Chapter 5

China Country Report

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Chapter 5

China Country Report

HAO YU AND RONG HAN, CENTER FOR ENERGY AND ENVIRONMENTAL POLICY RESEARCH, BEIJING INSTITUTE OF TECHNOLOGY, CHINA

1. Background

1.1. Natural Condition and History

The People's Republic of China has a land area of 9.6 million square kilometres and is situated in eastern Asia on the western shore 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 huge size, China's climate is obviously very diverse, ranging from an unbearable 48 ºC in the northwest during summer to an equally unbearable -40 ºC in the far north in winter.

China has more than 5,000 years of history and is one of five countries with a great ancient civilisation. The People's Republic of China was founded on 1 October 1949. Today, China is implementing reforms and opening up its economy, and has established a socialist market economy, thereby charting a course of socialist modernisation with Chinese characteristics.

1.1. Economy and Population

China's gross domestic product (GDP) in 2013 was around US$4,913 billion (in 2005 US$ terms), which translates into a per capita GDP of around US$3,610 (in 2005 US$ terms). China is currently the world's most populous country, with a population of about 1.37 billion in 2015.[1] To mitigate population growth, China

[1] China National Bureau of Statistics.

has implemented a family planning policy since the 1970s. However, in 2015, the 'one child' policy was discontinued and couples who satisfy certain conditions are now allowed to have two children. China has been experiencing a fast urbanisation process at an annual growth rate of approximately 1 percent since 1978 when China's reform and opening up started. At the end of 2015, around 56.1 percent of the population was living in urban areas.

1.2. 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, China 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 China's 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 percent and a dependence level of more than 60 percent. China is also a large producer and exporter of energy-intensive items. In 2015, it produced 1.12 billion tons of finished steel and 2.36 billion tons of cement, and exported 112 million tons of finished steel.

China's per capita energy reserve is considerably lower than the world average. The per capita average of both coal and hydropower resources is at present only about 50 percent 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 percent of the world average, which hinders the development of biomass energy.

Since 1990, coal has dominated the primary energy supply, with 60.6 percent, while oil, natural gas, and hydro consumption accounted for 13.6 percent, 1.5 percent, and 1.3 percent, respectively. However, biomass consumption represented 23.0 percent, which is lower only than coal consumption. In 2013, coal was still a major fuel, with a higher share of about 67.7 percent. The share of other energy sources increased from 1990 levels to 15.8 percent for oil, 4.6 percent for gas, and 2.6 percent for hydro, but the share of biomass decreased to

7.1 percent. Primary energy supply in China increased at an average annual rate of around 5.6 percent from 870.7 Mtoe in 1990 to 3021.9 Mtoe in 2013. Energy intensity (primary energy supply per unit of GDP declined from 1,641 tons of oil equivalent per million US$ in 1990 to 615 tons of oil equivalent per million 2005 US$ in 2013.

Final energy consumption in China increased at a lower annual average rate of 4.5 percent from 664.2 Mtoe in 1990 to 1814.06 Mtoe in 2013. Coal accounted for 47.9 percent of final energy consumption in 1990 and 33.3 percent in 2013. In 1990, oil consumption accounted for 12.7 percent of final energy consumption and increased at a rapid annual average rate of 7.4 percent from 1990 to 2013, resulting in a significant increase in its share of final energy consumption, which reached 24.0 percent in 2013. Both electricity and natural gas consumption grew sharply at 10.5 percent per year and 10.8 percent per year, respectively, from 1990 to 2013, which resulted in increases in the shares of electricity and natural gas consumption from 5.9 percent and 1.3 percent in 1990 to 21.3 percent and 5.2 percent in 2013, respectively. In 2013, the share of electricity consumption had become nearly equal to that of oil consumption in final energy consumption.

Among the sectors, industry is the major energy consumer in China, followed by the residential and commercial ('others') sectors. The share of industry consumption increased from 36.7 percent in 1990 to 48.4 percent in 2013. Conversely, the share of energy consumption in 'others' declined from 51.8 percent in 1990 to 30.2 percent in 2013, because of relatively faster growth in the industry and transport sectors.

Power generation in China is mainly from coal-fired plants, with their electricity generation accounting for around 71.0 percent of the total amount in 1990. By 2013, this share had increased to 75.4 percent. The share of hydro was 20.4 percent in 1990, but had declined to 16.8 percent in 2013. Gas and oil, collectively, accounted for about 2.0 percent of total generation in 2013. The share of nuclear power increased to about 2.1 percent in 2013.

The government is pushing the development of a modern energy industry. It has adopted resource conservation and environmental protection as two basic state

policies, giving prominence to building a resource-conserving and environment-friendly society as a key part of its industrialisation and modernisation.

2. Modelling Assumptions

2.1. Population and Gross Domestic Product

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

China's population increased from 1.143 billion in 1990 to 1.361 billion in 2013 and it is projected to grow at an annual average rate of 0.2 percent from 2013 to 2040. The population will peak at 1.450 billion around 2030 and reach 1.428 billion people by 2040.

China's economy grew at an average annual rate of 10.2 percent from US$530.6 billion in 1990 to about US$4,913.0 billion in 2013 (in 2005 US$ terms). In this study, GDP is assumed to grow at a slower rate of 6.2 percent per year from 2013 to 2020 because of the 'new normal' stage of China's economy, by 5.1 percent per year from 2020 to 2030, and by 3.7 percent per year from 2030 to 2040. The average annual GDP growth rate from 2013 to 2040 is 4.9 percent. It is estimated to reach US$17,683.8 billion by 2040. Given the GDP and population assumptions, GDP per capita in China is assumed to increase from around US$3.61 thousand per capita (in 2005 US$ terms) in 2013 to US$12.4 thousand per capita (in 2005 US$ terms) in 2040.

2.2. Energy and Climate Change Policies and Their Performance

Although China is still a developing country and GDP per capita was around one-seventh that of the United States (according to nominal exchange rate) in 2015, the government has set ambitious goals for energy intensity reduction and addressing climate change issues. According to the data from the 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 12th Five-Year Plan (2012–2015) for National Economic and Social Development stipulated that by 2015 energy consumption per unit of GDP would drop by 16 percent from 2010. To achieve this goal, the government implemented administrative measures, market-based measures, and legal measures to promote energy conservation. Energy intensity reduction goals were assigned to provincial governments and progress made was announced publicly every year. During the past five years (2011–2015), energy consumption grew at a rate of 3.6 percent and GDP increased at a rate of 7.8 percent. It resulted in a reduction of energy intensity of by 18.2 percent during the 5-year period, which achieves the target of 16 percent. Specifically, energy consumption per unit of GDP in 2015 decreased by 5.6 percent compared with 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 supply) would be controlled at an upper limit of 2,940 million tons of oil equivalent (Mtoe) in 2020 and the primary energy supply will be capped at 3,362 Mtoe in 2020. According to the 13th Five-Year Plan of Energy Development, which has not been issued officially, by 2020, the ratio of coal consumption to total energy consumption should be lowered to at most 60 percent and natural gas consumption should account for 10 percent of the total amount. In addition, the amount of new energy vehicles will reach 2 million.

China announced its goal of reducing carbon dioxide (CO_2) emissions per unit of GDP (carbon intensity) by 40–45 percent by 2020 and by 60–65 percent by 2030 from the 2005 level. Apart from the carbon intensity target, China also declared that CO_2 emissions will peak 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 (GhG) emissions. In 2014, China's CO_2 emissions per unit of GDP dropped by 9.1 percent compared with the 2013 level.

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

After the evaluation in 2015, China phased out backward production capacity in the following industries: small thermal power units, 4.23 GW; cement, 50 million tons; and steel, 30 million tons. To reduce the surplus production capacity, from 2016, no new coal mine projects are to be approved for 3 years, and crude steel production capacity will be reduced by 100–150 million tons in 5 years.

In our 2015 scenario analyses, we have established five APS scenarios, APS1–5, and they are as follows: APS1 – energy efficiency and conservation (EEC) in final consumption sectors; APS2 – EEC in thermal efficiency in coal, oil, and gas fired power generations; APS3 – increase of hydro, geothermal, and non-renewable energy (NRE); APS4 – increase of nuclear; and APS5 – implement all of these

scenarios, i.e. APS1 to APS4. If not specified otherwise, all results we present in this chapter under APS refer to APS5.

3. Outlook Results

3.1. Final Energy Consumption

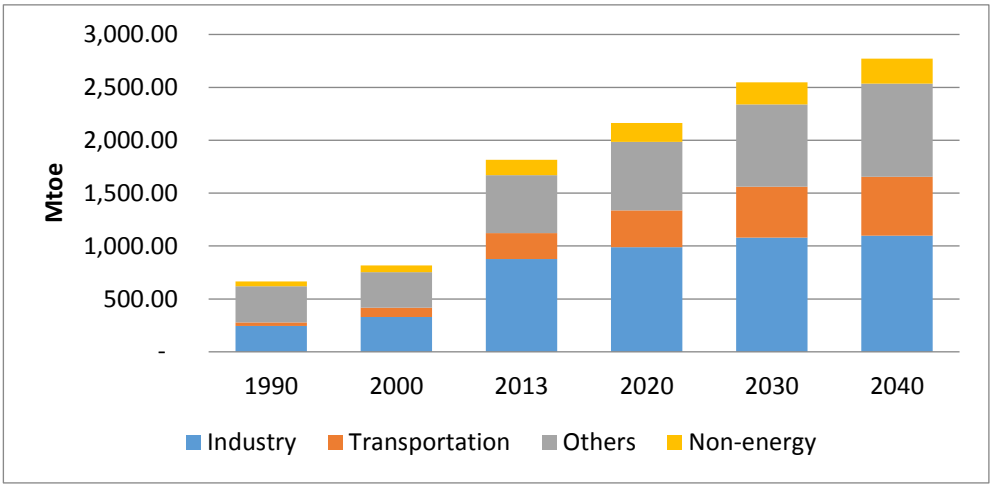
Between 2013 and 2040, growth in China's final energy consumption is projected to be slow, reflecting lower economic and population growth assumptions.

Business-as-Usual (BAU) Scenario

Final energy consumption is projected to increase at an average annual rate of 1.6 percent between 2013 and 2040. Transportation sector consumption is projected to grow the fastest, increasing by 3.1 percent a year, followed by the non-energy sector with 1.9 percent. Energy consumption in the industry sector is projected to grow at an average annual rate of 0.8 percent. Figure 5-1 shows China's final energy consumption by sector under the BAU.

Among energy sources, natural gas consumption in the BAU, which is projected to show the fastest growth, increases by 4.7 percent per year, from 93.79 Mtoe in 2013 to 325.73 Mtoe in 2040. Though coal will continue to account for a major portion of final energy consumption, it is projected to decrease by 0.5 percent per year, arriving at 528.24 Mtoe in 2040, compared with the increase of 2.8 percent per year over the last 2 decades.

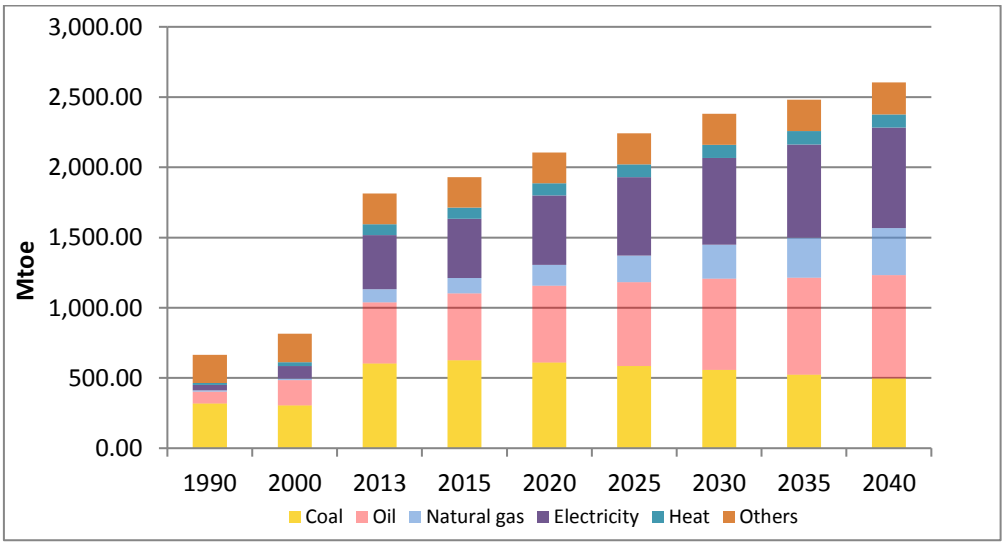
Figure 5-1. Final Energy Consumption by Sector, BAU



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

Consumption of electricity and heat are projected to increase at an average annual rate of 2.6 percent and 1.1 percent, respectively, over the same period, achieving 774.48 Mtoe and 101.24 Mtoe in 2040. Oil is projected to grow by 2.4 percent annually to around 815.86 Mtoe in 2040. Figure 5-2 shows China's final energy consumption by fuel under the BAU.

Figure 5-2. Final Energy Consumption by Fuel, BAU

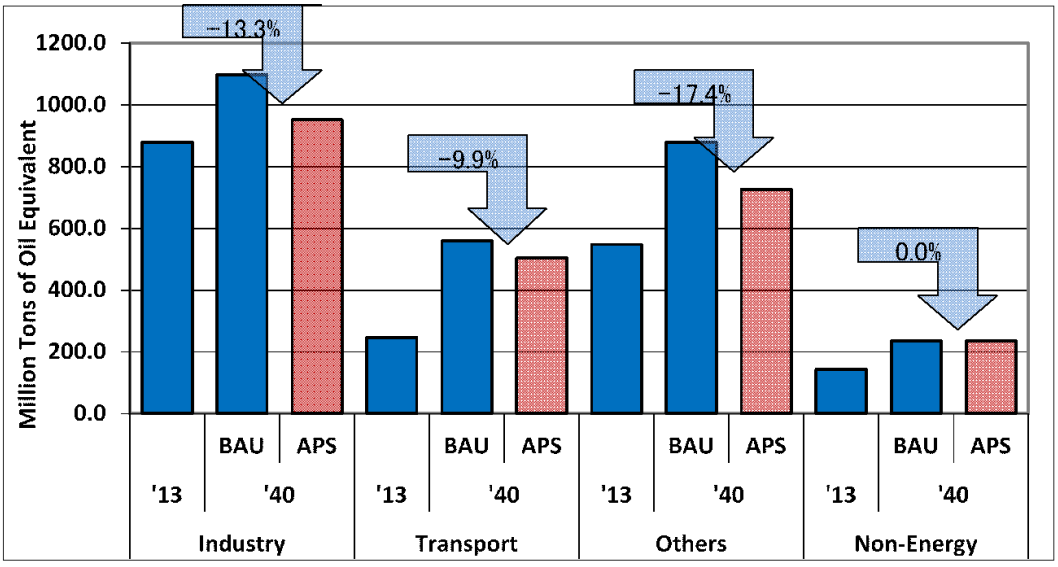


BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

Alternative Policy Scenario (APS)

In the APS scenario, final energy consumption is projected to increase by 1.1 percent per year, from 1814.06 Mtoe in 2013 to 2416.64 Mtoe in 2040, as a result of EEC programmes. An improvement in end-use technologies and the introduction of energy management systems is expected to contribute to slower energy growth in all sectors, particularly in the commercial, residential, and transportation sectors. Figure 5-3 shows the final energy consumption in China in 2013 and 2040 in both the BAU and the APS.

Figure 5-3. Final Energy Consumption, BAU and APS



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Authors' calculation.

3.2. Primary Energy Supply Consumption

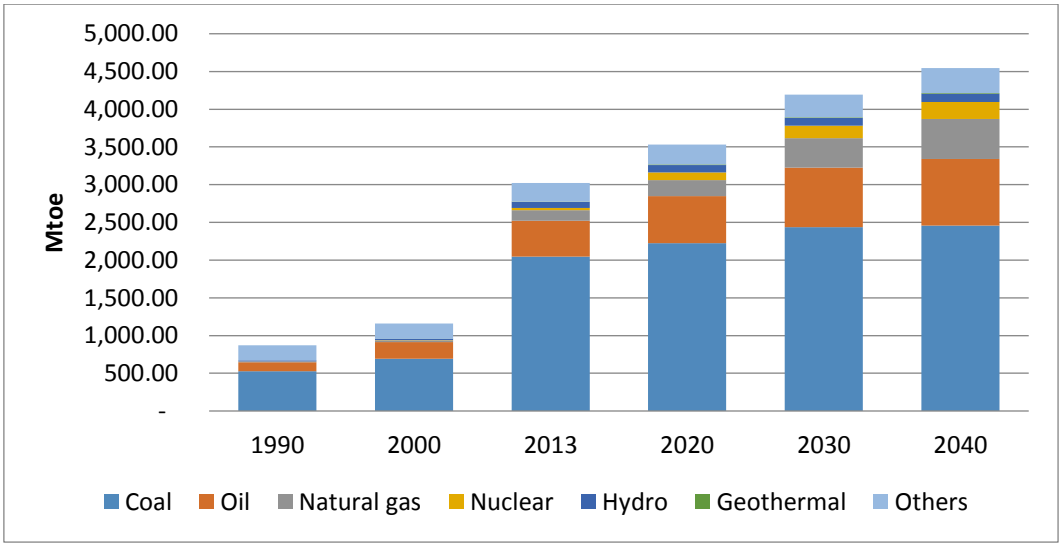
Primary energy supply in China is projected to grow at a slower pace than in the past years. Growth in primary energy supply/consumption is expected to be slightly slower than final energy consumption because of improved efficiency in the energy transformation sector.

Business-as-Usual Scenario

In the BAU, China's primary energy supply is projected to increase at an annual average rate of 1.5 percent per year to 4,544.85 Mtoe in 2040. Coal will still constitute the largest share in total primary energy, but its growth is expected to be slower, increasing by 0.7 percent a year. Consequently, the share of coal in total primary energy is projected to decline from 67.7 percent in 2013 to 54.1 percent in 2040.

Nuclear energy is projected to exhibit the fastest growth between 2013 and 2040, increasing at an annual average rate of 7.8 percent, followed by natural gas at 5.1 percent. Oil and hydro are projected to grow at lower rates of 2.3 and 1.2 percent per year, respectively. The share of natural gas is projected to increase from 4.6 percent in 2013 to 11.8 percent in 2040, whereas the share of nuclear will increase from 1.0 percent to 4.9 percent. The share of oil is projected to increase from 15.8 percent in 2013 to 19.4 percent in 2040 and hydro is projected to slightly decrease from 2.6 percent in 2013 to 2.4 percent in 2040. Figure 5-4 shows China's primary energy supply by energy under BAU.

Figure 5-4. Primary Energy Supply by Energy, BAU

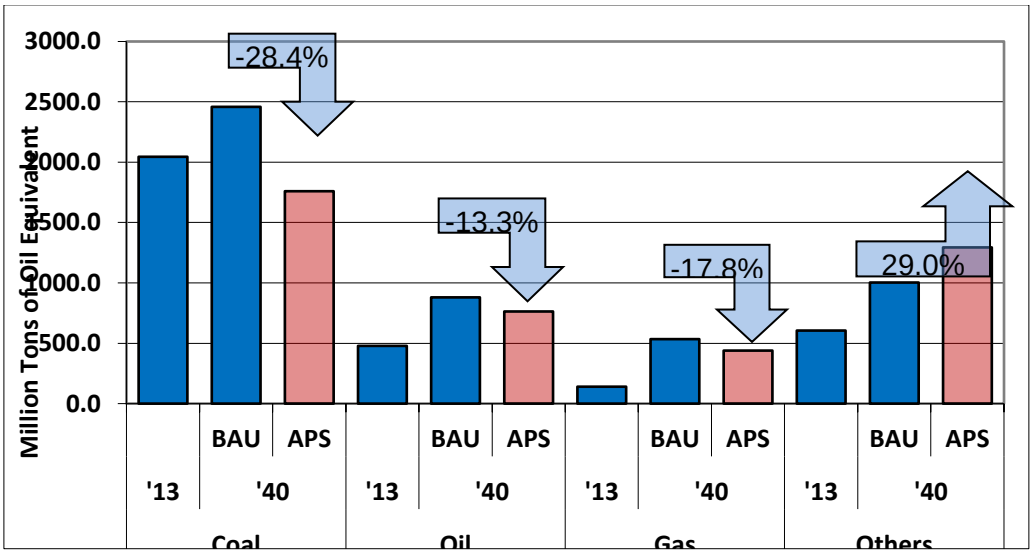


BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

Alternative Policy Scenario

In the APS, primary energy supply is projected to increase by 0.9 percent per year between 2013 and 2040. By 2040, primary energy supply is projected to have reached 3,810.28 Mtoe. The growth in primary energy supply is projected to be slower under the APS than the BAU (Figure 5-5). Coal is projected to decrease by 0.6 percent a year, oil will increase by 1.7 percent a year, and natural gas will grow by 4.3 percent a year. For nuclear, the annual average growth rate will be higher than the BAU, increasing by 9.7 percent a year between 2013 and 2040. The growth rate of hydro in the APS is expected to be higher than the BAU, increasing by 1.7 percent per year. The consumption mitigation in the APS is achieved through EEC measures on the demand side.

Figure 5-5. Primary Energy Supply by Source, BAU and APS



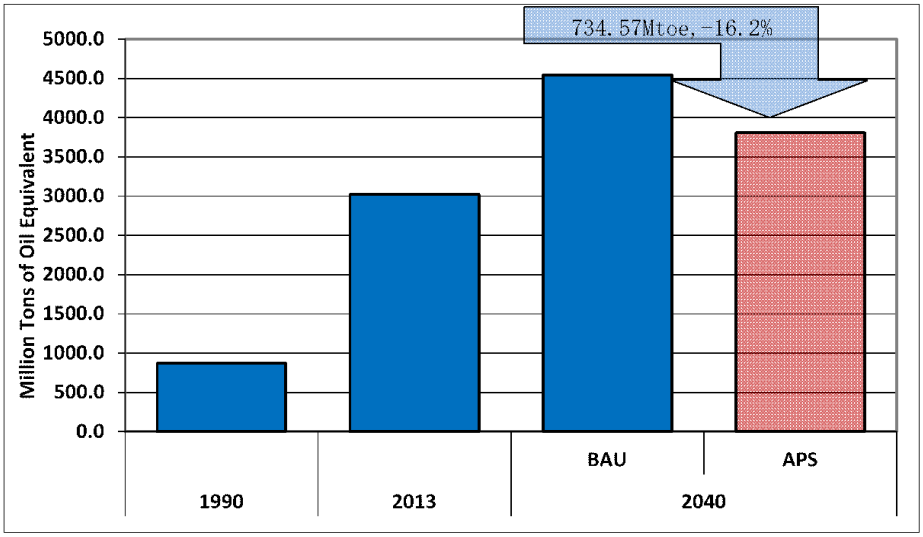
BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Authors' calculation.

3.3. Projected Energy Savings

It is estimated that the implementation of EEC goals and action plans in China could reduce primary energy supply/consumption in 2040 by about 734.6 Mtoe under the APS, relative to the BAU. In the APS, China's primary energy supply/consumption is around 16.2 percent lower than in the BAU (Figure 5-6).

In terms of final energy consumption, there is an estimated saving of 146.2 Mtoe in the industry sector, 55.2 Mtoe in the transportation sector, and 152.8 Mtoe in the 'others' sector in 2040 under the APS, relative to the BAU.

Figure 5-6. Primary Energy Supply, BAU and APS



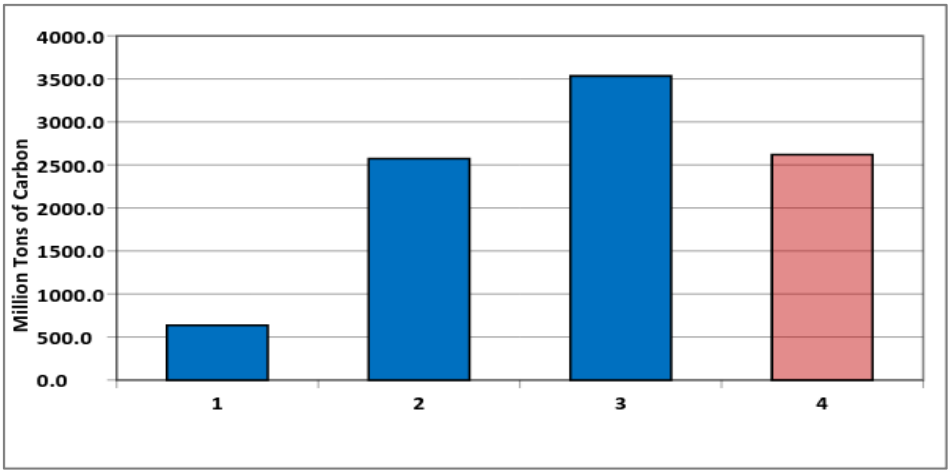
BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

3.4. CO_2 Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase by 1.2 percent per year from 2573.7 Mt-C in 2013 to 3533.5 Mt-C in 2040 under the BAU. This percentage increase is lower than that in primary energy supply (1.5 percent) over the same period, indicating an improvement in the emissions intensity of the China's economy.

In the APS, the annual increase in CO_2 emissions between 2013 and 2040 is projected to be 0.1 percent. 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 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 Emission from Energy Consumption, BAU and APS



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

3.5. Power Generation

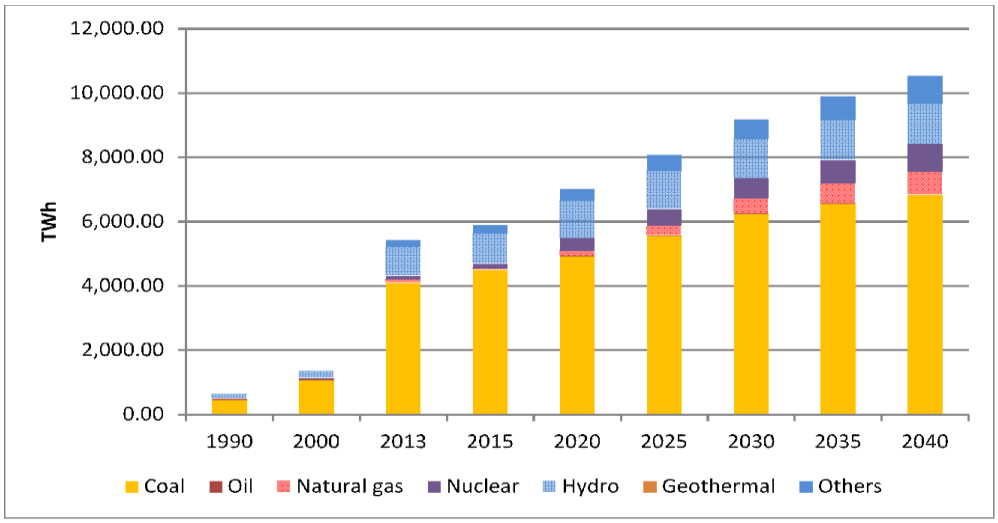
Power generation in China is projected to grow more slowly between 2013 and 2040 than in the last 2 decades.

Business-as-Usual Scenario (BAU)

In this scenario, power generation in China is projected to grow at a slower pace, by 2.5 percent per year from 5,422.16 TWh in 2013 to 10,535.51 TWh in 2040 (Figure 5-8).

The share of coal power under BAU is projected to see a decreasing trend from 75.4 percent in 2013 to 64.7 percent in 2040. Conversely, the share of natural gas and nuclear are both projected to grow, because of their cleanness compared with coal in particular, from 1.8 percent and 2.1 percent in 2013 to 6.9 percent and 8.1 percent in 2040, respectively. The share of oil is projected to decrease slightly. Other methods of power generation are projected to see their shares increasing. The fast development of photovoltaic power generation in China is a typical example reflecting China's clean power generation tendency. China's thermal efficiency by fuel under BAU is projected to increase between 2013 and 2040, as can be seen in Figure 5-9.

Figure 5-8. Power Generation, BAU

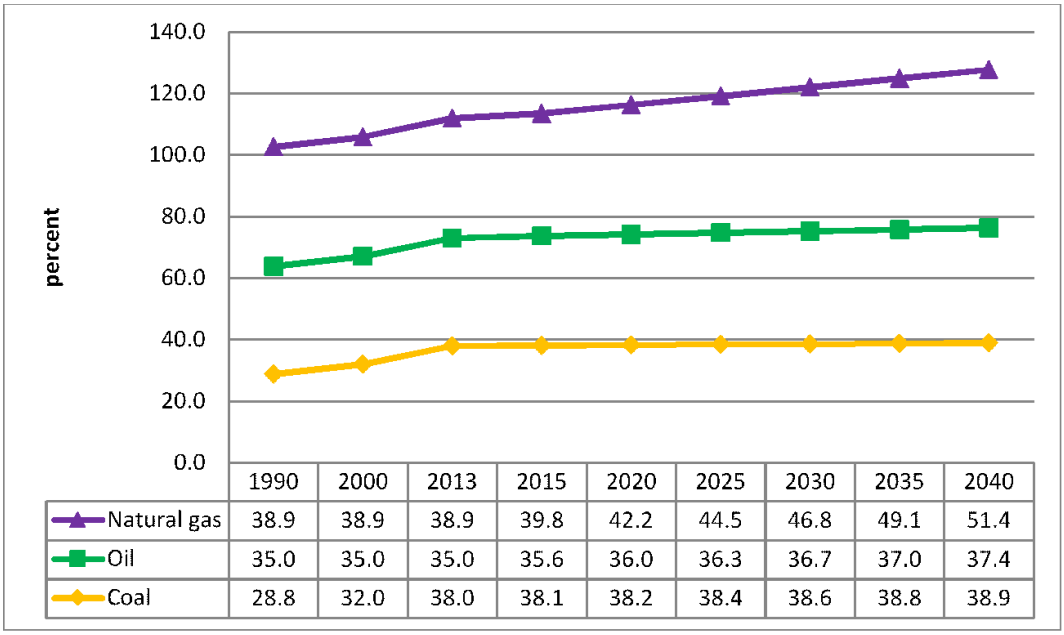


BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; TWh = terawatt-hour.
Source: Authors' calculation.

Alternative Policy Scenario (APS)

In APS, total power generation increases by 1.9 percent per year between 2013 and 2040. By 2040, total power generation output is projected to reach 8,895.01 TWh. Except for coal-fired power, oil power, and natural gas power, the annual growth rate per year between 2013 and 2040 of all other fuel power under APS are projected to grow faster than in BAU. In 2040, nuclear power, hydropower, geothermal power, and 'others' are projected to increase under APS by 9.7 percent, 1.7 percent, 6.1 percent, and 6.8 percent between 2013 and 2040, respectively.

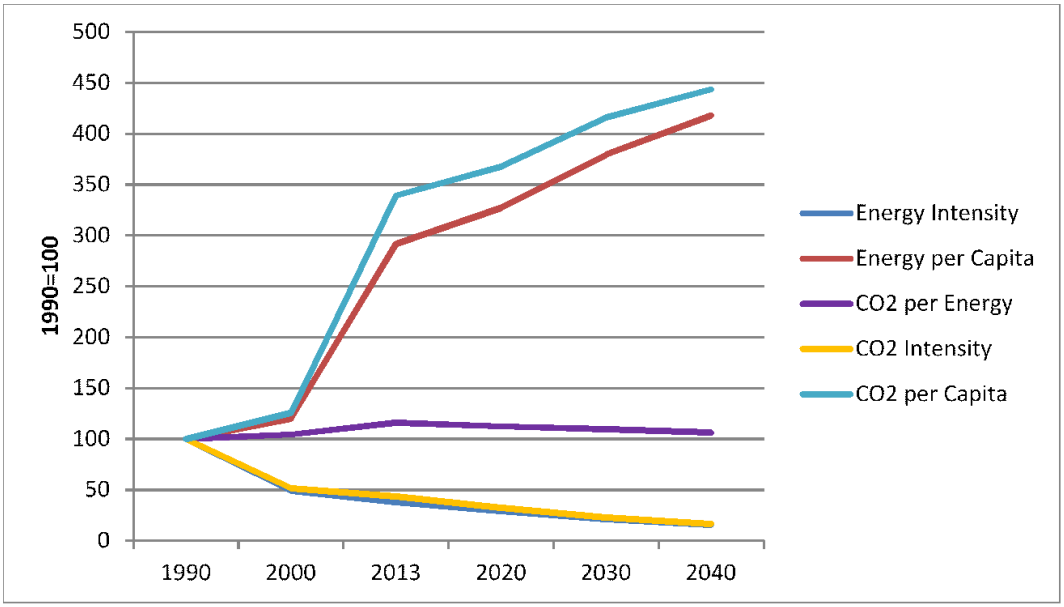
Figure 5-9. Thermal Efficiency by Fuel, BAU



	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 scenario.
Source: Authors' calculation.

Figure 5-10. Energy Indicators, BAU



BAU = Business-as-Usual scenario; CO_2 = carbon dioxide.
Source: Authors' calculation.

3.6. Energy Intensity

According to the assumed economic and population data along with the projected energy information of China, energy intensity (defined as primary energy supply over GDP) and energy per capita are presented in Figure 5-10 along with other vital energy indicators under the BAU. From 1990 to 2013, it shows that China's energy intensity saw a remarkable drop as a result of efforts on energy efficiency. In 2040, energy intensity in China is projected to drop to around 257 toe per million US dollars (in 2005 US$ terms). With the improvement of living standards in China, energy per capita under the BAU is projected to reach 3.18 toe per person in 2040. Compared with energy intensity in the BAU, energy intensity in the APS is projected to show a more rapidly decreasing rate of 3.8 percent from 2013 to 2040.

4. Implications and Policy Recommendations

Since China is the world's largest developing country, eliminating poverty and improving the quality of life have always been of paramount importance. In recent years, China has witnessed fast growth in its economy, but the urbanisation rate is still low, reaching 56.1 percent in 2015. On the other hand, China is the world's biggest energy consumer and CO_2 emitter, so it is also faced with great pressure on energy saving and CO_2 reductions. In the past 3 decades, China has made great efforts and set ambitious targets on energy conservation and climate change mitigation. During the 2014 Asia–Pacific Economic Cooperation (APEC) summit, China and the United States made a Joint Announcement on Climate Change, according to which China vowed to achieve a peak of CO_2 emission and increase the share of non-fossil fuels in primary energy supply to around 20 percent by 2030. In April 2016, China signed the Paris Agreement, in which the above commitments are included along with a commitment by China to cut carbon emissions per unit of GDP by 60–65 percent by 2030 from 2005 levels.

As China's GDP will keep growing fast, albeit at a slower pace compared with the last 20 years, its energy demand and CO_2 emissions will increase accordingly in the foreseeable future. But energy intensity (energy demand per unit of GDP) and

emission intensity (CO_2 emission per unit of GDP) are required to decrease for China to be able to meet its targets. According to the model results, if sound EEC policies could be implemented, China could reduce its total primary energy supply by around 16.2 percent and CO_2 emissions by about 25.9 percent by 2040.

Coal consumption has decreased since 2014 and it decreased by 3.7 percent in 2015. It is projected that coal consumption can be cut by 28.4 percent in the APS compared with the BAU. To improve urban air quality, Chinese metropolises, such as Beijing and Shanghai, have shown great ambition in controlling the use of coal, so the relatively low growth rate of coal consumption may persist in the coming years. Therefore, development of clean and low-carbon energies will be encouraged, especially renewable energy and nuclear energy in the power generation sector. To realise the optimisation of the energy structure, policies such as energy taxes and carbon taxes that will limit the energy-intensive and pollution-intensive industries should be carried out. And more market-based measures, for instance, electricity market reform, energy pricing reform, and the green certificate trade, are needed to make energy more market-oriented and motivate more enterprises to take actions.

Energy efficiency improvement in the final consumption sectors (APS1) has the largest potential to reduce CO_2 emissions. Of the final consumption sectors, the industry sector has the potential to reduce energy consumption by 13.3 percent based on the results. Measures such as the closure of small and inefficient power plants, coalmines, and small energy-intensive plants in industries like cement and steel, and stricter approval requirements for energy-intensive industries need to be implemented. And a change in industrial structure – from heavy to light industries and from industry to services – is also needed. Moreover, considering the fact that China has entered the 'new normal,' in which its economic growth rate will be only moderately high, and the GDP of the tertiary sector accounts for half of the total amount, in the long run it will be more important to enhance energy efficiency in the residential, commercial, and transportation sectors for energy saving and CO_2 reduction.