China's Energy-Supply Security in the Multi-Energy Transition Period from Fossil Fuels to Renewable Energy

Chapter · January 2021

DOI: 10.1142/9781786349224_0008

Volkan S. Ediger
Kadir Has University

China's Energy Security
Analysis, Assessment and Improvement

https://doi.org/10.1142/q0270 | January 2021
Pages: 248

Edited By: Jingzheng Ren (The Hong Kong Polytechnic University, Hong Kong)

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https://www.worldscientific.com/doi/10.1142/9781786349224_0008

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Chapter 8

China's Energy-Supply Security in the Multi-Energy Transition Period from Fossil Fuels to Renewable Energy

Volkan Ş. Ediger*,‡, John V. Bowlus*,§, and Ahmet Faruk Dursun†,¶

*Center for Energy and Sustainable Development (CESD), Kadir Has University, Cibali 34083 İstanbul, Turkey

†Energy and Sustainable Development Graduate Program, Kadir Has University, Cibali 34083 İstanbul, Turkey

‡volkanediger@gmail.com

§johnbowlus@gmail.com

¶ahmetfdursun@gmail.com

Abstract

The rise of China as an economic superpower after the 2008 global financial crisis has attracted increasing worldwide attention. Securing access to ample and affordable energy supplies — energy-supply security — has underpinned its rise and will continue to contribute to its economic prosperity. This chapter examines China's energy-security challenge with respect to its policies. The global energy system is currently undergoing a multi-energy transition away from fossil fuels: the powers will take different paths, creating competition between one another and thus between energy sources. The development of China's energy-security policies and challenges as well as climate change, both at home and abroad, will therefore shape this competition and the global energy transition in the coming decades.

Keywords: Energy-supply security; China; Multi-energy transition; Fossil fuels; Renewable energy.

1. Introduction

China is the newest member of the "economic superpower club" — even if it is not yet as powerful as the United States and the European Union (EU) — due to its incredible growth and deep integration into the global economy since 2008 (Bergsten, 2008). China's hard economic and military power is notable, but so is its soft power, as it now plays a significantly important role in world peace and global economic growth. It also provides great economic contributions and has cultural influences in Europe, Africa, and South America.

Energy has underpinned China's rise as a globally influential country. It overtook the EU in 2006 and the USA in 2008 to become the world's largest energy consumer (Figure 1). In 2019, it consumed 3.273 billion tons-of-oil equivalent (BToe) of total primary energy (Lee and Zhang, 2012; Song *et al.*, 2019; BP, 2019). Since China is rapidly industrializing and urbanizing, its consumption continues to rise; its per-capita consumption, however, is still considerably lower than that of developed countries (Bai *et al.*, 2014; Song *et al.*, 2019).

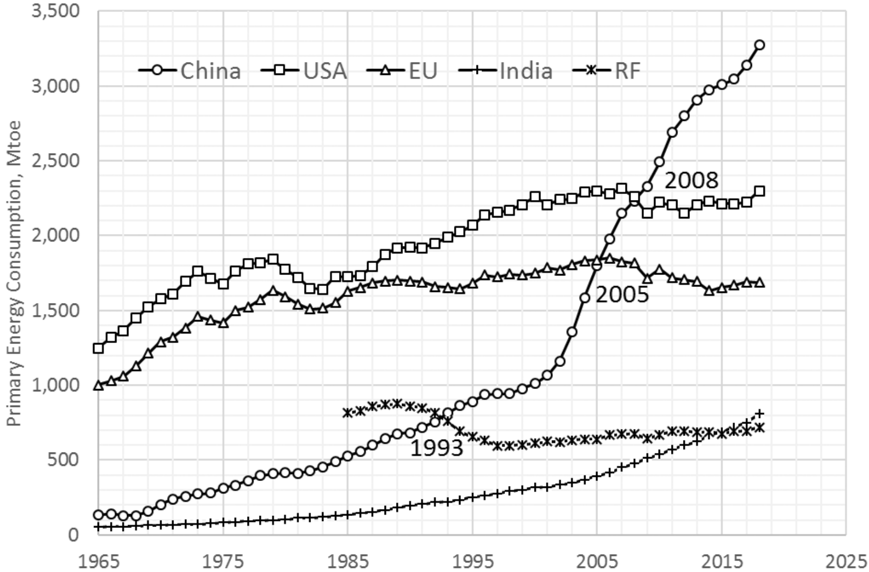

Figure 1: Primary energy consumption of China, USA, EU, India, and Russia, 1965–2018.
Source: BP (2019).

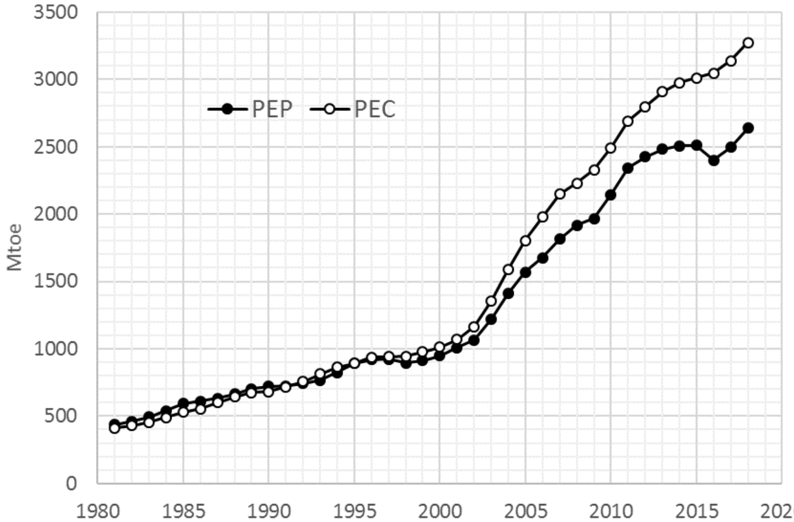

Figure 2: Primary energy production (PEP) and consumption (PEC) of China, 1980–2018.
Source: BP (2019).

China's domestic energy production, however, can no longer meet its consumption needs (Figure 2). The share of domestic production in consumption has declined from 100% in 1995 to 80% in 2018, and the gap is now met by imports, which reached 634.4 MToe in 2018. China's fossil fuel reserves are also below the world average (Zhao *et al.*, 2013; Liu, 2019). The exploitation duration ratios (reserve-to-production ratios) of coal, oil, and natural gas resources are estimated at 38 years, 18.7 years, and 37.6 years, respectively (BP, 2019). China's lack of sufficient domestic energy supplies to sustain its energy-based growth has been the most important driver of its foreign and energy policies (Cáceres and Ear, 2012).

China has also become the largest greenhouse gas (GHG) emitter, overtaking Russia in 1989, the EU in 2003, and the USA in 2005 (Figure 3). In 2019, its CO_2 emissions reached approximately 9.428 billion tons (BTon). Since 2005, it has faced more pressing challenges in climate change and energy security than any other country (Duan and Wang, 2018). Although per-capita emissions are still lower than those in developed countries, they grew 8.5% on average from 2001 to 2013.

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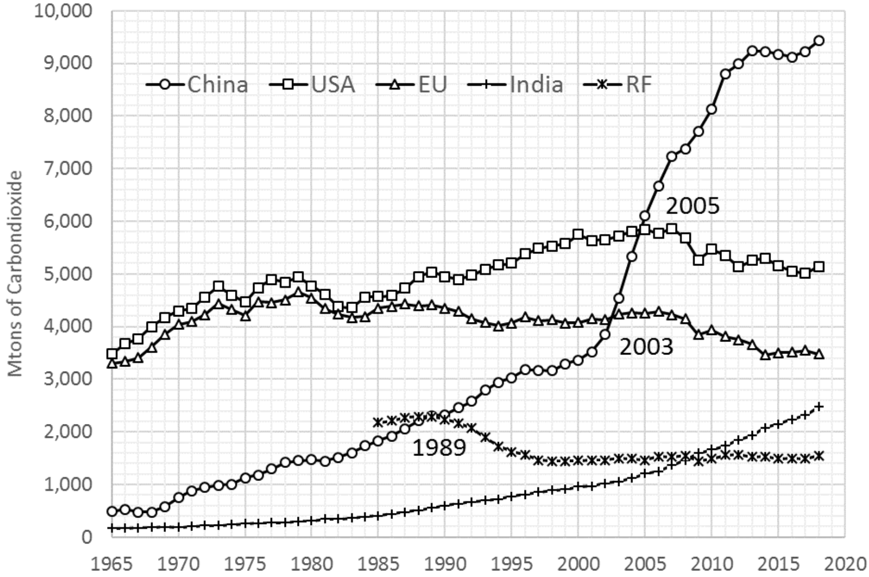

Figure 3: CO_2 emissions of China, USA, EU, India, and Russia, 1965–2018.
Source: BP (2019).

Energy-supply security and climate change are, thus, the two largest problems facing China's energy system. In order to lower GHGs emissions, the Chinese government has taken various measures to vigorously develop renewable energy (Zhang *et al.*, 2019). It has also persistently sought to secure its foreign gas and oil supplies through strategic bilateral relations with key energy producers and resource-rich countries (Cáceres and Ear, 2012). In addition, China's import of energy resources is changing global geopolitics (Broedsgaard and Heurlin, 2002; Marketos, 2010; Cáceres and Ear, 2012). Its energy plans and strategies will therefore increase competition in world energy markets (Song *et al.*, 2019).

Meanwhile, domestic and international conditions have changed drastically in recent years and are reshaping China's energy policy (Yatsui, 2017). The Chinese economy has slowed and its structure has shifted from an industry focus to services, causing a substantial decrease in the rate of primary energy consumption, from 16.5% in 2003, 17.0% in 2004, and 13.6% in 2005 to 1.2% in 2016, 3.0% in 2017, and 4.3% in 2018 (Figure 2). Moreover, air pollution caused by

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fine particulate matter has become a serious domestic problem, and the government is attempting to curb coal production and expand clean energy to combat it. At the same time, China has benefited from the decline in oil prices, from $111.26 per barrel in 2011 to $45.76 in 2016, $55.52 in 2017, and $71.31 in 2018.

In this chapter, we examine China's energy-supply security problem with respect to its policies. The second section chronologically summarizes China's past energy policies. The third section argues that the major changes in the global energy system should be viewed through the concept of a multi-energy transition concept. The fourth section summarizes the findings and places them in the context of current energy transition and geopolitical dynamics.

2. The Shifting Global Energy Scene

Since the Industrial Revolution, humans have been substituting fossil fuel energy sources (Ediger, 2011a, 2011b, 2019a, 2019b). Coal, the dominant energy source from 1881 to 1965, was first replaced by oil and then natural gas (Figure 4). Oil peaked as the dominant energy source in 1973 before it began declining after the 1970s oil crises (Ediger and Berk, 2018). In 1973, the shares of oil, coal, and natural gas were 47.4%, 25.5%, and 16.6%, respectively. Since then, oil has declined to 32.5%, whereas coal increased to 26.4% and gas to 23.1%. Assuming that past trends would continue, energy experts had expected that while oil would continue to decline, gas would increase its share and cut the coal curve to become the second most used energy source. The gas and coal curves converged twice, first around 1977 and then in 1999–2000, but gas never caught up with coal, as its rise slowed.

China's energy-security policies, especially its increased domestic production of coal and renewables, were the main reasons for this trend reversal. China has 138.819 BTons of coal reserves, ranking fourth after the USA, Russia, and Australia, with a global share of 13.2%. It ranks first both in coal production and consumption. Domestic coal production increased first from 310.8 MToe in 1981 to 800.3 MToe in 2002, with an average annual growth rate of 4.7%, and then from 945.3 MToe in 2003 to 1894.6 MToe in 2013 with an average annual growth rate of 8.3% (Figure 5). Notably, production

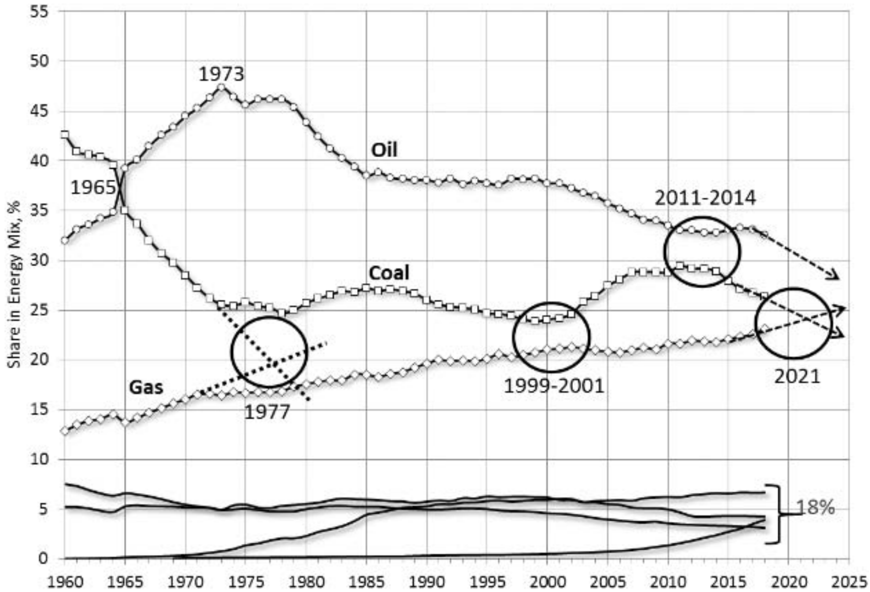

Figure 4: Trend reversal in world energy mix, 1960–2018.
Source: BP (2019).

has declined from 1864.2 MToe in 2014 to 1828.8 MToe in 2018, with an average annual growth rate of −0.6%. During the first period, production generally met demand, but in the second and third periods, consumption outpaced production. The difference between production and consumption reached 197.7 MToe in 2016 and 143.8 MToe in 2017. In 2018, China was responsible for 46.7% of world coal production and 50.5% of world coal consumption.

Renewable energy production (excluding hydro) started slowly in the 1990s, but increased rapidly after 2005. China overtook India and Japan in 2008, Germany in 2011, and the USA in 2016 to become the world's largest renewable energy producer. From 2005 to 2018, its average annual growth rate of 45.3% was, by far, the highest in the world (Figure 6). In 2018, its total renewable energy production was 634.2 TWh (143.5 MToe), accounting for a 25.6% share of the global total, followed by the USA (18.5%) and Germany (8.4%). Of this amount 57.7% was wind, 28.0% solar, and 14.3% others. China was the leader in wind energy, with 366.0 TWh (82.8 MToe) and a

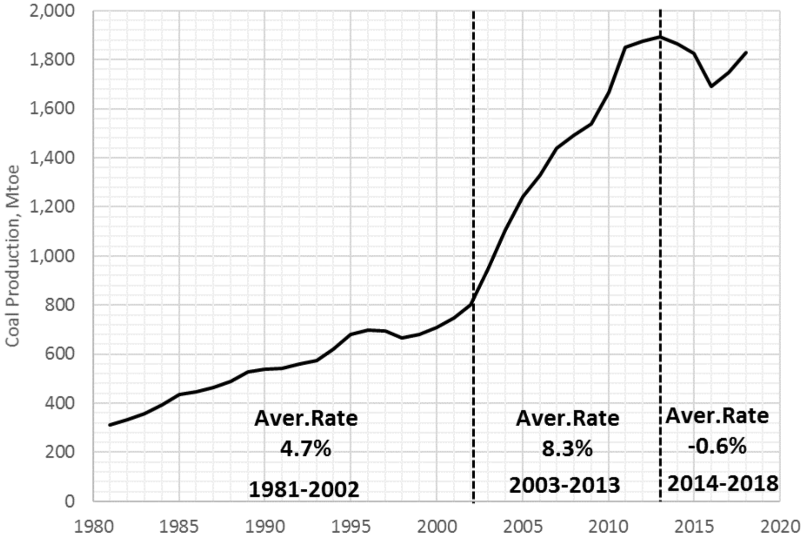

Figure 5: Coal production in China, 1981–2018.
Source: BP (2019).

28.8% share of the global total, and solar power, with 177.7 TWh (40.2 MToe) and a 30.4% share of the global total.

China's energy-security strategy not only reversed the trend of substituting fossil fuel sources but also affected the energy geopolitics of the powers (Ediger 2019a, 2019b). Power has grown steadily more diffuse, as world order became more multipolar, where China appears to be one of four centers of relative geopolitical autonomy (Bergsten, 2008; Haass, 2008; Wallerstein, 2010).

However it is defined, this new world order causes a divergence of fossil fuel consumption paths among the powers. To explain this dynamic, Ediger (2019a) suggested the concept of "multi-energy transition," which means that different countries will follow different paths for a transition from fossil fuels to renewables, resulting in different energy regimes. In our multipolar world order, the four powers are, in other words, expected to follow four different energy paths. China will continue to rely on coal while attempting to mitigate its negative environmental effects through a renewable energy revolution. Russia will continue to base its energy system on gas and produce and consume conventional oil and gas. The USA will continue to diversify its energy mix by using science and technology for

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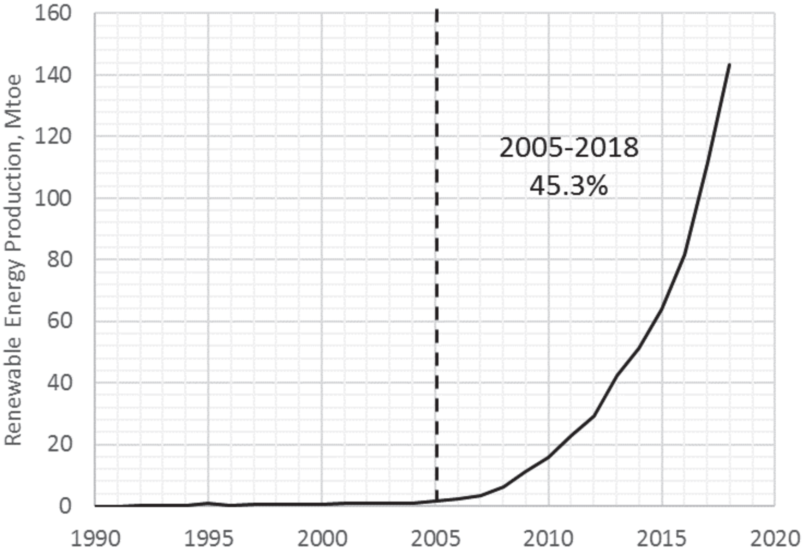

Figure 6: Renewable energy production in China, 1981–2018.
Source: BP (2019).

the development of its fossil fuel resources, especially unconventionals, most notably its shale oil and gas, and renewable energy sources. The EU's high ratio of fossil fuel import dependency and its current energy transition policies mean that it will continue to improve energy efficiency and increase domestic renewable energy usage.

3. China's Energy Policies

Ensuring adequate energy supplies to sustain economic growth has been a primary concern of the Chinese government since 1949 (Andrews-Speed, 2014). The First Five-Year Plan (1953–1957) aimed at developing strategies for the social and economic development of China was shaped. In this plan, China adopted the Soviet model, based on state ownership and centralized planning. Coal dominated this process, as primary energy consumption rose from 24 million tonnes-of-coal-equivalent (MTCE) to 500 MTCE from 1949 to 1976. China also made significant advances in energy exploration and extraction, becoming self-sufficient. During the second half of the 1970s and throughout the 1980s, China's energy policies became increasingly diversified and complicated, especially as the country took tentative steps to engage with the world economy (Meidan, 2016).

In the period of rapid economic growth, opening up to the world, reform, and modernization, China tried to ensure stable and sustained economic growth during the Eighth Five-Year Plan between 1991 and 1995 (UNDP China, 2012). In 2004, the National Development Research Center (NDRC) published the "China National Energy Strategy and Policy 2020 (NESP)" (Sinton *et al.*, 2005). This report included recommendations to China's government on energy security, economic growth, equity, and well-being, with specific changes in energy investment, supply, and efficiency. Subtitle 6 of the report, "Energy, Environment and Its Public Health Impact," outlined the energy-related environmental challenges that China would face in the coming two decades. These were described as environmental constraints and included environmental capacity, environmental management constraints, and global climate change (Jinnan *et al.*, 2004, p. 6). Chapter 7 of the report, "Renewable Energy Strategy and Policy," provided targets for 2020 for renewable energy development: an installed capacity of 90 gigawatts (GW)-100 GW and consumption of 400–500 MTCE. According to this chapter, there were four reasons to encourage renewable energy development in China: (1) the inevitability of executing sustainable energy strategies, (2) the need to speed up the development of rural economies and increase the income of farmers, (3) the creation of new job opportunities and promotion of economic growth, and (4) environmental protection and greenhouse gas abatement (pp. 8–12). The main barriers for the development of renewable energy in China were also enumerated: cost, market share, and policy (pp. 12–14). The chapter suggested a four-phase strategy for renewable energy development in China: (1) creating a nucleus of renewable energy technologies by 2010, (2) commercializing large numbers of renewable energy technologies by 2020, (3) realizing renewable energy commercialization in an all-round way and substituting fossil fuels at a large scale, and (4) bringing renewable energy consumption to 50% by 2100 (pp. 15–16).

Annex 1 of Subtitle 7 of the report, entitled "Global Climate Change: Challenges, Opportunities, and Strategy Faced by China," explained the central challenges relating to global climate change: (1) developed countries would continue to urge China to limit and control its GHG emissions, (2) climate change would undermine China's current development and consumption model, and (3) global climate change would present great challenges to China's coal-dominated energy mix (Huaqing *et al.*, 2004; pp. 7–8). On the other hand, climate change also offered opportunities for China's energy development. It would encourage China to carry out its sustainable development strategy and to obtain more advanced energy conservation technologies as well as new energy technologies, which would facilitate energy mix adjustment. The adoption of GHG emissions mitigation policies and measures, moreover, would help reduce air pollution (pp. 8–9).

During the 11th Five-Year Plan (2006–2010), the country transitioned from a communist economy to a socialist market economy, and the term "plan" was replaced by "guideline" (Andrews-Speed, 2014). In this guideline, the main targets for 2010 were to increase the rate of GDP growth to 7.5% and per capita GDP growth to 6.6% annually and to decrease the rate of energy intensity to 20%. In 2007, China became the first developing country to publish a national strategy on global warming, entitled "The First National Action Plan on Climate Change," which targeted to reduce annual GHG emissions by 1.5 BTons of carbon dioxide equivalent by 2010. It also sought to increase the share of electricity generation from renewable energy sources and nuclear power, increase the efficiency of coal-fired power stations, use cogeneration, and develop coal-bed and coal-mine methane.

Since the start of the 11th Five-Year Plan, China's policymakers have increasingly emphasized control of the country's rising energy demand and emissions and proposed targets for energy intensity and renewable energy, including in the 12th Five-Year Plan (2011–2015) (Qi *et al.*, 2019). In 2012, a report entitled "12th Five-Year Plan on Greenhouse Emission Control" set goals to reduce carbon intensity by 17% and to raise energy-consumption intensity by 16% by 2015. China also planned to meet 11.4% of its primary energy demand from non-fossil sources by 2015. Furthermore, the plan targeted the construction of a number of low-carbon development zones and low-carbon residential communities. In November 2014, President Xi Jinping announced that China would reduce carbon dioxide emissions and increase the use of non-fossil fuels as a percentage of primary

Chapter 8: China's Energy-Supply Security in the Multi-Energy Transition Period from Fossil Fuels to Renewable Energy
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energy consumption by 20% in 2030 (Sahu, 2018). China set national energy-intensity reduction targets of 20% and 16% in the 11th and 12th Five-Year Plans, respectively (Li *et al.*, 2016). In addition, the central government directed provincial governments to meet specific targets for the reduction in energy intensity (Zhang and Wu, 2018).

China is currently implementing its 13th Five-Year Plan (2016–2020), which was one of the most expected official documents in the world at the time, since it would significantly affect the growth of GHG emissions of the world's largest emitter (Tianjie, 2016). The plan aimed to switch from coal to natural gas and from fossil fuels to non-fossil fuels by championing policies such as "everyone is an entrepreneur," "creativity of the masses," and "made in China 2025" (Yatsui, 2017). The plan targeted to reduce energy consumption and carbon emissions per unit of GDP by 15% and 18%, respectively, as well as coal dependence more broadly. It also promoted clean energy developments, notably through a commitment to increasing nuclear energy capacity to 58 GW by 2020, with an additional 30 GW under construction. This would mean commissioning between six and eight nuclear reactors every year (Sahu, 2018). In December 2016, China also issued the "Energy Production and Consumption Reform Strategy (2016–2030)," which aimed to limit total energy consumption and energy intensity and revise the country's energy mix (NDRC, 2016). For example, energy consumption in 2020 and 2030 should not exceed 5 BTCE and 6 BTCE, respectively, while the share of non-fossil energy in primary energy consumption should increase to 20% by 2030 (Wang and Zhang, 2017; Duan *et al.*, 2018).

Recently, Song *et al.* (2019) revealed that the change in China's energy security index (CESI) has resembled an "N" curve. The country's best energy-security performance came in 2000; its worst was in 2010. The main strengths of China's energy security are its installed capacity to generate renewable energy and thermal power; its main weaknesses are indigenous energy availability and energy dependence.

4. Transition Towards Clean, Domestic Energy

To a large extent, China's energy-supply security will hinge on how rapidly it transitions to renewable energies, which do not depend on imports and access to the seas. The more renewable energy that China produces domestically, and even exports, the less it will pay for fossil fuel imports, increase export revenues, and decrease domestic pollution. China has long understood these dynamics, and President Xi Jinping underscored them at the 19th National Congress of the Communist Party in October 2017: "We will promote a revolution in energy production and consumption, and build an energy sector that is clean, low-carbon, safe, and efficient ... What we are doing today to build an ecological civilization will benefit generations to come. We should have a strong commitment to socialist ecological civilization and work to develop a new model of modernization with humans developing in harmony with nature. We must do our generation's share to protect the environment" 2017 (CNREC, 2018).

According to the China Renewable Energy Outlook 2018 (CNREC, 2018, p. 32): "The single most important step now is to reduce coal consumption in China ... The decisions and targets for coal reduction must be enforced strictly to avoid stranded investments and reduce vested interests in a continuation of high coal consumption."

China's coal-dominated energy consumption structure has resulted in many serious environmental problems (Zhen *et al.*, 2016). China aims, through its own development and joint efforts, to achieve clean and low-carbon energy goals that will optimize industrial structure, limit total energy consumption, and improve its energy consumption structure. On the other hand, according to Zhen *et al.* (2017, p. 305), in view of China's resource endowments and consumption levels, the clean-and-low-carbon utilization of coal is a realistic choice; to develop non-fossil energy sources vigorously is a strategic choice; as a dominant source of transportation fuel, oil will remain critical in the short and medium term, while gas will play an important role as a bridge to achieving clean and low-carbon energy goals.

Wang *et al.* (2014, p. 542) showed that China's ultimate recoverable coal reserves equaled 223.6×10^9 MT and that its production will peak between 2025 and 2030 at approximately 3.9×10^9 MT. According to them, the extent to which China can import coal in the future is uncertain. With rising coal demand, this combination is likely to complicate China's future economic development.

Before the 1990s, the main purpose of the development and utilization of renewable energy in China was to supplement the shortage of agricultural fuels. The relevant guidelines at that time were, thus, rural energy construction policies. From the 1990s to 2005, specialized policies and laws for renewable energy were gradually released that approached the issue of air pollution in addition to rural energy. The most important legal paper was the Renewable Energy Law (REL), which came into being in 2005 and was amended in 2009 (Schuman and Lin, 2012). Thus far, China has formed a comprehensive renewable energy legal system essentially based on the REL and supplemented by other related laws and policies (Liu, 2019). Currently, nearly 20% of China's electricity comes from renewables. Under the business-as-usual scenario, this is expected to rise to 30% by 2030 and, under the RE Map 2030 options, it approaches 40% (Sahu, 2018).

Wind and solar power-installed capacities have grown faster than that seen in any country in the world (Shen, 2017). The 11th Five-Year Plan stimulated high growth in wind energy, from 1.3 GW in 2005 to 44.7 GW in 2010, which was eight times higher than the original target of 5 GW. The National Energy Administration (NEA) revealed that China's renewable energy capacity and consumption have increased significantly since the 12th Five-Year Plan (Liu, 2019). China set the record for wind investment in 2015 with USD 102.9 billion, which represented a produced capacity growth of 17% and 36% of global investment that year (Sahu, 2018). Most of China's coastal belts have excellent wind energy resources, and the government has been introducing attractive subsidies for local and foreign manufacturers to enter the industry. Both pricing and non-pricing policies have played key roles for the developments of wind energy capacities (Sahu, 2018).

The legal framework of renewable energy in China has greatly contributed to past achievements, but limitations may impede further development. It is still, moreover, insufficient to integrate renewable energy into the national energy system (Liu, 2019). Binz *et al.* (2017, p. 418) summed up the challenges as follows: "We find that traditional top-down catching-up policies played a decisive role in the development of China's wind industry, but were of limited importance in the early solar PV industry, and resulted only in a limited period of rapid growth in the biomass power plant industry. The relative progress achieved in these three industries is not related to top-down policy guidance alone, but also to private sector initiative, international interdependencies, and flexibility in adapting policy mixes to each industry's technological characteristics. These results suggest that policy makers in newly industrializing countries (NICs) should avoid drafting generic sector plans, but should tailor plans to individual industries, and respond to changing policy support needs as technological capacities and global competitiveness develop."

5. Conclusion

China is the center of global supply chains and the world's largest importer of oil, but the uncertainties of the novel coronavirus have raised further questions about the future of China's energy-supply security and necessitate a reassessment of the themes and developments outlined in this chapter. The habits and practices undertaken by China's energy suppliers and consumers of its renewable energy technologies, as well as those of its energy suppliers, will shift, some more systematically than others. It is too early to predict what forms these shifts will take, but the current international environment and the international relationships could challenge China's energy-supply security.

Amid the global outbreak of COVID-19, Russia and Saudi Arabia launched an oil-price war that added uncertainty for China's oil-supply security. Lower prices will help China recover from COVID-19 and reduce the cost of oil and gas imports, but the price war will also create greater price volatility. China might well revert to more fossil fuel-friendly policies in light of lower prices, but it will prolong its own fight against environmental degradation, most notably pollution, and accelerate global climate change, if it chooses to do so. The energy-security decisions that China faces will involve trade-offs, as China is still a large developing country with around 1.4 billion people. Energy security will be one of the most critical factors for lifting the people in China's remote areas out of poverty. Regardless of how these developments play out, China's energy-supply security will remain a central story of the 2020s and beyond.

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Chapter 8: China's Energy-Supply Security in the Multi-Energy Transition Period from Fossil Fuels to Renewable Energy
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