The Future of China's Energy[1]

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Abstract

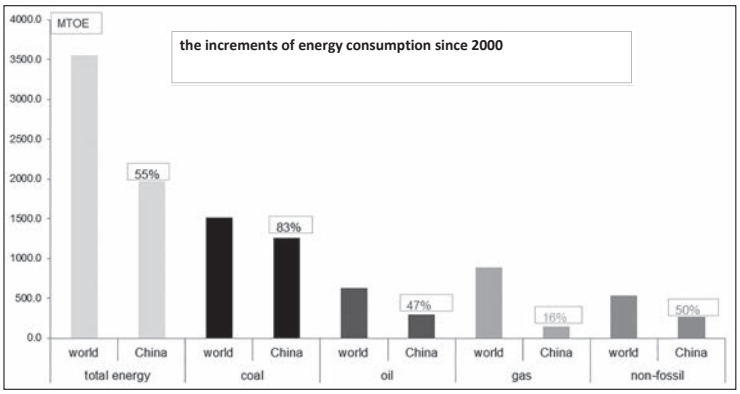
As the world's biggest energy-consuming and producing country, for a long time China's energy consumption structure has relied mainly on coal. It helped secure China's economic development, but also caused serious pollution problems. Now China's economy is entering a "New Normal" stage with a lower growth rate, the industrial share of GDP is declining, and the services industry share is increasing. At the same time, China's elderly population is growing, energy consumption growth is slowing down, and the competition among different energy sources is becoming intense. With the condition of easing supply and demand, China is setting energy structure optimization as a priority. The biggest change in China's energy development in the future will be in energy structure, with the share of coal in primary energy consumption notably decreasing and the proportion of non-fossil fuels significantly increasing. In 2050, China's non-fossil fuel share is expected to rise to more than 40%. The key to China's future energy development lies in how to achieve the upgrading and high efficiency of the whole energy system, how to bring the market into full play, and how to finally achieve the requirements of the energy revolution.

Keywords: China's energy, energy structure, energy policy, energy outlook

1. The History and Current Situation of China's Energy

Since China's reform and opening up, its economy has kept growing rapidly, as has its energy demand. The energy consumption elasticity has stayed at a high level, and energy supply tension has occurred from time to time. This made securing supply one of the key focuses of China's energy policy. The continued growth of energy consumption has led to China becoming the biggest energy-consuming and producing country in the world, and also driven global energy consumption growth. Today China's energy consumption plays an essential role in the world. As in Figure 1, since 2000, China has contributed to 55% of global energy consumption growth, 83% of coal consumption growth, 47% of oil consumption growth, 50% of non-fossil fuel consumption growth, and 16% (relatively lower) of natural gas consumption growth.

Figure 1: The Increments in Energy Consumption of the World and China, 2000–2014



Source: Author's calculations, based on BP Statistics, 2015.

Since 2014, China's economy has entered a "New Normal" stage. Excess capacity has brought a significant slowdown in industrial energy consumption growth, and the slide in energy consumption growth was more than that in GDP growth. China's energy consumption growth has entered a transitional phase. The path of China's economy and energy development is similar to that of some developed countries, such as the United States, Japan and the ROK. When those countries' economic growth declined to a lower level, their energy consumption growth slowed down more. Using electric power consumption as an example, as shown in Table 1, US electric power consumption growth and elasticity began to drop drastically from the 1960s, while China's electric power consumption growth and elasticity dropped significantly in the early 2010s after reaching its peak in the preceding decade, and will follow this trend in the future. One of the reasons of the decline is the enhancement of energy efficiency, and others are the adjustment of the economic structure and the sharp slowdown of the industrial use of energy.

Table 1: Average Growth of Electricity Use and GDP by the US and China

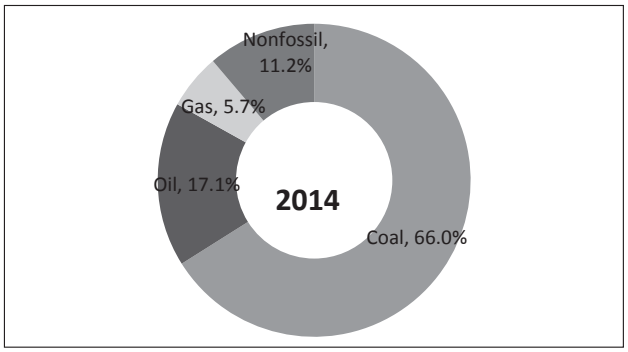
US				China			
Period	Electricity Use	GDP	Elasticity Coefficient	Period	Electricity Use	GDP	Elasticity Coefficient
1950s	9.8	4.2	2.3	1971–1980	9	6.2	1.5
1960s	7.3	4.5	1.6	1981–1991	7.6	9.3	0.8
1970s	4.7	3.2	1.5	1991–2000	7.9	10.4	0.8
1980s	2.9	3.1	0.9	2001–2010	11.8	10.5	1.1
1990s	2.4	3.2	0.8	2011–2020 (f)	5.8	7.2	0.8
2000–2013	0.7	1.9	0.4	2021–2030 (f)	2.5	6	0.4
2013–2040	0.8	2.4	0.3	2031–2040 (f)	1.5	5.6	0.3

Note: US data comes from the EIA's *Annual Energy Outlook 2015*; China data comes from the author's calculations, based on IEA statistics and ETRI forecasts.

2. Features and Problems of China's Energy Development

In China's primary energy consumption structure, the proportion of coal is overly high, reaching 66% in 2014, and has caused severe problems such as environmental pollution and CO_2 emissions. Controlling coal consumption has become the focus of China's energy development. Only half of the coal consumption in China is used for power generation, which is lower than that for other countries. At present, part of the coal power in eastern China has reached gas turbine emission standards, except for CO_2 emissions. In the next few years, there will be more newly built coal-power units and old coal-power units being upgraded to gas turbine emission standards. Besides power generation, China's coal utilization faces problems such as a lack of environmental protection facilities and poor operation of environmental protection facilities, and this constitutes one of the main reasons for environmental pollution.

Figure 2: China's Energy Structure, 2014



Source: Author's calculations, based on National Bureau of Statistics of China and ETRI data

At the same time, the proportion of natural gas in primary energy consumption is too low, being 5.7% in 2014, much less than the global average of 24%. This is mainly because the domestic natural gas price is too expensive compared to the price of coal. For the same calorific value, the gas price is three times higher than the coal price, and the price of gas power is twice as high as the price of coal power, making the economic efficiency of natural gas utilization lower than coal, even when considering the environmental costs. China's coal industry is facing a problem of overcapacity. The price of coal remains at a low level and it will be hard for it to recover quickly. More than 30% of China's natural gas consumption relies on imports at a higher price. Therefore, compared with coal, natural gas's economic efficiency will be at a disadvantage for a long time. Although power generation is the main usage of natural gas worldwide, it is hard for China to follow this because of its abundance of coal and its low price.

China's crude oil output has remained at over 4Mb/d in recent years. Although China faces a problem of poor resource quality, its western region and offshore oilfields still have a certain potential to increase production, so China's crude output is expected to maintain the present level in the future. China's fuel quality will improve soon, and in the next 2–3 years China will promote a National V (same as Euro V standard) gasoline and a diesel fuel standard nationwide. Currently National VI gasoline and diesel quality standards are being formulated. Overcapacity is now a problem in China's refinery industry. China's oil stockpile capacity is lower than the IEA's 90-day standard. With sufficient global oil supply, China should consider both the strategic value and economic value of oil stockpiles. China also faces a lack of a gas peak-shaving stockpile. Moreover, China's natural gas pipeline network still needs to be improved.

China's electric power industry has developed very fast, with power generation in 2014 accounting for a quarter of the world total, being 1.3 times as high as that of the United States, and also higher than that of Europe and Eurasia. With its strong power grid, China has not experienced any excessive blackout incidents in decades. However, China's power generation structure relies too much on coal, which accounts for about 70% thereof. In recent years renewable energy has developed very quickly, but it has been largely driven by financial subsidies. Since China's wind and solar resources are mainly located in the northwestern region, with the major consumption area in the eastern region, there are also the problems of high cost in long distance transportation and incremental losses. The rapid development of renewable energy also has a problem in compatibility with the power grid; because of the power demand growth is declining, and the average abandon rate of wind reached 15.2% in early 2015. One of the reasons is the insufficiency of the power grid's load capacity, such as the gas electricity proportion being

too low (lower than 5%). Another reason is the inflexibility of the electricity pricing mechanism, for example, the lack of peak and valley prices.

In addition, since China is now the biggest energy-consuming country in the world, and two-thirds of the consumption is coal, with high CO_2 emissions, China's CO_2 emissions equal the sum of the emissions of the United States and European Union. However, there is also research showing that China's carbon emissions are overestimated. Researchers, publishing in the journal Nature, found that emission factors for Chinese coal are on average 40% lower than the default values recommended by the IPCC, and that emissions from China's cement production are 45% less than recent estimates.[2] Nevertheless, China is still trying hard to reduce CO_2 emissions, and achieve the goal of reaching a carbon emission peak before 2030. Reducing CO_2 emissions requires enhancing energy efficiency, controlling coal consumption, and improving the utilization level of clean energy.

3. China's Energy Policy

China's energy development is entering a new stage. In the circumstances of easing global energy supply and demand, combined with the decline of China's economic growth rate, as well as the adjustment of the economic structure, energy policy will gradually shift from the ensuring of supply in the past to demand optimization and environmental improvement.

3.1 Total Energy Consumption Control

One of the priorities of China's energy policy is to control total energy consumption, and essentially to control coal consumption. In 2014, China's coal consumption fell for the first time since the Asian financial crisis in 1998 and is expected to continue to decline in 2015. The main reason for the decline is a sharp slowdown in industrial energy consumption and an increase in hydropower consumption. Because the growth of renewable energy alone cannot meet all the electricity demand, and China's coal chemical industry still has a certain potential for development even though facing environmental and economic constraints, the future growth potential of China's coal consumption is mainly from electric power and the coal chemical industry. The Chinese government has proposed that the total energy consumption will be kept below 4.8 billion tce in 2020, and the proportion of coal consumption in primary energy will drop below 62%. Coal consumption is expected to gradually near its consumption peak by the 2020s.

3.2 Vigorously Developing Clean Energy

Regarding fossil fuels, China needs to vigorously develop the natural gas industry. The Chinese government has put forward that the proportion of natural gas consumption should reach 10% in 2020. It is difficult to achieve this goal under the current situation, unless the government significantly reduces the natural gas price or compulsorily replaces coal with gas. Natural gas is currently in an awkward position in China, for the reason that it is difficult for it to compete with coal on price.

China has focused much attention on the development of non-fossil resources. Development of nuclear power is one of the keys for China's aim of achieving non-fossil fuel consumption

amounting to 15% of total energy consumption in 2020. At present, nuclear power plants on the southeast coast are under construction, and the Chinese government has proposed achieving a goal of 58 GW of installed nuclear power in 2020. To accomplish this goal is difficult but possible. In addition, with security assurances, future development of inland nuclear power is also possible. The development rate of hydropower may be lower than expected because of the problems of rising costs, immigration, as well as the ecological environment.

Up to 2015, China's total installed wind power was 120 GW, leading the world. China's on-grid wind power price is 0.51~0.61 yuan/kWh (the price of new onshore wind-power projects approved after 1 January 2015 is 0.49~0.61 yuan /kWh), being divided into four categories according to different resources, and is 40% higher than the average coal-power on-grid price. The installed capacity of solar power has reached 43GW, second only to Germany and will soon overtake Germany to be first in the world. Depending on different regions' light conditions, large ground-based solar stations will implement four levels of the electricity on-grid price of 0.75~1 yuan/kWh. China has announced that by 2020, wind power installed capacity will reach 200 GW, and solar installed capacity will reach 100 GW, which is highly possible in the current situation.

3.3 Striving to Achieve an Energy Revolution

An energy revolution is the bigger long-term goal of China, but it needs to take action immediately. The development of unconventional oil and gas in the United States has become a realistic version for an energy revolution. China's energy revolution has a wider range, including a consumption revolution, a supply revolution, a technological revolution, a system revolution, and an overall strengthening of international cooperation. Its essence is to build a clean, high-efficiency, economical and sustainable energy system. The main measures are: to promote an energy consumption revolution through efficient and clean utilization of fossil fuels; to achieve wider and better use of renewable energy through constructing smart energy systems, building a diversified, reliable and clean energy supply system; to further open up the market, improving the pricing system and energy management system, making the market play a more important role in energy development, and gradually promote the "separation of network and transportation" for the electric and oil industries; to make energy technological innovation a new growth point for stimulating industrial upgrading with a focus on green and low-carbon energy; and to achieve energy security under the conditions opening up with the opportunity of "One Belt One Road".

4. China's Energy Outlook

4.1 Energy Consumption Growth Gradually Declining

Most domestic researchers believe that China's economic growth will gradually slow down, from the current 7% to approximately 5% in 2030. In 2050, China's per-capita income is expected to reach the level of moderately developed countries, and economic growth may drop to around 3%. The share of service industries will continue to rise, while the share of industry, especially heavy industry, will continue to decline due to overcapacity. Steel, cement, nonferrous metals and other energy-intensive industries will gradually reach or approach peak consumption in 2020, which will bring a gradual slowdown in energy consumption growth. At the same time,

China's total population is expected to reach a peak of approximately 1.5 billion in 2030, and the trend of the aging of the population will become evident.

China's energy consumption peak is expected to reach 4 billion tonnes of oil equivalent around 2030. China's energy consumption annual average growth rate is expected to be less than 2% before 2030. In contrast, during 2000 to 2014, China's annual energy consumption growth rate was more than 8%. China's energy consumption growth will gradually slow down to zero or negative growth in the 2030s, with total energy consumption in 2050 expected to be 10% lower than in 2030. China's energy self-sufficiency rate is expected to be above 80% in the future.

From the present to 2050 the increase in China's energy supply will be mainly from clean energy. The non-fossil fuel supply is expected to account for approximately 45% of the total increase, and the other 40% will be from growth in the natural gas supply. However, coal is still the largest primary energy when talking about a single energy source.

From the perspective of China's energy contribution, China will contribute the largest portion of the increase in global energy consumption before 2030. After 2030, China's contribution to global primary energy consumption will gradually decline, while India, South America, and Africa will become new sources of energy consumption growth.

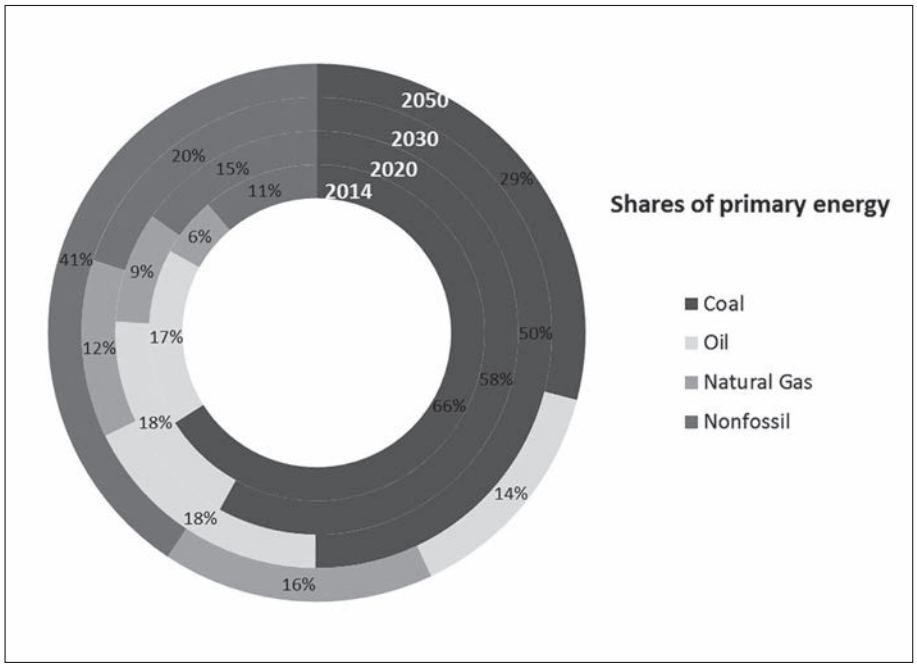
4.2 Constantly Optimizing the Energy Structure

One of the most obvious changes in China's future energy structure will be the decrease of coal and the increase of clean energy. In 2014, the proportion of coal in China's primary energy was still as high as 66%, while hydropower, wind power, nuclear power, natural gas and other clean energies accounted for 16.9%. With the rapid decrease of coal consumption growth and the speedy development of clean energy, the proportion of coal in primary energy consumption is expected to significantly drop to around 58% in 2020, and the non-fossil fuel share will increase to approximately 15%, which is China's expected target. This is mainly because of the higher-than-expected growth in wind power, and the development of nuclear power and solar power achieving the expected target, but hydropower development as mentioned above may be worse than expected. Oil consumption accounts for about 18%, and gas consumption accounts for about 9%, lower than the expected development goal.

In 2030, the proportion of coal in China's primary energy consumption will drop further to approximately 50%, while the natural gas share will rise to 12%, and the oil share will continue to remain at approximately 18%. Fossil fuels in total will account for 80%, remaining in the lead position. The non-fossil fuel consumption share is expected to reach the anticipated goal of 20%, which the Chinese government has announced it wants to achieve. Hydropower resource development will gradually slow down, and solar and wind power will develop rapidly. China's inland nuclear power project may be started.

After 2030, renewable energy technology, such as wind power and solar power, will be more mature, and will accelerate the replacement of fossil fuels, especially coal. By 2050, China's energy structure will have changed more greatly, with the share of coal in primary energy consumption dropping to less than 30%, the share of gas rising to 16%, the share of oil dropping to 14%, and the overall proportion of fossil fuel dropping below 60%. At the same time, the share of non-fossil fuel will rise to more than 40%. Non-fossil fuels as a whole will become the largest energy source. This will achieve the fundamental transformation from a fossil fuel-oriented energy consumption structure to one where fossil fuels and non-fossil fuels are equal.

Figure 3: China's Energy Structure from 2014 to 2050



Source: National Bureau of Statistics of China; ETRI forecasts

4.3 The Continued Growth of Power

From the perspective of electric power development, improvement in electrification levels will be another major trend. The demand for electricity will continue to grow in China, and the main driving force will come from service industries and the residential sector. By 2020, electric vehicles will gradually achieve commercial application in the transportation sector, and the number of miles for railway electrification will achieve rapid growth. After 2020, with technological breakthroughs, cost reductions, and better infrastructure, electric vehicles will become more and more popular. After 2030, traditional gasoline cars may be replaced by electric cars on a large scale, and the status of petroleum in the transportation sector will gradually decline. By 2050, China's consumption of electric power is expected to reach approximately 12 trillion kWh, and electric power will account for more than 60% of final energy consumption. Regarding the make-up for power, coal power is expected to account for 44%, gas electricity approximately 8%, and clean energy such as nuclear power, hydropower, wind power, and solar power will account for nearly 50%. If the utilization efficiency of nuclear fission increases dramatically or nuclear fusion can be commercialized, other generating modes will gradually exit the stage of history.

5. Conclusion

There is no prior experience to follow in energy development for such an economically and demographically large country like China. With China's economy entering a "New Normal" phase, as well as increasing the emphasis on the environment, how to achieve clean, efficient, diversified and sustainable development of energy is key to China's future energy development.

China's energy consumption growth has entered a transitional phase, and the growth rate of the economy will gradually decline in the future. The coal-based energy structure dictates that China's energy structure adjustment will be arduous. China's energy structure adjustment cannot be achieved overnight. It should be optimized gradually with competition between different varieties of energy and through the support of clean energy via national energy policy.

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[1] This paper represents only the author's personal views and not those of the company.

[2] source：http://www.nature.com/nature/journal/v524/n7565/full/nature14677.html；http://www.bbc.com/news/science-environment-33972247