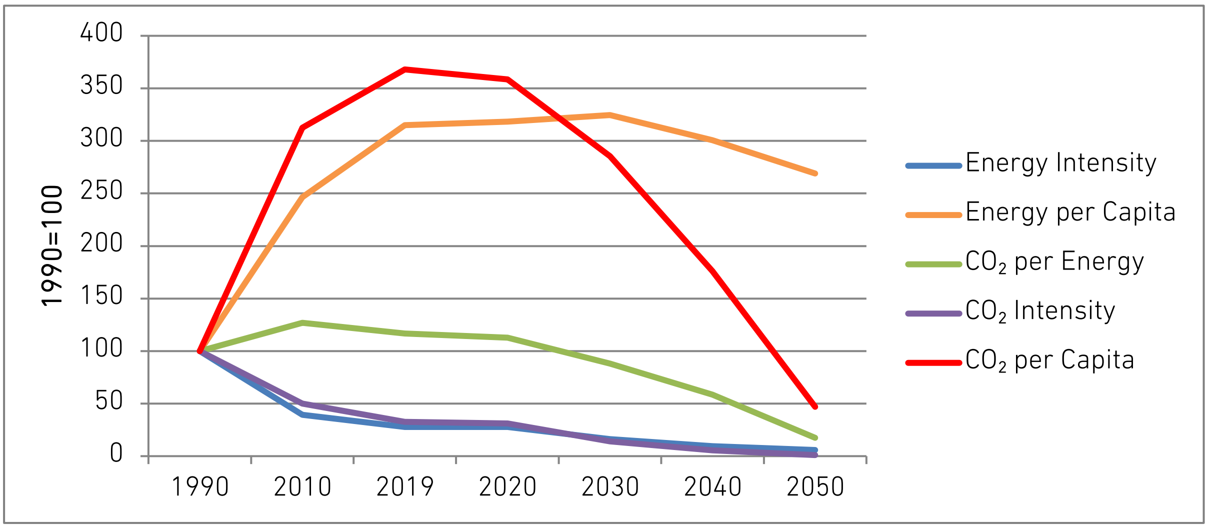


CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, TWh = terawatt-hour.
Source: Economic Research Institute for ASEAN and East Asia.

3.4. Energy Indicators

Figure 4.6 shows the energy indicators in the LCET scenario. Both the energy intensity and carbon dioxide (CO_2) intensity are expected to decrease steadily from 1990 to 2050. The year 1990 serves as the baseline. By 2050, the energy intensity is projected to decline to around 5.8% of the level observed in 1990. The projected CO_2 intensity will probably drop to around 1% of the level documented in 1990. Energy per capita, CO_2 per energy, and CO_2 per capita are forecast to increase and subsequently decrease between 1990 and 2050. Energy per capita is expected to increase to 325% of the 1990 levels by 2030, and will decrease after that. In 2050, energy per capita is projected to be 269% higher than that in 1990. CO_2 per energy reached their highest level in 2010, at 127% of the level recorded in 1990. However, by 2050, they had decreased significantly to only 17.5% of the 1990 level. The per capita CO_2 emissions reached their highest point in 2019, reaching 368% of the levels recorded in 1990. It is projected that these emissions will gradually decline and are predicted to be at 47% of the 1990 levels by 2050.

Figure 4.6. Energy Indicators, LCET Scenario (1990–2050)

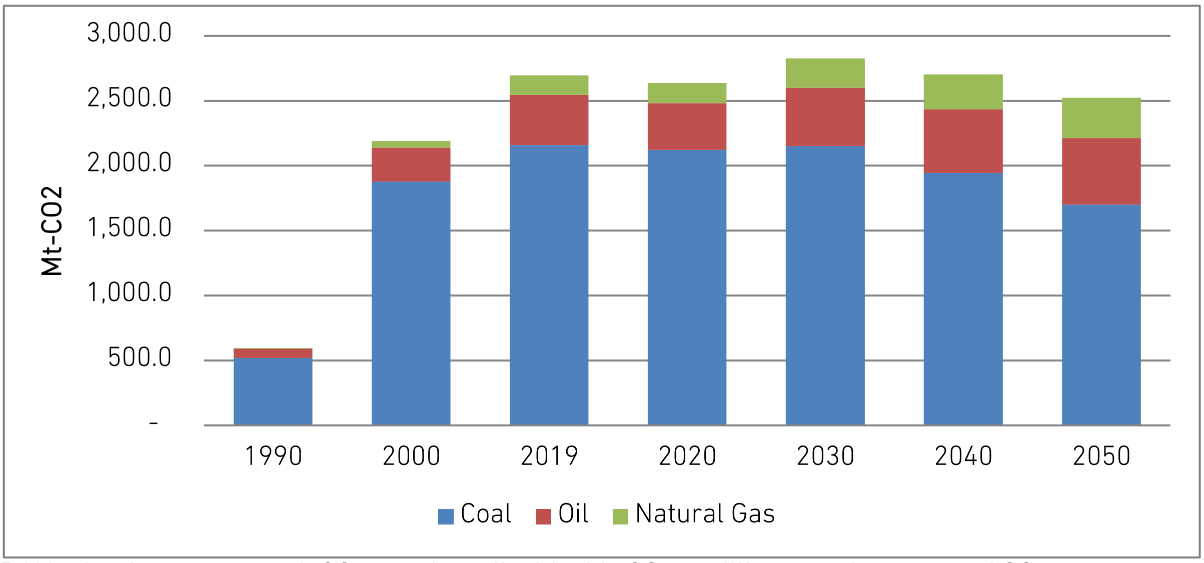


CO_2 = carbon dioxide, LCET = low-carbon energy transition.
Source: Economic Research Institute for ASEAN and East Asia.

3.5. Carbon Dioxide Emissions

Figure 4.7 shows CO_2 emissions in 1990–2050 in the BAU scenario. Under this scenario, the amount of CO_2 emitted from burning fossil fuels is projected to reach its highest point at 2,827 million metric tons of CO_2 (Mt-CO_2) in 2030. By 2030, coal is projected to account for 76% of the total CO_2 emissions, with oil contributing 16%, and natural gas contributing 8%. Projections indicate that there will be a reduction in CO_2 emissions to 2,523 Mt-CO_2 by 2050. Out of this total, coal is responsible for 67.4% of the emissions, crude oil contributes 20.4%, and natural gas accounts for 12.2%.

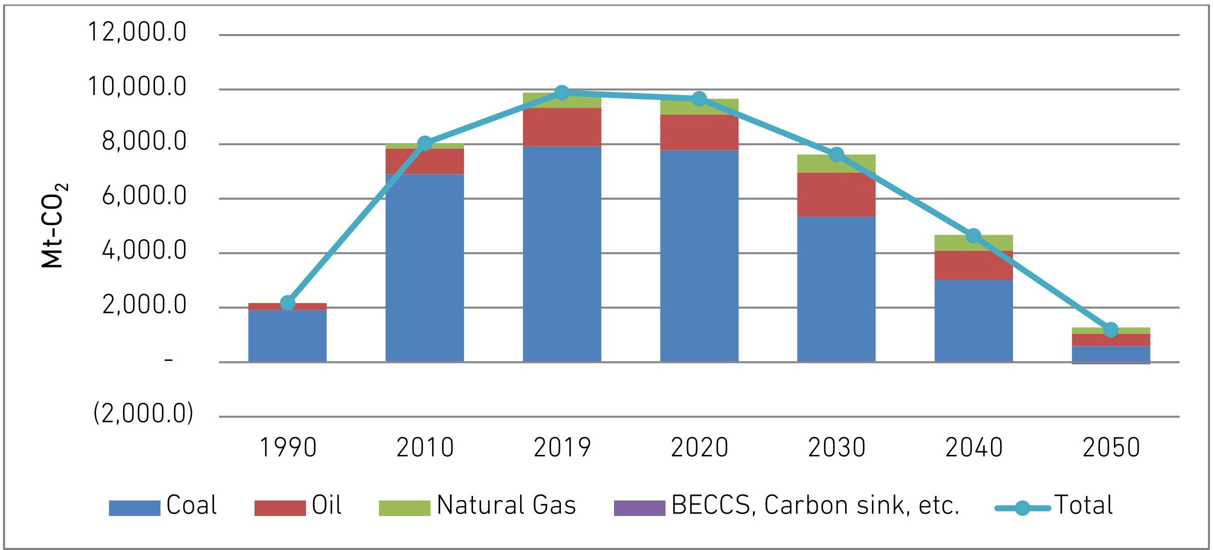
Figure 4.7. CO_2 Emissions by Fossil Fuel Type, BAU Scenario (1990–2050)



BAU = business as usual, CO_2 = carbon dioxide, Mt-CO_2 = million metric tonnes of CO_2.
Source: Economic Research Institute for ASEAN and East Asia.

Figure 4.8 shows CO_2 emissions in 1990–2050 in the LCET scenario. Compared with the BAU scenario, CO_2 is projected to reach its highest point earlier in the LCET scenario. According to ERIA, carbon dioxide would peak in 2019 at 9,882 Mt-CO_2 if it was in the LCET scenario. By 2050, the projected amount of CO_2 is 1191 Mt-CO_2, with coal contributing 590 Mt-CO_2, which represents 50% of the total CO_2 emissions. The CO_2 emissions resulting from the combustion of crude oil amount to 455 Mt-CO_2, representing 38% of the total emissions. Meanwhile, the implementation of bioenergy with carbon capture and storage (BECCS), carbon sinks, and other advanced technologies will effectively decrease carbon emissions by 83 Mt-CO_2.

Figure 4.8. CO_2 Emissions by Fossil Fuel Type, LCET Scenario (1990–2050)



BECCS = bioenergy with carbon capture and storage, CO_2 = carbon dioxide, LCET = low-carbon energy transition, Mt-CO_2 = million metric tonnes of carbon dioxide.
Source: Economic Research Institute for ASEAN and East Asia.

4. Cost Analysis

Increasing investment in clean energy technology is necessary to reach carbon neutrality, but doing so will raise investment costs. This section estimates and calculates final energy consumption costs, construction cost of power plants, and carbon capture and storage cost in both the BAU and LCET scenarios.

4.1. Fuel Cost

Fuel cost assumptions are shown in Table 4.2. Based on the assumption of fuel cost and corresponding final energy consumption, the cost of coal, oil, gas, and hydrogen in 2019 and 2050 in both the BAU and LCET scenarios are estimated and compared.

Table 4.2. 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$/MMBtu
Hydrogen	0.8	0.3	US$/$Nm^3$

bbl = barrel, MMBtu = metric million British thermal unit, Nm^3 = normal cubic metre.
Source: The Institute of Energy Economics, Japan.

Table 4.3 exhibits the final energy consumption of each fuel and the corresponding cost in 2019 and 2050. From the results, in both the BAU and LCET scenarios, the amount of coal as China's final energy consumption in 2050 will be significantly reduced compared with 2019, and the corresponding fuel cost will also decrease. The cost of coal will be reduced by US$47.6 billion in the BAU scenario and US$67.09 billion in the LCET scenario. The fuel cost for gas and oil as end-energy sources will rise in 2050 compared to 2019 by US$17.29 billion and US$134.3 billion in the BAU scenario and drop by US$27.9 billion and US$172.2 billion in the LCET scenario. Hydrogen consumption in the BAU scenario is zero, compared to 48.16 Mtoe in 2050 in the LCET scenario, at an additional cost of US$18.7 billion. Overall, the total cost of coal, oil, gas, and hydrogen as end-energy fuels in 2050 will decrease by US$248.5 billion compared to 2019 in the LCET scenario and increase by US$ 104 billion in the BAU scenario.

Table 4.3. Fuel Cost in BAU and LCET Scenarios

	Final Energy Consumption (Mtoe), BAU in 2019	Final Energy Consumption (Mtoe), BAU in 2050	Final Energy Consumption (Mtoe), LCET in 2050	Fuel Cost 2050–2019, BAU (US$ million)	Fuel Cost 2050–2019, LCET (US$ million)
Coal	574.20	272.88	149.66	–47,616	–67,087
Oil	542.50	737.75	292.11	134,299	–172,217
Gas	178.96	238.83	82.18	17,285	–27,947
Hydrogen	0	0	48.16	0	18,705
Total	**1295.66**	**1249.46**	**572.11**	**103,968**	**–248,546**

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.
Note: 2050-2019 means the increased fuel costs in 2050 compared to 2019. If the number of 2050–2019 is less than zero, it means that the cost in 2050 is lower than that in 2019.
Source: Authors' calculations.

4.2. Power Generation Investment

The assumption of construction costs and capacity factors of power plants are shown in Table 4.4. Based on the assumption, the additional capacity and corresponding investment cost of power plants with different fuel types in the scenario of both the BAU and LCET scenarios are calculated.

Table 4.4. Power Plant Assumptions

	Construction Costs of Power Plants		Capacity Factor of Power Plants	
	US$/kW		%	
	2019	by 2050	2019	by 2050
Coal	1,500	1,525	75	80
Oil	--	--	75	80
Gas	700	700	75	80
Hydrogen	--	700	--	80
Nuclear	4,500	3,575	100	80
Hydro	2,000	2,223	50	40
Geothermal	4,000	4,256	50	50
Solar	1,600	307	17	17
Wind	1,600	1,235	40	40
Biomass	2,000	3,019	50	70

kW = kilowatt.
Source: The Institute of Energy Economics, Japan.

Non-fossil fuels will predominate the energy in power plant construction throughout the next 30 years. These coal-fired power plants, equipped with CCS, will increase by 84,130 megawatt (MW) under the BAU scenario, necessitating an extra expenditure of roughly US$128.3 billion. There will be no further expansion of coal-fired power stations in the LCET scenario. Oil-fired power stations are uncommon in China due to the scarcity of oil. Natural gas has the advantages of both stability and cleanliness. Gas-fired power plants will be expanded, with an additional investment of US$81.9 billion under the BAU scenario and an additional US$67.2 billion under the LCET scenario.

The hydrogen generation capacity will see a 90.7 billion MW expansion in the LCET scenario, not an increase in the BAU scenario. Nuclear power plants account for 5% of additional plant capacity over 30 years. However, their investment costs are much higher than other power plants, accounting for 18% of the total investment cost in the BAU scenario and 24% in the LCET scenario. Future investments will primarily focus on solar power generation. The increased solar generation capacity in the BAU scenario amounts to 789,686 MW; in the LCET scenario, it accounts for 71% with 2,700,892 MW. Though not as much as solar power, wind nevertheless will contribute significantly. In the BAU scenario, wind capacity additions made up 16%, whilst in the LCET scenario, they made up 14%.

Table 4.5. Total Investment Cost of Power Plants

	Electricity Generation (TWh)			Additional Capacity (MW)		Total Investment Cost (US$ million)	
	2019	2050					
	BAU	BAU	LCET	BAU	LCET	BAU	LCET
Coal	4,876	5,465	763	84,130	--	128,299	--
Oil	11	4	3	--	--	--	--
Gas	213	1,033	886	117,062	96,067	81,944	67,247
Hydrogen	0	0	636	0	90,690	0	63,483
Nuclear	348	797	1,652	64,007	186,085	228,826	665,255
Hydro	1,273	1,597	1,849	92,527	164,458	205,687	365,590
Geothermal	0	1	1	89	163	378	694
Solar	224	1,400	4,246	789,686	2,700,892	242,434	829,174
Wind	406	1,200	2,286	226,589	536,634	279,837	662,743
Biomass	122	364	389	39,465	43,589	119,145	131,595
Total	**7,472**	**11,861**	**12,711**	**1,413,555**	**3,818,578**	**1,286,549**	**2,785,780**

BAU = business as usual, LCET = low-carbon energy transition, MW = megawatt, TWh = terawatt-hour.
Source: Authors' calculations.

4.3. Carbon Capture and Storage Costs

Carbon capture and storage (CCS) is estimated to cost about US$70/$CO_2$ ton. The overall cost of the CCS investment for coal-fired power plants and natural gas-fired plants in the LCET scenario is assessed based on the assumption that only these plants will be outfitted with CCS technology under LCET scenarios. Ninety-five percent of all gas-fired and coal-fired power plants are predicted to be composed of plants with CCS. Based on that, the total coal consumption of CCS coal-fired power plants is approximately 196.55 Mtoe. Of that, 733.59 Mt CO_2 is produced and 660.23 Mt CO_2 is anticipated to be absorbed by CCS. As a result, the cost of CCS for coal-fired power plants is anticipated to reach US$46.2 billion in 2050. Similarly, it is estimated that in 2050, the cost of CCS for natural gas plants will be US$25.7 billion (Table 4.6).

Table 4.6. Total Investment Cost of CCS, LCET Scenario

	Consumption of Coal or Gas in 2050 (Mtoe)	CO_2 for CCS ($Mt\text{-}CO_2$)	Total Investment Cost of CCS (US$ million)
Coal-fired Power Plant with CCS	196.55	660.23	46,216
Natural Gas-fired Power Plant with CCS	191.55	367.16	25,701
Total	**388.10**	**1027.39**	**71,917**

CCS = carbon capture and storage, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, $Mt\text{-}CO_2$ = million metric tonnes of CO_2.
Source: Authors' calculations.

4.4. Overall Costs

Based on the results above, the overall costs including additional fuel cost, investment cost of power plants, and CCS cost in 2050 are calculated. As shown in Table 4.7, although the construction of plants using clean energy and CCS are costly, the LCET scenario reduces the use of fossil fuels by a significant amount, resulting in lower overall energy costs in 2050 than in 2019. The overall cost in 2050 is estimated to be US$145.5 billion greater than it was in 2019 under the BAU scenario and US$86.8 billion less than it was in 2019 under the LCET scenario.

Table 4.7. Overall Increased Costs in 2050 Compared to 2019

	BAU	LCET
Total fuel cost investment (US$ million)	103,968	–248,546
Annual investment cost of power plants (US$ million)	41,502	89,864
CCS Cost in 2050 (US$ million)	0	71,917
Total (US$ million)	**145,470**	**–86,765**

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.
Source: Authors' calculations.

5. Implications and Policy Implications

Global climate change poses a threat to humankind's capacity for long-term prosperity. China has long prioritised combating climate change, has been a leader in green development, and has advocated for the integration of human and environmental well-being. The urgency of the energy transition arises from the increasing unpredictability brought about by climate change. This report primarily predicts the total final energy consumption, total primary energy supply, electricity generation, energy indicators, and carbon emissions on the scenario of low-carbon energy transition. The main findings follow.

First, China's low-carbon revolution has resulted in a decline in the country's terminal coal use share. Coal in TFEC will drop to 18% in 2030 and 10% in 2050. By contrast, electricity consumption is predicted to reach 54% of TFEC, by 2050, making it the main energy source for final consumption. Most energy is used for industry and transport. As China's industrial energy utilisation efficiency improves, future industrial energy consumption is expected to drop to 43% by 2030 and 37% by 2050. As China's transport infrastructure improves and private automobiles become more popular, energy use in the transport sector is predicted to rise to 20% by 2030 and reduce to 16% by 2050.

Second, China's major energy supply continues to rely predominantly on coal. To ensure energy security, the Chinese government will prioritise national circumstances and promote the eco-friendly use of coal. Simultaneously, the government is proactively advancing the development of renewable energy. The share of photovoltaics, wind power, and other energy sources is expected to rise to 35% by 2050 from 14% in 2030.

Third, China's electricity generation climbed 8.7% yearly from 1990 to 2020. The switch to sustainable electricity will see coal's share of electricity fall steadily, to 34% by 2030 and 0.3% by 2050. To reduce CO_2 emissions, China is promoting CCS technology in coal-fired and natural gas-fired power plants. Furthermore, the production of renewable energy is expected to rise quickly and take over as the primary source of electricity. In 2010, the electricity generated by solar and wind sources accounted for only 0.02% and 1.1%, respectively. However, it is projected that by 2050, these percentages will significantly increase to 33.4% and 18.0%, respectively.

Fourth, despite the high cost of building renewable energy power plants and CCS facilities, the LCET scenario lowers the overall costs in 2050 compared to 2019 by reducing the consumption of fossil fuels by a considerable amount on an annual average. The total cost in 2050 is $145.55 billion more than it was in 2019 under the BAU scenario and US$86.8 billion less than it was in 2019 under the LCET scenario.

Given the current status of energy outlook, three policy implications are put forward.

First, enterprises are the primary entities responsible for implementing energy conservation and carbon reduction measures. It is suggested to promote the prominent position of leading companies, implement environmentally-friendly supply chain management, and provide a novel framework for energy efficiency and carbon reduction in small and medium-sized businesses led by more giant corporations. Enterprises in the supply chain that proactively engage in low-carbon technology research and development can receive enhanced policy support from the government, including financial assistance, green procurement, green credit, and tax relief.

Second, it is important to include several socioeconomic aspects when evaluating the benefits and costs of energy transition. Whilst energy transition may have long-term positive impacts on society, it is essential to note that not all groups will see equal gains from it. Conversely, a sizeable portion of the coal industry's workforce is unemployed, and it is challenging for the unemployed to find jobs in the emerging energy sector. Simultaneously, energy transition will cause talent losses in areas rich in coal resources, stalling economic growth. The interests of different groups and areas should be adequately recognised, and policy support should be given to those impaired by the transition to guarantee fairness and justice.

Third, it is also critical to reduce demand-side energy use and carbon emissions. Ecological civilisation education can be incorporated into the national education system to guide young people to establish green, low-carbon environmental protection concepts. It is recommended that the government encourage residents to prioritise the acquisition and utilisation of energy-efficient and water-efficient equipment, whilst also minimising the use of disposable products like plastic shopping bags. The government actively advocates for the implementation of a 'carbon inclusive' system, employing the 'internet + big data + carbon finance' strategy to establish a comprehensive framework for tracking, quantifying, and incentivising citizens' efforts to reduce carbon emissions. This initiative aims to guide the entire society towards adopting a sustainable and environmentally-friendly lifestyle.

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