CHAPTER 5

# CHINA COUNTRY REPORT

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## 1. Background

### 1.1 Natural Conditions and History

China (officially known as the People's Republic of China, the PRC) has a land area of 9.6 million square kilometres (km2) and is situated in eastern Asia on the western shores of the Pacific Ocean. China's continental coastline extends for about 18,000 kilometres, and its vast sea surface is studded with more than 5,000 islands. Due to its size, China's climate is diverse, ranging from an unbearable 48°C in the northwest during summer to an equally unbearable –40°C in the far north in winter.

China has more than 5,000 years of history. The PRC was founded on 1 October 1949. China has been implementing reforms and opening up its economy for 40 years and has established a socialist market economy, thereby charting the course for socialist modernisation with Chinese characteristics.

### 1.2 Economy and Population

China's gross domestic product (GDP) in 2017 was around US$12,225 trillion, which translates into a per capita GDP of around US$8,848.0 (in 2017 US$ terms). China is currently the world's most populous country, with about 1.39 billion people in 2017 (National Bureau of Statistics, 2017). To mitigate population growth, China has implemented a family planning policy since the 1970s. However, in 2015, the 'one child' policy ended, and couples that satisfy the conditions can have two children. China has been experiencing fast urbanisation at the annual growth rate of about 1% since 1978 when China's reform and opening up started. At the end of 2017, around 58.5% of the population lived in urban areas.

## 1.3 Energy Situation

In terms of energy resources, China is endowed with coal, oil, and gas reserves and tremendous hydropower potential. China is the world's largest coal producer and has the third-largest coal reserves, with recoverable reserves of 114.5 billion tons. In 2015, the country produced 3.75 billion tons of raw coal. China is still a major crude oil producer, with output of 214.6 million tons of crude oil in 2015. However, driven by very fast increases in oil demand, China became an oil importer in the 1990s. In 2014, the amount of net imported oil reached 328 million tons with a growth rate of 6.4% and a dependence level of more than 60%. China is also a large producer and exporter of energy-intensive items. In 2015, it produced 2.36 billion tons of cement and 1.12 billion tons of finished steel, of which 112 million tons were exported (National Bureau of Statistics and China Energy Statistics Yearbook).

China's per capita energy reserves are considerably lower than those of the world average. The per capita average of both coal and hydropower resources is only about 50% of the world average, while the per capita average of both oil and natural gas reserves is only about one-fifteenth of the world average. The per capita average of arable land is less than 30% of the world average, which hinders the development of biomass energy.

Since 1990, coal has dominated primary energy consumption, at 60.6%, while oil, natural gas, and hydro consumption accounted for 13.6%, 1.5%, and 1.3%, respectively. However, biomass consumption represented 23%, which is only lower than that of coal consumption. In 2015, coal was still a major fuel, with a higher share of about 66.7%. The share of other energy sources increased from 1990 levels to 18.0% for oil, 5.3% for gas, and 3.2% for hydro, but the share of biomass decreased to 3.5%. Primary energy consumption in China increased at an average annual rate of around 5% from 870.7 million tons of oil equivalent (Mtoe) in 1990 to 2,973.3 Mtoe in 2015. Energy intensity (primary energy demand per unit of GDP) declined from 1,050 tons of oil equivalent per million US$ in 1990 to 344 tons of oil equivalent per million US$ in 2015.

Final energy consumption in China increased at a lower average annual rate of 4.4%, from 664.2 Mtoe in 1990 to 1,905.7 Mtoe in 2015. Coal accounted for 47.9% of final energy consumption in 1990 and 36.8% in 2015. In 1990, oil consumption accounted for 12.7% of total final energy consumption and had increased rapidly at 7.4% per year between 1990 and 2015, significantly increasing its share to 25.2% in 2015. Both electricity and natural gas consumption grew sharply at 16.0% and 5.5% per year, respectively, between 1990 and 2015. It makes the shares of electricity and natural gas consumption increase from 5.9% and 1.3% in 1990 to 21.9% and 5.5% in 2015. In 2015, the share of electricity consumption had almost reached the same as that of oil consumption.

Industry is the major energy-consuming sector in China, followed by the residential and commercial ('others') sectors. The share of industry consumption increased from 36.7% in 1990 to 50.7% in 2015. Conversely, the share of energy consumption in the 'others' sector declined from 51.8% in 1990 to 25.4% in 2015 because of relatively faster growth in the industry and transport sectors.

Power in China is mainly generated from coal-fired power plants, whose electricity generation accounted for around 71% of the total amount in 1990. By 2015, this share increased to 78.2%. The share of hydro was 20.4% in 1990 but declined to 16.4% in 2015. Gas and oil, collectively, accounted for about 2.7% of total generation in 2015. The share of nuclear power increased to about 2.9% in 2015.

The Chinese government is pushing for the development of a modern energy industry. Resource conservation and environmental protection are two basic state policies, giving prominence to building a resource-conserving and environment-friendly society in the course of its industrialisation and modernisation.

# 2. Modelling Assumptions

## 2.1. Population and Gross Domestic Product

The model results for China have been developed by the Institute of Energy Economics, Japan and were taken from modelling of the Business-As-Usual (BAU) scenario and the Alternative Policy Scenarios (APS).

China's population increased from 1.135 billion in 1990 to 1.375 billion in 2015. It is assumed to increase at an average rate of 0.2% per year in 2015–2040, the projection period. The population will peak at 1.450 billion around 2030 and reach 1.428 billion by 2040.

China's economy grew at an average annual rate of 10.2% from US$530.6 billion in 1990 to about US$4.913 trillion in 2013 (in 2005 US$ terms). In this study, GDP is assumed to grow at a slower rate of 6.5% per year from 2015 to 2020 because of the 'new normal' state of China's economy, 5.3% per year in 2020–2030, and 4.2% per year in 2030–2040. The average annual growth rate of GDP in 2015–2040 is 5.1%. It is calculated to reach US$31.116 trillion by 2040. Given GDP and population assumptions, GDP per capita in China is assumed to increase from around US$6,500 per capita in 2015 to US$22,400 per capita in 2040.

## 2.2. Energy and Climate Change Policies and their Performance

Although China is still a developing country and its GDP per capita is around one-seventh that of the United States (according to nominal exchange rate) in 2015, the government has set ambitious goals of reducing energy intensity and addressing climate change issues. According to the data from relevant official departments, in the last 5 years, China has achieved significant energy conservation and remarkable progress in environmental protection and climate change mitigation.

China's Outline of the 13th Five-Year Plan (2016–2020) for the National Economic and Social Development stipulates that, by 2020, energy consumption per unit of GDP will drop by 15% from 2016. To achieve this goal, the government has already implemented administrative, market-based, and legal measures to promote energy conservation. Energy intensity reduction goals are assigned to provincial governments and progress is announced publicly every year. During the 12th Five-Year Plan (2011–2015), energy consumption grew at the rate of 3.6% and GDP increased at the rate of 7.8%. Accordingly, energy intensity decreased by 18.2%, successfully achieving the target of 16%. Energy consumption per unit of GDP in 2015 decreased by 5.6% compared with that of 2014.

In addition to energy intensity targets, controlling the total amount of energy consumption is proposed. According to the Energy Development Strategic Action Plan (2014–2020), China's coal consumption (primary energy consumption) would be controlled at 2,940 Mtoe in 2020 and primary energy consumption would be controlled at 3,362 Mtoe in 2020. According to the 13th Five-Year Plan of Energy Development, by 2020, the ratio of coal consumption to total energy consumption should be lowered to at most 60%, and natural gas consumption should account for 10% of the total amount. In addition, the amount of new energy vehicles will reach 2 million.

China announced its goal of reducing $CO_2$ emissions per GDP (carbon intensity) by 40%–45% by 2020 and 60%–65% by 2030 from the 2005 level. Apart from the carbon intensity target, China also declared that the $CO_2$ emissions will reach their peak at around 2030. To meet the target, China has implemented ambitious energy efficiency and fuel-switching policies. For instance, the government proclaimed its goal of cultivating 40 million hectares of forested land to mitigate greenhouse gas emissions. In 2014, China's $CO_2$ emissions per unit of GDP dropped by 9.1% compared to the level of 2013.

China also exerted great effort to develop non-fossil fuels and accelerate the development of renewable energy. The National People's Congress passed the Renewable Energy Development Law of China in 2005 to support renewable energy development in the country. The government also announced the target of increasing the share of non-fossil energy to about 15% by 2020 (measured in coal-equivalent) and about 20% in 2030. Subsidisation policies have also been developed to encourage the development of wind power, solar photovoltaic (PV), and biomass. In 2015, China invested US$102.9 billion on renewable energy, accounting for 36% of the total amount in the world. By the end of 2015, power generation capacity had reached 1,508 gigawatts (GW). Within this, the capacity of hydropower, which ranked first globally, reached 319 GW, increasing at a growth rate of 4.9%; the capacity of nuclear power plants was 26.08 GW; on-grid wind power capacity, which was the largest in the world, amounted to 129.34 GW, increasing 33.5% year on year; on-grid solar power reached 43.18 GW, growing 73.7% from a year earlier. The installed electricity capacity of non-fossil fuel such as hydro, nuclear, wind, and solar energy – in 2015 took up 34.3% of the whole, 1.5% higher than that of 2014. The electricity generated from non-fossil fuels accounted for 25.1% of the total on-grid electricity in 2015. China's current installed capacity, under-construction capacity, and generation of hydropower, the accumulative installed capacity of PV solar power, and the capacity of under-construction nuclear power all rank first in the world, which have positively contributed to addressing the problem of global climate change.

After the evaluation in 2015, China phased out the backward production capacity in the following industries: small thermal power units (4.23 GW), cement (50 million tons), and steel (30 million tons). To consume the surplus production capacity, from 2016 no new coal mine projects will be approved for 3 years, and steel production capacity will decrease by between 100 million and 150 million tons over 5 years.

The 2015 scenario analyses set five APSs: APS1 – energy efficiency and conservation (EEC) in the final consumption sectors; APS2 – EEC in thermal efficiency in coal, oil- and gas-fired power generation; APS3 – increase of hydro, geothermal, and new and renewable energy; APS4 – increase in nuclear energy; APS5 – implement APS1 to APS4. If not specifically declared, all results shown in this chapter under the APS refer to APS5.

# 3. Outlook Results

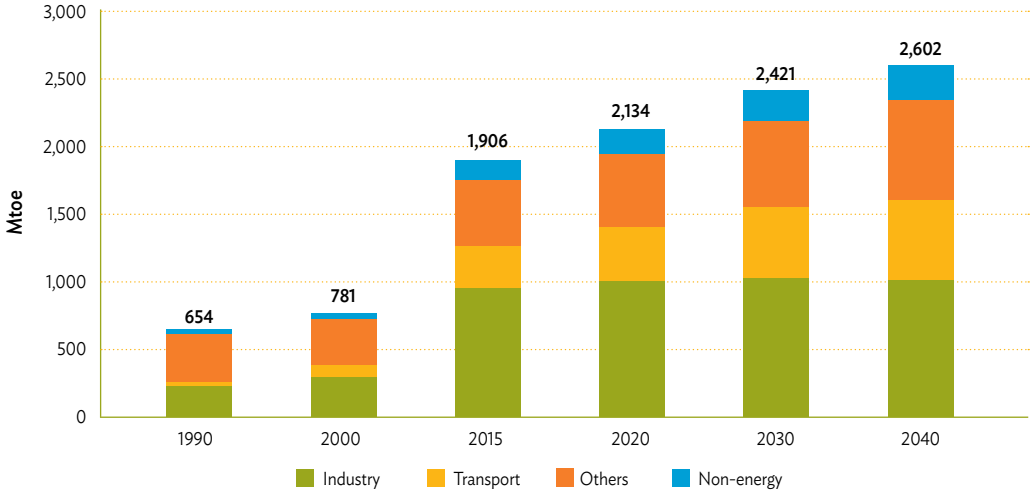
## 3.1. Total Final Energy Consumption

Between 2015 and 2040, China's final energy consumption is projected to grow slowly, reflecting lower assumed economic and population growth.

***Business-As-Usual Scenario***

Final energy consumption is projected to increase at an average rate of 1.3% per year between 2015 and 2040. Transport sector consumption is projected to grow the fastest, increasing by 2.7% a year, followed by the non-energy sector of 1.9%. Energy consumption in the industry sector is projected to grow at an average annual rate of 0.2%. Figure 5.1 shows China's final energy consumption by sector under the BAU scenario.

**Figure 5.1: Final Energy Consumption by Sector, BAU**

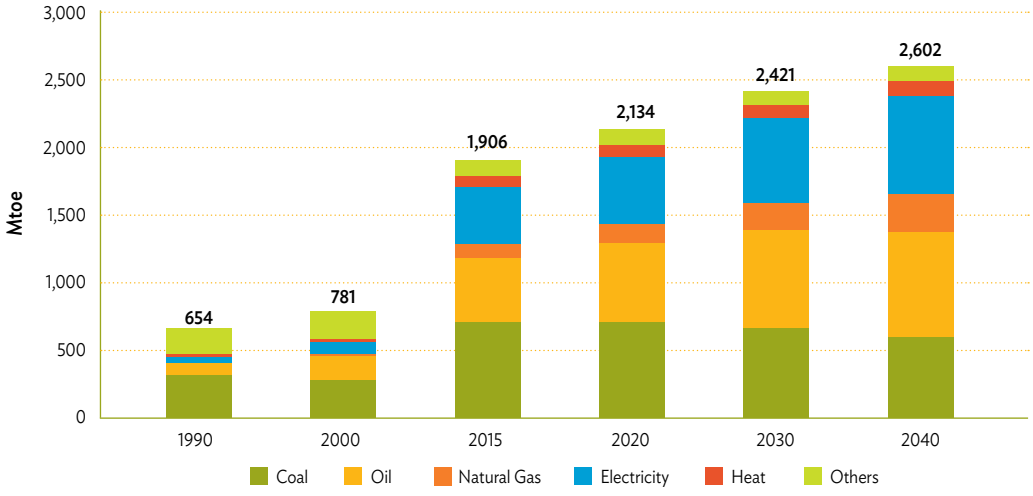



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Amongst energy sources, natural gas consumption in the BAU scenario, which is projected to exhibit the fastest growth, will increase by 5.2% per year, from 158.5 Mtoe in 2015 to 556.5 Mtoe in 2040. Though coal is still a large portion in the whole final energy consumption, it is projected to increase at such a lower growth rate, -0.1% per year, achieving 1938.6 Mtoe in 2040, compared with -0.7% per year over the last 2 decades. Consumption of electricity and heat is projected to increase at an average annual rate of 2.3% and 0.8%, respectively, over the same period, achieving 737.6 Mtoe and 110.0 Mtoe in 2040. Oil is projected to grow by 1.9% annually to around 853.4 Mtoe in 2040. Figure 5.2 shows China's final energy consumption by fuel type under the BAU scenario.

**Figure 5.2: Final Energy Consumption by Fuel Type, BAU (1990–2040)**



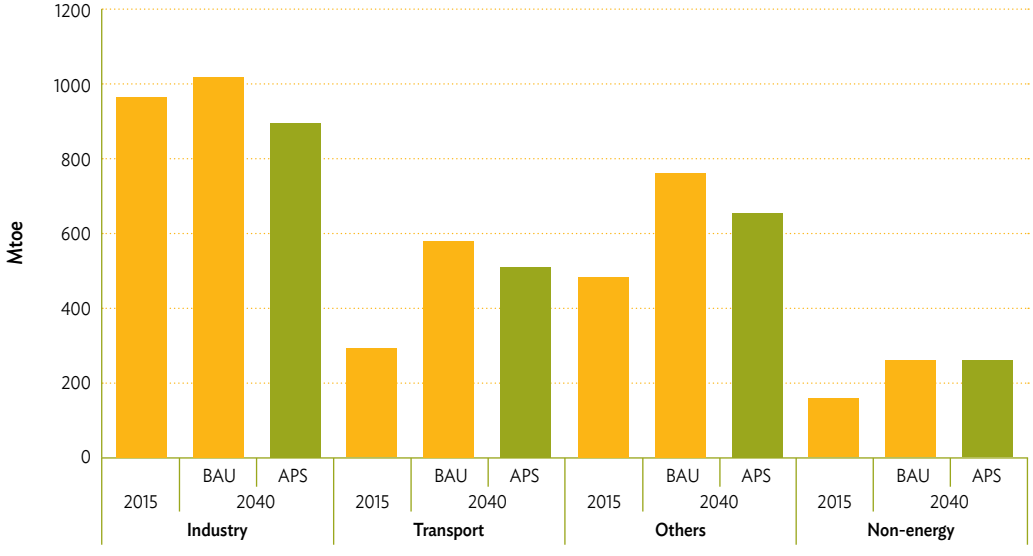

BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

### *Alternative Policy Scenario*

In the APS, final energy consumption is projected to increase by 0.6% per year, from 2,973.3 Mtoe in 2015 to 3,494.9 Mtoe in 2040, as a result of EEC programmes. An improvement in end-use technologies and the introduction of energy management systems are expected to contribute to slower energy growth in all sectors, particularly in the commercial, residential, and transport sectors. Figure 5.3 shows the final energy consumption in China in 2015 and 2040 in both the BAU scenario and the APS.

**Figure 5.3: Final Energy Consumption, BAU and APS (2015 and 2040)**




APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

## 3.2. Primary Energy Supply

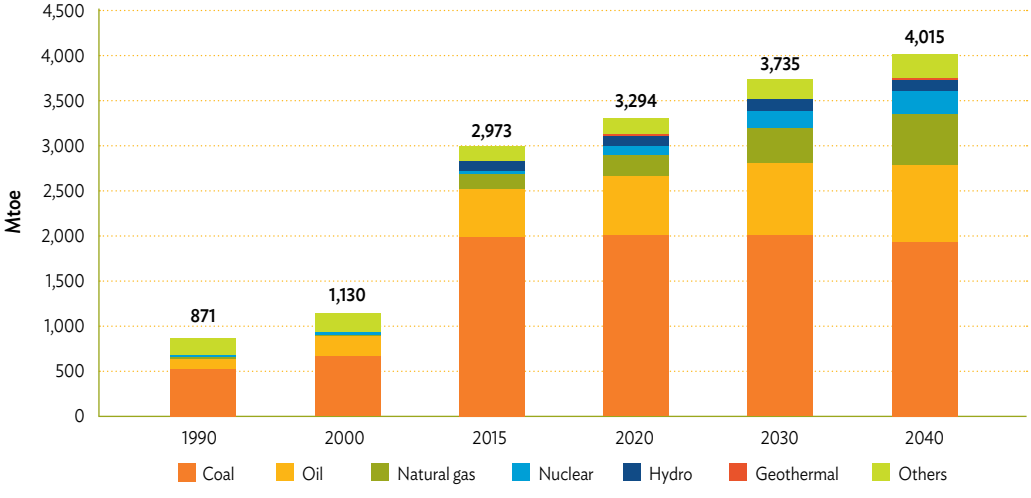
Primary energy supply in China is projected to grow at a slower pace than in the past years. Growth in primary energy supply is also expected to be slightly slower than final energy consumption because of improved efficiency in the energy transformation sector.

***Business-As-Usual Scenario***

In the BAU scenario, China's primary energy supply is projected to increase at an average annual rate of 1.2% per year to 4,014.9 Mtoe in 2040. Coal will still constitute the largest share in total primary energy, but its growth is expected to be slower and decreasing by -0.1% a year on average. Consequently, the share of coal in total primary energy is projected to decline from 66.7% in 2015 to 48.3% in 2040.

Nuclear energy is projected to exhibit the fastest growth between 2015 and 2040, increasing at an annual average rate of 7.2%, followed by natural gas at 5.2%. Oil and hydro are projected to grow at lower rates of 1.9% and 1.1% per year, respectively. The share of natural gas is projected to increase from 5.3% in 2015 to 13.9% in 2040, whereas the share of nuclear will increase from 1.5% to 6.3%. The share of oil is projected to increase from 18% in 2015 to 21.3% in 2040, and hydro is projected to decrease from 3.2% in 2015 to 3.1% in 2040. Figure 5.4 shows China's primary energy supply by energy type under the BAU scenario.

**Figure 5.4: Primary Energy Supply by Energy Type, BAU (1990–2040)**



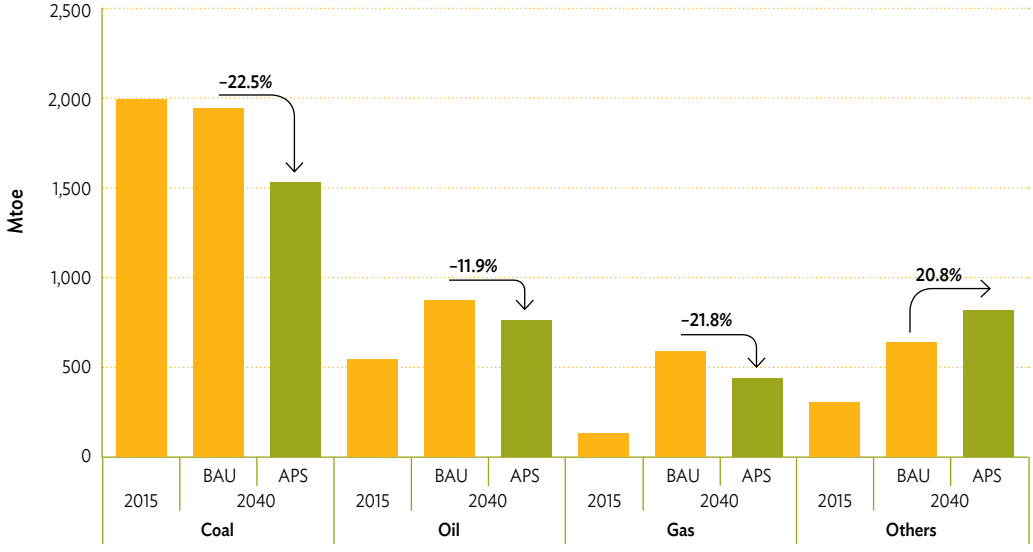

BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

***Alternative Policy Scenario***

In the APS, primary energy consumption is projected to increase by 0.6% per year between 2015 and 2040, reaching 3,494.9 Mtoe by 2040. The growth in primary energy supply is projected to be slower under the APS than the BAU scenario (Figure 5.5). Coal is projected to decrease by -1.1% a year, oil by 1.4% a year, and natural gas by 4.1% a year. For nuclear, the average annual growth rate will be higher than the BAU scenario, increasing by 8.7% a year between 2015 and 2040. The growth rate of hydro in the APS is expected to be higher than that of the BAU scenario, increasing by 1.3% per year. The consumption mitigated in the APS is achieved through EEC measures on the demand side.

**Figure 5.5: Primary Energy Supply by Source, BAU and APS (2015 and 2040)**




APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

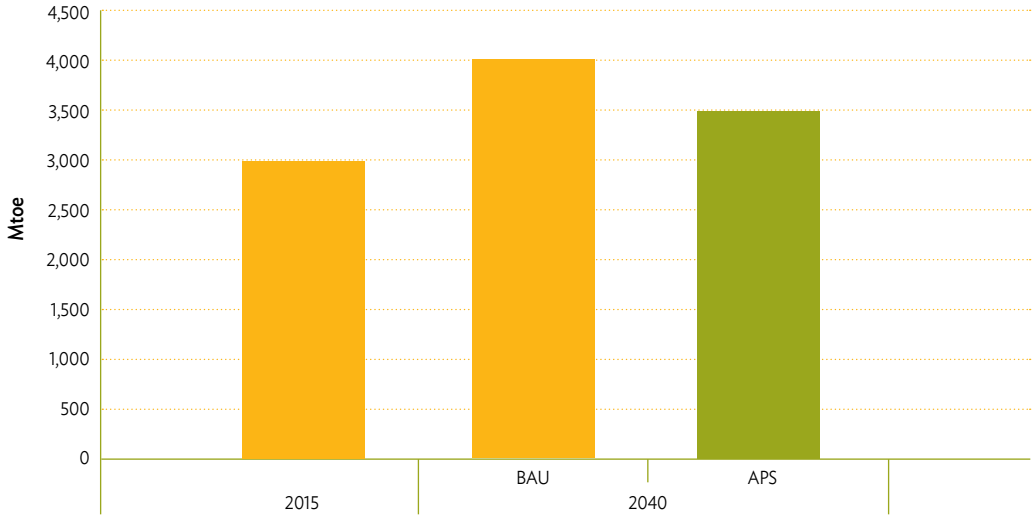
Source: Authors' calculation.

## 3.3. Projected Energy Savings

The implementation of EEC goals and action plans in China could reduce primary energy supply in 2040 by about 267.3 Mtoe under the APS relative to the BAU scenario. In the APS, China's primary energy demand is around 10.3% lower than the BAU scenario (Figure 5.6).

In terms of final energy consumption, there are estimated savings of 110.6 Mtoe in the industry sector, 71.5 Mtoe in the transport sector, and 85 Mtoe in the 'others' sector in 2040 under the APS.

**Figure 5.6: Total Primary Energy Supply, BAU and APS (2015 and 2040)**




APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

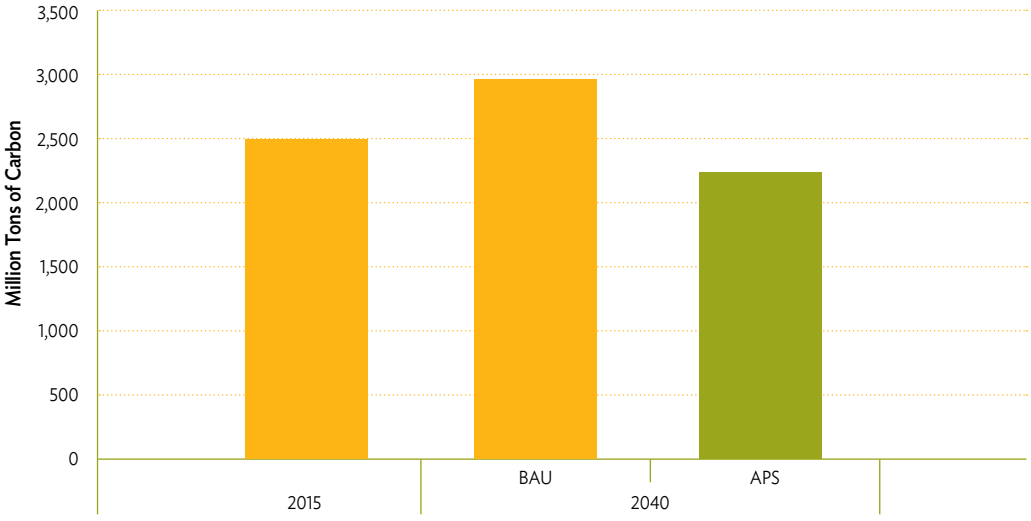
Source: Authors' calculation.

## 3.4. $CO_2$ Emissions from Energy Consumption

$CO_2$ emissions from energy consumption are projected to increase by 0.6% per year, from 2,545.4 million tons of carbon (Mt-C) in 2015 to 2930.9 Mt-C in 2040, under the BAU scenario. This percentage increase is lower than that in primary energy supply (1.3%) over the same period, indicating improved emissions intensity in China's economy.

In the APS, the annual increase in $CO_2$ emissions between 2015 and 2040 is projected to be -0.4%. This rate is also lower than the average annual growth rate in primary energy supply over the same period. The difference between the APS and the BAU scenario $CO_2$ emissions growth rates indicates that the energy-saving goals and action plans of China are effective in reducing $CO_2$ emissions (Figure 5.7).

**Figure 5.7: $CO_2$ Emissions from Energy Consumption, BAU and APS (2015 and 2040)**




BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

## 3.5. Power Generation

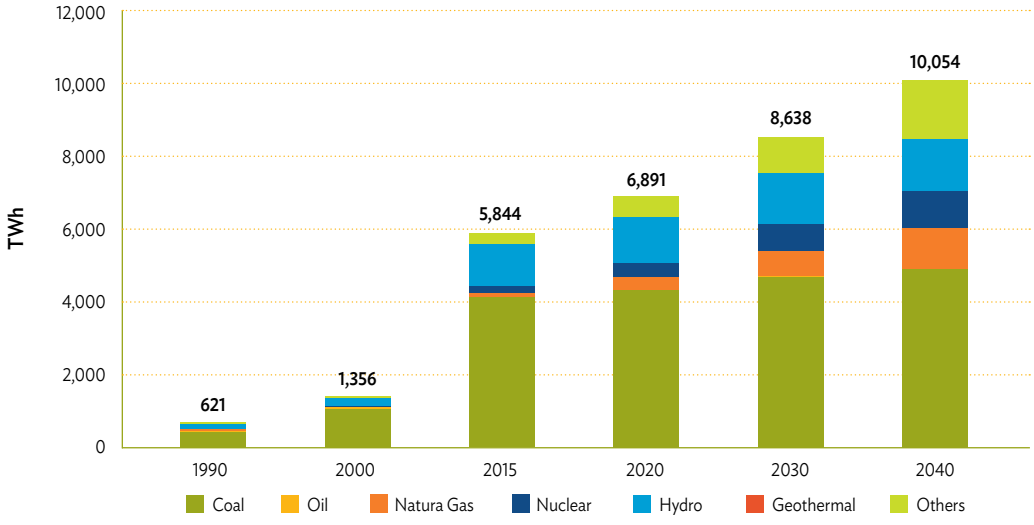
Power generation in China is projected to grow more slowly between 2015 and 2040 than in the last decade.

***Business-As-Usual Scenario***

In the BAU scenario, power generation in China is projected to grow at a slower pace, by 2.5% per year from 5,844.2 terawatt-hour (TWh) in 2015 to 10,054.5 TWh in 2040 (Figure 5.8).

The share of coal power under the BAU scenario is projected to experience a decreasing trend from 70.3% in 2015 to 48.6% in 2040. Conversely, the share of natural gas and nuclear are both projected to grow because of cleanness, from 2.5% and 2.9% in 2015 to 11.3% and 9.6% in 2040, respectively. The share of oil is projected to decrease slightly. In addition, other methods of power generation are projected to be increasing. The fast development of PV power generation in China is a typical example reflecting the country's clean power generation tendency. China's thermal efficiency by fuel under the BAU scenario is projected to increase between 2015 and 2040 (Figure 5.9).

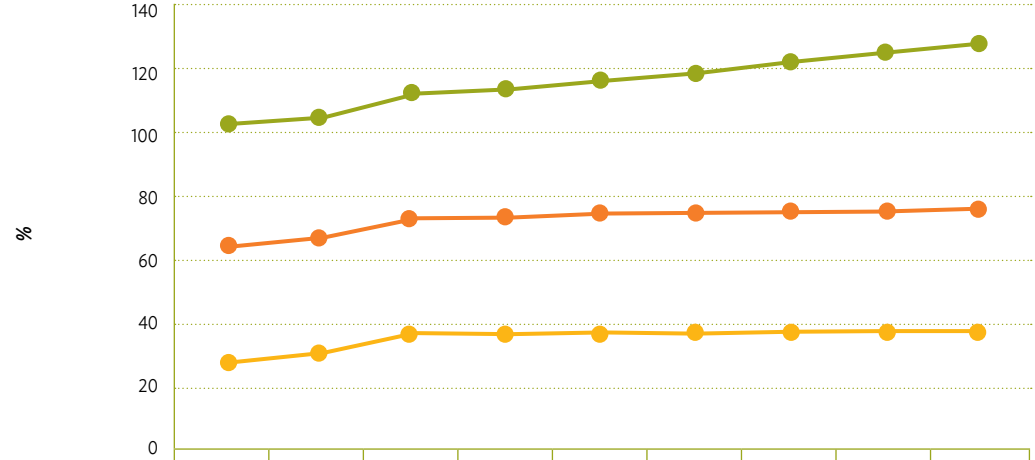
## Figure 5.8: Power Generation, BAU (1990–2040)




BAU = business as usual, TWh = terawatt-hour.

Source: Authors' calculation.

## Figure 5.9: Thermal Efficiency by Fuel, BAU




| % | 1990 | 2000 | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|---|
| Natural Gas | 38.9 | 38.9 | 38.9 | 39.8 | 42.2 | 44.5 | 46.8 | 49.1 | 51.4 |
| Oil | 35.0 | 35.0 | 35.0 | 35.6 | 36.0 | 36.3 | 36.7 | 37.0 | 37.4 |
| Coal | 28.8 | 32.0 | 38.0 | 38.1 | 38.2 | 38.4 | 38.6 | 38.8 | 38.9 |

BAU = Business-As-Usual.

Source: Authors' calculation.

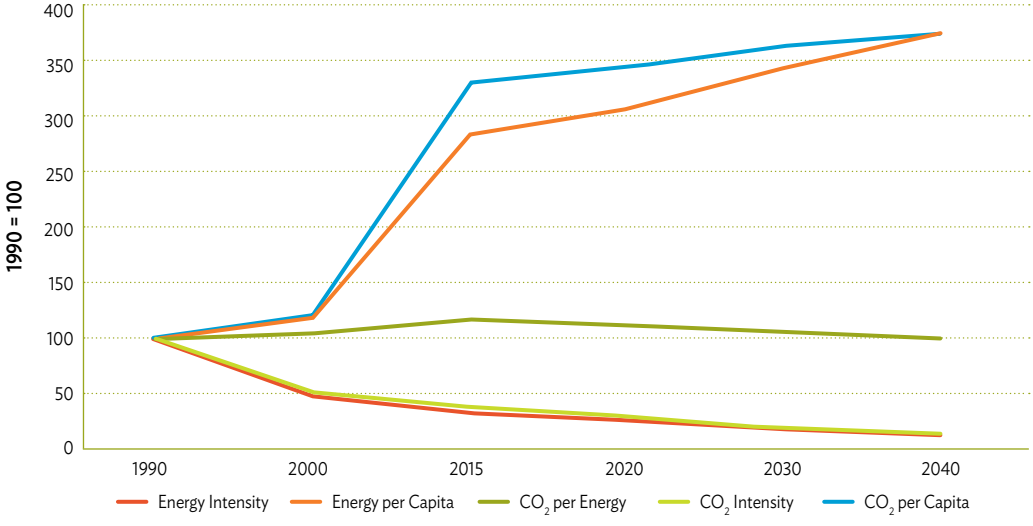
***Alternative Policy Scenario***

In the APS, total power generation will increase by 2.2% per year between 2015 and 2040. By 2040, total power generation output is projected to reach 10,054.5 TWh. Except for coal-fired power, oil power, and natural gas power, the annual growth rate per year between 2015 and 2040 of all other fuels under the APS is projected to grow faster than in the BAU scenario. In 2040, nuclear power, hydro power, geothermal power, and 'others' are projected to increase under the APS by 7.2%, 1.1%, 5.1%, 7.0% in 2015–2040, respectively.

## 3.6. Energy Intensity

According to the assumed economic and population data, along with the projected energy information of China, energy intensity defined as total primary energy supply/GDP (TPES/GDP) and energy per capita are accounted and illustrated in Figure 5.10, along with other vital energy indicators under the BAU scenario. From 1990 to 2015, China's energy intensity experienced a remarkable drop through efforts on energy efficiency. In 2040, it is projected to drop to about 257 toe per million (in 2005 US$ terms). With improved living standards in China, energy per capita under the BAU scenario is projected to reach 3.18 toe per person in 2040. Compared with the energy intensity in the BAU scenario, that in the APS is projected to show a faster decreasing rate of 3.6% from 2015 to 2040.

**Figure 5.10: Energy Indicators, BAU (1990–2040)**




BAU = Business-As-Usual.

Source: Authors' calculation.

# 4. Implications and Policy Recommendations

For China, which is the world's largest developing country, eliminating poverty and improving the quality of life have always been paramount tasks. In recent years, China has witnessed fast growth in its economy, but the urbanisation rate is still low, with 58.5% in 2017.

On the other hand, being the world's biggest energy consumer and $CO_2$ emitter, China also faces great pressure to save energy and reduce $CO_2$. Since the1990s, China has made great efforts and set ambitious targets on energy conservation and climate change mitigation. During the 2014 Asia-Pacific Economic Cooperation summits, China and the United States issued a joint announcement on climate change, in which China vowed to decrease $CO_2$ emissions from its peak and increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030. In April 2016, China signed the Paris Agreement, which includes the above commitments in addition to the provision that China cut its carbon emissions per unit of GDP by 60%–65% by 2030 from the 2005 levels. In the 13th Five-Year Plan (2016–2020), China plans to control the total energy consumption within 41 billion tons of standard coal and decrease its $CO_2$ emissions per unit of GDP by 18% compared with 2015 levels.

As China's GDP keeps growing, albeit at a slower pace compared with that of the last 20 years, its energy demand and $CO_2$ emissions will increase in the foreseeable future accordingly. However, energy intensity (energy demand per unit of GDP) and emissions intensity ($CO_2$ emissions per unit of GDP) are required to decrease considering China's targets. According to the model results, if sound energy efficiency and conservation policies could be implemented, China could reduce its total primary energy consumption by around 13.0% and $CO_2$ emissions by about 21.6% by 2040.

Coal consumption has decreased since 2014; it decreased by 3.7% in 2015. It is projected to be cut by 22.5% in the APS compared with the BAU scenario. To improve urban air quality, Chinese metropolises, such as Beijing and Shanghai, have shown great ambitions in controlling the use of coal, so the relatively low growth rate of coal consumption may persist in the following years. Therefore, clean and low-carbon energies are encouraged to develop, especially renewable and nuclear energy in the power generation sector. To optimise the energy structure, policies such as on energy and carbon taxes should be carried out, to limit the energy- and pollution-intensive industries. On the other hand, more market-based measures, for instance, electricity market reform, energy pricing reform, and green certificate trade, are needed to make energy more market-oriented and to motivate more enterprises to act.

The energy efficiency improvement in APS5 has the largest potential to reduce $CO_2$ emissions. Based on our calculation of 2015 scenario, within the APS5, the industry sector can potentially reduce energy consumption by 10.9% based on the APS5 results. Measures such as the closure of small and inefficient power plants, coal mines, and small energy-intensive plants in industries like cement and steel, and stricter approval requirements for energy-intensive industries are necessarily implemented. Moreover, the change in industrial structure (heavy to light industries or industry to services) is also needed. Furthermore, since China has entered the 'new normal' state of economy, in which economic growth rate would be moderately high, and the GDP of the tertiary sector has accounted for half of the total amount, in the long run, it is more important to enhance energy efficiency in the residential, commercial, and transport sectors for energy saving and $CO_2$ reduction. Moreover, the Belt and Road Initiative (BRI) proposed by President Xi in 2013 is also a good chance to further save energy and reduce emissions. The countries along the route of BRI contribute to 50% of global energy consumption and more than 60% of global carbon emissions. Thus, establishing a BRI low-carbon community is greatly significant to the improvement of energy structure and emissions reduction in both China and the world.

## Reference

National Bureau of Statistics (2017), *China Statistical Yearbook 2017* (*Chinese-English Edition*). Beijing: China Statistics Press.