Chapter 2
The State and Trend of China's Low-Carbon Development

2.1 New Paradigm of Global Response to Climate Change Under the Paris Agreement

The Paris Agreement established the long-term temperature goal to hold global average temperature rise to well below 2°C above pre-industrial levels and to pursue efforts to limit the global temperature rise to 1.5°C. Based on a "bottom-up" approach, countries are asked to set their emission reduction targets and action plans independently, and a global stocktake is mandated every five years to assess and drive collective progress under the new global climate governance mechanism. The global community has now fully entered the implementation phase of the Paris Agreement, and arduous challenges and tasks await.

First, there is still a considerable gap between emission reduction commitments by countries and those necessary to limit temperature rise to well-below 2°C. By estimate, the annual emission gap by 2030 under the current NDCs would be 12–15 billion tons of CO_{2e} [1], and the world is on track to an average 2.7°C increase by 2100. There is a less than 5% probability of a temperature rise below 2°C, a greater than 25% probability of a temperature increase above 3°C, and a 10% probability of exceeding 3.5°C. Therefore, it is imperative that countries implement and enhance their emission reduction targets and climate actions [2].

Second, a growing number of studies and facts demonstrate that the negative impacts of climate change is more extensive, more severe, and accelerating at a greater speed than originally predicted. In the current high-emissions scenario without reinforced actions, there is the risk of temperature rise of 5°C by the end of this century with the chance of crossing the tipping points or risk thresholds in many areas, resulting in irreversible catastrophic consequences. For instance, heat waves, which currently feature an occurrence of less than 5% globally, will happen almost every year; both the probabilities of flooding and agricultural droughts may increase by ten folds; China's grain production will shrink by 20%, and glaciers by 70% [2]. In essence, if temperature rises too fast and too dramatic in the future, extremely high

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systemic risks to the economy, society, and ecosystem will pose significant threats to water and food security, urban infrastructure, and the public health system. To reverse the situation, active steps must be taken to improve the climate resilience of the economy, society and ecosystem, and prevent climate risks.

Third, the *IPCC Special Report on Global Warming of 1.5°C* highlighted the urgency of addressing climate change, and reinforced and advanced the goal of achieving "carbon neutrality" globally. The report, issued by IPCC in October 2018 as per the provisions of the Paris Agreement, not only provides scientific climate assessment, but also serves to inform decision-makers for negotiations and political consensus under the UNFCCC framework. The report shows the impacts and risks of climate change can be dramatically reduced at 1.5°C warming compared to 2°C. But that would entail much more urgent efforts in emission reduction: emissions should be down by 45% from 2010 levels by 2030; global net zero CO_2 emission and deep reduction of non-CO_2 GHGs is required in 2050. However, at the current pace of emissions, global average warming is likely to reach 1.5°C between 2030 and 2052, resulting in needing even more drastic reductions now. On the other hand, the cost of 1.5°C will be three to four times greater than the 2°C pathway. The *IPCC Special Report on Global Warming of 1.5°C* reinforced and advanced the global target of achieving carbon neutrality by the middle of this century and explored the pathways for long-term low-carbon emissions reductions, which is expected to influence the targets and choice of pathways as countries submit their 2050 long-term low-emission strategies by the end of 2020.

Fourth, developed nations and regions such as the EU have laid out specific timetables and action plans for the 1.5°C goal. The European Green Deal announced by the European Commission in December 2019 aims to make Europe the first climate-neutral continent, by pledging to cut GHGs by 50–55% by 2030 compared with 1990 levels, and to achieve net-zero emissions by 2050, and these objectives will be enshrined in legislation. The European Green Deal also proposes actions in seven strategic areas, including supplying clean, affordable and secure energy; mobilizing industry for a clean and circular economy; building and renovating in an energy and resource efficient way; accelerating the shift to sustainable and smart mobility; designing a fair, healthy and environmentally-friendly food system; preserving and restoring ecosystems and biodiversity; and a zero-pollution ambition for a toxic-free environment. In 2019, the British government passed legislation to cut GHG emissions to net zero prior to 2050, making the UK the first country to incorporate long-term climate targets into official laws and regulation. Although the Trump administration withdrew the US from the Paris Agreement, US climate actions have not come to a halt, and instead moved from the federal level to sub-state levels of states, cities, companies, and universities. More than 20 states in the US, cummulative accounting for more than 60% of the country's GDP and 55% of population, formed the United States Climate Alliance and pledged to honor their commitments under the Paris Agreement. States such as California, Nevada, New Mexico, and Washington have all passed legislations setting a goal of 100 percent carbon-free electricity by 2050 or earlier. In 2019, the New York State Legislature passed the Climate Leadership and Community Protection Act, which mandated net zero emissions in

all sectors of the economy by 2050—reduction by 85% in GHG emissions from 1990 levels, with the remaining 15% being offset through reforestation, restoring wetlands, carbon capturing or other green projects. The more urgent the goal of carbon neutrality, the tighter the constraints on emissions for all countries to achieve sustainable development and the greater the pressure to bring about low-carbon transition.

Fifth, the world is giving higher priority to the coordinated governance of climate change, ecology and environment protection and sustainable development. The global community is becoming increasingly aware of the interlinkages between climate actions and the UN Sustainable Development Goals. Actions to mitigate and adapt to climate change will help promote local ecological protection and sustainable development, creating extensive synergies. Global climate efforts have triggered low-carbon transformation of the economic and energy systems, and ushered socioeconomic development onto a green, low-carbon cycle and sustainable development path. This is also the ultimate solution to improving regional ecology and environment and promoting the coordination of socioeconomic development with the environment capacity. Therefore, the increasing awareness of all countries on the urgency for energy revolution and low-carbon economic transition in the global response to climate change presents enormous opportunities for the pursuit of domestic sustainability goals. Efforts should be made to achieve the coordinated governance of energy, economy, environment, and climate to create a win–win scenario for all parties. In the meantime, greater attention should focus on the coordination of measures to mitigate and adapt to climate change.

Sixth, as the world is experiencing profound shifts unseen in a century, the sentiments of unilateralism, protectionism and self-interest of some developed countries have taken a stronger hold in climate negotiations, impeding the implementation of the Paris Agreement. At the 2019 UN climate change conference (COP25) held in Madrid, some developed countries sought to advance self-interests in a non-constructive manner during the negotiations while rejecting the concerns and demands voiced by the vast majority of other parties, especially the developing countries. They failed to advance various agendas in a comprehensive and balanced approach due to a lack of political will to reinforce pragmatic actions, and opposed to review and advance actions before 2020 while focusing solely on strengthening the 1.5°C temperature controlling goal. Consequently, the contracting parties were unable to settle on rules for market mechanism under Article 6 of the Paris Agreement, and to achieve balanced progress and estimated effects in negotiations on key areas including mitigation, adaptation, funding, technology, capacity building and transparency. COP25 ended with unfulfilled expectations, and the implementation of the Paris Agreement remains a serious challenge and daunting task.

Seventh, COVID-19 will significantly reshape the global climate process and competitive landscape between major powers. The pandemic has triggered a massive global economic downturn. Countries will give priority to restoring production, ensuring people's livelihood, and remediating deficiencies in the industrial chain in the post-pandemic era, which might result in weaker actions and policy measures for climate change and low-carbon transformation. Nevertheless, a consensus is also

forming around "green economic recovery" in coping with the deeper global crisis of climate change. The response to climate change will remain one of the front-burner issues and critical battleground for major powers in their diplomatic efforts. Tackling climate change represents the shared interest of humankind and high ground of international moral, so there is also room for exchanges and cooperation among China, the US, the EU, and other regions in this regard. It is imperative for China to coordinate diplomatic policy and domestic green and low-carbon transition effectively.

2.2 The State and Outlook of China's Domestic Low-Carbon Transition

2.2.1 The New Situation of China's Low-Carbon Transition

The Chinese economy entered a "new normal" after 2013 when the country adopted new development philosophies, transformed the drivers of growth through innovation, transitioned to green development, and gave full play to the synergistic of environmental governance and CO_2 emission reduction. The results of China's energy saving and carbon reduction measures have exceeded expectations, setting the stage for achieving its 2030 NDC target.

The "new normal" prompted a shift of China's economic development from size and speed to quality and efficiency. GDP growth slowed down from an average 10.2% during 2005–2013 to 6.9% during 2013–2018. In the meantime, the acceleration of economic restructuring, industrial transformation and upgrading have saturated the market for energy-intensive raw-materials products and lowered energy elasticity. Between 2005 and 2013, energy elasticity stood at roughly 0.59 with an annual drop of 3.8% in energy consumption per unit of GDP, compared to 0.32 and 4.7% during 2013–2018. The dual reductions in energy elasticity and GDP growth led to a significant contraction in the growth of total energy demand. During the period from 2005 to 2013, China's energy consumption grew by 6% annually, and that growth slid to 2.2% during 2013–2018, which reflected the decreasing energy demand. When the GDP growth is held constant, the lower the elasticity of energy consumption, the greater the decrease in energy intensity. However, with constant energy elasticity, slower GDP growth would make for slower drop in energy consumption per unit of GDP. The above two factors could offset each other so that the drop in energy intensity will most likely remain at a level of 3.0–3.5% annually in the future.

While growth in China's energy demand has been slowing, new and renewable energies have kept a robust growth of roughly 10%. As the energy structure adjustment accelerates its pace, CO_2 emissions per unit of energy consumption have continued to fall. Prior to the "new normal", CO_2 emissions per unit of energy consumption fell by 0.57% on average annually between 2005 and 2013, as opposed to 1.38% between 2013 and 2018 under the "new normal". CO_2 emissions per unit

Table 2.1 Changes in energy consumption and CO_2 emissions under the "new normal"

	2005—2013	2013—2018
GDP growth (%)	10.2	6.9
Energy consumption elasticity	0.59	0.32
Average annual growth of energy consumption (%)	6.0	2.2
Annual decline of energy intensity of GDP (%)	3.8	4.7
Annual growth of CO_2 emissions (%)	5.4	0.8
Annual decline of CO_2 intensity of GDP (%)	4.4	5.7

of GDP also increased from 4.4% on average annually in 2005–2013 to 5.7% in 2013–2018, which signified speedier energy transition (see Table 2.1).

In the three years following 2017, the growth of energy consumption and CO_2 emissions has rebounded. In 2017 and 2018, total energy consumption rose by 3.0% and 3.3% respectively, and CO_2 emissions were up by 1.8% and 2.2% respectively. The Chinese economy grew by 6% and energy consumption by 3.3% in 2019. The total energy consumption was 4.98 billion tce in 2020, realizing the goal of limiting total energy consumption below 5 billion tce set in the 13th FYP period. Coal consumption has entered a downward trajectory since 2013. Despite the rebound in the past two years, total consumption has not exceeded the level of 2013. Generally speaking, China has moved into a peak platform period of coal consumption, which still might fluctuate in the future. But with a further slowdown in energy consumption growth and rapid expansion of renewable energy, coal consumption will no longer see steady growth. On the whole, as economic growth stabilizes and high-quality development becomes the norm, the growth of energy demand and CO_2 emissions will further ease. Chances are slim for a comeback of the strong growth experienced prior to 2013.

The COVID-19 put a severe damper on economic growth in 2020, dragging the average annual GDP growth during the 13th FYP period to below 6%. Energy consumptions per unit of GDP dropped by 13%, and CO_2 emission intensity by 18.8% during the 13th FYP, meaning that China has achieved the 13th FYP target of reducing CO_2 intensity by 18%.

2.2.2 Scenario Analysis of Energy Conservation and Carbon Reduction During the 14th FYP Period

The 14th Five-Year Plan period marks the first five years for China to embark on a new journey of building a modern socialist country in all respects. China would face a series of urgent tasks such as reviving the economy after the pandemic, ensuring people's livelihood and remedying the deficiencies of the industrial chain. Meanwhile, China is also in a critical period of transition to high-quality growth. During the 14th FYP period, China will adhere to new development concepts and

speed up the creation of a clean, low-carbon, safe and efficient energy system and a green, low-carbon, circular, and sustainable economic system. New progress in energy conservation and carbon reduction is on the horizon.

The current capacity of high energy-consuming industries such as the modern coal chemical and petrochemical sectors might continue to expand into the early phase of the 14th FYP period, driving the growth in energy consumption. However, the latter part of the period will see no more capacity expansion in heavy and chemical industries, with a slowdown in the growth of energy consumption. As China presses ahead with industrial transformation and upgrading and high-quality economic development, it will witness consistent and steady improvements in energy conservation and carbon reduction during the 14th FYP period.

China will pursue the new development philosophies, intensify economic restructuring, industrial transformation and upgrading, and strive for high-quality development during the 14th FYP period, prompting increasingly faster energy conservation and carbon reduction. As for GDP growth during the period, the pandemic has wreaked on the international economy, industrial chain, and global supply and demand, which will hamper China's economic recovery and development. Most domestic research institutions project a roughly 5% of average annual economic growth under relatively optimistic circumstances during the 14th FYP period. Following the slowdown in GDP growth, the market for energy-intensive raw materials such as steel and cement will become saturated and begin to march downward, further pushing down the elasticity of energy consumption. The current stimulus package for reviving the economy, boosting new infrastructure and urbanization investment, spurring development of the digital economy and technological upgrading of traditional industries, and advancing the integrated development of intelligent urban infrastructure and low-carbon transitions will contribute to the decline of energy intensity.

Power generation costs for wind and solar will be comparable to that of coal during the 14th FYP period. Non-fossil fuels could maintain the 7% annual growth during the 14th FYP period; the non-fossil share of China's total primary energy consumption might reach roughly 20% in 2025; and the share of coal will fall further from 56.8% in 2020 to approximately 51% in 2025. Based on these projections, CO_2 emissions per unit of GDP will drop by roughly 19% during the 14th FYP period. By 2025, total energy consumption can be held under 55 tce, and total CO_2 emissions under 10.5 billion tons. See the table below for more details (Table 2.2).

The 14th FYP period is a critical stage for the green and low-carbon transition of China's economy and the attainment of high quality development. On one hand, China should keep up and drive the current momentum and achievements made in the energy conservation and carbon reduction by employing active energy conservation and carbon reduction targets as key instruments for the green and low-carbon transition and high-quality development of Chinese economy. On the other hand, China should boost the robust low-carbon transition since the implementation of the 11th FYP, maintain strategic determination amid economic slowdown, stick to energy conservation, carbon reduction and high-quality economic development, and holistically advance other related policies and measures aside from continued

Table 2.2 Analysis of the effects of energy conservation & carbon reduction by period

	12th FYP		13th FYP		14th FYP
	Planned	Actual	Planned	Estimated	Projected
Average annual GDP growth (%)		7.9		5.7	5.3
Decline in energy intensity of GDP (%)	16	18.5	15	13	14.7
Non-fossil share at end of period (%)	11.4	12.1	Approx. 15	15.8	20
Decline in CO_2 intensity of GDP (%)	17	21.7	18	18.8	19
Total energy consumption at end of period (billion tce)		4.30	< 5	4.98	5.5
Total CO_2 emissions at end of period (billion tCO_2)		9.29		9.9	10.4

efforts to establish quantitative energy-saving and carbon-reduction targets. Specific suggestions are as following:

1. Developing guiding targets for curbing total energy consumption and CO_2 emissions. In fact, the target for total energy consumption was formulated and implemented during the 13th FYP period. That, coupled with the target of a non-fossil energy share, virtually means that a CO_2 emissions target has been determined. It is imperative that target for curbing total CO_2 emissions be stated more explicitly during the 14th FYP period so that they are aligned with the policies and measures introduced to achieve CO_2 emissions peak before 2030, and gradually be integrated with and eventually replace the energy consumption cap. By capping total CO_2 emissions, a ceiling for energy consumption will not be set for local governments and enterprises. Instead, they are incentivized to develop and utilize more new and renewable energy, which will promote the green and low-carbon transition of the economy. A carbon emission allowance system for enterprises will gradually replace the allowance of energy consumption, and will be linked with the nationwide carbon trading market currently being developed. Total CO_2 emissions management is more aligned with international norms and practices than placing a cap on energy consumption.
   As uncertainties abound in the future growth of the economy and energy consumption, if GDP growth exceeds expectations, it will have less of an impact on energy intensity, but will significantly affect the total energy consumption target. Therefore, certain amount of leeway should be reserved for a looser target for total energy consumption than that for energy intensity reduction.
2. Encouraging optimal development zones to peak CO_2 emissions first. It was proposed in the 13th FYP that "China supports optimal development zones to reach the peak of carbon emissions first." China's CO_2 emissions could, in general, plateau after 2025. The more developed eastern coastal areas are well-positioned to take the lead nationwide in peaking emissions, with some

cities on track to peak carbon emissions by around 2020. Under this circumstance, the target for optimal development zones in the eastern coastal areas to reach emissions peak ahead of the nation should be included in the 14th FYP, and developed provinces and cities should be encouraged to formulate and implement the appropriate plans and policy measures.

3. Driving the peaking of CO_2 emissions in energy-intensive industries earlier. Industrial sector accounts for two-thirds of the country's total end-use energy consumption, and is the sector with the most energy-saving potential. With industrial restructuring, transformation and upgrading during the 14th FYP period, the industrial sector will be well-positioned to peak its carbon emissions earlier. The goal of peaking CO_2 emissions in the energy-intensive industries can be stated explicitly in the 14th FYP.
4. Controlling energy-related non-CO_2 greenhouse gas emissions. China's current emission mitigation efforts and commitments are mostly centered on energy-related CO_2 emissions. Starting from the 14th FYP period, the country should start to manage and rein in CO_2 and other greenhouse gas emissions from industrial production processes, agriculture, forestry, and waste management, and in particular the production and use of hydrofluorocarbons (HFCs). A monitoring, reporting, and verification system for all greenhouse gas emissions should be established with emission reduction measures and actions.
5. Deepening market-oriented reform of the energy management system. The boom of energy technologies and industrial innovation has accelerated the transformation of the energy industry, although institutional and policy obstacles remain to be overcome. China must plough ahead with reforms of the systems of energy management and pricing, and promote the development of distributed renewable energy. In the meantime, greater progress need to be made in the establishment of the emissions trading market. It is recommended that during the 14th FYP period, the coverage of China's national emissions trading market is expanded to include major energy-intensive industries as soon as possible and emissions allowance management is improved to promote the low-carbon transition of energy and economy through market-based approaches.

2.2.3 Challenges and Arduous Tasks Facing China for Rapid Low-Carbon Transition

China has scored remarkable and internationally acclaimed success in energy conservation and carbon reduction since the implementation of the 11th FYP. The country has pursued new development philosophies, sped up economic restructuring and industrial upgrading, and strengthened energy conservation and carbon reduction policies and measures under the new normal. Consequently, the rapid rises in energy consumption and CO_2 emissions have been reversed. The energy consumption and CO_2 emissions will, slowly but surely, continue their growth in the near future. Thus enormous efforts are still required to peak CO_2 emissions.

China's energy consumption per unit of GDP plunged by 42.4% from 2005 to 2019, down 3.86% year-on-year, much higher than that of developed countries over the same period. However, due to the unique industrial structure during this stage of industrialization and urbanization, the share of the industry, especially energy-intensive sectors, in the Chinese economy is higher than that of developed countries, and the manufacturing sector is also situated at the middle and low ends of the global industrial value chain, which are dominated by energy-intensive and low value-added products. This explains the fact that China's energy consumption per unit of GDP still stood at 1.6 times the global average and 2–3 times that of developed countries in 2017. Tremendous potential exists in the areas of energy conservation and CO_2 emission reduction as China presses ahead with economic restructuring and industrial upgrading, although the journey will take a considerable amount of time.

China is well endowed with coal resources, which have always predominated the energy mix. China has spared no effort to develop renewable energy, and the non-fossil share of China's energy mix more than doubled from 7.4% in 2005 to 15.3% in 2019 while the share of coal slid from 72.4 to 57.7%. China still faces tough tasks in terms of expediting the development of new and renewable energy sources, curbing and reducing coal consumption and speeding up low-carbon transition of the energy mix.

The peaking of CO_2 emissions means that sustained economic growth will be completely decoupled from carbon emissions. When fossil energy consumption has plateaued, increasing alternative energies for coal will not only slow down carbon emissions, but also curtail and reduce conventional pollutants from the source, promoting fundamental improvements in environmental quality. Peaking CO_2 emissions will be a landmark in the low-carbon transition of China's economic development as well as a historic milestone in the fundamental improvement of the country's ecological environment and the building of a beautiful China.

To ensure sustained economic growth while peaking carbon emissions, the decline in CO_2 emissions per unit of GDP must be greater than the growth of GDP, so that the increase in emissions brought by GDP growth is offset by a reduced emission intensity. Currently, China's economic growth remains at a level between 5–6% and is expected to continue tapering off after 2020. After the basic completion of the country's industrialization and urbanization drive around 2030, China will have joined the ranks of high-income countries in terms of national income per capita. Intensive growth will become the norm and GDP growth will slow further to roughly 4.5–5.0%, still higher than the average of developed countries as well as the global average. Therefore, efforts on energy conservation and substitution must be intensified so that the annual decline in emissions intensity of GDP will not be lower than 4.5–5.0%, and emissions peak will occur as soon as possible before 2030.

As China transitions to an increasingly low-carbon energy mix, it is expected to peak CO_2 emissions before it reaches the peak in total energy consumption. Another key precondition for emission peak is that the drop in CO_2 emissions per unit of GDP must be greater than the growth of energy consumption, so that the increase in emissions brought by growth in energy consumption is offset by a reduced CO_2 emissions per unit of energy consumption, and carbon emissions will plateau or

trend downward. By around 2030 when GDP growth is projected to be 4.5–5.0%, the elasticity of energy consumption will also drop below 0.3, bringing the growth of total energy demand down below 1.5%. Yet the supply of non-fossil energy will need to sustain its growth of more than 6% on an annual basis in order for the increase in total energy demand to be met entirely by non-fossil sources. The annual reduction of CO_2 emissions per unit of energy consumed needs to exceed 1.5% and continue to rise, and CO_2 emissions will peak and then turn downward.

For China to peak CO_2 emissions around 2030, it needs to undertake greater efforts than its counterparts in the developed world. China will peak its CO_2 emissions earlier in the stage of development than developed countries, who only reached their emission peaks after industrialization when GDP growth was relatively modest (no higher than 3% in general) and the annual decline of CO_2 intensity of GDP was below 3%. To peak CO_2 emissions around 2030, China needs to secure a 4.5–5.0% annual decline in carbon intensity of GDP, which in turn entails painstaking efforts in energy conservation and low-carbon transition of the energy mix, and in particular the acceleration of new and renewable energy development and the reduction of CO_2 emissions per unit of energy consumed. The work on these fronts will play a critical role in driving the country to peak emissions.

In the long haul, the goals of holding the rise in global temperature below 2°C or even further to 1.5°C and achieving global net zero emission in the second half of this century or even by mid-century pose considerable challenges for China. The majority of EU members had peaked their CO_2 emissions in the 1980s while the United States and Japan also reached their peaks around 2005. There is a 50–70 years of transition from carbon peak to carbon neutrality for these countries. In comparison, China will only have a window of 20–30 years between its carbon peak in 2030 and the deadline for net zero emission. Therefore, more ambitious, rigorous, and faster emission reduction efforts are required for China, and greater challenges and costs lie ahead.

2.3 China's Long-Term Economic and Social Development Prospects

The 19th Party Congress put forward the goals, basic strategies and blueprints of China's socialist modernization drive. "By 2020, not only must we finish building a moderately prosperous society in all respects and achieve the first centenary goal," the report of the 19th Party Congress notes, "we must also build on this achievement to embark on a new journey toward the second centenary goal of fully building a modern socialist country."

In the first stage from 2020 to 2035, China will largely realize socialist modernization. The country's economic and technological progress will experience a giant leap, and it will become a global leader in innovation. There will be a fundamental

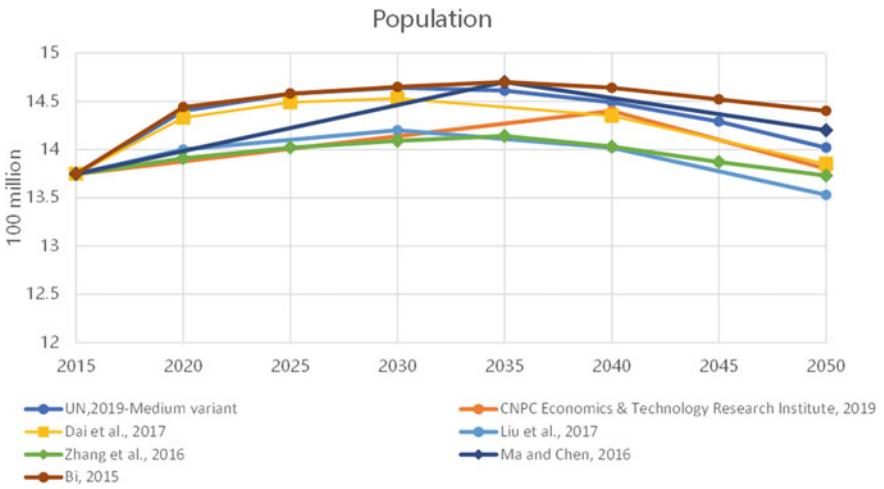

Fig. 2.1 Related studies on population projections [3–9]

improvement in the environment with the goal of building a beautiful China basically reached. In the second stage from 2035 to 2050, the country will develop into a great modern socialist country that is prosperous, strong, democratic, culturally advanced, harmonious, and beautiful. China's material, political, spiritual, social and ecological civilizations will be upgraded in all respects. China will rise to become a leading nation in terms of national power and global impact, and the goal of common prosperity for all will be basically realized, and a beautiful China will become a reality.

China's GDP per capita surpassed 10,000 USD in 2019 and is steadily closing the gap as an upper-middle-income country with a high-income country. This section presents the main trends of China's future economic and social development based on current national realities and the two centenary goals.

2.3.1 Population and Urbanization Rate

Existing studies have generally made similar predictions regarding the population trends of China (see Fig. 2.1). The country's population will hit a ceiling between 2030 and 2035 with 1.4–1.5 billion people, and then trend downward. According to a projection by the National Health and Family Planning Commission in 2017, China's population will likely reach a peak of 1.45 billion in 2030, after which it will drop to 1.4 billion by 2050.[1]

Since the beginning of this century, people over 60 years old in China has comprised more than 10% of the total population, which makes China officially

[1] http://news.cri.cn/gb/1321/2017/03/10/661s5236359.htm.

an aging society. According to the projection of *National Population Development Plan (2016–2030)*, the growth of the population aged 60 and older will accelerate sharply from 2021 to 2030, and its share in the total population will hit roughly 25% by 2030. The working-age population will shrink rapidly from 2021 to 2030, and by 2030, the share of workers aged 45–59 years is projected to reach around 36%. The dwindling labor force and population aging will hurt China's economic development. However, the improvement of population skills and the development of informationization and intellectualization will help offset the decline in the size of the labor force and ensure sustained economic and social development.

The level of urbanization is one of the key factors underlining China's economic development and energy consumption. Existing researches generally agree on the trends of China's urbanization in the coming three decades (see Fig. 2.2). Data shows that permanent urban residents exceeded 60% of the Chinese population in 2019, and by 2050, approximately 75% of the population will inhabit urban areas, an increase of nearly 20 percentage points compared to 2015. Looking at the trends by period, some studies suggest that the urbanization rate will surge before 2030 and see slower growth afterwards while others indicate that the growth will be more evenly distributed in different period. It can be assumed that China's urbanization rate will reach 65–70% in 2035 and 75–80% in 2050.

Projections of future population size and urbanization rate are presented below after incorporating results from various studies (Table 2.3).

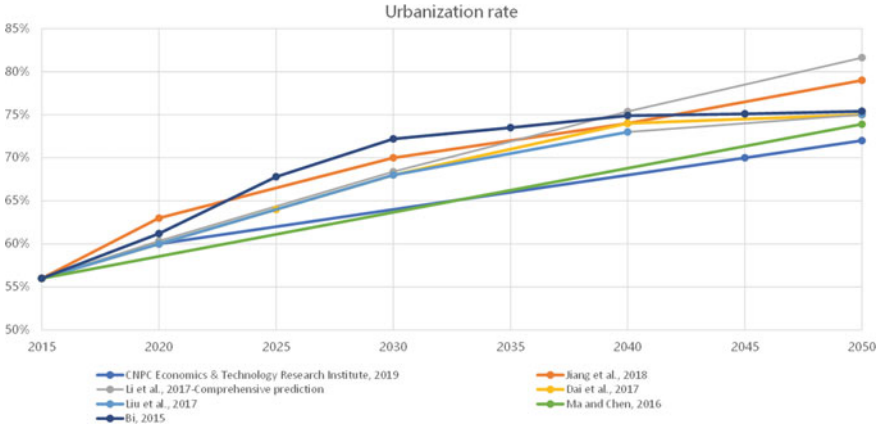

Fig. 2.2 Related studies on urbanization rate [4–6, 8–11]

Table 2.3 China's future population and urbanization rate

	2015	2020	2025	2030	2035	2050
Population (billion)	1.375	1.416	1.426	1.450	1.444	1.395
Urbanization rate (%)	56.1	60.4	64.6	66.9	68.5	75.0

2.3.2 Economic Growth and Changes in Industrial Structure

China's economic development is currently in the mid to late stage of industrialization and urbanization. The country's per capita GDP topped 10,000 USD in 2019 as it transitions from an upper-middle income economy into a high-income economy. The historical trajectory of development in developed countries also demonstrates that after the 10,000-dollar mark is crossed, economic growth will generally shift from the pursuit of quantity and scale to quality and efficiency; the share of the industrial sector will fall while that of the services will grow; the share of traditional manufacturing will shrink while that of high-tech industries is slated to rise; and economic growth will slow down but maintain steady growth as the economy transitions from extensive to intensive growth. China's economic development in the future will also by and large follow this pattern.

In the first stage of China's socialist modernization efforts from 2020 to 2035, the country's industrialization and urbanization will be largely completed. The economy will fall back to a medium growth and, in the meantime, overtake the US economy as the world's largest during this period. Investment growth will slow down but remain at a high level. Despite the shrinking of the labor force, human capital growth, labor transfer, coupled with reforms to enhance market vitality, will accelerate the growth of total factor productivity. With the completion of the massive infrastructure construction phase, the market for energy-intensive raw materials such as steel and cement will become saturated and trend downward, with a reduction in the share of the heavy and chemical industry in GDP. The manufacturing industry will move toward the mid-to-high end of the global value chain, with improvements in China's foreign trade structure and added value. The weight of modern services in the economy such as information and finance will experience steady growth, and the country will make notable strides in agricultural modernization. In the meantime, the consumption structure of Chinese society will undergo enormous changes as the caliber of demand rises, the middle class expands and the overall purchasing power of residents increases. Emerging consumption trends driven by the higher needs of the people such as culture and entertainment, health services, training, and tourism, will flourish. While capital accumulation will remain the main driver of economic growth, the role of consumption will take on greater prominence and the contribution of total factor productivity will continuously expand. Broadly speaking, economic growth at this stage will feature a slower speed but substantial improvements in efficiency and quality.

In the second stage of China's socialist modernization, from 2035 to 2050, the country will evolve into a post-industrial economy, and urbanization will also have stabilized and been largely achieved. This phase will be characterized by slower growth in investment, diminishing labor force and economic growth primarily driven by services and consumption. From the standpoint of total factor productivity, the world will witness a new wave of technological innovation with increasing penetration of new technologies in various sectors of the economy. The contribution of investment to economic growth will take a backseat to technological innovation,

which will become the core driver of growth. The increase in total factor productivity will become the main ingredient of economic growth.

Projections on future GDP growth are given in Table 2.4 based on comprehensive consideration of factor inputs that affect China's potential growth and the laws of change as well as findings of other domestic researches (see Fig. 2.3). On the whole, China's future average annual GDP growth will feature a steady decline, dropping to roughly 3% by 2050, which is still slightly higher than that of the current developed countries. Growth is expected to experience fluctuations in the near term due to the impact of the pandemic.

Changes in future GDP growth will bear considerable impact on the reduction of CO_2 intensity, the schedule of peaking and the amount of emissions at the time of peaking. In the wake of the CO_2 emissions peak around 2030, economic growth will be decoupled from emissions, and changes in GDP growth will exert minor impact on long-term CO_2 emissions. This research opts for more optimistic estimates of pre-2030 GDP growth, or in other words, it chooses a scenario where the path to peaking emissions is more challenging. Industry, and in particular manufacturing, has always featured a large uptake in Chinese economy. The secondary industry made up 40% of GDP in 2018, higher than that of developed countries during their industrialization. China will maintain its status as a manufacturing powerhouse for a long time, and will not follow the footsteps of developed countries in the massive offshoring of manufacturing. The secondary industry will still represent considerable weight in the economy (see Figs. 2.4 and 2.5). The share of the tertiary industry will rise steadily to reach roughly 60% in 2030 and possibly more than 70% in 2050—on a par with that of developed countries in the current stage (Table 2.5).

2.3.3 Energy Consumption and CO_2 Emissions

Future energy demand and CO_2 emissions are not only related to factors such as economic and social development, industrial structure, and technological progress, but also dependent on strategic goals and policy decisions. The analysis of quantities and types of energy consumption and CO_2 emission trends is not built on projections of existing trends, but rather, on the scenario analysis of various strategic goals and policies. In particular, the pathway of emission reduction to reach the goal of the Paris Agreement to limit global warming to 2°C and 1.5°C will drive ambitious energy conservation and low-carbon transition of the energy mix. The strategy and goal of China's energy revolution in the future must not only provide a clean, safe, economical, and efficient energy supply for socialist modernization, but also be aligned with the CO_2 emission pathway of staying below 2°C. The long-term energy strategy ought to be both problem and goal-oriented by coordinating the two major interests of domestic sustainable development and global ecological safety, as well as the goals and tasks of the two stages of the country's development, namely the fulfillment of NDC ambitions in 2030 and the fundamental improvement of China's environment by 2035 during the first stage, and the building of a beautiful China

Table 2.4 Reference scenarios for future GDP growth

	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Average annual GDP growth (%)	11.3	7.9	5.9	5.3	4.8	4.4	4.0	3.6	3.2

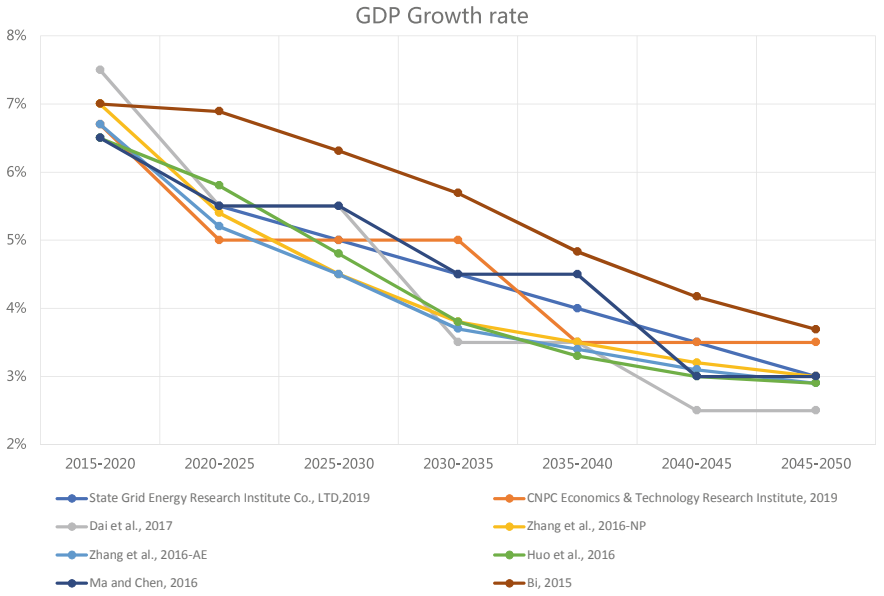

Fig. 2.3 Related studies on average annual GDP growth [4, 5, 7–9, 12, 13]

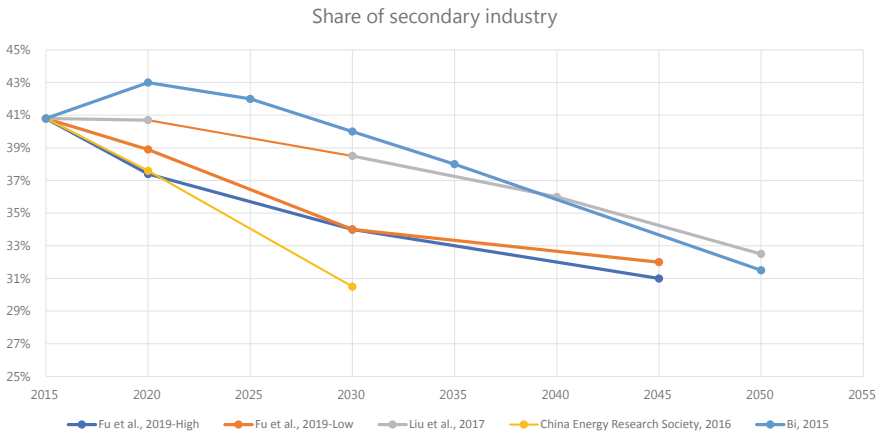

Fig. 2.4 Related studies on the share of the secondary industry [6, 9, 14, 15]

and the achievement of deep decarbonization by 2050 during the second stage. The Chinese government needs to coordinate its efforts and plan ahead, develop an energy revolution and low-carbon emissions strategy aligned with the two-stage plan of China's socialist modernization, strive toward a great modern socialist country and a beautiful China while pursuing a deep decarbonization pathway consistent with the target of near-zero emissions by mid-century under the global warming scenario

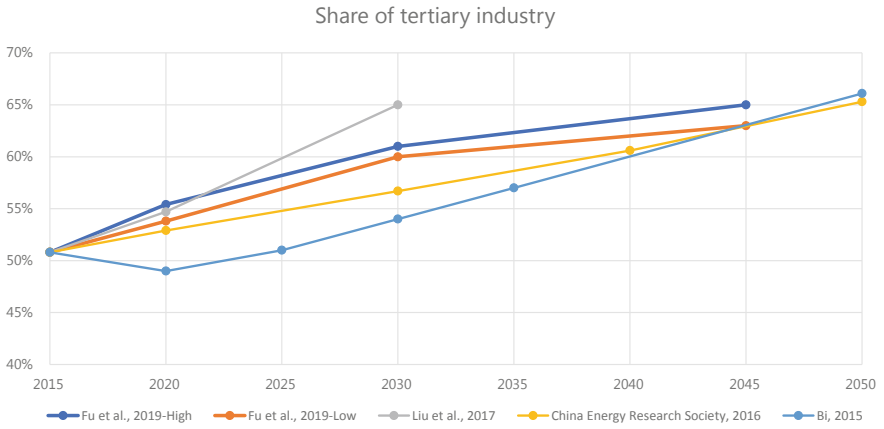

Fig. 2.5 Related studies on the share of the tertiary industry [6, 9, 14, 15]

Table 2.5 Reference scenarios for China's future industrial structure

	2015	2020	2025	2035	2050
Primary industry (%)	8.83	7.52	6.89	5.42	3.48
Secondary industry (%)	40.93	37.47	34.10	28.10	24.22
Tertiary industry (%)	50.24	55.01	59.01	66.48	72.30

of 2°C, make contributions commensurate with China's rising national strength and international profile, and spearhead the low-carbon transition of the global energy system and economy.

Most domestic research studies predict future energy demand and CO_2 emissions under the scenario of enhanced energy conservation and substitution. There is a dearth of studies on the 2°C or even 1.5°C target-driven scenario, where systematic research is needed. The findings of other domestic researches are illustrated in Figs. 2.6 and 2.7, which suggest that the pathway to achieve the 2°C goal is an extremely challenging one. Various studies have produced divergent estimates of CO_2 emissions in 2050 under different policy scenarios in the future. Most studies conclude that China's energy-related CO_2 emissions will reach between 4–10 billion tCO_2 by 2050, which is also a matter that will receive granular discussion in subsequent chapters of this report.

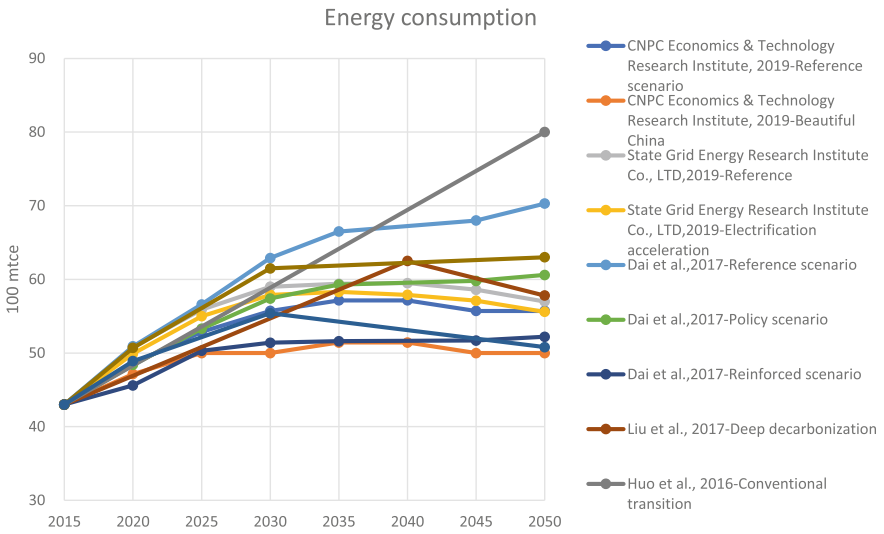

Fig. 2.6 Related studies on future energy consumption [4–6, 12, 13]

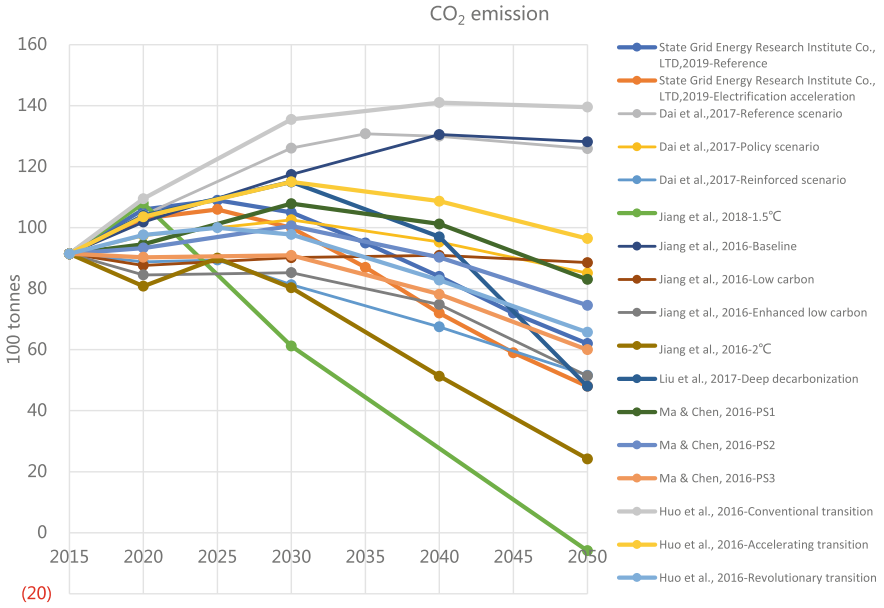

Fig. 2.7 Related studies on total CO_2 emissions [5, 6, 8, 10, 12, 13, 16]

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