CHAPTER 5

China Country Report

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This chapter should be cited as:
Li., H. and R. Zhang (2023), 'China Country Report', in Kimura, S., H. Phoumin, and A.J. Purwanto (eds.), *Energy Outlook and Energy-Saving Potential in East Asia 2023*. Jakarta: ERIA, pp.121-134

1. Background

Since 2020, the global economy, social development, and public health have been threatened by the coronavirus disease (COVID-19) pandemic. China has explored a series of policies to bring the domestic outbreak under control and to recover gradually. China's significant progress in many aspects is noteworthy, such as the victory in the critical battle against poverty, promotion of digital currency, outstanding achievements in ecological conservation, and targeting of carbon peak and carbon neutrality.

In 2021, energy production grew steadily, energy efficiency continued to improve, the energy consumption structure was optimised, and the level of electrification of end-use energy accelerated. Production of raw coal, crude oil, natural gas, and electricity rose by 4.7%, 2.4%, 8.2%, and 8.1%, respectively, on a year-on-year basis. Energy consumption per unit of gross domestic product (GDP) was reduced by 2.7% compared with that of 2020 (30% lower than in 2012). The clean energy industry grew rapidly. The proportion of clean energy consumption reached 25.3% in 2021: a remarkable achievement in the energy structure transition. Electricity consumption increased to 8,312.8 billion kilowatt-hours (KWh) or by 10.3% year on year.

The report will explore China's energy development and propose policy recommendations.

2. Macro Assumptions

China has gradually recovered from the COVID-19 pandemic. In 2021, GDP exceeded CN¥100 trillion for the second consecutive year and the economic growth rate of 8.1% was the highest in the past 10 years. Table 5-1 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 5.3%, 4.5%, and 3.4% in 2019–2030, 2030–2040, and 2040–2050, respectively. China's GDP in 2050 is estimated to be US$44,340 billion.

Table 5.1 China – Assumptions of Annual Growth Rates of Gross Domestic Product and Population

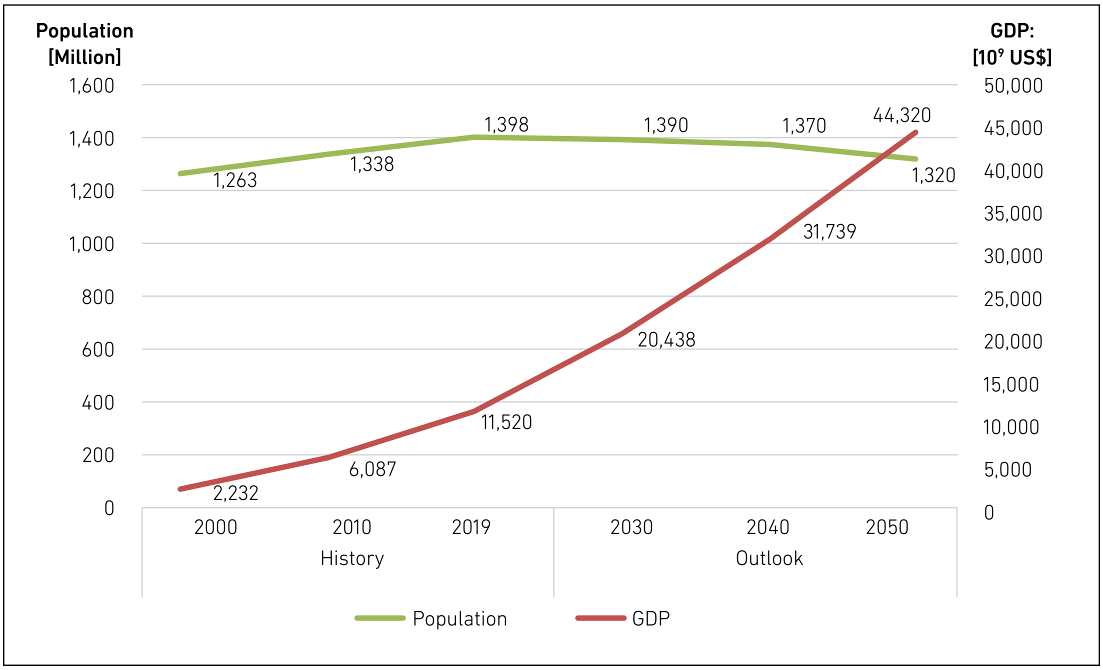
	2000–2010	2010–2019	2019–2030	2030–2040	2040–2050
GDP	10.6%	7.3%	5.3%	4.5%	3.4%
Population	0.6%	0.5%	–0.1%	–0.1%	–0.4%

GDP = gross domestic product.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.1 shows China's GDP and population assumptions. The population increased from 1.135 billion to 1.403 billion in 1990–2020, with an AAGR of about 0.7%, making China the world's most populous country. As the economy progresses, the population growth rate is expected to decrease by 0.1%, 0.1%, and 0.4% in 2019–2030, 2030–2040, and 2040–2050, respectively. By 2050, the population will be 1.320 billion. Economic development encourages people to pursue higher quality of life, leading to higher parenting costs, e.g. education, and a lower fertility rate. The continuous decrease in the number of women of child-bearing age can also explain the trend that population growth momentum has weakened.

Figure 5.1 China – 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, 2020.

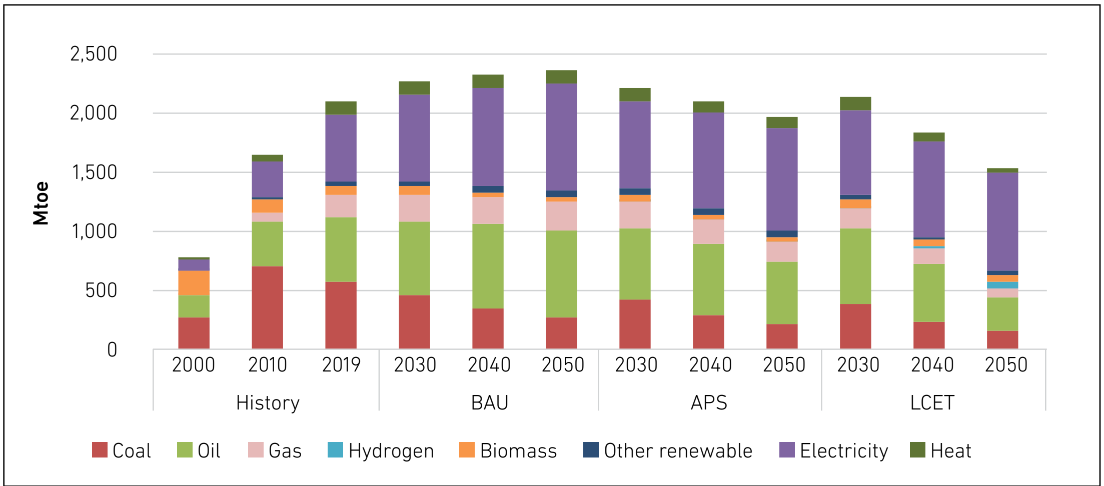
3. Outlook Results

3.1. Total Final Energy Consumption

Figure 5.2 shows total energy consumption by fuel in 2000–2019 and in 2030–2050 under different scenarios: business as usual (BAU), alternative policy scenario (APS), and low-carbon energy transition (LCET). China is the largest consumer of coal in the world (BP, 2022). Although coal accounts for a large portion of total final energy consumption, it is projected to decrease annually. In 2019–2050, China's coal consumption will decrease from 574 to 273 million tonnes of oil equivalent (Mtoe) in BAU, 206 Mtoe in APS, and 150 Mtoe in

LCET. The reason is that the government has introduced a series of policies to reduce coal consumption (Liao et al., 2019) and promote clean energy transition (Li et al., 2022). In 2050, the consumption of oil and gas is projected to reach 738 Mtoe and 239 Mtoe, respectively, in BAU; 533 Mtoe and 173 Mtoe, respectively, in APS; and 292 Mtoe and 82 Mtoe, respectively, in LCET. Oil and gas consumption will increase in BAU to meet rising energy demand. However, if the government adopts low-carbon emission technology or implements other alternative measures, oil and natural gas consumption will decrease because the government is pursuing a clean energy transition from fossil fuels to renewable energy, which is conducive to sustainable development. Consumption of biomass and heat energy is projected to reach about 29 Mtoe and 112 Mtoe, respectively, in BAU; 42 Mtoe and 86 Mtoe, respectively, in APS; and 62 Mtoe and 42 Mtoe, respectively, in LCET. Hydrogen consumption, despite being almost non-existent in BAU, is predicted to increase from 16 thousand tonnes of oil equivalent (Ktoe) to 123 Ktoe in APS, and from 13 Ktoe to 48 Ktoe in LCET in 2030–2050. Consumption of other renewable energy will increase from 48 Mtoe to 53 Mtoe in BAU in 2030–2050. However, in the other two scenarios, consumption will decrease: from 46 Mtoe to 40 Mtoe in APS and from 41 Mtoe to 23 Mtoe in LCET in 2030–2050. Electricity has long been the most important energy. The government has introduced policies to develop it, as reflected in its rapid growth rate of consumption. In 2030–2050, electricity consumption is projected to increase by 24.5% in BAU, 21.2% in APS, and 15.1% in LCET. Electricity consumption will rise from 729 Mtoe to 905 Mtoe in BAU, from 729 Mtoe to 882 Mtoe in APS, and from 722 Mtoe to 830 Mtoe in LCET, which is attributed to the attention recently paid to electricity development by the government.

Figure 5.2 China – Final Energy Consumption by Fuel, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)

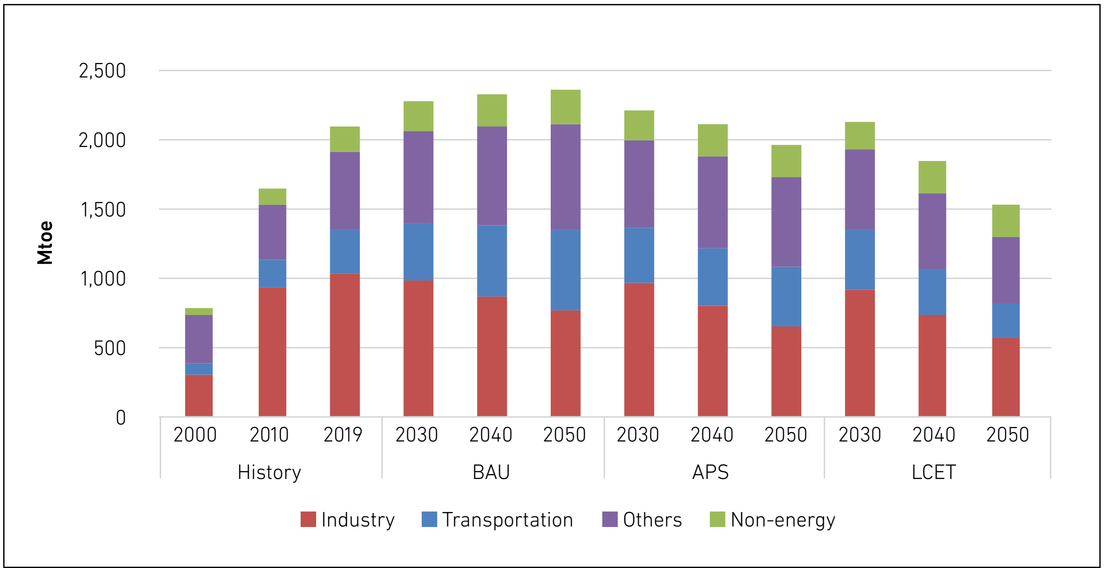


APS = alternative policy scenario, BAU = business as usual, GDP = gross domestic product, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.3 shows total final energy consumption (TFEC) by sector in 2000–2019 and 2030–2050 in different scenarios. TFEC increased by 5.2% in 2021, higher than its 2.2% growth rate in 2020 (CSY, 2021). According to ERIA, TFEC increased from 781 Mtoe to 2,093 Mtoe in 2000–2019. TFEC is projected to rise from 2,270 Mtoe to 2,350 Mtoe in 2030–2050 in BAU, from 2,201 Mtoe to 1,962 Mtoe in APS, and from 2129 Mtoe to 1529 Mtoe in LCET. Energy consumption in industry will decrease from 980 Mtoe to 761 Mtoe in 2030–2050 in BAU, decline from 964 Mtoe to 648 Mtoe in APS, and decrease from 918 Mtoe to 563 Mtoe in LCET. Since the supply-side structural reform during the 13th Five-Year Plan Period, the government has taken a series of measures to address overcapacity and adjust the industrial structure (Zhao et al., 2021). Energy consumption in industry will decrease even in BAU. Due to the effectiveness of low-carbon–emitting technologies, energy consumption in industry will decrease even more remarkably in LCET. Although its results may not be as significant as those in LCET, APS is still an effective emission-reduction strategy. In transport, energy consumption will decrease from 417 Mtoe to 248 Mtoe in LCET, but will increase from 420 Mtoe to 588 Mtoe in BAU and from 391 Mtoe to 425 Mtoe in APS. As the economy grows, an increasing number of people can afford private cars. The number of private cars rose from 6.25 million to 225.09 million in 2000–2019 (CSY, 2021). Transport energy consumption is, therefore, constantly increasing. The upward trend will continue in BAU. In APS, even if the rate of rise slows down, energy consumption will still increase. Only in LCET can the trend be inhibited. In 'others' (residential and commercial sectors), low-carbon technologies and other policies are effective in reducing energy consumption. In 2030–2050, energy consumption in 'others' will continue to increase in BAU, reach a peak, start to decline in APS, and steadily decrease in LCEP.

Figure 5.3 China – Final Energy Consumption by Sector, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)



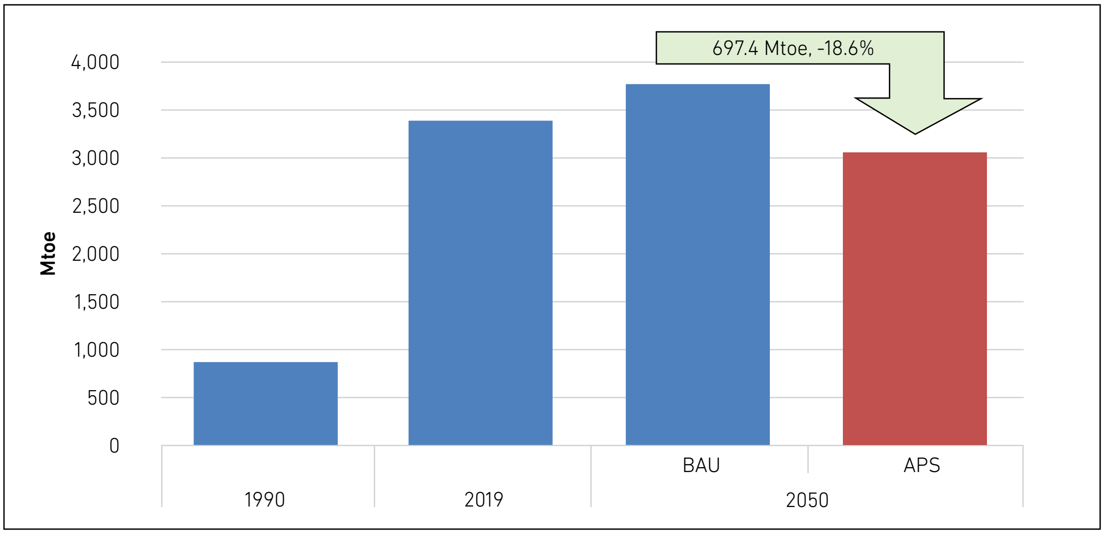
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.2. Total Primary Energy Supply

Figure 5-4 shows total primary energy supply (TPES) in 1990, 2019, and 2050. TPES increased from 873.6 Mtoe in 1990 to 3,389.3 Mtoe in 2019, for an annual growth rate of 4.8%. In BAU, energy consumption is predicted to continually increase in 2019–2050. In contrast, energy consumption is projected to be lower in 2050 than in 2019 in APS. TPES will decrease by 18.6% in APS compared with BAU, equivalent to 697.4 Mtoe.

Figure 5.4 China – Total Primary Energy Supply in 1990, 2019, and 2050

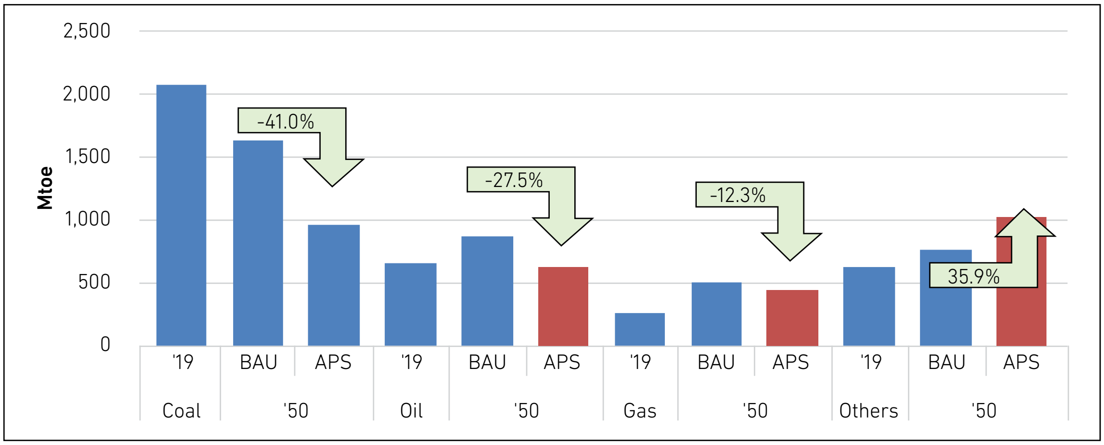


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.5 shows TPEC by fuel. Despite being the primary energy source, coal is projected to decrease in the next 30 years, even if alternative policies are not adopted. However, TPEC in APS is 41.0% lower than in BAU, suggesting that policies are significant in reducing energy consumption. For oil, TPEC in APS drops by 27.5% (239 Mtoe) more than in BAU. As natural gas is generally regarded as clean energy, its share in TPEC is expected to increase. However, APS can decrease the share of natural gas in TPEC by 12.3%. Regarding other fuels (e.g. renewable energy), their share in TPEC is estimated to improve by 35.9% because alternative policies are adopted.

Figure 5.5 **China – Total Primary Energy Supply by Fuel, Business as Usual and Alternative Policy Scenario (2019–2050)**



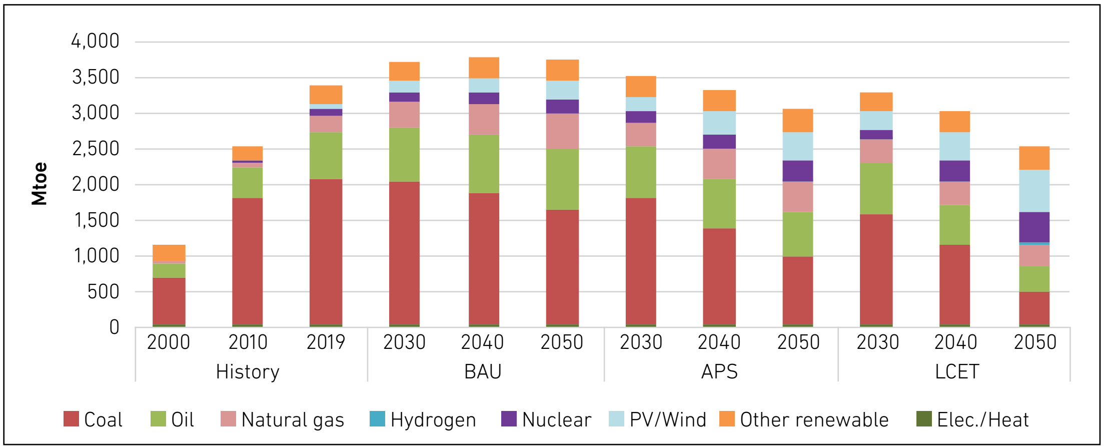
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.3. Total Primary Energy Supply

Figure 5.6 shows total primary energy supply (TPES) by source in 2000–2019 in BAU, APS, and LCET. Since 2000, coal has constituted the largest share of total primary energy and that share has been increasing. However, its growth in 2010–2019 was slower than in 2000–2010. Oil accounts for a noticeable part of primary energy supply, whilst the proportion of other energy sources, such as natural gas and renewable energy, is relatively low. In 2030–2050 in BAU, primary energy supply is projected to increase at an annual average rate of 0.1%, from 3,710 Mtoe to 3,753 Mtoe. Coal will still constitute the largest share in total primary energy, but it is projected to decrease slightly by 1.1% every year. Consequently, the share of coal in total primary energy is projected to decline from 55.2% in 2030 to 43.4% in 2050. Oil and natural gas are projected to grow at lower rates of 0.7% and 1.6% per year, respectively. Hydrogen, nuclear energy, and other renewable energy resources will increase slightly. In APS, TPES will decrease from 3,522 Mtoe to 3,056 Mtoe, by an average of 0.7% every year. Coal and oil are projected to decrease by 3.1% and 0.7%, respectively. Natural gas, hydrogen, nuclear, solar photovoltaic (PV) and wind, and other renewable energy resources are estimated to increase each year by 1.1%, 19.7%, 3.2%, 3.5%, and 0.5%, respectively. In LCET, TPES will decrease from 3,289 Mtoe to 2,452 Mtoe, by 1.3% per year. Hydrogen is projected to grow the fastest in 2030–2050, by an annual average rate of 47.7%, and nuclear and solar PV and wind energy at 5.3% and 4.5%, respectively. Fossil fuels such as coal, oil, and natural gas are predicted to decrease each year by 5.7%, 3.5%, and 0.1%, respectively.

Figure 5.6 China – Primary Energy Supply by Source, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)



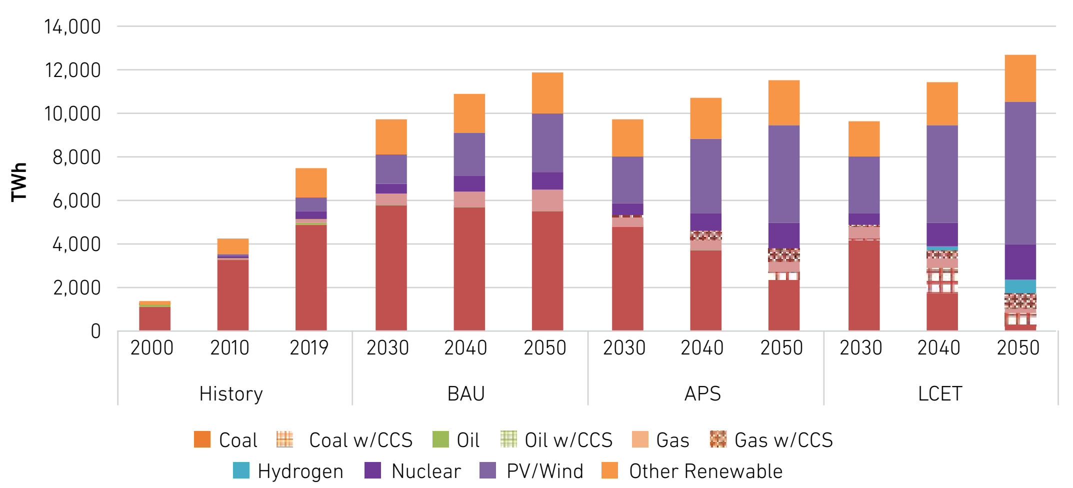
APS = alternative policy scenario, BAU = business as usual, elec. = electricity, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, PV = photovoltaic.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.4. Power Generation

Figure 5.7 shows historical and future power generation in BAU, APS, and LCET. Power generation is projected to grow more slowly in 2030–2050 than in 2000–2019. In BAU, power generation is projected to grow at a slower pace, by 1.0% per year, from 9,702 TWh in 2030 to 11,862 TWh in 2050. The share of coal power in BAU is projected to decrease, from 58.8% to 46.1% in 2050. Conversely, the shares of natural gas and nuclear energy are projected to grow because they are clean, from 5.4% and 5.2% in 2030 to 8.7% and 6.7% in 2050, respectively. The share of oil is projected to decrease slightly. Other methods of power generation are projected to increase. In APS, total power generation will increase by 0.9% per year in 2030–2050. By 2050, total power generation output is projected to reach 11,505 TWh. The annual growth rate in 2030–2050 of all fuels in APS, except for coal-fired power, oil power, and natural gas power, is projected to grow faster than in BAU. In LCET, solar PV and wind and other renewable energy sources for power generation will grow significantly at 51.4% and 17.6%, respectively, in 2050. In contrast, coal is expected to account for only 1.2% in 2050, much lower than its 65.2% share in 2019. Coal with carbon capture and storage (CCS) and gas with CCS are expected to be 4.8% and 5.6%, respectively, in 2050.

Figure 5.7 **China – Power Generation by Source, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)**

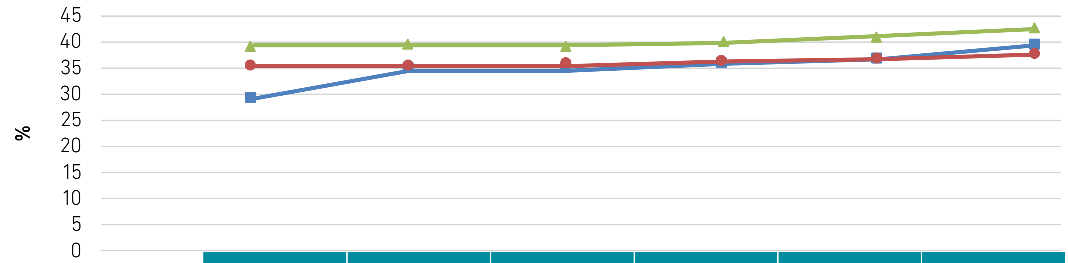


APS = alternative policy scenario, BAU = business as usual, CCS = carbon capture and storage, low-carbon energy transition, PV = photovoltaic, TWh = terawatt-hour.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.8 presents the thermal efficiency of coal, oil, and natural gas in 1990–2050 in BAU. The fast development of PV power generation typifies the country's preference for clean power. Thermal efficiency of fuel in BAU is projected to increase in 2020–2050. In 1990–2020, the thermal efficiency of coal, oil, and natural gas increased from 28.8%, 35.0%, and 39.0% to 34.4%, 35.4%, and 39.1%, respectively. Thermal efficiency of coal, oil, and natural gas is projected to reach 39.1%, 37.2% and 42.1%, respectively, in 2050.

Figure 5.8 **China – Thermal Efficiency of Fossil Fuel, Business as Usual (1990–2050)**



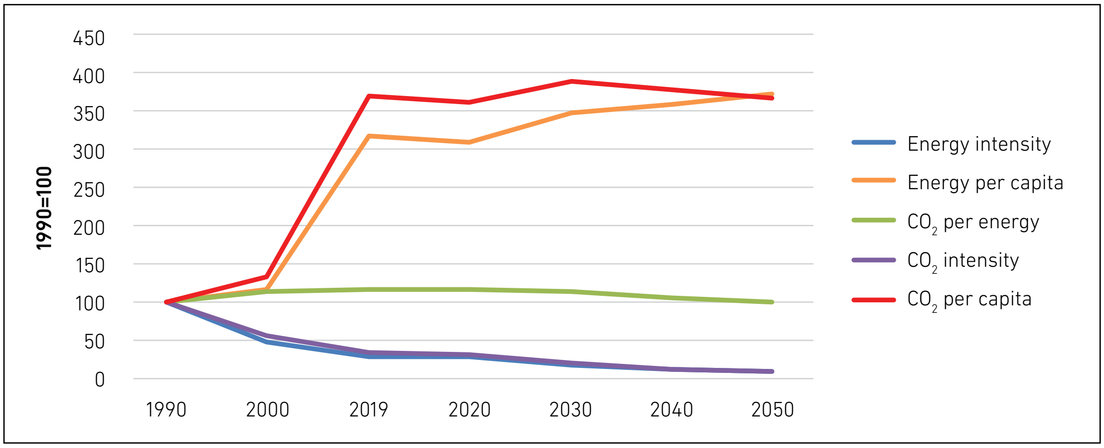
	1990	2019	2020	2030	2040	2050
Coal	28.8	34.4	34.4	35.5	36.6	39.1
Oil	35.0	35.0	35.4	36.0	36.7	37.2
Natural gas	39.0	39.3	39.1	39.7	40.9	42.1

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.5. Energy Indicators

Figure 5.9 shows the energy indicators in BAU. Energy intensity dropped remarkably because of energy efficiency efforts. In 2050, energy intensity is projected to drop to about 8% of that in 1990. Carbon dioxide (CO_2) intensity similarly is expected to decrease by 7.9% in 2050 compared with 1990. With improved living standards, energy per capita in BAU is projected to reach 369.5% of that in 1990. CO_2 per capita is expected to gradually peak in 2030 at 388% of that in 1990. CO_2 per energy is relatively stable in 1990–2050.

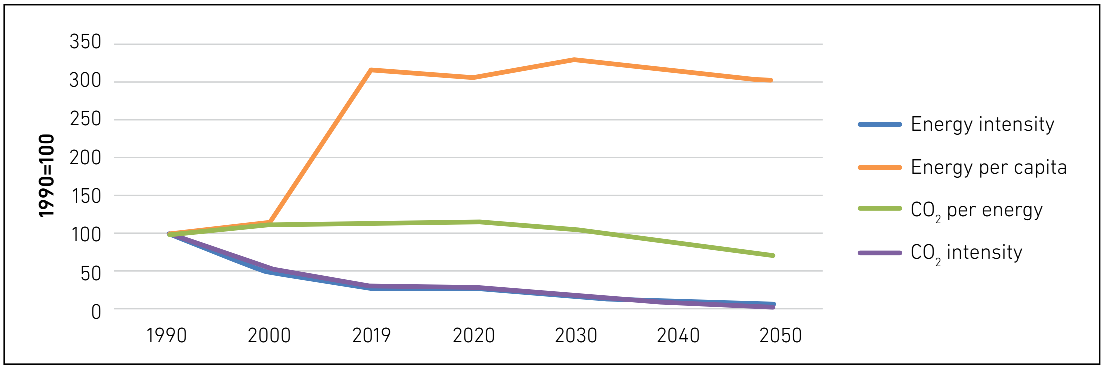
Figure 5.9 China – Energy Indicators, Business as Usual (1990–2050)



Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.10 shows the energy indicators in APS in 1990–2050. Compared with energy intensity in BAU, energy intensity in APS is projected to decrease faster in 1990–2050. CO_2 intensity is expected to decrease to 4.5% of that in 1990 (7.9% in BAU), and energy intensity to drop to 6.5% (8% in BAU) of that in 1990. Similarly, energy per capita is projected to decrease to about 300.8% of that in 1990 (369.5% in BAU), and CO_2 per energy is estimated to decline to 68.3% of that in 1990 (98.7% in BAU).

Figure 5.10 China – Energy Indicators, Alternative Policy Scenario (1990–2050)

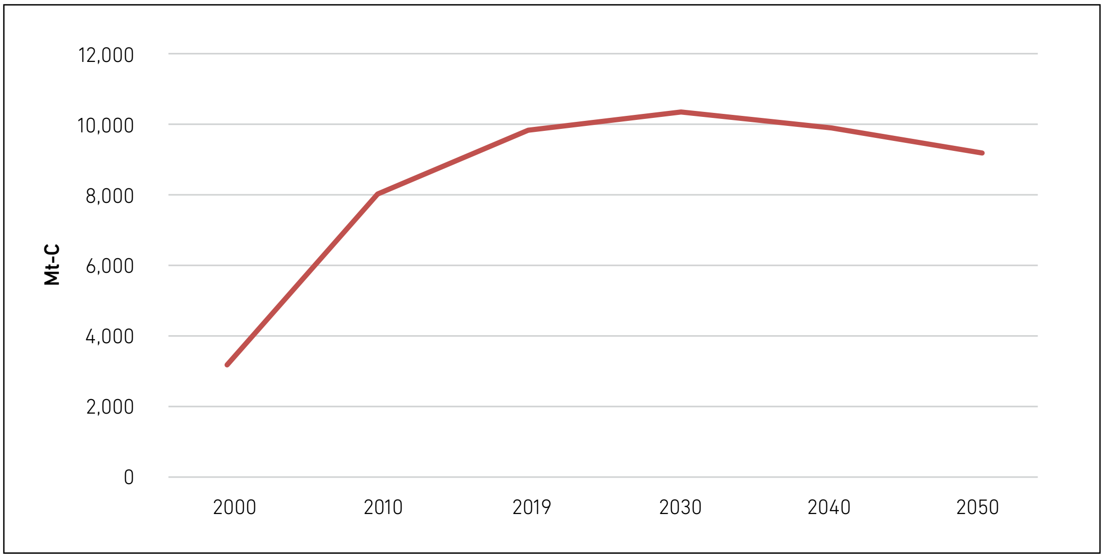


Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.6. CO_2 Emissions

Figure 5.11 shows CO_2 emissions in 2000–2050. In 2019–2030, they are projected to slowly increase, with an annual growth rate of 0.4%, and peak in 2030 in BAU, equivalent to 10,365 metric tonnes (Mt). China aims to achieve peak carbon by 2030, as reflected in the prediction results. However, China's carbon peak still faces challenges. Traditional industries with high input, high energy consumption, high pollution still account for a relatively high proportion. The manufacturing industry of a considerable scale is still in the middle and low end of the international industrial chain, with large consumption of high-carbon fuels and low added value of products. Chinese government has promoted a series of policies in an effort to reduce carbon emissions. In 2030-2050, CO_2 emissions are expected to decrease from 10,365 Mt to 9,250 Mt, or by 0.57% annually. Besides, China is striving to be carbon neutral by 2060.

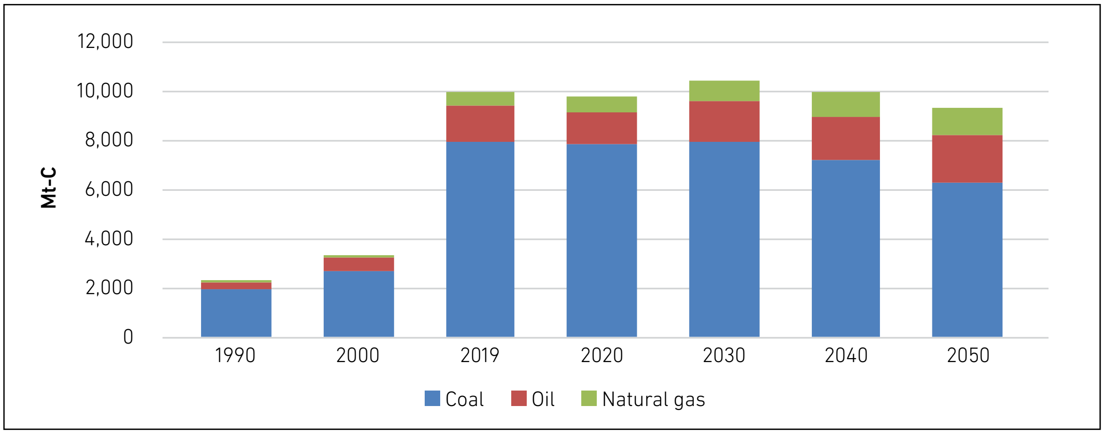
Figure 5.11 China – CO_2 Emissions, Business as Usual (2000–2050)



Source: Economic Research Institute for ASEAN and East Asia, 2021.

Figure 5.12 shows CO_2 emissions from fossil fuels in BAU. A high-carbon energy source, coal contributes the most to CO_2 emissions. In 1990–2019, CO_2 emissions caused by burning fossil fuels increased from 2,180 Mt to 9,882 Mt, whilst emissions from coal accounted for more than 80%. In BAU, even though coal is still the largest contributor to CO_2 emissions, the proportion of emissions from coal is predicted to drop from 80.5% to 67.4%. Oil contributed 11.9%–13.6% in 1990–2020 and is expected to increase by 15.9%–20.4% in 2030–2050. Regarding natural gas – the cleanest amongst the three fossil fuels – the proportion of CO_2 emissions grew by 0.8%–5.9% in 1990–2020 and is projected to reach 12.2% in 2050.

Figure 5.12 China – CO_2 Emissions by Fossil Fuel, Business as Usual Scenario (1990–2050)



Mt-C = metric tonne of carbon dioxide.

Source: Economic Research Institute for ASEAN and East Asia, 2021.

4. Implications and Policy Recommendations

As the world's largest energy consumer and largest CO_2 emitter, China faces great pressure to improve energy efficiency and reduce CO_2. In recent years, the government has made great efforts and set ambitious targets to deal with climate change. In 2021, it published China's Achievements, New Goals and New Measures for Nationally Determined Contributions, and China's Mid-Century Long-Term Low Greenhouse Gas Emission Development Strategy, indicating its determination to achieve peak CO_2 emissions around 2030 and to make best efforts to peak early. The main findings follow.

First, TFEC is projected to increase in BAU and decrease in APS and LCET in 2030–2050. Coal is projected to decrease annually and electricity to increase rapidly. Other new energy, such as hydrogen, will increase in APS and LCET. Energy consumption by industry is estimated to decrease annually in all scenarios. Transport energy consumption will continually increase in BAU and APS and decrease in LCET.

Second, TPEC in 2050 is predicted to be higher than in 2019 in BAU and to be lower than in 2019 in APS. TPEC will be lower in APS than in BAU for coal, oil, and natural gas, but higher for other fuels in APS than in BAU. TPES in 2050 is projected to be lower than in 2019 in APS. Coal will still constitute the largest share but is projected to decrease slightly every year. In APS and LCET, hydrogen, nuclear, solar PV and wind, and other renewable energy will increase.

Third, power generation is projected to grow slower in 2030–2050 than in 2000–2019. The share of coal power is projected to be 46.1% in BAU and 1.2% in LCET in 2050. The generation source is transitioning to cleaner fuels, such as hydrogen, nuclear, and solar PV and wind. The thermal efficiency of coal, oil, and natural gas will continually increase in 2019–2050.

Fourth, CO_2 emission trends are different in the three scenarios. In BAU, they will grow slowly in 2019–2030, peak in 2030, and decrease slightly in 2030–2050. In APS and LCET, they will decrease in 2019–2050; LCET is more effective in reducing CO_2 emissions. Those from fossil fuels will continually decline in 2020–2050.

Given the current energy outlook, three policy recommendations are put forward.

First, explore the paths of CO_2 reduction and design specific development plans. To better deal with climate change, consider different scenarios to analyse the corresponding energy consumption and emissions. For instance, society is ageing and small families are more prevalent. Policies or businesses associated with time-use and consumption patterns shape energy demand and CO_2 emissions. Considering regions' heterogeneity, regional plans should be different from the national plan. The governance mechanism is regionally decentralised authoritarian, where the central government determines the performance appraisal of local officials. Sometimes, emission-reduction goals may negatively affect economic growth. Since regional competition can produce positive effects on environmental governance, a regional competition mechanism may be introduced when setting emission-reduction goals.

Second, emphasise low-carbon–emitting technologies since they significantly reduce carbon reduction in industries, especially traditional ones. The iron and steel industry must accelerate the deployment of small-ball sintering, low-temperature sintering, electric arc furnace steelmaking, and CCS technology. The chemical industry should focus on lightweight raw materials, advanced coal gasification technology, low-carbon hydrogen production, and CO_2 utilisation technology. Buildings should improve their heating and cooling efficiency, increase their electrification level, and develop distributed energy. In transport, railways and waterways should be given priority and electric and hydrogen-fuel vehicles promoted.

Finally, introduce policies to promote energy transition. Despite the wide use of clean energy in urban areas, many rural households still depend on traditional energy. Rural household energy transition projects, such as the Clean Winter Plan in northern China, are important to promote energy transition. Since low-income residents still have difficulty affording the high cost of transition, the government should subsidise them.

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