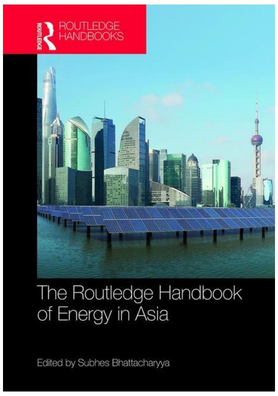

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REVIEW OF THE OVERALL ENERGY SITUATION IN CHINA

Ming Su and Songli Zhu

Introduction

China, as one of the biggest countries in the world, has been increasingly influential in global energy issues. In terms of population, China, being the most populous nation in the world, had 1371.22 million persons by mid- 2015, accounting for 18.66% of the world's total. The country's Gross Domestic Product (GDP) on the basis of exchange rate stood at 10866.44 billion USDs at the end of 2015, accounting for 14.8% of the global GDP and ranking the second in the world since 2010. On the basis of purchasing power parity (PPP), the share of China's GDP increased to 15.8% in the same year, still ranking the second, but with a narrowed gap compared to the US.[1] The country is urbanizing rapidly, leading to a large rural-to-urban migration and half of the population currently lives in cities. Because more than 75% of the Chinese population is expected to reside in cities within the next 20 years, the establishment of new cities and extension of the existing ones is expected to continue (He et al., 2016). The "opening and reforming" polices, initialized at the beginning of the 1980s and deepened more in recent years, have prompted China to actively participate in the globalization process, taking an important role in the field of economy, trade and energy development.

This chapter presents an overview of the energy situation in China, particularly focusing on the recent period starting from 2000 onwards. First, energy production is briefly presented, followed by discussions on energy consumption, energy mix, energy conversion, end-use profile, the energy–economy relationship and finally environmental issues.

Overall picture of energy production

China is generally rich in energy sources, particularly coal, but has relatively limited oil and gas reserves. The basic energy production profile is decided by the resource endowment to a great extent.

Since 2000, the production of energy has expanded rapidly in response to China's fast-growing economy. Between 2000 and 2015, primary energy production grew from 1390 million tons coal equivalent (Mtce) to 3620 Mtce,[2] increasing by 6.6% annually (see Figure 3.1). The annual growth rate between 2002 and 2005 was over 10%, and it was nearly 10% between 2009 and 2011. Nevertheless, a constrained energy supply was still observed during these two periods. In other

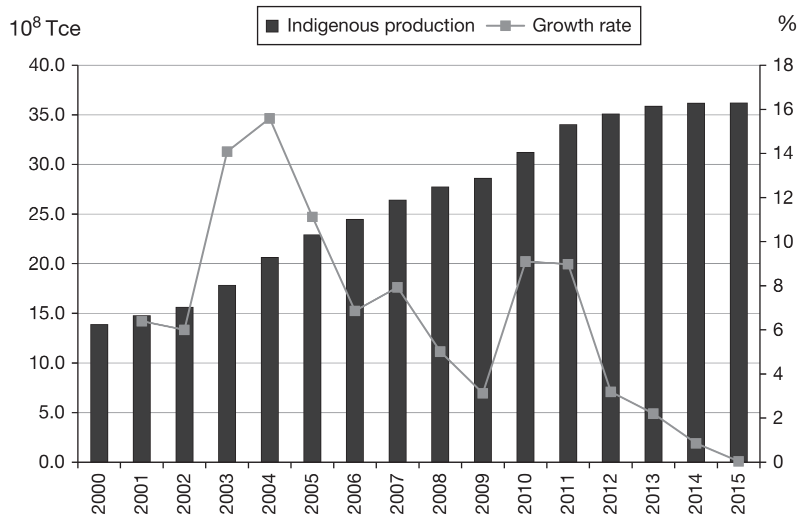

Figure 3.1 Energy production in China in 2000–2015

Data source: Authors.

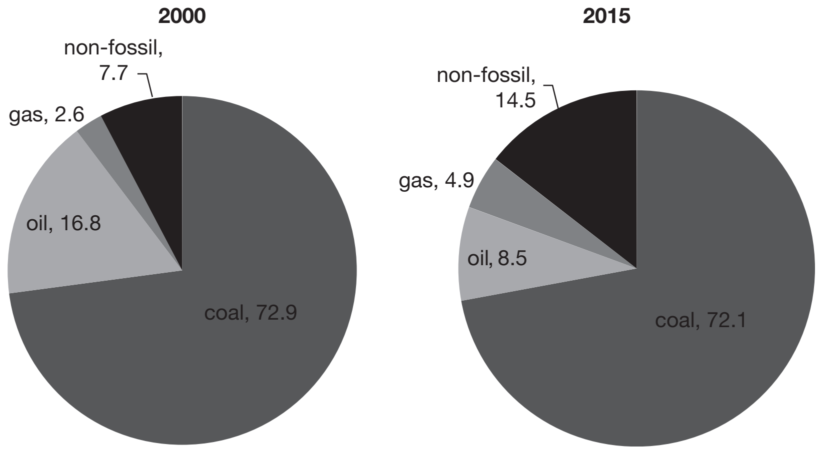

Figure 3.2 China's energy mix in 2000 and 2015

Data source: Authors.

years, the annual growth rate of energy supply was lower than 8%, with the rate being as low as 1% during the period 2013–2015, growing only marginally.

Coal is the most important primary energy product, sharing over 70% of the overall production. In physical terms, coal production increased from 1380 million tons (Mt) in 2000 to almost 4000 Mt in 2013 (half of the world production), slightly decreasing in 2014 and 2015. Crude oil production has been maintained at 200 Mt since 2000, accounting for 8.5% of overall production in 2015. Fast growth has been observed in natural gas production, from 27.2 billion cubic meters (m^3) in 2000 to 124.4 billion m^3 in 2015, increasing at an average rate of 10.7% annually. Consequently, the share of gas in the energy supply grew from 2.6% to 4.9% (see Figure 3.2). The production scale of non-fossil fuel (hydro, wind, solar and nuclear) rose dramatically, from 107 Mtce and 7.7% in 2000 to 525 Mtce and 14.5% in 2015.

Overall picture of energy consumption

The total energy consumption of China grew fast and steadily during the period of 2000–2015, increasing from 1469 Mtce to 4300 Mtce by an average growth rate of 7.4% per year. Up to 2015, as the biggest energy consumer in the world, China shared 20% of the world total; energy consumption per head amounted to 3.1tce, catching up and surpassing the world average which is around 2.6 tce.

China had two notably different phases from 2000 in its energy consumption trend: 2003–2011 and 2012–2015. In the former phase, the annual average of growth rate (AAGR) amounted to 8.6% with the higher-end at nearly 17% in 2003–2004, as shown in Figure 3.3. This meteoric growth meant, on average, over 240 Mtce was stocked onto the level in the previous year during this period (even 300 Mtce in particular years), which is almost the total energy demand in UK. In contrast, the latter phase saw the rate dropping to an average of 2.7% per year and further decline is expected. The preliminary data for 2015 shows the energy consumption almost stayed flat, growing by 0.9% compared with 2014 (NBS, 2016).

Unbalanced regional development and consequent energy consumption is observed across China. The eastern area, which produces the majority of the GDP, has consumed around 50% of the total energy since 2000. Nevertheless, the growth rate of energy consumption in this area decreased significantly in recent years, and its share fell to 46.8% in 2014 (see Figure 3.4). In contrast, energy consumption in the western area moved upwards, owing to the "Go West" Program initiated in 2000, from 22.6% in 2000 to 27.1% in 2014. The middle region of China kept stable with a slight down trend. Regarding energy density (i.e. energy consumption per square kilometer (km^2)), the eastern area consumes the highest amount, 1942tce/km^2,

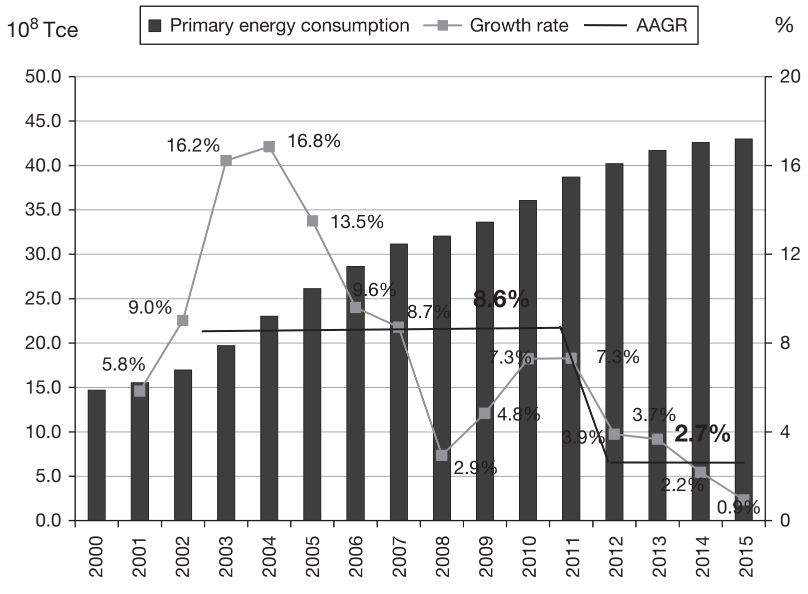

Figure 3.3 China's energy consumption and growth rate trend in 2000–2015

Data source: Authors.

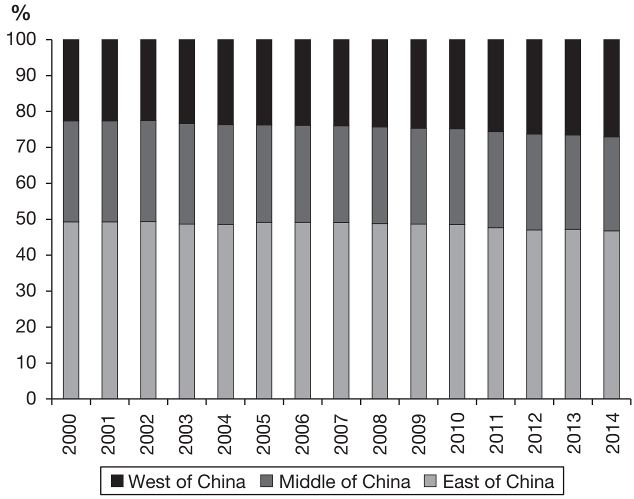

Figure 3.4 Share of energy consumption by regions

Data source: Authors.

Note: Eastern area includes: Beijing (BJ), Tianjin (TJ), Hebei (HB), Liaoning (LN), Shanghai (SH), Jiangxu (JX), Zhejiang (ZJ), Fujian (FJ), Shandong (SD), Guangdong (GD) and Hainan (HN); Middle area includes: Shanxi (SX), Jilin (JL), HeilongJiang (HLJ), Anhui (AH), Jiangxi (JX), Henan (HN), Hubei (HB) and Hunan (HN); Western area includes: Sichuan (SH), Chongqing (CQ), GuiZhou (GZ), Yunan (YN), Tibet (XZ), Shaanxi (SAX), Ganxu (GS), Qinghai (QH), Nixiang (NX), XiJiang (XJ), Guangxi (GX) and Inner Mongolia (NMG).

followed by the middle region (688tce/km^2); whereas the western area, because of its vast land space, has the lowest value, 173tce/km^2, less than one tenth of the eastern area.

An enlarged demand and supply gap has resulted as China's energy demand has grown faster than energy production. China has had to increase its energy imports continuously. In 2000, the total energy import was 50 Mtce and the rate of external dependence was only 3.4%. By 2015, the total net import had exceeded 700 Mtce and the external dependence rate surpassed 16.0%. Of that total, the net import of oil rose from 76 Mt in 2000 to 340 Mt in 2015, and the external dependence rate soared to 63.5%. China began to import natural gas from 2006, and in 2015, the net import had increased to 58 billion m^3, with an external dependence rate of 32.0%. Besides vast domestic production, China's coal imports also increased dramatically. It started importing coal from 2009 and in 2015 increased the amount to over 200 Mt.

Trend of energy mix

Because of high domestic availability, China's energy mix is dominated by coal. In general, coal met over 70% of the energy demand until recently. As early as the 1990s, policies for optimizing energy mix were formulated to reduce the over-dependence on coal and to promote the contribution of oil and gas. In the new century, a specific target on non-fossil fuel (15% up to 2020) was officially announced in 2009, followed by the long-term target (20% up to 2030) set in 2014. Nevertheless, the leading position of coal remains unchanged so far. During the time period of 2000–2013, coal consumption grew from 1360 Mt to 4250 Mt, climbing to an unprecedented average of 9.2% per year. The consequence is that the share of coal in the energy mix continued to grow in the first ten years of the new century.

Fortunately, driven by technological progress in non-fossil fuels and an aggressive policy push, the terrible trend was turned around gradually after 2010 (Wang and Yang, 2015; Wang and Liu, 2014; Price et al., 2011). The installed capacity of hydro power was increased to 320GW and its electricity production amounted to 1.1 TWh by the end of 2015. China's wind energy capacity continuously ranks first in the world in terms of both newly installed and accumulated capacity which reached 130GW by 2015. The highest growth was observed in solar photovoltaic (PV) systems whose capacity was 43GW in 2015, compared with 19MW in 2000. Figure 3.5 shows synchronous growth of wind and solar power in China and the world.

Nuclear is also an important alternative option and its capacity was over 26GW in 2015. By the end of 2015, the overall share of non-fossil fuels in the energy mix increased to 12.0% (see Figure 3.6), whereas it was just 7.3% in 2000. Regarding power generation, electricity generated from renewable energy (RE) accounted for 23.9% of the 2015 total compared to 16.6% in 2000 (NSB, 2016). Meanwhile, the scale of natural gas is expanding. As mentioned before, the domestic production of natural gas amounted to 124.4 billion m^3, increasing by an average of 10 billion m^3

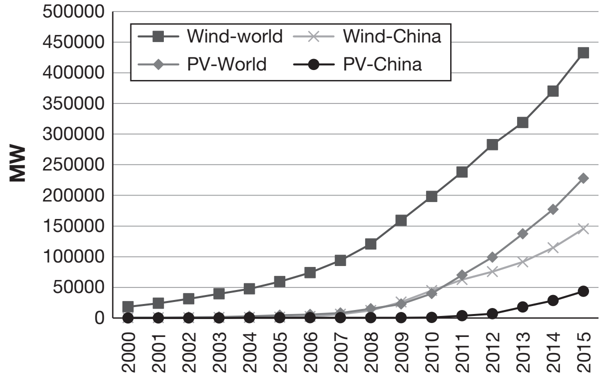

Figure 3.5 Development of wind and solar power in China and the world

Data source: Authors.

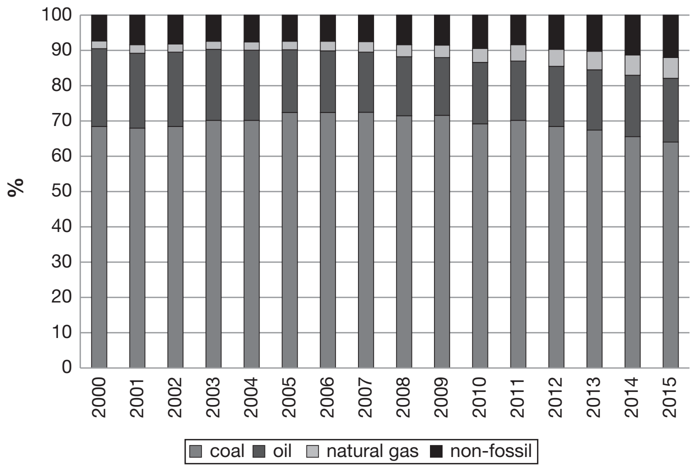

Figure 3.6 Trend of energy mix in China 2000–2015

Data source: Authors.

per year from 2000. Along with the completion of the Central Asia–China gas pipeline, the China–Myanmar pipeline and a series of LNG stations in the south-east coastal area, 58 billion m^3 was imported in 2014 and more in 2015. All these contributed to the noticeable promotion of natural gas in primary energy consumption, measuring 5.9% in 2015 against 2.2% in 2000. In the year of 2013–2014 coal consumption in physical units dropped 2.9%, and dropped a further 3.7% in 2014–2015, hailed as an historic event after China's meteoric growth in the 2000s (Green and Stern, 2015).

Fossil energy conversion and processing activities

Since this century, China's energy conversion and processing, including thermal power, centralized heating, coking and oil refining, witnessed a rapid growth. The input of thermal power energy rose from 422 Mtce in 2000 to 1,320 Mtce in 2014, up 8.5% year on year. Along with the installation of a large number of efficient coal-fired units and closure of small ones, the power generating efficiency rose constantly from 32.4% in 2000 to 39.8% in 2014. The input in centralized heating grew from 72 Mtce in 2000 to 178 Mtce in 2014, up 6.7% year on year, with heating efficiency around 70%; coking input rose from 139 Mtce in 2000 to 554 Mtce in 2014, mainly driven by the dramatic development of the iron and steel industry, up 10.4% year-on-year, with coking efficiency around 96.5%; oil refining output rose from 290 Mtce in 2000 to 722 Mtce in 2014, up 6.7% year on year, with refining efficiency about 97%.

Energy end-use profile

In this century, with the continuous and swift development of the economy and the upgrading of living standards, China's final energy use grew quickly, from 1,062 Mtce in 2000 to 3,139 Mtce in 2014, with an average annual growth rate of 8.05% (see Figure 3.7).[3] Manufacturing's share of final energy use was still close to 70% in 2014, with both transportation and residential sharing almost 11%, respectively. The fastest growth rate was observed in the commercial and transportation sector during 2000–2014, up to 8.85% and 8.93% per year, respectively.

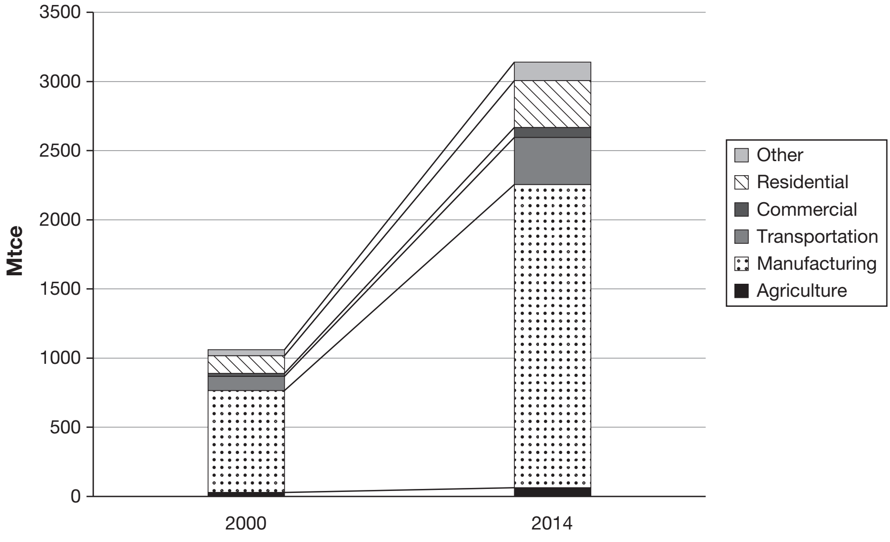

Figure 3.7 China's energy end-use by sector in 2000 and 2014

Data source: Authors.

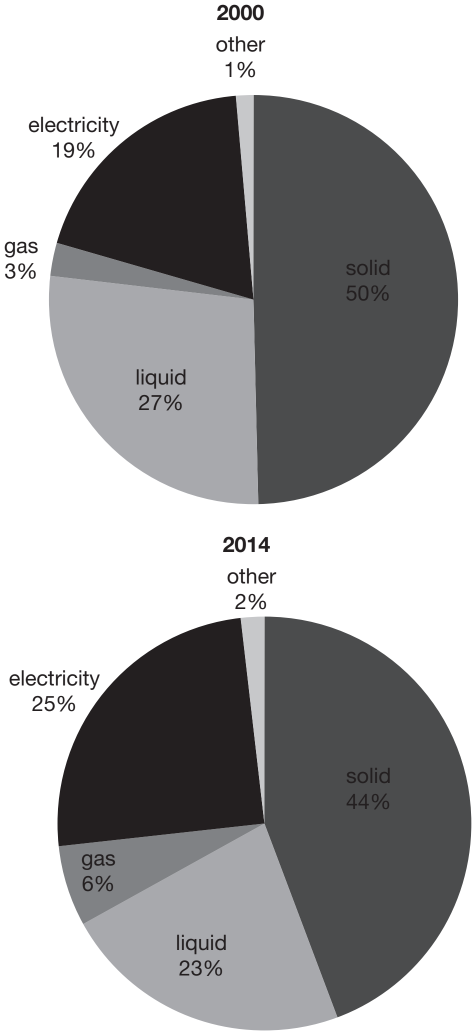

Figure 3.8 Mix of final energy use in 2000 and 2014

Data source: Authors.

Regarding the fuel mix of final energy use, from 2000 to 2014, coal-related products were always leading, but its proportion declined constantly from 49.6% to 44.3%; petroleum products also experienced a substantial decline from 27.2% to 22.7% (see Figure 3.8). At the same time, the consumption of electricity increased continuously, from 19.1% to 24.9%, about 5% up; consumption of natural gas grew rapidly from 2.6% to 6.3%, rising about 4%. The share of other energy sources (commercialized biomass, waste incineration for energy purpose) was relatively stable at about 1.5%.

Relationship between energy development and economic growth

Energy intensity (energy use per GDP) and energy elasticity (the ratio between annual growth rate of energy consumption and that of GDP) are two commonly used parameters to show the relationship between energy and economic growth.

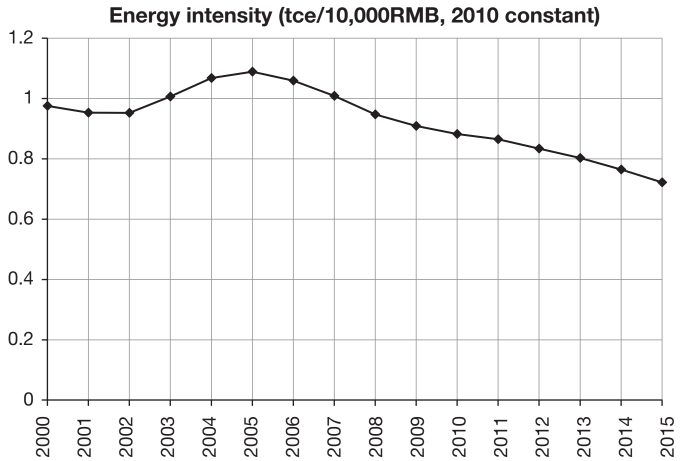

Figure 3.9 Trend of energy intensity since 2000 in China

Data source: Authors.

Between 1970 and 2001, China was able to limit energy demand growth to less than half of its GDP. Energy use per GDP has declined by approximately 5% per year during the period (Zhou et al., 2010). However, the period of 2001–2005 saw a dramatic reversal of the historic relationship between energy use and GDP growth, for the sake of the accelerated evolution of industrialization and urbanization. Energy use per unit of GDP increased by an average of 3.8% per year between 2002 and 2005 (see Figure 3.9).

The global impact of this dramatic increase is significant. By 2006, nearly 50% of global energy demand growth was due to growth in China (Zhou et al., 2010). In recognition of the unsustainable pace of energy demand growth and its associated adverse consequences, stringent energy conservation and emission reduction policies and measures (PAMs) were initiated in November 2005 and implemented progressively in the Eleventh five-year plan (FYP, 2006–2010) and the Twelfth FYP (2011–2015). The effectiveness of these policies was significant, as energy use per GDP dropped 19.1% after the Eleventh FYP and further dropped 18.2% after the Twelfth FYP. Specifically, it dropped from 1.089 tce/10000RMB in 2005 to 0.722 tce/10000RMB in 2015 (in 2010 constant price).

Nevertheless, based on the exchange rate in 2015, China's energy intensity was almost 55% higher than the world average, nearly 2.2 times that of the USA, over 2.5 times that of Japan, and even higher than other emerging economies such as Brazil. Particularly, the energy efficiency of major energy-intensive industrial products was 15–40% lower than the advanced level in the world (Jiang et al., 2014). Expressed in an alternative way, China's GDP is about 60.5% of USA in 2015 (in terms of exchange rate), whereas energy consumption is 30% higher. Compared also with Japan, China's GDP is 2.6 times bigger, but its energy consumption is 6.5 times higher than that of Japan. In the global context, China shares 14.5% of GDP output, but consumes 23% of global energy demand.[4]

A similar trend was also observed in terms of energy elasticity which climbed from 2000 until 2005, and then declined (Figure 3.10). In 2003 and 2004, the parameter was as high as an unprecedented 1.6. A difference was observed during the international financial crisis in 2008, when the parameter decreased to about 0.3, yet soon rebounded after strong investment from the central government to stimulate the economy. Along with the emergence of the "new norm"

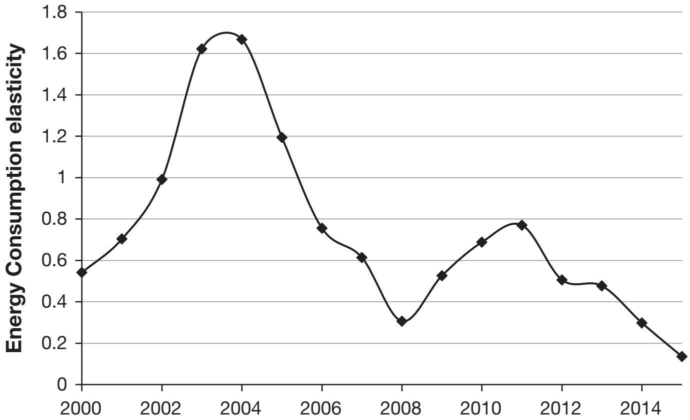

Figure 3.10 Trend of energy elasticity since 2000

Data source: Authors.

status of economic development since 2011(Green and Stern, 2015), energy elasticity declined once again, to around 0.3 in 2014, and even lower than 0.2 in 2015.

Similar to the general trend of the country, regional energy intensity from 2000 to 2005 increased by a different scale, and began to decrease, pushed by the rigorous energy-saving policies since 2006. Compared to the level in 2000, energy intensity in the eastern, middle and western areas of China dropped in 2014 by 40.4%, 41.2% and 30.4%, respectively. In terms of physical units, 2014 energy intensity in these areas was 0.578tce/10000RMB, 0.737tce/10000RMB and 0.945tce/10000RMB, respectively. The major reason for the rebounding of energy intensity and large energy elasticity observed at the beginning of the new century was the fast growth of heavy industries during the industrialization process, and the export of industrial products on a larger scale after China joined the WTO in 2002 (Yang et al., 2014). Meanwhile, the inferior energy efficiency in China's manufacturing industries was very relevant to the rapid expansion of energy demand. Along with the basic completion of industrialization and urbanization, the energy elasticity dropped back to around 0.5 and even lower, indicating a more healthy relationship between energy and economic growth. The overall trend was consistent with that of other major developed countries at a similar evolutionary stage.

The environmental issues related to energy development

The large and fast growing energy industry in China has caused significant environmental degradation, including land subsidence, water intrusion and, particularly, air pollution. By the end of 2014, the area of land subsided, destroyed or occupied by coal-mining and related activities amounted to over one million hectares, and the area suffering from severe water and soil erosion caused by coal-mining has amounted to over 200 square kilometers in the North-west region (CAE, 2011). Oil and gas production in North China is highly related to the formation of a cone of depression of groundwater in that area. Intensive hydropower development changed significantly the ecological conditions of related rivers, lakes and wetlands in specific regions. Last but not least, the issues that have arisen from uranium resource exploitation, such as solid residual disposal and waste water discharge, should not be neglected either.

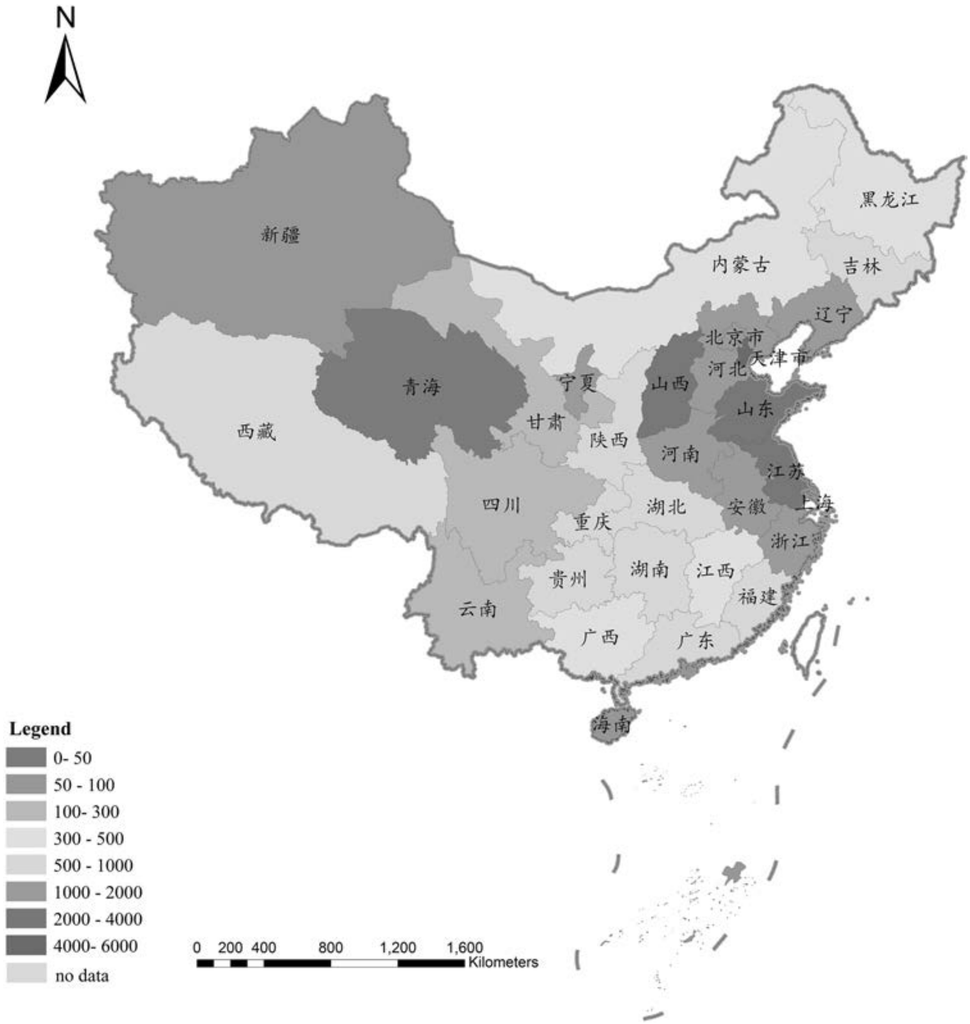

Figure 3.11 Coal consumption density in China

Data source: Authors.

Most of the air-borne pollutants come from fossil fuel combustion. China has been the largest emitter of SO_2, NOx, soot/dust, anthropogenic mercury and CO_2 since 2006. The super-high coal consumption density (in terms of coal consumption per square kilometer) in middle and east China, (see Figure 3.11), is the major reason for the haze that has troubled China since the winter of 2012. It is estimated that coal burning contributes 50–60% to the concentration of $PM_{2.5}$, the number one primary pollutant in many cities (CCCPT, 2014). Taking the Beijing-Tianjin-Hebei Metropolitan Region, the Yangtze River Delta and the Pearl River Delta as examples, the coal density is as high as 1794, 2267 and 981 tons/km^2 (see Figure 3.11), respectively, in these three regions where the worst haze was monitored as well. Regarding CO_2 emissions from fuel combustion and cement production, China shared 28.7% of total emissions in the world in 2015, and accounted for 68% of the incremental emissions for the period of 2000–2015 (GCB, 2016).

Particularly, road transport is one of the major sources with fast increasing trend. According to the Initial and Second National Communication of China submitted to the United Nation Framework of Climate Change Convention (NDRC, 2004; 2012), in 1994, CO_2 emission from road transportation was estimated as 105Mt, accounting for 3.8% of CO_2 emission from fuel combustion, and 2.6% of overall emission (not including land use, land use change and forestry, LULUCF); in 2005, CO_2 emission from road transportation was estimated as 373 Mt, accounting for 6.4% of CO_2 emission from fuel combustion, and 4.5% of overall emission (not including LULUCF). Though the share of road transport emission overall is still quite low, compared with the level in developed countries, the annual growth rate between 1994 and 2005 was as high as 12.2%, and the growth continued after 2005 – it was estimated by the authors that the CO_2 emission from road transportation in 2015 was over 700 Mt, more that double of 2005. Although the growth rate has slowed with the progress of exhaust gas emission standards, road transport is also the major source of NOx. In 2014, 6.28 Mt NOx, 30.2% of the total, came from this sector (Ministry of Environment Protection (MEP), 2015), compared to 5.83 Mt in 2009 (Ministry of Environment Protection (MEP), 2010). Generally, the eastern area which is more economically active, populous and mobilized than the middle and western regions tends to generate more emissions (Cai et al., 2011; Hao et al., 2014).

Summary

This chapter provides a general picture of China's energy development since 2000. The indigenous energy supply is expanding rapidly, especially coal and natural gas; however, this has failed to meet the fast growing energy demand. Up to 2015, about 16% of total energy was imported from overseas, mainly oil and gas. The energy mix is still dominated by coal, although with a general downwards trend, owing to a strong policy to save energy and the expansion of low-carbon energy. From end-use perspectives, the manufacturing industry still accounted for nearly 70% of final energy use in 2014, transportation accounts for 10.9%. There is however a strong regional difference in energy use in China, with the eastern region consuming a major share.

Two different phases, 2003–2011 and 2012–2015, were particularly pronounced. In the former phase, a much higher annual energy demand, growth rate (>10%) and elasticity (>1.0), and rebounded energy intensity were observed, warning the country of the concerns on energy security, the over-consumption of coal, GHG emissions and air pollutant emissions. With moderated economic expansion and strong policy intervention, the latter phase saw a much relieved situation. It seems energy demand in China has come to a period of low growth, along with the "new norm" status of economic development.

China announced its Nationally Determined Contribution (NDC) under the United Nations Framework of Climate Change Convention (UNFCCC) in June 2015 and ratified the Paris Agreement in October 2016, promising to peak its GHG emission around 2030 and, possibly, to pursue an even earlier peak. Furthermore, to achieve the 2°C target, a study from the Inter-governmental Panel of Climate Change (IPCC) concludes that world emissions must return at least to the level of 2010 by 2030, and be cut by 40% or more by 2050, and reach near-zero emission by the end of this century (IPCC, 2014). This challenges the whole world energy system especially in China, which still heavily depends on coal. Although coal consumption would appear to have already peaked in 2013 (Asuka, 2016), contributing significantly to the surprising declining of world CO_2 in 2015 and 2016 (Robert et al., 2016; Nature editor, 2016), the uncertainty is still large. China needs to transfer more speedily to a real low-carbon system.

Notes

1 All data above is cited from World Bank database: http://datacatalog.worldbank.org/
2 Data regarding gross energy production/consumption is generated by the method of coal equivalent conversion, including non-fossil fuel energy.
3 Non-fossil fuel energy is converted by a calorific value calculation method before it is included in final energy consumption.
4 Most of the data in this paragraph comes from WDI2015; BP Statistical Review of World Energy (2016).

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