Achieving a Socially Equitable Energy Transition in China

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List of Abbreviations

ADBC	Agricultural Development Bank of China
Air Quality Plan	Action Plan for the Prevention and Control of Air Pollution
AVIC	Aviation Industry Corporation of China
CDB	China Development Bank
CEPF	China Environmental Protection Foundation
CI	Confidence Interval
CMCN	China Mangrove Conservation Network
CPAD	State Council Leading Group Office of Poverty Alleviation and Development
EIA	Environmental Impact Assessment
ETS	Carbon Emission Trading System
FIT	Feed-in Tariff
FYP	Five-Year Plan
GHG	Greenhouse Gas
GBD	Global Burden of Disease
GDP	Gross Domestic Product
HAP	Household Air Pollution
IRENA	International Renewable Energy Agency
LNG	Liquefied Natural Gas
NEA	National Energy Administration
MEP	Ministry of Environmental Protection
MRV	Monitoring, Reporting and Verification
MOHRSS	Ministry of Human Resources and Social Security
NDRC	China's National Development and Reform Commission
NDC	Nationally Determined Contribution
NOx	Nitrogen Oxides
PE	Private Enterprise
PPAP	PV Poverty Alleviation Project
PM2.5	Fine Particulate Matter
RPS	Renewable Portfolio Standard
SGCC	State Grid Corporation of China
SJVE	Sino-Foreign Joint Venture Enterprise
SO2	Sulfur Dioxide
SOE	State-Owned Enterprise
TCE	Tonne of Standard Coal Equivalent
TPS	Tradable Performance Standard
TRS	Target Responsibility System
T&D Tariff	Transmission and Distribution Tariff
UHV	Ultra-High Voltage
USD	US Dollar
WHO	World Health Organization

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Foreword

Tackling climate change will not be possible without a significant contribution from Asia. Although most Asian countries currently have relatively low levels of per capita greenhouse gas emissions and historically Asia's contribution to global climate change has been limited, Asia now contributes already substantially to global greenhouse gas emissions. This is both because of the region's large population and relatively robust economic growth. According to economic forecasts, Asia's share of global greenhouse gas emissions will grow dramatically in the coming decades. At the same time, millions of people in the region will be affected by climate change. Serious environmental pollution has resulted from the burning of fossil fuels. Health risks due to air pollution already affect millions of Asians.

There are signs of growing interest in renewable energies in many parts of Asia out of energy security and environmental concerns as well as to bring electricity to energy poor regions. With dropping renewable energy prices there is growing investment in the sector in Asia. This makes it increasingly possible to talk about the beginning of energy transitions, which are occurring in the region. Greater use of renewable energy may lead to more socially and environmentally just energy structures. We still know, however, little about the actual social and political contributions, costs and implications of renewable energy expansion.

The Friedrich-Ebert-Stiftung decided to examine these questions with a series of country studies in Asia. The studies address the political and social factors that drive, but also hamper socially just energy transitions. To this end, authors from China, India, Indonesia, Japan, the Philippines, the Republic of Korea (South Korea), Thailand, and Vietnam worked together with Miranda Schreurs, Professor of Environmental and Climate Policy at the Bavarian School of Public Policy, Technical University of Munich to provide an in-depth analysis of the situation in their respective countries. The preparation of the country studies and their review was supported by Julia Balanowski.

The studies provide insights into the status of climate and energy policies, their socio-economic implications and the actors involved in developing and implementing those policies. Two of the important questions that motivated this comparative study were whether renewable energy development was contributing to a more socially just energy structure and which factors foster and impede political acceptance of renewable energy development.

The energy transition efforts of China show an increasing level of ambition and policy alignment both regarding specific targets, policy pathways and frameworks to achieve them. Although these policies have ushered in rapid gains in renewable energy, China's continued reliance on coal and its steadily rising energy consumption suggests a challenging path for a true clean energy transition. We hope that this study on China provides a starting point for further analysis and for a learning process on a transition towards renewable energy and that it will provide useful information to policymakers, academics and civil society to work together towards low-carbon development in China and beyond.

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I. Background

1.1 Introduction of the Chinese context

Located in East Asia, China is the world's most populous and largest emerging economy. Covering approximately 9.6 million square kilometres, China is the world's third-largest country by total area. Since the introduction of economic reforms in 1978, China has become one of the world's fastest-growing major economies (see Figure 1). During the past three decades, China's gross domestic product (GDP) has increased by 50.1 times with an average annual growth rate of 9.6 per cent.[1] As of 2016, China has become the world's second-largest single-country economy, with a GDP of 11.2 trillion US dollars.

China's rapid economic growth has largely depended on low-cost investment, cheap and abundant labour, and the massive use of natural resources. The achievements in economic development have given rise to a number of challenges, including a high debt to GDP ratio, inequality in income distribution, and environmental degradation (Zhang et al., 2017). Over the past five years, China's

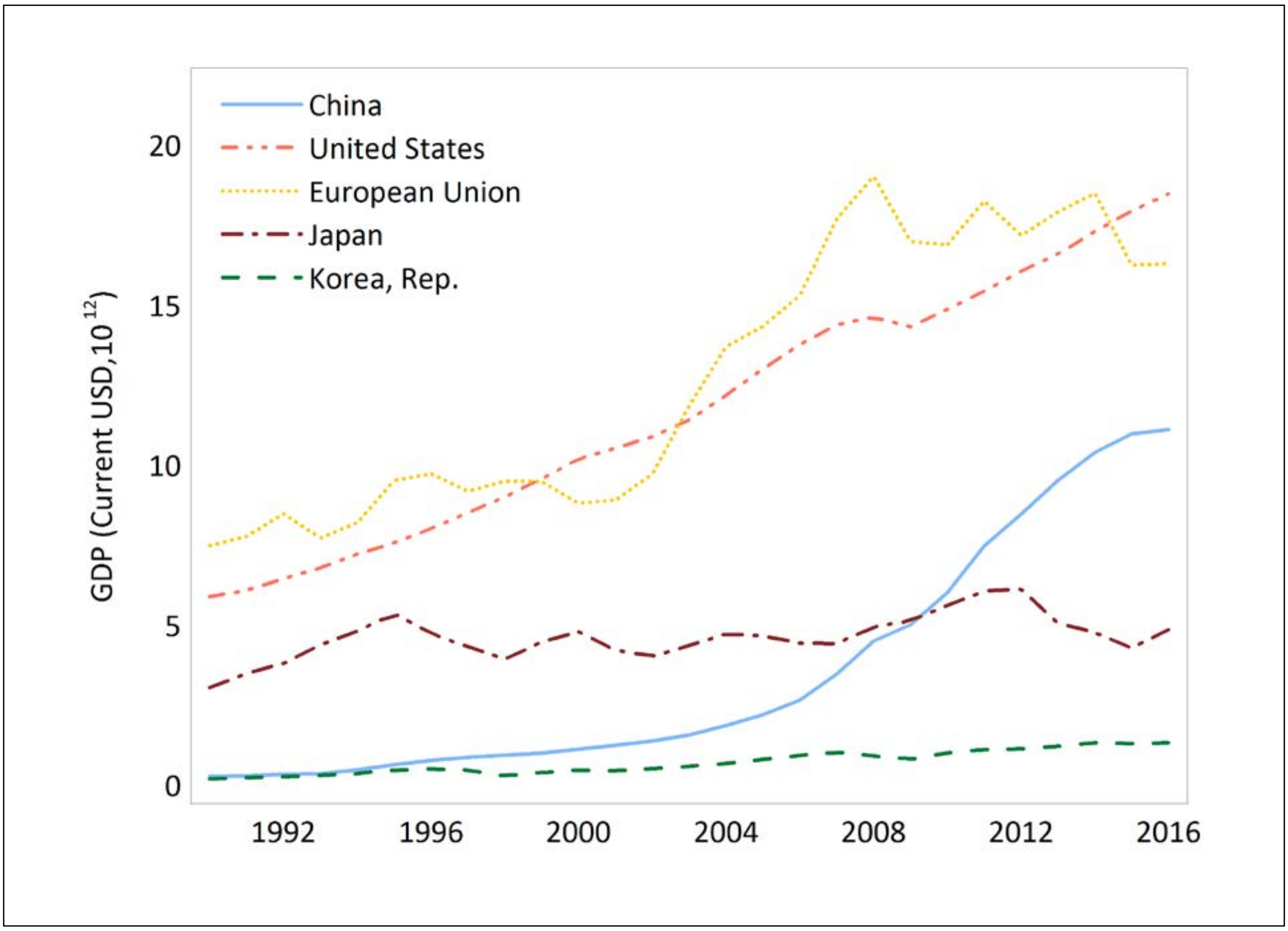

Figure 1: GDP of five countries in the past few decades.
Data Source: World Bank (1990-2016).

[1] Data source: World Bank (1987-2016).

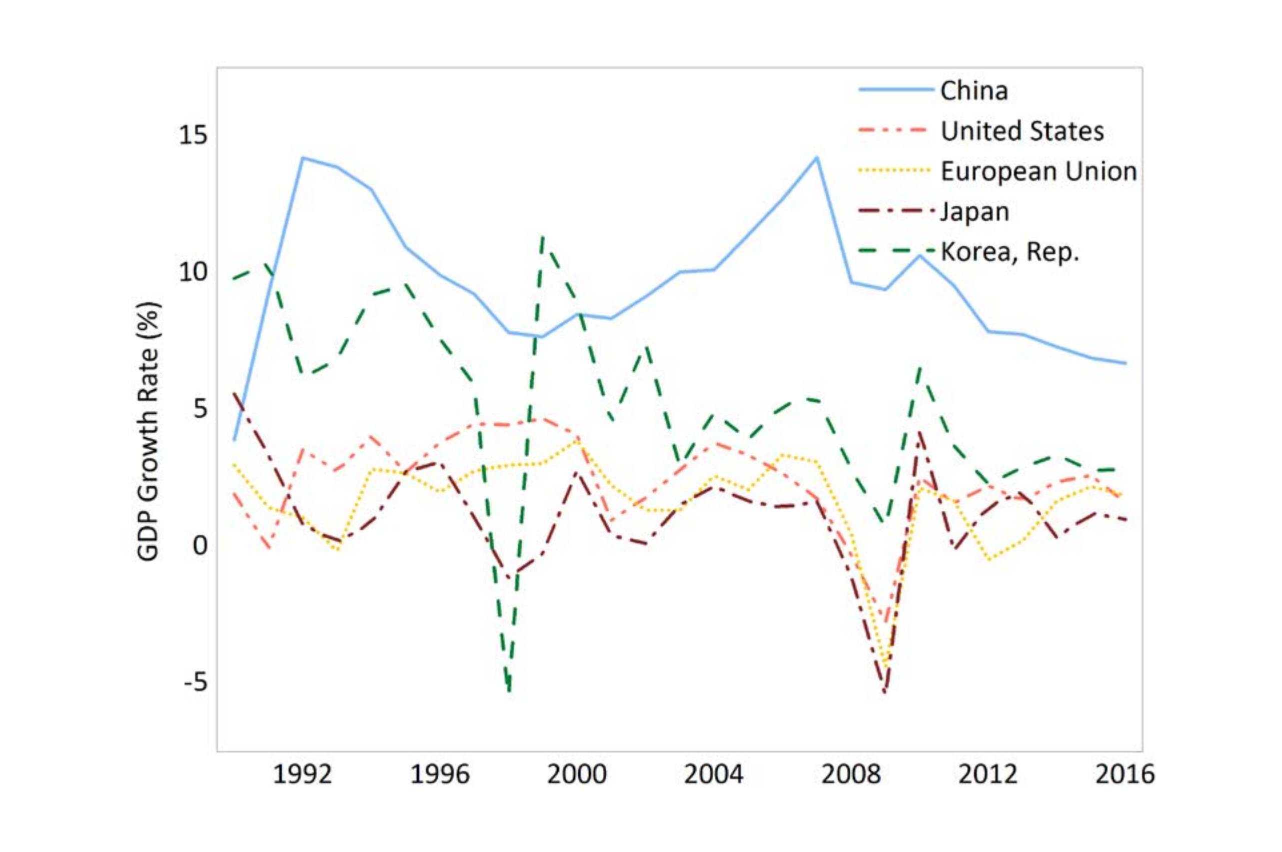

Figure 2: GDP growth rate of five countries from 1990 to 2016.
Data Source: World Bank (1990-2016).

economic growth rate has fallen from historic double-digit rates to 6-7 per cent (see Figure 2). Experiencing a significant slowdown in economic development, China is now at a critical point and must restructure its economy, and achieve a "new normal" of slower but more sustainable economic development.

China's economic growth can be broken down by sector into primary industry (agriculture), secondary industry (construction and manufacturing) and tertiary industry (services). With a significant shift in China's economic structure, the service sector doubled in size from 1990 to 2015, and surpassed the secondary sector to become the biggest contributor to China's GDP in 2015. In 2015, tertiary industry accounted for 53.7 per cent of total GDP, while secondary and primary industries accounted for 41.6 per cent and 4.7 per cent, respectively (see Figure 3).[2]

As the world's most populous country, the Chinese population exceeded 1.375 billion in 2015. The population is forecasted to reach 1.42 billion by 2021[3]. China's labour force accounted for about 56.3 per cent of the total population in 2015, and about 0.5 per cent of the workforce are working in energy-related sectors in cities and towns. Thanks to rapid urbanization in the past three decades, the percentage of the country's population living in urban areas increased from 20 per cent in 1980 to 56 per cent in 2015, and is predicted to reach 60 per cent in 2020.

2 Data source: China Statistical Yearbook (2016).
3 Data source: https://www.statista.com/topics/1317/employment-in-china/ (Accessed on July 24, 2017).

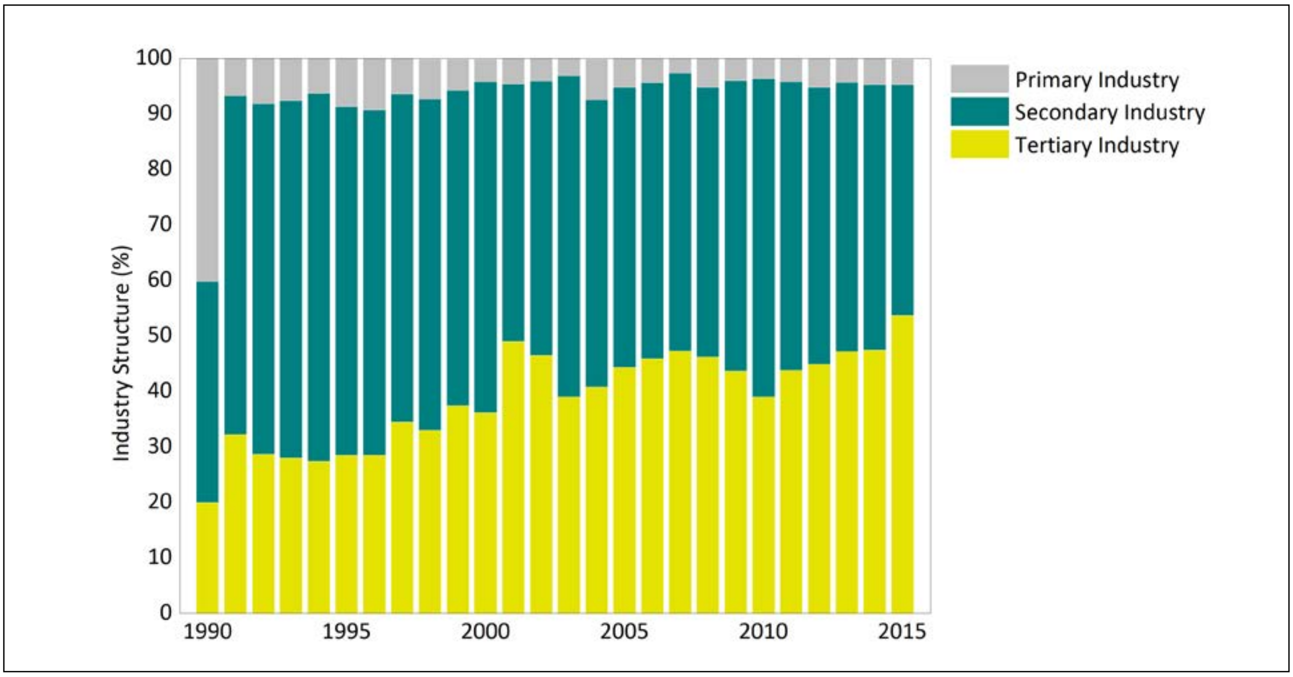

Figure 3: China's industrial structure by sector from 1990 to 2015.
Data Source: China Statistical Yearbook (2016).

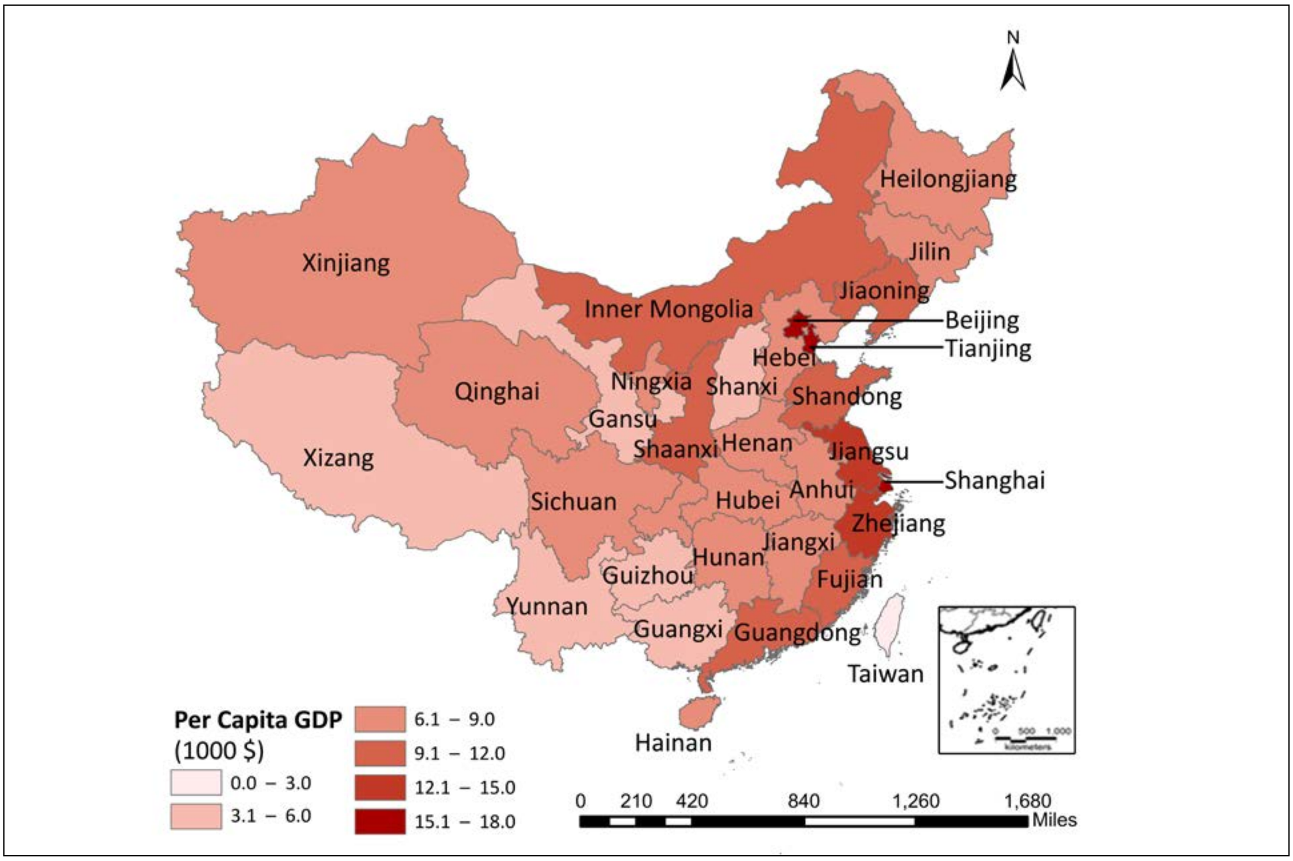

Figure 4: China's provincial GDP per capita in 2015.
Data Source: China Statistical Yearbook (2016).

Prosperous development brings with it the issue of income inequality. China's Gini coefficient for income was nearly 0.5 in 2015, compared to 0.4 in the United States and 0.3 in Japan.[4] The richest 1 per cent of households own a third of the country's wealth, while the poorest 25 per cent own just 1 per cent.[5] The consumption level in urban areas is two to three times higher than in rural areas. In addition to the disparity between cities and rural areas, the regional gap is also large. China's coastal provinces like Shanghai, Guangzhou, Jiangsu, and Beijing are relatively wealthy, while most of the poverty-stricken areas are located inland, such as Guizhou, Gansu, and Xizang. Provincial GDP per capita varies significantly, and the gap between the richest province (Tianjing) and the poorest one (Gansu) is 12,160 US dollars, which is almost twice the national average (see Figure 4).

1.2 Energy Consumption and Energy Mix

As a result of robust economic growth, domestic living standards have improved but so too has China's demand for energy. China has quickly become one of the biggest energy consumers in the world. During the past 20 years, China's energy consumption increased by 2.8 times with an annual growth rate of 5.1 per cent.

Energy consumption is mainly supplied by fossil fuels, among which coal is the main source. Coal power accounted for nearly 69.8 per cent of primary energy consumption in 2014, while the share of coal in US primary energy consumption was less than 20 per cent in the same year (see Figure 6). Because of abundant coal reserves, thermal power dominates China's electric power generation. In 2015, fossil fuel-fired power plants accounted for 66 per cent of total power generation capacity, in which the share of coal power was 61 per cent. With China's effort to diversify its energy supplies, the share of coal in China's energy consumption has decreased slightly during the past few years. However, hydroelectric sources (3.3 per cent), nuclear power (0.4 per cent) and other renewables still accounted for relatively small shares of China's energy consumption in 2014 (see Figure 5).

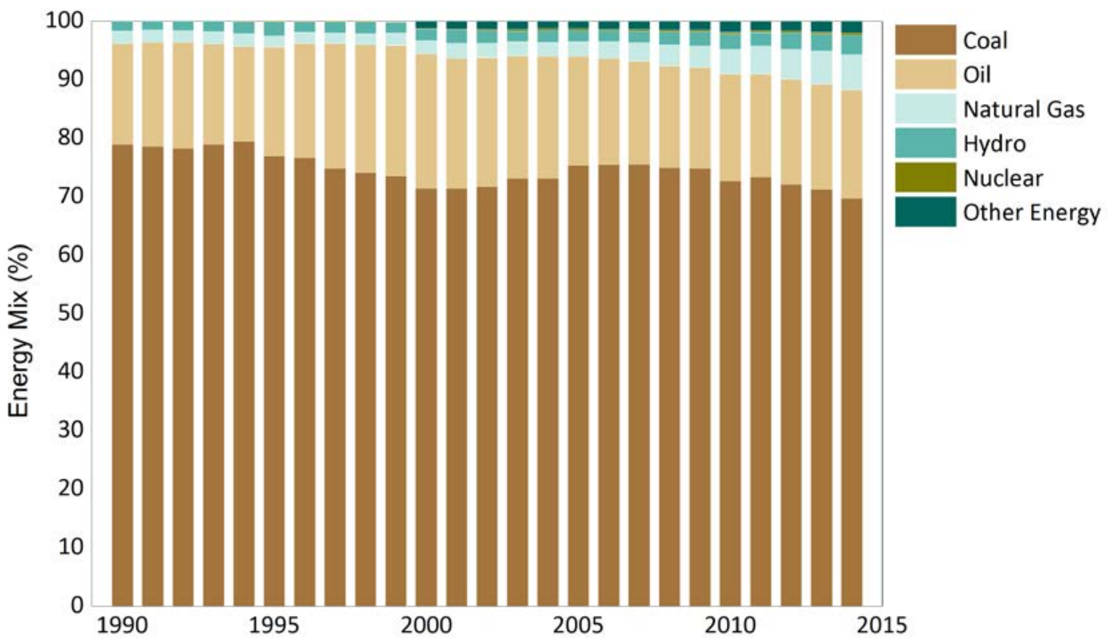

Figure 5: China's energy consumption mix since 1990.
Data Source: China Energy Statistical Yearbook (2015).

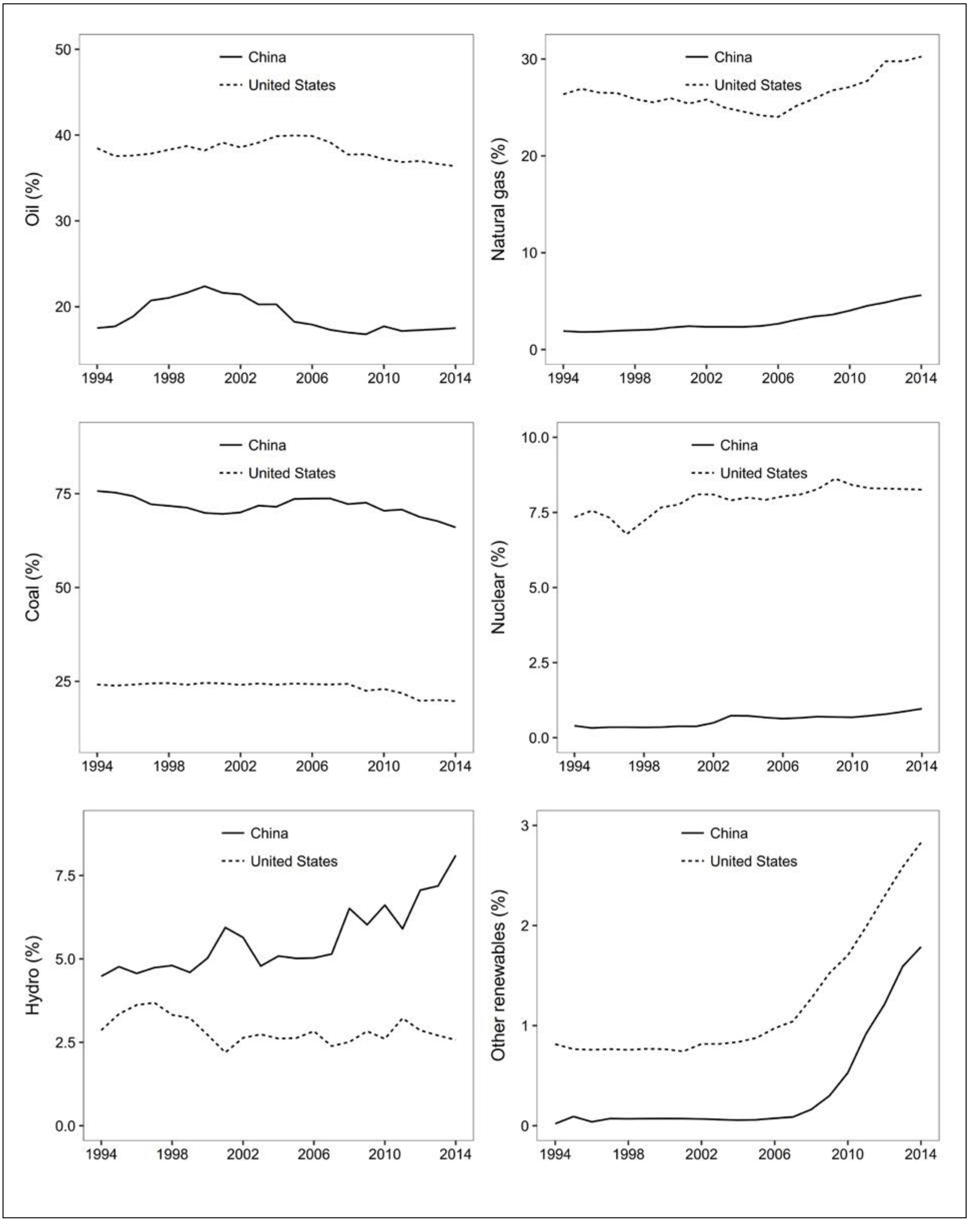

Figure 6: Energy mix in China and the United States (1994-2014).
Data sources: The BP Statistical Review of World Energy (2006-2015).

Table 1: China's energy possession and utilization levels compared to the global average [8]			
	Coal	Oil	Natural gas
Per capita possession	69%	6%	11%
Per capita production	255%	26%	21%
Per capita consumption	267%	69%	45%

There is a large spatial disparity between where energy resources and users are located. The western regions have abundant coal, oil, and natural gas resources, while most industries are located on the east coast. The seven eastern provinces—comprising Beijing, Tianjin, Hebei, Shanghai, Zhejiang, Jiangsu, and Guangdong—consume nearly 40 per cent of electricity.[6] The gap between energy demand and supply has motivated the central government to invest in several mega projects for energy redistribution, such as the west-east electricity transfer project.[7]

Electric power, industry, buildings, and transportation are the four key sectors of China's energy demand and related carbon emissions (Wang et al., 2015). Combined, these four sectors accounted for 73 per cent of national energy consumption and 82 per cent of energy-related carbon emissions in 2012. Therefore, these sectors will have the greatest potential in reducing emissions through an energy transition.

1.3 Energy Challenges

Rapidly increasing energy consumption in China has given rise to the challenge of accessing sufficient energy. In addition, the energy mix dominated by coal has caused large emissions of greenhouse gases (GHGs) and air pollutants in the past few years. The following will present three main challenges in the energy sector:

(1) Energy security

With rapid economic growth, China faces the challenge of rising energy insecurity. Domestic energy reserves are far from adequate to meet burgeoning demand, especially for oil and natural gas. China only has a 1.65 per cent share of global natural gas reserves and a 1.39 per cent share of global oil reserves, compared with 13.31 per cent for coal. Despite the abundance of coal, the per-capita reserves and production of coal energy in China are far below the global average (see Table 1).

As is illustrated in Figure 7 and Figure 8, rapid economic growth has boosted oil and natural gas consumption remarkably. Production has been unable to keep up with consumption since 1995 in the case of oil and 2009 for gas. In order to fill the large gap between energy supply and demand, China depends heavily on oil and gas imports, mostly from the Middle East and Africa. Currently, China is the largest importer of petroleum and second-largest importer of liquefied natural gas (LNG) behind Japan, with foreign oil and natural gas dependence at over 62 per cent and 32 per cent, respectively, in 2015.

The heavy dependence on imported energy exposes China's fast-growing economy to the potential risks of global energy supply disruptions (Liu, 2006). To prevent energy insecurity from undermining vibrant economic growth and social stability, the government has taken actions, such as diversifying China's energy sources with an emphasis on renewables (Dent, 2015).

[6] Data Source: https://www.wilsoncenter.org/wilsonweekly/chinas-west-east-electricity-transfer-project.html (Accessed on April 20, 2017).

[7] The west-east electricity transfer project, initiated in the 10th Five-Year Plan (FYP) (2000-2005), was designed to develop China's western regions and meet the growing electricity demand in the eastern provinces. The first phase of this project was to expand the electricity-generating capacity of western provinces, primarily through the construction of new thermal power stations and hydroelectric dams. The second phase mainly focused on building three electricity-transmission corridors, which connect the suppliers in the west and the consumers in the east. The capacity for each corridor is expected to exceed 40 GW by 2020, with the combined capacity equivalent to 60 Hoover Dams.

[8] Data source: The BP Statistical Review of World Energy (2015).

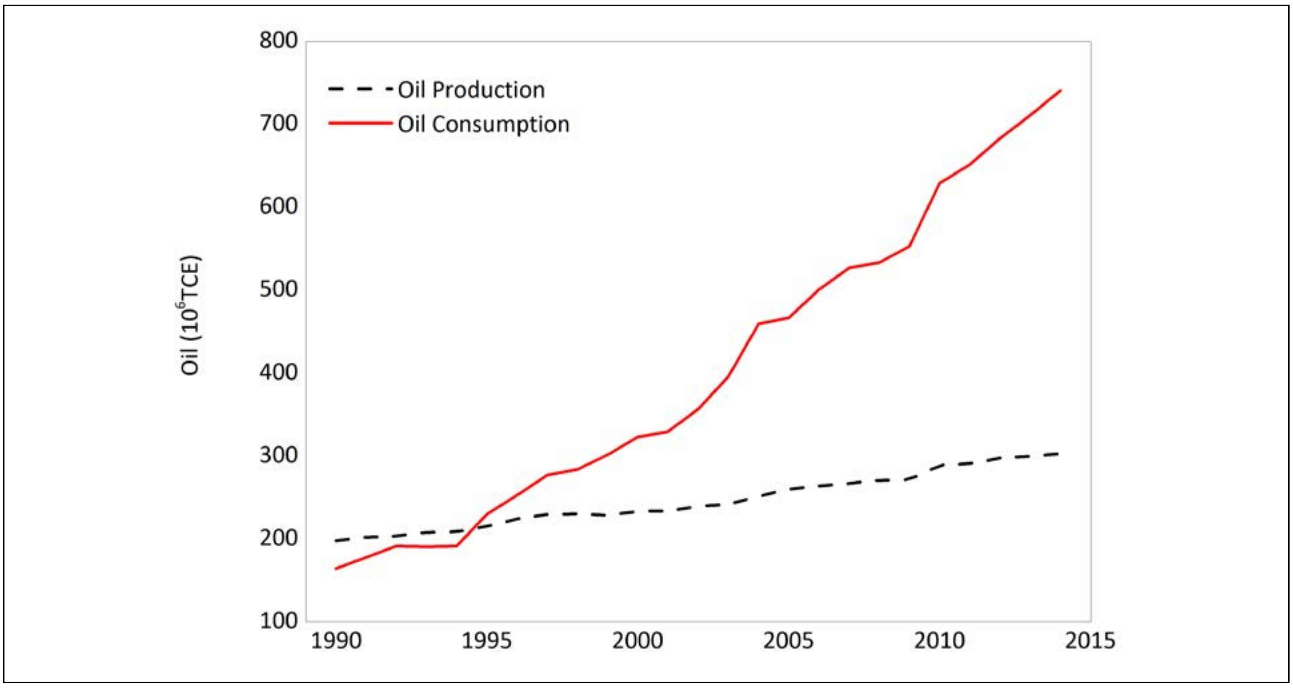

Figure 7: China's production and consumption of oil from 1990 to 2015.
Data Source: China Statistical Yearbook (1991-2015).[9]

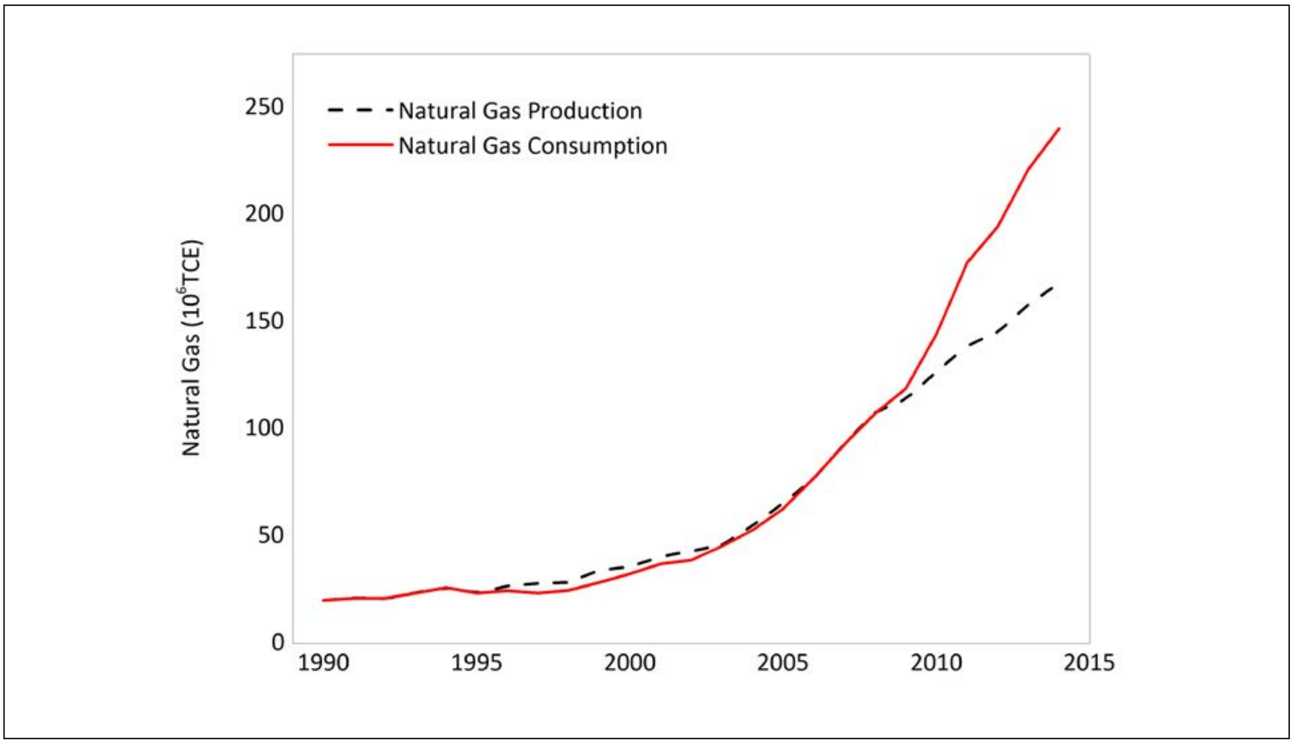

Figure 8: China's production and consumption of natural gas from 1990 to 2015.
Data Source: China Statistical Yearbook (1991-2015).

[9] TCE: tonne of standard coal equivalent.

(2) Air pollution

China has the world's largest coal production and consumption, which has sparked environmental concerns. In addition, raw coal is the main source for burning and heating in households and industrial boilers, which results in severe pollution. The massive consumption of fossil fuels has caused severe regional air pollution and other environmental problems in recent years, particularly in coal-reliant north China (Tambo et al., 2016). In 2015, the mean fine particulate matter ($PM_{2.5}$) concentration was 47μg/m^3, 34 per cent higher than the maximum value recommended by the World Health Organization (WHO) (35μg/m^3).

Air pollution has therefore become a major public health concern. The exposure to ambient air pollution is a leading contributor to the national disease burden. The Global Burden of Disease (GBD) project reported that 1.1 million (95 per cent CI 1.0 million to 1.8 million) deaths in China could be attributed to ambient $PM_{2.5}$ in 2015 (Cohen et al., 2017).[10] In addition, household air pollution (HAP) is ranked among the top 10 risk factors for mortality, causing about 1 million premature deaths in 2010 (Lim et al., 2012). The most pronounced health impact of HAP is observed in rural areas, where the frequent use of traditional fuels and inefficient stoves leads to high exposure levels to soot and particulates.

The negative health effects of air pollution significantly increase the public's demand for effective environmental actions, and highlight the need for cleaner energy. Severe haze has motivated environmental groups to advocate more aggressive environmental and climate actions, further accelerating the measures of air pollution control and energy transition.

(3) Climate change in China's context

Because of high coal consumption levels, China surpassed the United States to become the world's largest emitter of GHGs in 2007 (See Figure 9). China

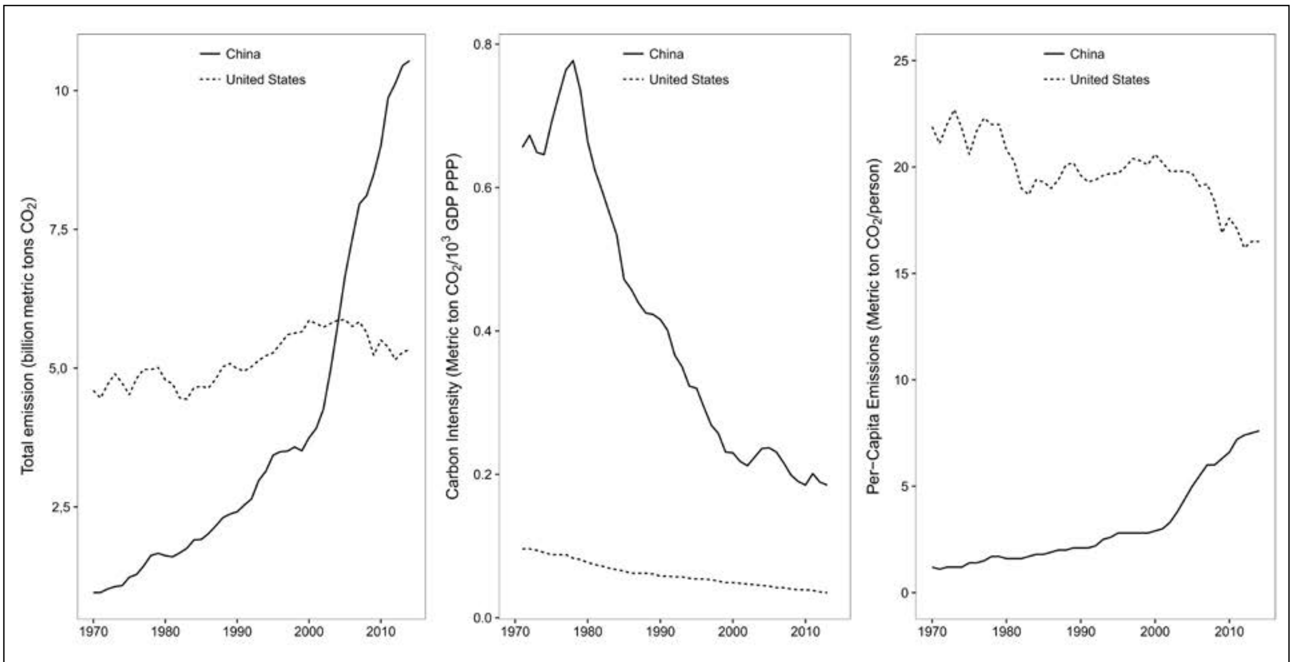

Figure 9: CO2 emissions from fossil fuel consumption in China and the United States (1978-2011).
Data sources: The emission data are provided by the Carbon Dioxide Information Analysis Center at the Oak Ridge National Laboratory. The GDP (PPP in 2005 US dollars) and population data are from the World Bank (1997-2015).

10 CI: Confidence Interval.

accounted for 29 per cent of the global carbon dioxide emissions in 2011.[11] China is predicted to be responsible for about 40-50 per cent of global emission growth before 2040 under the business-as-usual scenario (Yang et al., 2014). With the continuous expansion of carbon emissions, China has become the focus of scrutiny in the international climate negotiations. Meaningful actions by China would be necessary for the global community to achieve its climate targets.

Moreover, China already suffers from the adverse effects of global warming. The annual average air temperature has increased by 0.5-0.8°C during the past 100 years, which is slightly higher than the global average (NDRC, 2007). The changes in rainfall and heat patterns caused by climate change bring more frequent climatic hazards, such as more droughts and floods, shrinking wetlands and frozen soils, ocean acidification, and declining quality of cultivated land (Li et al., 2011). These kinds of extreme weather events also aggravate the economic burden. The Chinese government estimates that extreme weather events have cost over 3 billion US dollars per year since 2010.[12]

Facing international and domestic pressures, China has attached great importance to addressing the challenges associated with energy security, air pollution, and climate change. Its relevant commitments provided an important driving force for the energy transition. Since the 12th Five-Year Plan (FYP), China has integrated energy transition measures into its national development strategy, and highlighted the renewable energy industries as "strategic." In order to have a better understanding of the planned energy transition, the next section provides an overview of China's official targets and measures. Their political feasibility and social aspects are examined in detail in sections 3 and 4, respectively. In order to facilitate China's energy transition, we will focus on the main challenges and make specific recommendations for the Chinese government and for FES in sections 5 and 6, respectively.

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11 European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. Emission Database for Global Atmospheric Research (EDGAR), release version 4.2. http://edgar.jrc.ec.europe.eu, 2011.

12 China Climate Bulletin: http://zwgk.cma.gov.cn/web/showsendinfo.jsp?id=15603 (Accessed on April 10, 2017).

2. Energy transition in China

2.1 The Renewable Energy Law and feed-in tariffs

An energy transition is a long-term structural change in energy systems, pursuing an energy mix in which the major share is generated by renewable sources.[13] Driven by the issues of energy security, the environment, and climate change, China aims to increase the share of non-fossil fuels with a particular focus on the development of renewable energy, including wind, solar, geothermal, small hydro, and ocean power. The official target according to the 13th FYP is to increasing the share of renewable energy and non-fossil fuel in primary energy consumption to 12 per cent and 15 per cent, respectively, by 2020. In addition, China committed to increase the share of non-fossil fuels to approximately 20 per cent by 2030 in its Nationally Determined Contribution (NDC). This target again confirmed China's great ambition in energy transition.

As energy transition is essential for climate and environmental affairs, China's energy transition has a close relationship with multiple departments. Up until the 19th National People's Congress,[14] the Department of Climate Change in the NDRC was in charge of China's climate change strategy, taking the lead in organizing and implementing key plans and policies in response to climate change. The Ministry of Environmental Protection (MEP) was responsible for implementing policies to improve environmental quality.Directly under the State Council, the MEP took charge of protecting China's air, water, and land from pollution and contamination.[15] Although the development of non-fossil fuels was essential for the agenda of the above two agencies, energy transition is the responsibility of the NEA. As a subdivision of the NDRC, the NEA was empowered to administer energy sectors including coal, oil, natural gas, and new and renewable energy. Under this decentralized governance, effective coordination among these departments is crucial for the implementation.

China's energy transition is guided by the Renewable Energy Law that was initially promulgated in 2005 and revised in 2009. As the legal foundation for renewable energy development, the law provides a crucial long-term commitment to the growing renewable energy industry by adopting a feed-in tariff (FIT). The FIT accelerates investment into renewable energy by offering cost-based compensation to producers based on the power resources used to generate electricity and the region where production takes place. Foreseeing relatively higher resource and construction costs, the FIT for renewable power is set to a level higher than the average tariff for grid-connected thermal power.[16] This indicates that the government is willing to provide guaranteed benefits to renewable electricity generators. Areas with more abundant renewable resources have lower tariffs, while those with less renewable resources have higher tariffs. This has been the case for onshore wind power since 2009 and for solar power since 2013.

Grid utilities are required to purchase all the renewable energy that is produced and feed it into the grid. However, the gaps between the tariffs for renewable energy and fossil fuels are not borne by the grid companies alone, but are shared by the whole of society. China set up a fund called 'Renewable Power Plus' to cover the FITs and other renewable energy costs. The fund collects 'Renewable Power Plus' fees from targeted users according to their electricity consumption. The levy has increased gradually from 0.0001 US dollars per KWh in 2006 to 0.003 US dollars per KWh in 2016.

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13 World Energy Council, Global Energy Transitions: https://www.atkearney.com/documents/10192/5293225/Global+Energy+Transitions.pdf/220e6818-3a0a-4baa-af32-8bfbb64f4a6b (Accessed on July 3, 2017).

14 The National People's Congress is the national legislature of China. During the institutional reform launched by the 19th National People's Congress in 2018, the governance of climate change and emissions reduction policies in China has been shifted to the newly expanded Ministry of Ecology and Environment (MEE), which absorbed functions from the Ministry of Environmental Protection (MEP), the NDRC and several other ministries. While it remains unclear what the exact outcomes of this institutional reshuffle will be, the governance of the energy transition and its incentives seem to be more divided than before. An effective coordination of efforts will be the most pressing need for carrying out China's energy transition.

15 Data source: https://en.wikipedia.org/wiki/Ministry_of_Environmental_Protection_of_the_People%27s_Republic_of_China (Accessed on August 16, 2017)

16 The average tariff for grid-connected thermal power is about 0.051 US dollars per KWh in 2016.

Table 2: The FITs of wind power by zones (US dollars).					
Region	2009-2014	2015	2016-2017	2018-	Geographical Coverage
Category I	0.077	0.074	0.071	0.061	Inner Mongolia (except Chifeng, Tongliao, Xing'an, and Hulun Buir) and Xinjiang (Urumchi, Ili Kazak Autonomous Prefecture, Karamay, and Shihezi).
Category II	0.082	0.079	0.076	0.068	Hebei (Zhangjiakou and Chengde), Inner Mongolia (Chifeng, Tongliao, Xing'an, and Hulun Buir), Gansu (Jiayuguan and Jiuquan), and Yunnan.
Category III	0.088	0.085	0.082	0.074	Jilin (Baicheng and Songyuan), Heilongjiang (Jixi, Shuangyashan, Qitaihe, Suihua, Yichun, Great Khingan), and Gansu (except Jiayuguan and Jiuquan), Xinjiang (except Urumchi, Ili Kazak Autonomous Prefecture, Karamay, and Shihezi), and Ningxia.
Category IV	0.092	0.092	0.091	0.086	Others

The Chinese government has adopted a stepped tariff degression for renewable energy. As Table 2 and Table 3 show, there has been a significant decline in the FITs for onshore wind power and solar power. The tariff rate for renewable power has dropped about 20 per cent from 2009 to 2017. China's National Development and Reform Commission (NDRC) issued the latest FITs adjustment plan on December 1, 2016. The plan noted that, depending on the resource area, the tariff for onshore wind power in 2018 will be reduced to four different levels: 0.061, 0.068, 0.074, and 0.086 US dollars per KWh, while the tariff for solar power will be reduced to 0.098, 0.114, and 0.129 US dollars per KWh in 2017.

Although the "tariff degression" is a fatal blow to small and medium-sized renewable firms that have relied heavily on these subsidies, it can also promote technology efficiency and competitiveness in the renewable energy sector.[17] The past decade has seen a dramatic and sustained improvement in the competitiveness of renewable power generation technologies. As Chinese renewable manufacturing has grown, the costs of renewable energy have declined greatly. Innovation and market expansion are the main drivers of reduced costs.[18] In addition, lower FITs can resolve the country's renewable energy subsidy gap. In 2015, the gap reached 6 billion US dollars, so it is imperative to improve China's renewable energy policies.

17 Source: http://www.renewableenergyworld.com/articles/2016/10/china-to-lower-feed-in-tariff-cut-subsidies-for-solar-pv-systems.html (Accessed on July 3, 2017).

18 Source: http://www.nature.com/news/economics-manufacture-renewables-to-build-energy-security-1.15847 (Accessed on July 3, 2017).

Table 3: The FITs of solar power by zones (US dollars).					
Region	2011.7-2013.8	2013.9-2015.12	2016.1-2016.12	2017.1-	Geographical Coverage
Category I	0.151 [19]	0.136	0.121	0.098	Ningxia, West of Qinghai, Gansu (Jiayuguan, Wuwei, Zhangye, Jiuquan, Dunhuang, Jinchang), Xinjiang (Kumul, Tacheng, Altay, and Karamay), and Inner Mongolia (except Chifeng, Tongliao, Hinggan League, and Hulun Buir).
Category II		0.144	0.133	0.113	Beijing, Tianjing, Heilongjiang, Jilin, Liaoning, Sichuan, Yunnan, Hebei (Zhangjiakou, Tangshan, Qinhuang Island and Chengde), Inner Mongolia (Chifeng, Tongliao, Xing'an, and Hulun Buir), Shanxi (Datong, Suzhou and Xinzhou), and Shanxi (Yulin and Yanan), Qinghai, Gansu, and Xinjiang (except Kumul, Tacheng, Altay, and Karamay).
Category III		0.151	0.148	0.129	Others

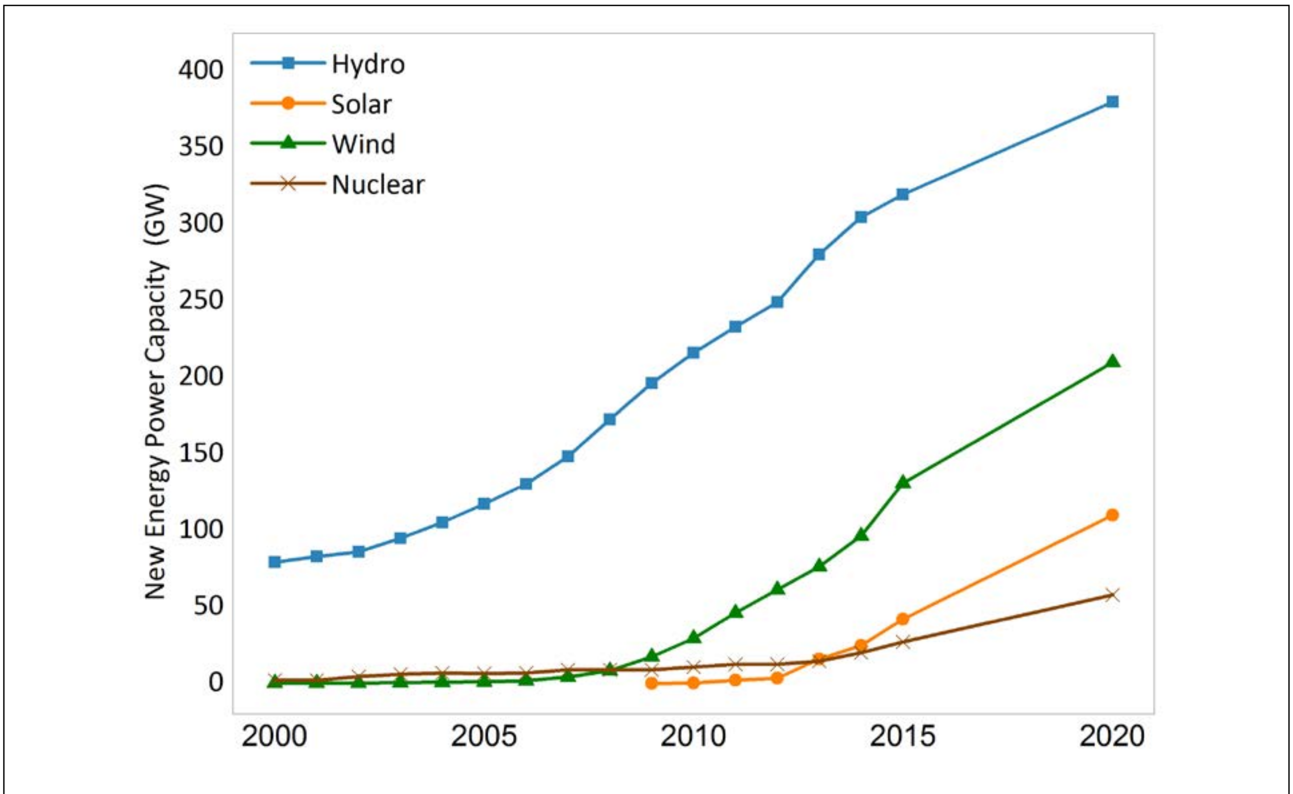

Figure 10: China's renewable energy and other non-fossil fuel power capacity.
Data Source: The US Energy Information Administration (2000-2015).

[19] Except Xizang.

2.2 Rapid Expansion of Renewable Energy

FITs and other associated renewable policies can create large incentives for domestic and foreign investors to participate in the exploitation and utilization of renewable energy. With strong policy support, China's renewable energy sector is growing fast. The renewable power generation capacity quadrupled from 122 GW in 2005 to 492 GW in 2015, with targets for 700 GW by 2020.[20] China is leading the global expansion of renewables. In 2014, China had a total capacity of 434 GW of renewable power, followed by the US (160 GW), Germany (82 GW), India (71 GW), and Japan (48 GW).[21] Most of China's renewable capacity is based on hydroelectric and wind power (see Figure 10). In order to have a more comprehensive view of China's energy strategy, our analysis in this section also covers the development of large hydro and nuclear energy.[22]

Although China currently has the world's largest installations of hydro, solar, and wind power, the electricity provided by renewable sources is still far from meeting China's huge demand. In 2015, renewable power only accounted for 27.4 per cent of China's power generation, with most of the remainder provided by traditional coal power facilities (see Figure 11).

(1) Hydropower

Hydropower is derived from the energy of falling water. It is an important source of electricity generation. Due to its cost-effectiveness and sizeable resource potential, hydroelectricity is China's largest source of non-fossil

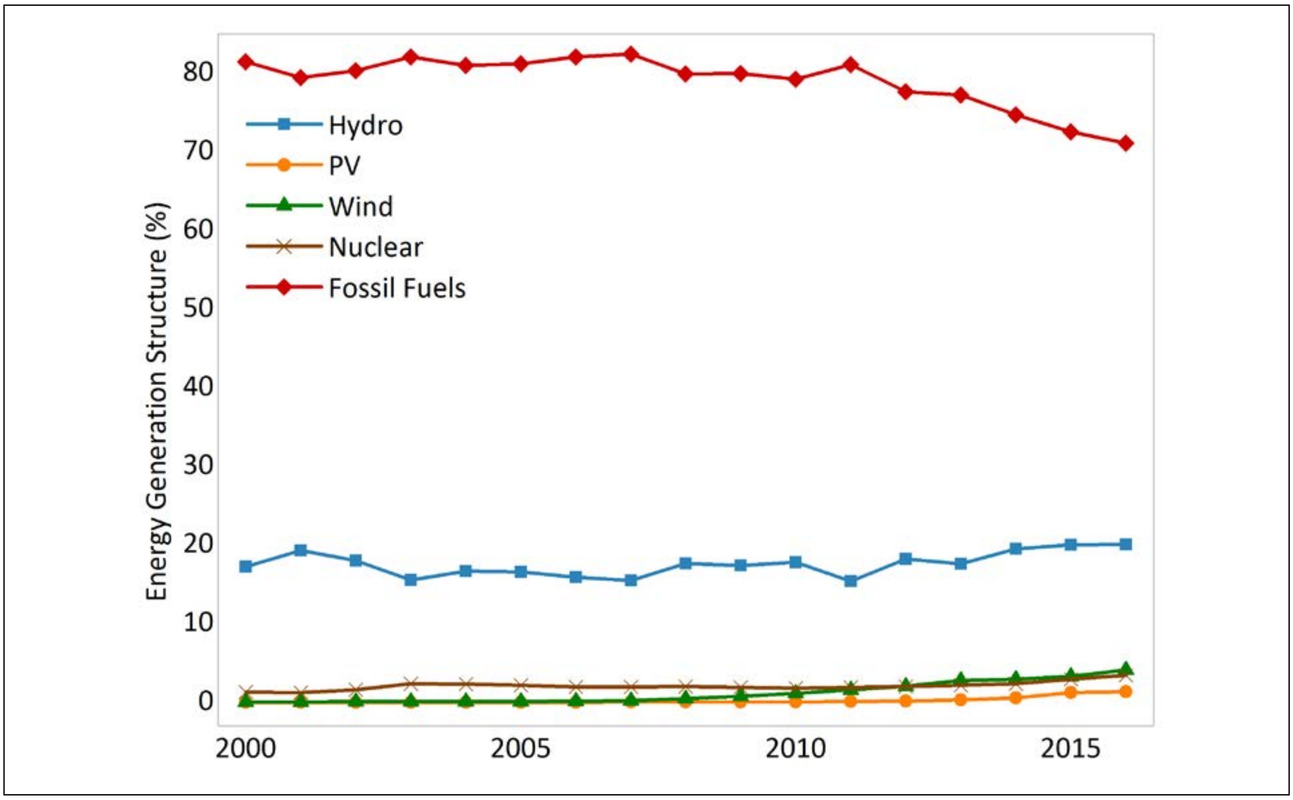

Figure 11: China's generation structure by energy source.
Data Sources: China Statistical Yearbook and China Electric Power Yearbook (2000-2016).

20 This target includes the power generation capacity of hydro, wind, and solar power in 2020.
21 Data source: The US Energy Information Administration (EIA) (2014).
22 The collective term in China for nuclear energy and renewables is "new energies".

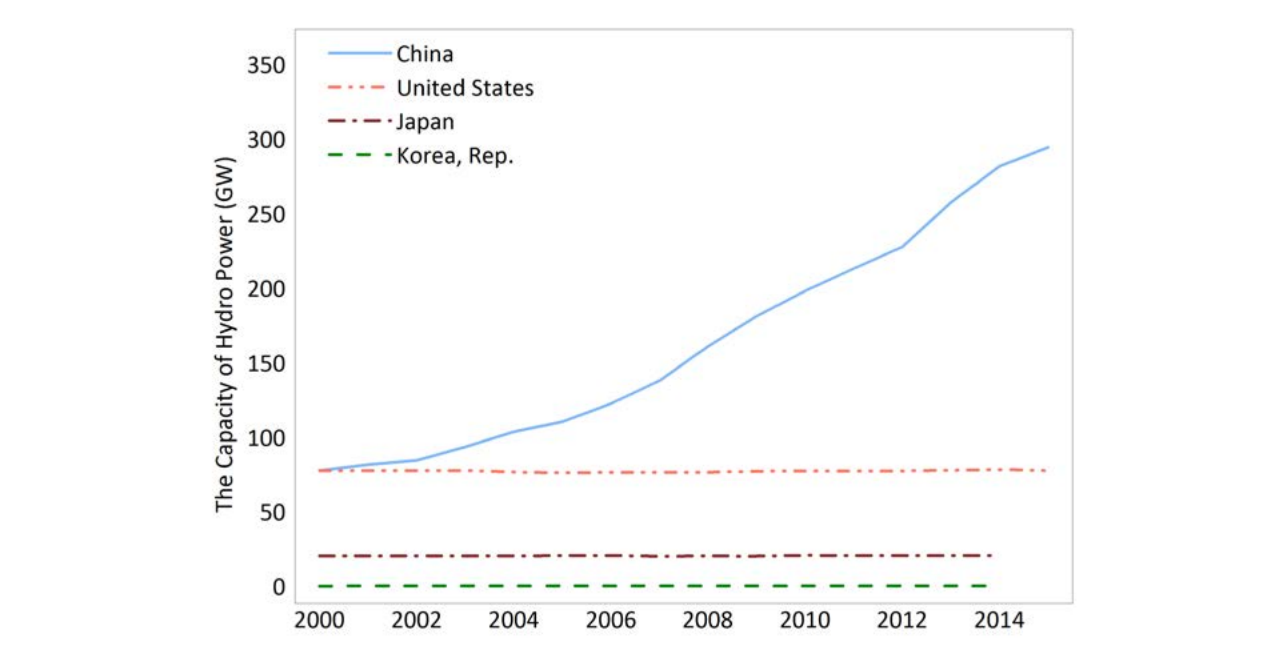

Figure 12: Hydropower capacity in different countries.
Data Source: The US Energy Information Administration (2000-2014).

fuel energy.[23] In 2015, China generated 1,099 TWh of hydropower, accounting for roughly 20 per cent of China's total electricity generation. In addition, China held the largest share (27.9 per cent) of global hydropower (see Figure 12). The capacity even exceeds that of Brazil, the United States, and Canada combined (Adib et al., 2016). Building on past momentum, China set ambitious targets for continued hydropower installation. In the past several years, China's installed hydro capacity increased from 79 GW in 2000 to 320 GW in 2015, with a target of 380 GW by 2020.[24]

With a spatially uneven distribution of water resources in China, over two-thirds of China's hydroelectric resources are located in the southwest (see Figure 13). The Three Gorges Dam, which spans the Yangtze River, is the world's largest power station in terms of installed capacity (22,500 MW).[25] State Owned Enterprises

Table 4: China's top 10 hydro facility operators in 2011. Source: State Electricity Regulatory Commission. [26]

Operators	Market Share	Operators	Market Share
China Yangzi River Utility	55%	China Huaneng	5%
China Utility Investment	10%	State Direct Investment	5%
China Huadian	8%	Hubei Energy	2%
China Datang	7%	Guangdong Electricity Dev.	2%
China Guodian	7%	Zhejiang Energy Group	1%

[23] Data source: http://instituteforenergyresearch.org/analysis/china-worlds-largest-energy-consumer-and-greenhouse-gas-emitter/ (Accessed on July 29, 2017).
[24] Data source: China Statistical Yearbook (2016).
[25] Data source: https://en.wikipedia.org/wiki/Three_Gorges_Dam (Accessed on August 2, 2017).
[26] Data source: http://www.ecology.com/2013/03/28/hydro-power-in-china/ (Accessed on August 2, 2017).

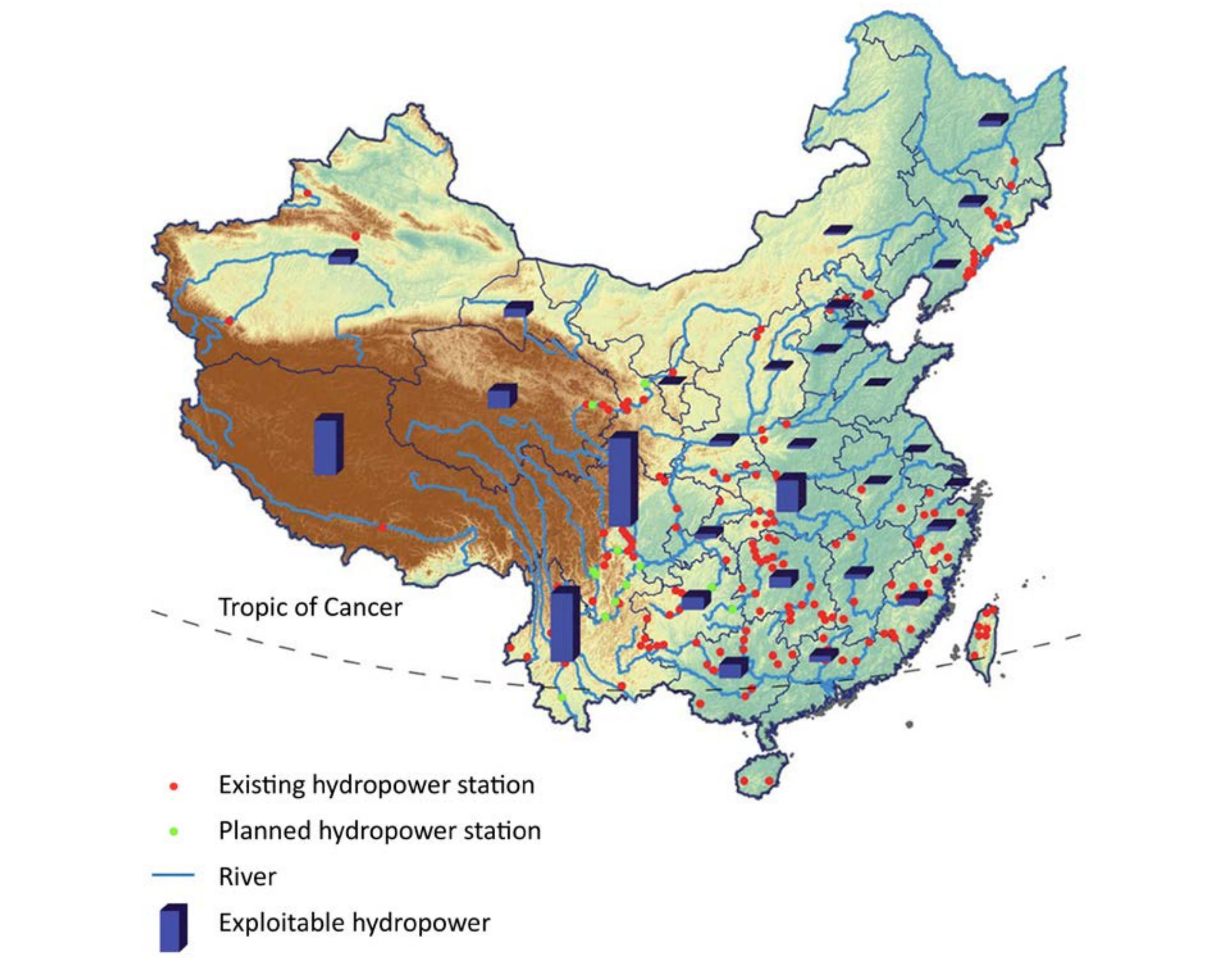

Figure 13: Distribution of hydropower resources and the major hydroelectric dams in China's mainland (2013 data). Blue blocks indicate the exploitable hydropower in the corresponding province. Tibet, Sichuan, and Yunnan host over two-thirds of total hydroelectric resources (Hu et al., 2013).

(SOEs) operate almost all of China's installed hydropower capacity. Table 4 shows China's top 10 hydro facility operators in 2011.

(2) Wind power

As a clean and relatively reliable alternative to fossil fuels, wind power is important to China's energy transition. There has been a rapid growth in wind power generation. The installed capacity of wind increased from 0.3 GW in 2000 to 148 GW in 2015 (see Figure 14). By the end of 2015, China had generated 181 TWh of wind power, supporting 3.3 per cent of national electricity consumption.[27] Inner Mongolia, Xinjiang, Gansu, Hebei, and Ningxia are the top five provinces, accounting for 52.1 per cent of total wind power capacity in 2016. All of the top five provinces except Hebei are located in northwest China, where wind power is abundant, albeit far from population and electricity consumption centres.

China is the world's leader in installed wind power capacity, with a capacity of 148 GW in 2015 (see Figure 14). In addition, with a global record of newly added wind power capacity of 30.8 GW in 2015, which corresponds

[27] Data source: The US Energy Information Administration (EIA) (2015).

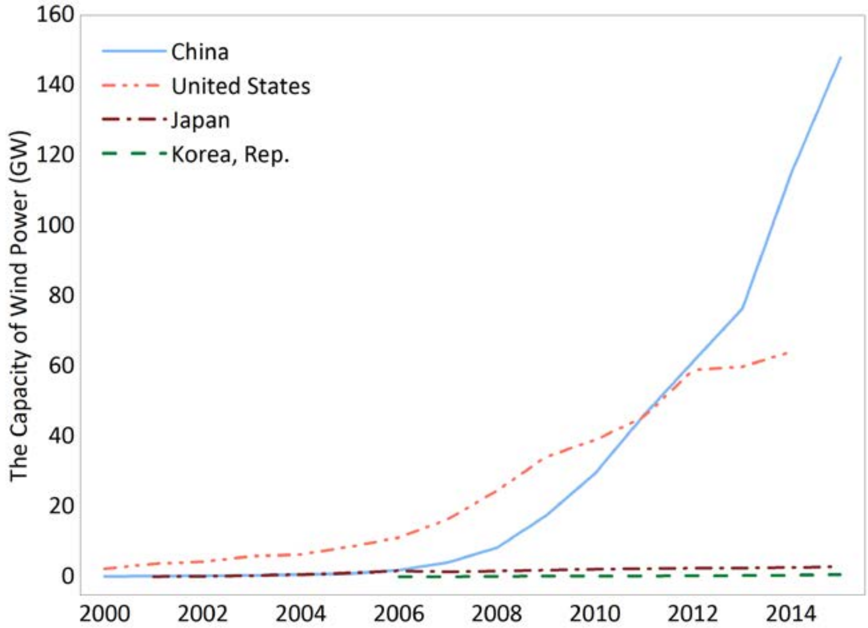

Figure 14: Installed wind power capacity in different countries.
Data Source: The US Energy Information Administration.

to almost half of the total worldwide additions in the same year, China has become the main driver of the global wind power market (Adib et al., 2016). Based on the rapid growth in renewables, China has set its 2020 target for on-shore wind power capacity at 210 GW, which indicated that the implied annual growth rate for wind power will be 7.3 per cent.

The table below shows key players in China's wind market. As of 2015, Goldwind was the largest competitor in the

Table 5: Key players in the Chinese wind market in 2015.

	Manufacturer	Type	New Installations (MW)	Market Share
1	Goldwind	SJVE[28]	7,748.9	25.2%
2	Guodian United	SOE	3,064.5	10.0%
3	Envision	SOE	2,510.0	8.2%
4	Mingyang	SJVE	2,510.0	8.2%
5	China Shipbuilding Industry	SOE	2,092.0	6.8%
6	Shanghai Electric	SJVE	1,926.5	6.3%
7	Xiangtan Electric Manufacturing	SOE	1,510.0	4.9%
8	DongFang Electric	SOE	1,388.0	4.5%
9	Windey	SOE	1,260.0	4.1%
10	Sany	PE[29]	951.0	3.1%
	Others		5,792.1	19%
	Total		30,753.0	100%

28 SJVE: Sino-Foreign Joint Venture Enterprise.
29 PE: Private Enterprise.

market, with a 25.2 per cent share of new installations. It is followed by Guodian United Power Technology Company (a subsidiary of China Guodian Corporation) at 10 per cent, Mingyang Wind Power at 8.2 per cent, and Envision Wind Power at 8.2 per cent (Pullen et al., 2016).

The utilization of wind energy, however, is not keeping up with the remarkable rate at which wind power capacity is being constructed. Challenges, including the lack of transmission infrastructure, delays in connecting new installations to the grid, and regulatory barriers and management problems have led to significant wind curtailment in the past few years. Starting from the first severe wind curtailment in 2010, the problem has worsened every year. In 2011, the national overall wind power volume exceeded 10 billion KWh. The average number of hours when this capacity was used, however, decreased enormously, and the economy of wind power operation was therefore greatly damaged. It is reported that more than 46.5 billion kilowatt hours of the electricity generated by wind and solar power was abandoned in 2016 due to the difficulty of grid-connection.[30] Such large proportions of wind curtailment are not only wasteful of clean energy resources, but will dent investors' enthusiasm for developing renewable energy in the future.

(3) Solar power

Solar is the fastest growing source of renewable energy in China. The total generation capacity of solar photovoltaic (PV) has rocketed upward by a factor of almost 97 in the past five years. In 2015, China had a total solar PV capacity approaching 44 GW, overtaking Germany, the long-term leader, to become the top country for cumulative solar PV capacity (see Figure 15).[31]

At the end of 2016, Xinjiang, Gansu, Qinghai, Inner Mongolia, and Jiangsu were the top five provinces in terms of cumulative solar PV capacity, accounting for

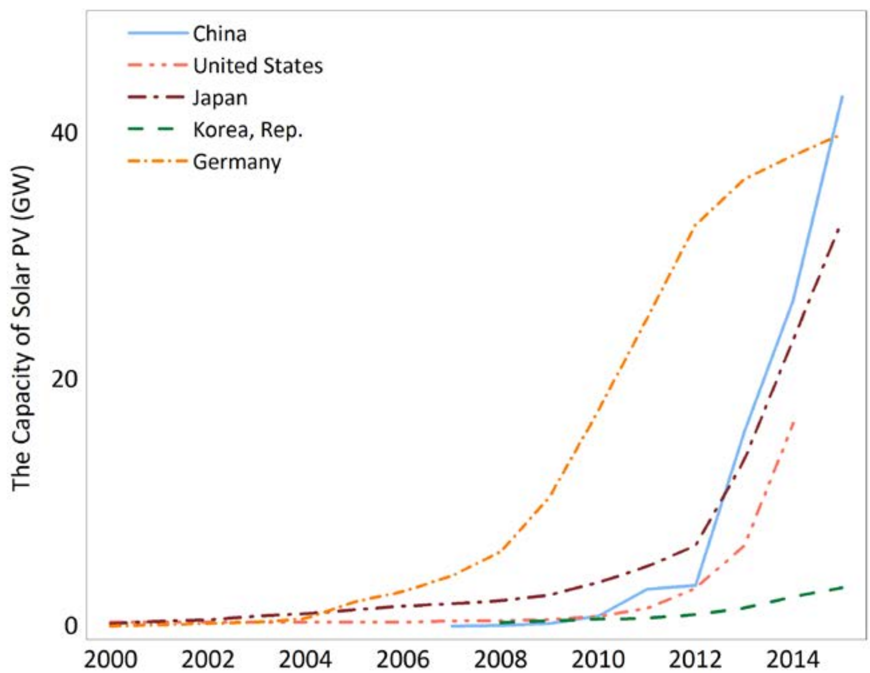

Figure 15: Solar power capacity in different countries.
Data Source: The US Energy Information Administration (2000-2015).

[30] Source: http://www.bmlink.com/xzcgxny/news/832932.html (Accessed on April 25, 2017).
[31] Data Source: https://www.reuters.com/article/china-solar-idUSL3N15533U (Accessed on August 2, 2017).

43.7 per cent of national capacity. Similar to the situation of wind power, all top five markets except Jiangsu are located in northwest China, with the majority of their capacity far from economic and population centres.[32]

Large-scale power plants accounted for 86 per cent of total solar PV capacity, with the remainder coming from distributed solar power systems and other small-scale installations. Distributed solar power refers to the PV projects found on the rooftops of industrial buildings, malls, and schools. The data from China's solar market shows that 4.24 GW of distributed solar-power was installed in 2016, accounting for 12 per cent of new solar PV installations in China. The majority of these new distributed installations are found in central and east China. In 2016, Zhejiang, Shandong, Jiangsu, Anhui, and Jiangxi had the highest annual solar PV capacity rates, with a share of 68.6 per cent in total.[33]

Similar to the situation facing wind power, curtailment has become a serious challenge to the full utilization of solar power and threatens its expansion. The curtailment rate was particularly high in the northwest provinces of Gansu (31 per cent) and Xinjiang (26 per cent) in 2015. The national average solar power curtailment rate is 12 per cent. Insufficient grid capacity significantly hindered the development of new plants, and investors were growing wary due to delays in subsidy collection and problems with solar panel quality.[34]

In addition, China is the largest market for solar water-heating capacity in the world, with 309 GW in operation at the end of 2015, accounting for about 71 per cent of the total world capacity (see Figure 16) (Adib et al., 2016).

(4) Nuclear

As of August 2017, China had 37 nuclear reactors operating with a capacity of 32.4 GW and 20 nuclear reactors are under construction with a capacity of 20.5 GW.[35] Most of the installed reactors are located along

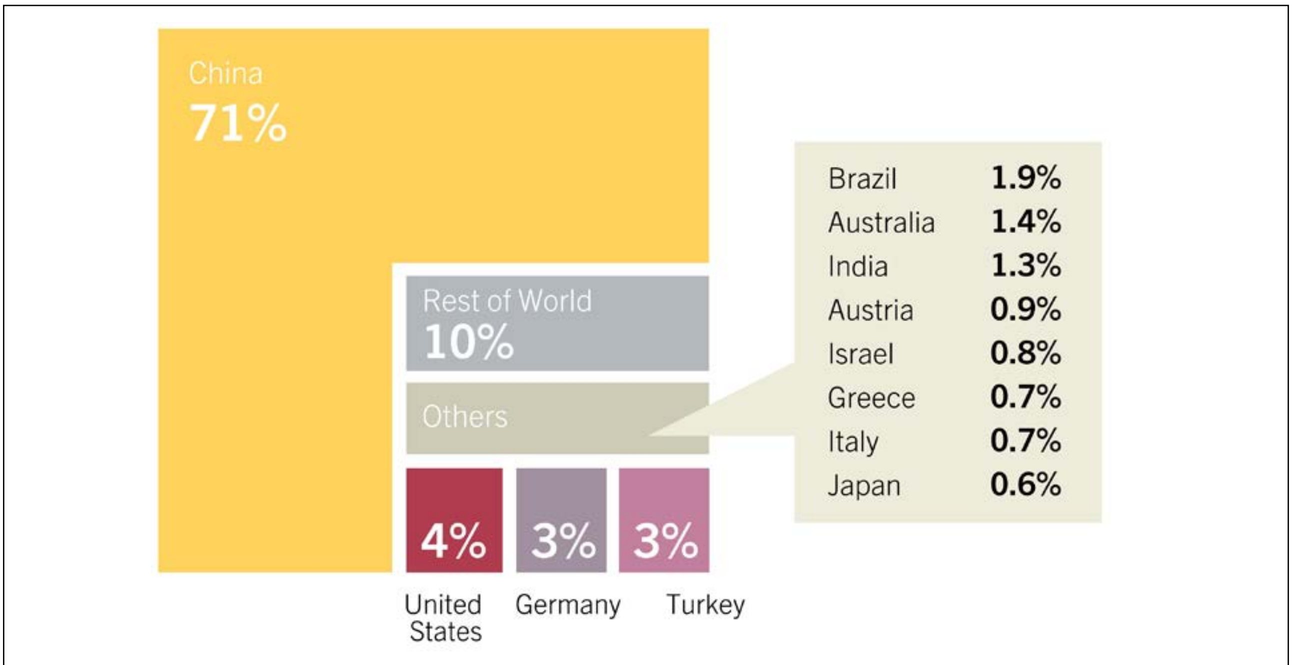

Figure 16: Solar water heating collectors' global capacity in operation. Share of top 12 countries and rest of world, 2014. Source: REN21, Renewables 2016 Global Status Report.

32 Data Source: http://www.cnenergy.org/yw/201702/t20170206_411688.html (Accessed on August 2, 2017).
33 Data source: http://www.cnenergy.org/yw/201702/t20170206_411688.html (Accessed on July 30, 2017).
34 Data source: https://www.reuters.com/article/us-china-solar-idUSKCN0S21FG20151008 (Accessed on July 30, 2017).
35 Data source: https://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=CN (Accessed on July 30, 2017).

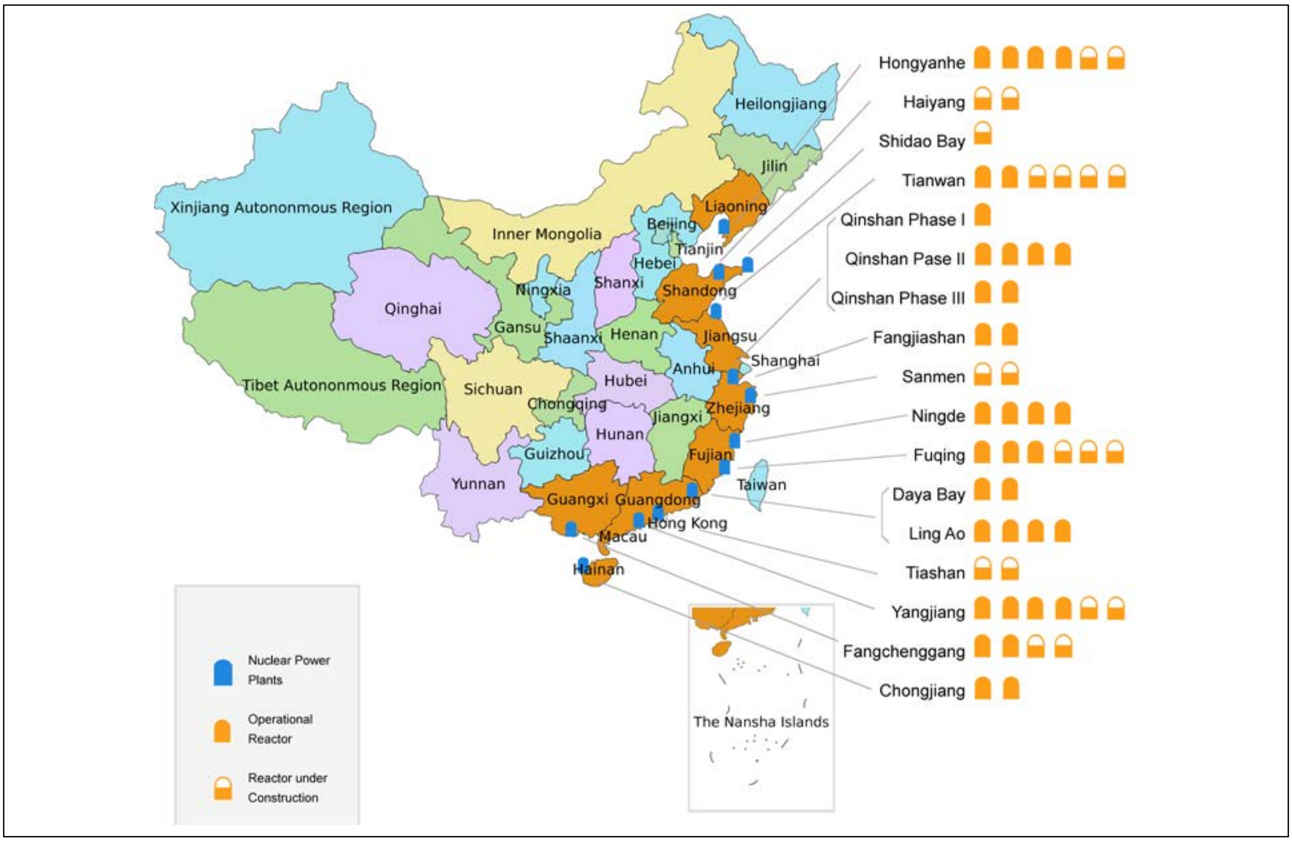

Figure 17: Nuclear Power Plants in China.
Data source: National Nuclear Safety Administration.

the coast (see Figure 17). The construction of nine new nuclear power plants is planned, three of which will be located in inland provinces, namely Hunan, Hubei, and Jiangxi.[36]

China generated 123.8 billion KWh of nuclear power in 2014, accounting for 2.3 per cent of the world's total nuclear power (see Figure 18). China's nuclear power only contributed 3 per cent of national electricity production in 2015, compared to 19.3 per cent in the United States and 10.6 per cent in the whole world.[37] However, with a strong motivation to control air pollution and mitigate climate change, China is expecting a rapid development in nuclear power in the next 15 years. The government proposed to double the pace of nuclear power development in the 13th FYP by constructing six to eight new plants per year. China is scheduled to have 58 GW of nuclear capacity in operation by 2020, providing 6 per cent of national power. Another 30 GW are under construction.[38]

The China National Nuclear Corporation and the China General Nuclear Power Group are the two major nuclear power companies in China. The former mainly operates the reactors in northeast China, while the latter mainly functions in southeast China.

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36 Data source: http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx (Accessed on August 5, 2017).
37 Data source: World Bank (2015).
38 Data source: the 13th FYP for Energy Development; the Action Plan of Energy Development.

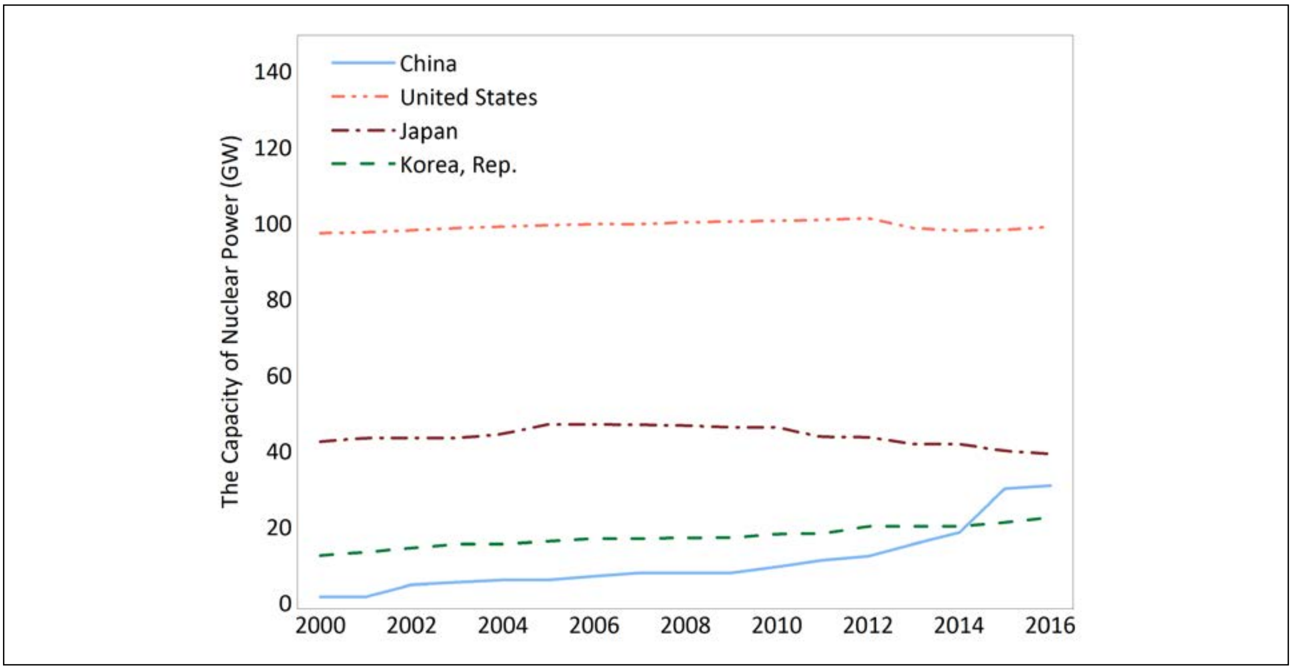

Figure 18: The capacity of nuclear power in different countries.
Data Source: US Energy Information Administration (2000-2014).

3. Political Feasibility of Energy Transition

3.1 Climate change policy

China launched the National Climate Change Program in 2007 and advanced numerous policy measures related to the transformation of its industrial structure, promotion of energy conservation and efficiency enhancement, and decarbonization of the energy mix.[39] Based on its sustainable development strategy and international responsibilities, China has made various commitments in recent international climate agreements. Its NDC under the Paris Climate Accord makes the following pledges:

- To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak earlier;
- To lower carbon dioxide emissions per unit of GDP by 60 per cent to 65 per cent from the 2005 level;
- To increase the share of non-fossil fuels in primary energy consumption to around 20 per cent; and
- To increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level by 2030.[40]

The energy transition plays a central role in China's climate policy. In particular, the development of non-fossil fuels is the cornerstone of achieving China's GHG emission control target.[41] The Chinese government has tied its national climate initiatives to the energy transition by:

- Revising the renewable energy law and relevant regulations to incentivize long-term energy restructuring;
- Developing and deploying low-carbon energy such as wind, solar, biomass, hydro, geothermal, coal-bed methane, and cleaner coal technologies;
- Reforming the nuclear-power sector to ensure healthy, safe, and rapid development; and
- Encouraging natural gas exploitation.[42]

Under the guidance of relevant plans, China has accelerated the adjustment of its industry and energy structures and devoted great efforts to improving climate change polices.[43] In addition, China has initiated low-carbon development pilots in 42 cities in order to explore a new mode of low-carbon development. These active carbon market experiments demonstrate China's commitment to climate change mitigation, and are hoped to provide a cost-efficient way for an energy transition.

China has launched carbon emission trading system (ETS) pilots in seven provinces and is going to launch a national ETS in 2017. ETS is a market-based instrument that allows emitters with different marginal abatement costs to trade their emission quotas (Liu et al., 2015). China's ETS by design is similar to the tradable performance standard (TPS), under which the government determines a maximum emission intensity with respect to output. Firms whose emission rates are below the standard can earn tradable allowances. However, if they exceed the standard, they must submit allowances to cover excess emissions. The carbon market provides firms with flexibility by allowing the trading of carbon quotas.

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39 The National Climate Change Program: http://www.ccchina.gov.cn/Detail.aspx?newsId=28013 (Accessed on April 20, 2017).

40 Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions: http://www4.unfccc.int/ndcregistry/PublishedDocuments/China%20First/China's%20First%20NDC%20Submission.pdf (Accessed on June 13, 2017).

41 The Second National Communication on Climate Change of the People's Republic of China: http://qhs.ndrc.gov.cn/zcfg/201404/t20140415_606980.html (Accessed on April 19, 2017).
The White Paper on China's Policies and Actions for Addressing Climate Change: http://www.sdpc.gov.cn/gzdt/201611/t20161102_825493.html (Accessed on April 19, 2017).

42 Renewable Energy Law of the People's Republic of China (hereafter referred to as the Renewable Energy Law): http://www.gov.cn/fwxx/bw/gjdljgwyh/content_2263069.htm (Accessed on April 19, 2017).

43 Related Plans include the National Strategy for Climate Adaptation, the National Program on Climate Change, the Work Plan for Controlling Greenhouse Gas Emissions during the 13th FYP Period, the 13th Five Year Plan for Energy Conservation and Emission Reduction, and the National Plan on Climate Change (2014-2020).

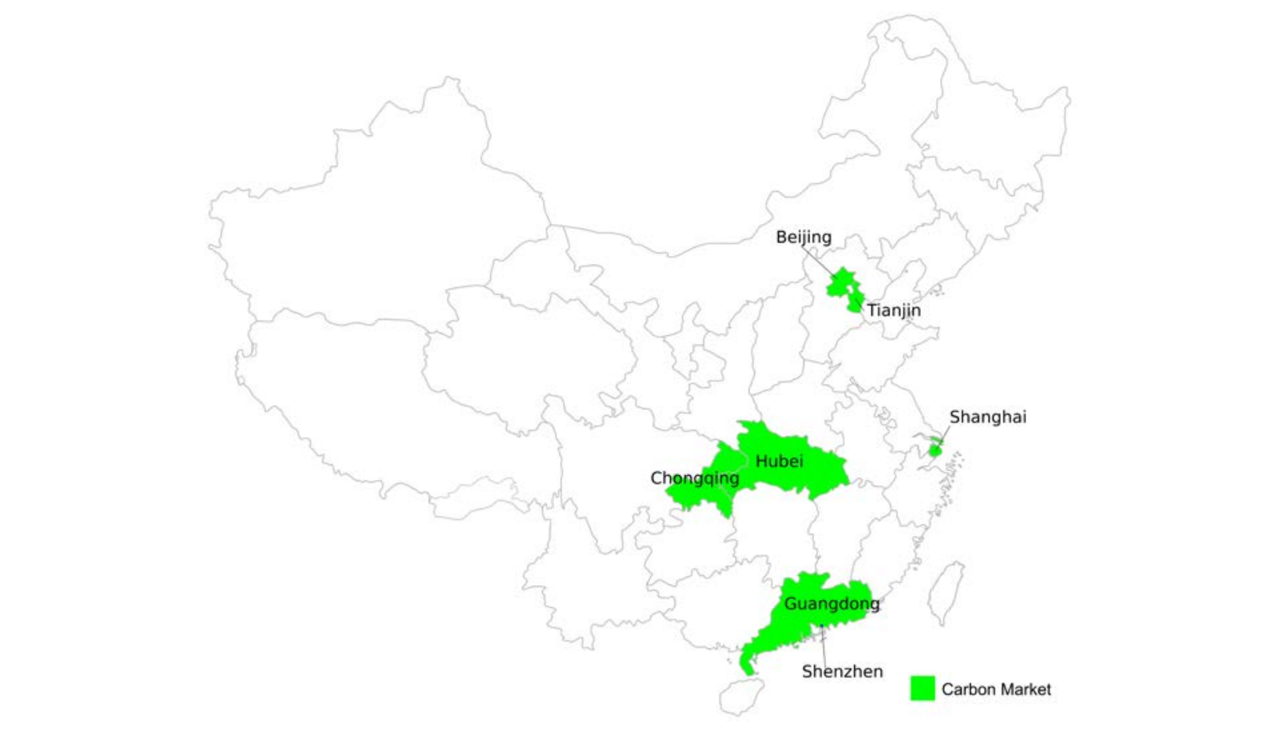

Figure 19: The seven carbon market pilots in China.

Flexibility can cut emission reduction costs because of the heterogeneity in energy efficiency potentials and technology availability of firms. Emission reduction costs differ among firms. Under the ETS, firms with high costs can purchase allowances from those with low costs. Compared with traditional standards that are rigid and one-size-fits-all, the market-based mechanism can help the whole nation realize the emission reduction target with large cost savings by allocating resources optimally.

Seven regional carbon market pilots cover all four province-level municipalities (Beijing, Shanghai, Tianjin, and Chongqing), two provinces (Guangdong and Hubei), and one special economic zone (Shenzhen) (see Figure 19). The total allowances for the seven trading programs add up to 1.2 billion tons of carbon dioxide per year, equalling about 11.4 per cent of national emissions in 2014 (Zhang et al., 2017).

The seven pilots cover a range of sectors with different thresholds based on their unique industrial structure and emission intensity. The sectoral coverage includes most energy and emission intensive industries such as power and heating, iron and steel, chemicals, and cement. The covered shares of emissions range from 33 per cent (Hubei) to 61 per cent (Tianjin).

The seven pilots use different ways to allocate allowances. Almost all allowances are given out for free, except that Guangdong auctions a small share of its allowances (Guangdong DRC, 2013). Benchmarking (rewarding innovation and more efficient entities) and grandfathering (based on historical emissions or intensities) are the two approaches used for allowance allocation. Most pilots use both approaches except that Chongqing only uses grandfathering (Chongqing DRC, 2014). The total emission allowance for each pilot should not be interpreted as a cap determined in a top-down approach, but rather as the sum of individual allowances calculated by benchmarking or grandfathering plus some allowance reserves.

Each pilot has established a system of monitoring, reporting and verification (MRV) to ensure that trading is based on credible emission reductions. The accounting of firms' emissions needs to follow uniform standards, and monitoring and reporting of emissions are self-conducted by the covered entities.

All pilots have built in a variety of penalties to ensure compliance. All pilots but Tianjin have adopted financial penalties for excess emissions that are not covered by the allowance (Tianjin People's Government, 2013). Some pilots charge 3-5 times the market value of the excess emissions, while others charge a predetermined fine.

Overall, the impacts of regional ETS on carbon emissions reduction and cost savings, and thus on the energy transition, are probably very limited. This is mainly because the regional pilots have only generated moderate emission trading activities so far. For the near future, the role of the carbon market in furthering the energy transition will remain uncertain due to deficiencies in the ETS design. It is also uncertain whether China will rely on carbon markets as a primary policy instrument. If it does, then in the long run, the national ETS can be used to regulate GHG emissions and strengthen MRV. Carbon markets thus could play an increasingly important role in the energy transition.

3.2 Air pollution control policy

China's increasing demand for energy has led to significant environmental pollution challenges.[44] Over 90 per cent of the thermal electricity is generated by highly polluting coal-fired plants, which lead to serious air pollution problems because of their release of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particles (Hu et al., 2013). Therefore, the control of air pollution requires significant reductions in coal consumption. China's Action Plan for the Prevention and Control of Air Pollution (Air Quality Plan) illustrates the government's desire to reduce the share of coal in primary energy consumption to 65 per cent by 2017.[45] Furthermore, the 13th FYP calls for the enhanced coordination of reducing carbon emissions and air pollutant emissions simultaneously by targeting the energy mix and energy efficiency.[46] It sets energy transition targets and plans to reduce the share of coal in total energy consumption below 58 per cent by 2020.

The plan to cut China's coal consumption was accompanied by specific policies. The Air Quality Plan calls for a medium and long-term target for a coal consumption cap and the implementation of a target responsibility system. In the 13th FYP, China committed to a coal capacity cap of 4.1 billion tonnes. Most provinces have included absolute coal consumption targets in provincial FYPs, expecting negative growth in terms of the absolute coal consumption. The city of Beijing has set an ambitious goal to reduce coal consumption by 71.2 per cent (12 million tonnes) by 2020 (compared to 2014).

In order to reduce pollutant emissions and tackle the coal overcapacity crisis, the government ordered key regions to stop approving new coal-fired electricity generation plants. Any increment of coal consumption in key air pollution regions, such as Beijing-Tianjin-Hebei, the Yangtze River Delta, and the Pearl River Delta must be accompanied by an equivalent or double decrement. Furthermore, restrictions on new coal-fired power plants have been expanded to 25 provinces in the 13th Five-Year Plan.[47]

In July 2017, China committed to limiting its total coal-fired power generation capacity to 1,100 GW by 2020, while cancelling or deferring coal-fired power plants equivalent to 150 GW and closing down outdated production facilities amounting to another 20 GW.[48] In order to meet these ambitious targets, China is cancelling or deferring 94 coal-fired power plants that were planned or under construction, eliminating 106 GW of future coal-fired capacity.[49] The suspended

[44] Data source: https://www.atkearney.com/documents/10192/5293225/Global+Energy+Transitions.pdf/220e6818-3a0a-4baa-af32-8bfbb64f4a6b (Accessed on July 21, 2017).

[45] China's Action Plan for the Prevention and Control of Air Pollution (Air Quality Plan) was issued by China's State Council in September 2013.

[46] The 13th FYP for GHG Emission Control: http://www.ccchina.gov.cn/Detail.aspx?newsId=64463 (Accessed on April 21, 2017).
The White Paper on China's Policies and Actions for Addressing Climate Change: http://www.sdpc.gov.cn/gzdt/201611/t20161102_825493.html (Accessed on April 19, 2017).

[47] Data source: http://www.jsdpc.gov.cn/zixun/tzgg_1/201605/t20160506_419095.html (Accessed on August 4, 2017).

[48] Data source: http://news.bjx.com.cn/html/20170801/840667-2.shtml (Accessed on August 4, 2017).

[49] Data source: http://news.bjx.com.cn/html/20170804/841506.shtml (Accessed on August 4, 2017).

plants include dozens of projects in 22 provinces, and leave space for China to advance its development of clean and renewable energy.

For the sake of health and a better living environment, the transition to cleaner fuels is also taking place in households. Many polluted areas are switching household fuels from biomass and solid fuel (firewood or coal) to more efficient and portable energy such as LPG and electricity, and large-scale projects such as “coal to gas” have often hit national headlines in recent years. From 2000 to 2010, the number of households using solid fuel as their main cooking fuel fell substantially, from 900 million to 650 million. In 2010, 80 per cent of urban and 23 per cent of rural households reported having clean fuels (gas or electricity) as their main cooking fuel (Aunan et al., 2014). [50]

3.3 Central-local government relations

China is characterized by a mixed governance pattern of political centralization and fiscal decentralization. Energy policy formulation is centralized but successful implementation of the energy transition needs the compliance of local governments. Local governments play an important role in allocating economic and political resources, and have considerable liberties in energy policymaking. Under the tendency of streamlining administration and delegating authority, local governments have taken over from the central government the responsibility for issuing approval rights in the energy sector, including for hydropower, wind power, and thermal power projects. In addition, local governments are the designers of regional generation schedules, controlling the allocation of the generation capacity of different energy sources at different power plants. In terms of the energy transition, local officials usually have their own, sometimes conflicting, priorities and targets, which are deeply affected by the central government’s relationship with local governments.

The central government applies the target responsibility system (TRS) to ensure the compliance of local governments. TRS is a cadre assessment system that is generally reserved for socio-economic goals such as economic growth and social stability (Whiting, 2006). In order to address challenges in the fields of energy, the environment, and climate change, local governments are now expected to meet quantified targets for carbon intensity reduction and the share of renewable energy in total energy consumption. Nevertheless, economic growth tends to remain the top priority for local officials concerned about their career advancement. Their attitude towards renewable energy development is determined by the impact of the energy transition on local economic growth. Despite adjustments in the performance appraisal criteria for evaluating local officials’ performance, which now places greater emphasis on environmental performance, local governments still have no strong incentive to sacrifice GDP growth simply to support the energy transition, unless the transition has significant local economic co-benefits.

Until now, local governments in developed regions have been reluctant to develop renewables because their potential contribution to local GDP growth has been limited. Taking wind power as an example, the taxes on wind and thermal power companies include a value-added tax (17 per cent), a corporate income tax (25 per cent), a stamp tax (0.3 per cent), an urban maintenance and construction tax (7 per cent for cities, 5 per cent for towns and 1 per cent for rural areas), and an education tax (3 per cent).[51] With respect to both the value-added tax and the corporate tax, the central government has granted many preferential policies to wind power companies. The value-added tax for renewables is 50 per cent lower than thermal power and there is also a three-year corporate tax waiver, followed by a three-year 50 per cent reduction of corporate tax for renewable energy. Therefore, local governments collect less tax revenue from renewables compared with thermal power plants. In particular, the tax revenue obtained from a 200-MW wind farm only becomes significant after 10 years, which is five years later than in the case of thermal power plants (Zhao et al., 2013).

[50] Data sources: 2000 and 2010 China Country Population Census Data.

[51] The calculation of construction tax and education tax is based on value-added tax.

Furthermore, developing renewable power plants, as well as importing renewable power from other provinces will squeeze the generation quotas of thermal power generation, which further harms the interests of local governments.[52] Under these circumstances, local governments will not only become reluctant to advance renewable energy development, but also slow down the transition pace as much as possible, which makes any energy transition policy hard to implement.

The difficulty of implementing the Renewable Portfolio Standard (RPS) is a case in point. RPS requires each province to have a certain share of electricity generated or consumed from renewable energy. In 2005, when China started to draft the Renewable Energy Law, RPS was regarded as a significant policy supporting renewable energy. RPS was mentioned in the 12th FYP for Renewable Energy Development. Nevertheless, despite over 10 years of studies and pilot projects, this policy has still not been implemented at the national level.

The period of the 12th FYP was regarded as the best phase to advance RPS but the policy did not gain traction. In 2011, facing the difficulty of renewable energy integration, the National Energy Administration (NEA) drafted the Regulation on Renewable Portfolio Standard (Draft) and clearly defined the renewable portfolio that each province should undertake. It also proposed to include the RPS indicator in the performance appraisal system in provincial governments. In 2014, the Regulation on Renewable Portfolio Standard (Draft) was completed and ready for release. However, because of the objection of some provincial governments, the policy was not promulgated.[53] The mandatory requirement of using renewable energy was in conflict with local interests, which led to the failure of the RPS policy.

While the present approach to the energy transition is less cost-effective than it might be due to current taxation policies, there are several benefits for local governments in adopting renewable energy. First, as the energy transition is an important part of the central government's development strategy, pursuing renewable energy and energy efficiency provide more advancement opportunities to local officials. Second, the energy transition is a promising means for dealing with air pollution and energy security, which are key factors related to the public interest and social stability. The potential benefits of economic growth associated with renewable energy development incentivize the investments of local governments, especially in areas with abundant renewable resources. They increasingly regard renewable energy as a way to promote economic growth and create new jobs. Furthermore, after more than one decade of rapid development in renewable energy, many technologies are now indigenously available. This mitigates the cost concerns of renewable energy and incentivizes local governments to set more ambitious targets for renewables (Shi, 2016). For example, Shandong is one of the most active provinces in implementing an energy transition pathway.

Facing the dual pressures of air pollution and energy security, Shandong adopted a low-carbon energy transition policy as the best way to cultivate a new economic growth model featuring low energy consumption, low pollution, and high efficiency. By the end of 2016, Shandong had 15.8 GW of capacity of new and renewable power, accounting for 14.4 per cent of total electricity capacity. Local finance in Shandong provides 45 million US dollars each year to subsidize the loan interest of the new power projects including wind, solar, nuclear, and a smart power grid. Based on FITs, Shandong provides extra subsidies to PV plants, distributed PV generation projects, and wind power projects with 0.045, 0.008, and 0.003 US dollars per KWh, respectively.[54]

Shandong's active involvement in renewable energy development is partly due to the pressures from the central government and the public. It also benefits from having competitive large-scale energy enterprises like Luneng Group, which are more cost-effective in developing renewable energy. Nevertheless, with the slowing down of the economic growth rate, the debate

52 This is because there is a cap on annual generation quotas for all power plants.

53 Data source: https://news.baidu.com/news#/detail/1932010651722212754?_k=23o1zz (Accessed on June 8, 2017).

54 Data Source: http://news.bjx.com.cn/html/20160822/764883.shtml (Accessed on June 8, 2017).

about the trade-offs between the low-carbon energy transition and local economic growth has started to heat up again. If the current trend of lower economic growth continues, it is unlikely that local officials will treat the energy transition as a priority, unless there is evidence that new energy industries help with GDP growth.

3.4 Dominance of state-owned enterprises

State-owned enterprises (SOEs) take a major and active role in China's energy businesses, including fossil fuels, renewables, and nuclear energy. The five state-owned power generation groups account for half of the power market share. Other major fossil energy companies, such as China National Petroleum Corporation, China Petroleum and Chemical Corporation, and China National Offshore Oil Corporation are also state owned. Large SOEs dominate in new energy development as well. They accounted for 39 per cent of the new energy market in 2014, while foreign companies, private enterprises, and other actors only accounted for 28 per cent, 20 per cent, and 13 per cent, respectively. Three SOEs—China National Nuclear Corporation, China General Nuclear Power Group and China Datang Corporation—are among the top 10 new energy enterprises in China.[55]

Enjoying privileged status from the central and local governments as well as monopolistic advantages, SOEs are often deemed to be inefficient economic actors in comparison to private enterprises. However, instead of undermining the energy transition, SOEs have at times facilitated a better implementation of low-carbon policies. Perceiving political benefit outside formal profit-maximization criteria, SOEs have a mixed economic and political agenda. Their behaviour is thus partly driven by the political incentives created by the central government to promote renewables (Ma et al., 2017). Therefore, managers of SOEs may voluntarily enhance energy transition efforts in order to get honours and seek opportunities for career advancement. Moreover, by implementing the energy transition, SOEs can expand their business and seize bigger market control. (Zhao et al., 2010).

The efforts of SOEs have played a key role in China's energy transition. With their stronger financial and negotiation power, SOEs are able to adopt super critical fossil-fired generation technologies, and to afford the investment needed for renewables' technological updating. Improving the utilization of renewable energy capacity also requires efforts by the state-owned grid operators as the lack of long-distance transmission lines is the main cause of wind and solar curtailments. This is now a major focus of government officials in the State Council. The State Grid has worked hard to solve this issue and has taken action to urge trans-provincial renewable energy consumption. Since January 2017, the State Grid has adopted 20 measures to tackle renewables curtailment, including prioritizing the transmission of electricity generated by renewables and accelerating infrastructure projects.

3.5 The electric power system and its deregulation

(1) China's electricity system

China has the world's largest electricity market with six wide area synchronous grids and five major generation companies. In 2015, China provided electricity to the last 200,000 people who did not have access to it before and finally achieved universal access.[56]

As a global leader in large-scale power grid development, China has also achieved a high level of grid stability.[57] Compared with other countries, large-scale blackouts occur much less frequently in China (Lun et al., 2012). From 2003-2012, 15 large-scale blackouts occurred outside China, including three events in the United Stated and two events in Europe and Brazil. While the blackouts in other countries were mostly caused by technological

55 Data source: http://finance.qq.com/original/bigdata/xinnengyuan.html (Accessed on April 21, 2017).

56 Data source: http://www.gov.cn/guowuyuan/2015-03/16/content_2835101.htm (Accessed on April 28, 2017).

57 In 2016, the State Grid Corporation of China (SGCC) owned more than 4,146 invention patents and set up 28 international standards, such as the fundamental technology of grid and Ultra-High Voltage (UHV) transmission. The world's highest voltage level of UHV transmission lines are established by SGCC.

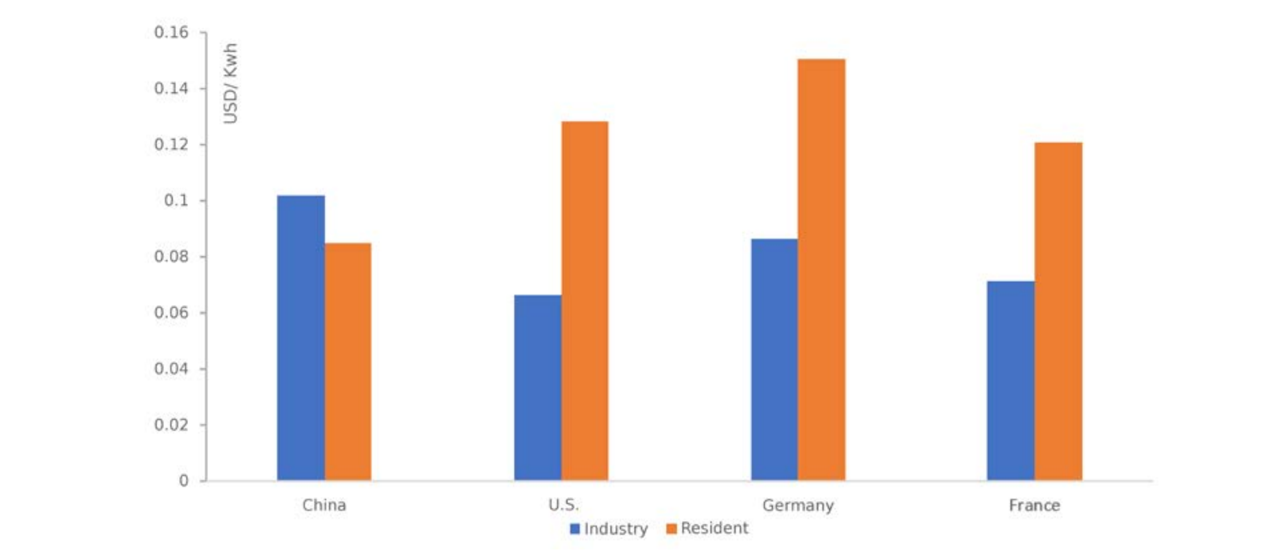

Figure 20: Comparison of industrial and residential electricity prices in 2015.
Data sources: US Energy Information Administration (2015).

failures, China's last large-scale blackout was in 2008, it was triggered by a snowstorm of historic size.

In order to guarantee equality in universal electricity service, China made great efforts to unify urban and rural electricity prices. For a long time, China's rural and urban areas had different access to electricity, partly due to their different grid management systems. Low-voltage grids in urban areas were directly regulated by the five major power companies, as well as other provincial power companies, while the grid in rural areas was constructed and managed by town-level governments. Therefore, there were both higher electricity wastage and higher maintenance costs in rural areas and this in turn resulted in higher electricity prices. In order to achieve a uniform price in the same power grid, the governments called for upgrading rural power grid facilities and management from 1998. Shandong, Henan, and other provinces have already completed the reform. The reform is still ongoing in some counties in Inner Mongolia and Sichuan because of high construction costs.[58]

Four groups of electricity users exist in China, comprising large-scale industries, general industries and commerce, agriculture, and residents. Cross-subsidies for electricity tariffs have been employed for decades. Unlike most countries in the world, China charges higher electricity tariffs to industrial and commercial groups, subsidizing the consumption in the residential and agriculture sectors (see Figure 20). This is done out of affordability considerations. The average tariff gap between residents and general industry is 0.016 US dollars per KWh in 2014, nearly 10 per cent of the industrial tariff. As a consequence of cross subsidies, there has been a concern that the high electricity price in the industrial and commercial sectors is harming China's industrial competitiveness.

China sets a higher priority for residential energy consumption for the sake of maintaining social stability. During periods of energy shortage, households take priority over industrial sectors in terms of electricity supply. In high load seasons like winter and summer, many Chinese cities limit industrial energy use to meet the power demand of households and to protect the security of the grid. For example, during hot days in Chengdu, the industries within the city centre are required to cease production at a scheduled time to guarantee residential electricity supply. In addition, during peak hours (10:30 am-12:30 pm, 18:00 pm-21:00 pm), energy

[58] Data source: http://www.jiangyang.gov.cn/template/default/news_detail.jsp?id=8ac081e45938c5d101593f90503d03dd (Accessed on May 6, 2017).

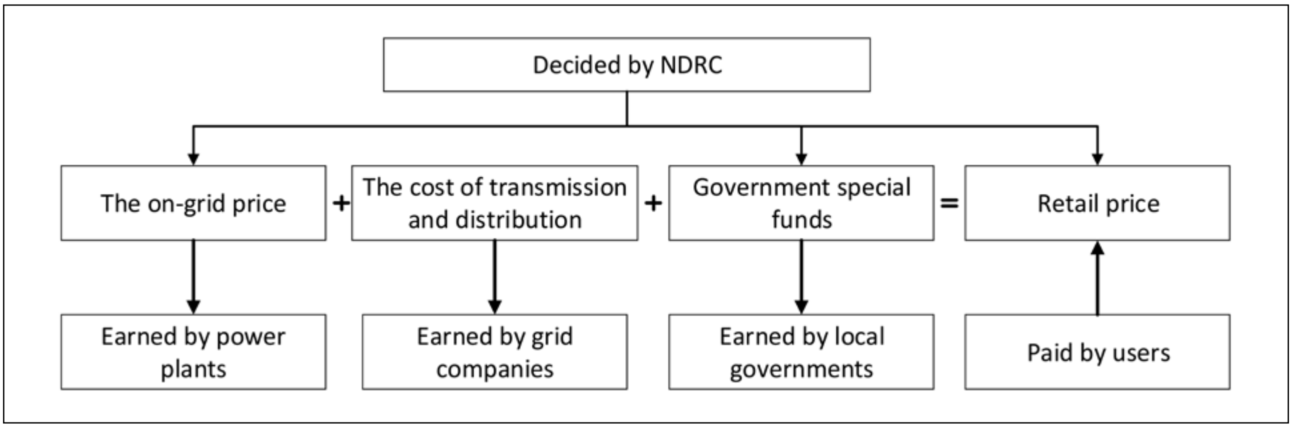

Figure 21: The price structure of the power industry since 2002 in China.

intensive industrial enterprises are required to control their electricity usage strictly. In many southern cities, companies are scheduled to produce at different times. Even some public streetlights are turned off to deal with the electricity shortage.[59] Although industrial companies have to shut down during peak hours, for some highly energy-intensive industrial enterprises, electricity can be held in reserve, but only for safety reasons.

China's electricity market is characterized by government planning. Governments heavily regulate the production, dispatch, and price of electricity. China's electricity price consists of a grid-tied price, the cost of transmission and distribution (T&D), and government special funds. The grid companies purchase electricity from power plants at the grid-tied price, and make a profit from its T&D services. Local governments retain the government funds. The grid-tied price and government funds are determined by the NDRC. Figure 21 illustrates the structure of the electricity price since 2002.

Heavy regulation could improve the stability of the market, and ensure that the electricity is accessible and affordable to residents. Heavy regulation leads, however, to inefficiency in both energy investment and consumption. China is gradually liberalizing its electricity system in order to establish a market-oriented pricing mechanism. On the one hand, the price needs to reflect the cost of power generation and a normal rate of return. On the other hand, the price also needs to create incentives for energy efficiency and energy conservation.

(2) China's electricity market reform

Realizing that the energy industry can improve its efficiency in an increasingly liberalized, open, and integrated market, China has embarked on electricity market reform since 2005. The reform has switched the state-dominated energy industry from a centrally planned market to a more market-oriented industry (Cherni et al., 2007). In 2015, China announced a new round of reforms in the No.9 Government Document, which aims to build a national market and to optimize the pricing mechanism of electricity.[60]

The reform will sequentially open up the planning of generation and consumption, and establish markets in electricity purchasing and retailing. It encourages large consumers to buy electricity from generation companies directly. The direct purchase of electricity with a voltage higher than 110 KV is first opened up for large industrial and commercial consumers. Thermal power generators with an ultra-low emission system have priority admission to the direct purchase market, while generation not conforming to the state environmental standards is banned.

[59] Sources: http://www.hb.xinhuanet.com/WangQun_QiYe/2008-01/22/content_12291742.htm (Accessed on April 23, 2017), http://www.sc.xinhuanet.com/content/2016-08/24/c_1119448656.htm (Accessed on April 23, 2017), http://www.cdgy.gov.cn/content.jsp?classId=010301033402&newsId=42752 (Accessed on May 6, 2017).

[60] Relative Policies on Deepening the Reform of Power Industry: http://www.sdpc.gov.cn/gzdt/201511/t20151130_760131.html (Accessed on April 15, 2017).

In terms of retailing, investment opportunities have been opened up to non-state-owned investors. Three kinds of retail companies exist, comprising retail companies that are affiliated to grid companies, retail companies with self-operated grids, and independent retail companies without the right to operate power grids. The minimum registered capital of a retail electricity company is 300,000 US dollars. The opening up of a generation and consumption market introduces market influence into electricity price formation. Grid-tied and retail tariffs in this market are based on market supply and demand, instead of the regulations established by the NDRC.

In order to support the development of a liberalized electricity market, two national and 31 provincial independent trading institutions have been established. More supportive documents will be published to develop an open and fair platform, and to promote the quality and efficiency of electricity services, such as offering targeted retail contracts, and providing energy saving plans and demand-side management to large consumers (NDRC, 2015a).

In consideration of social equality and sustainable development, the latest reform has set up a system of differentiated priorities in electricity purchasing and generation. Agriculture, hospitals, water and gas supply, public transport, and residential sectors have priority purchasing rights for electricity at regulated tariffs. Generation and dispatch priority are provided to new and renewable energy sources such as wind, solar, hydro, and nuclear (Liu et al., 2016). Local governments have to ensure that there is a sufficient share of renewables in annual planned generation. Renewable generators can still accept the regulated tariffs, or join in the deregulated electricity market, selling their electricity based on the prices negotiated with retail companies and large consumers (NDRC, 2015b).

Another highlight of this reform is the adjustment of the transmission and distribution (T&D) tariff. In order to prepare for a transparent cost system of grids, tariffs in the T&D sector should be set under the principle of "cost plus reasonable profit." China has approved pilot reforms on T&D tariffs in seven regions, and is expected to apply the reform to the whole country, based on the pilots' collective experiences. Moreover, electricity cross-subsidy reforms will take place along with the adjustment of the T&D tariff. Cross-subsidies within the industry sector will be eliminated step by step, while the cross-subsidy to renewable energy will still be retained. The reform of electricity pricing is of great significance in the No.9 Document. In addition, the transaction price that is determined by the market supply and demand will replace the former grid-tied price (NDRC, 2015c).

As China further pursues sustainable development, preferential policies for clean energies will likely remain or even be enhanced under the electricity market reform. However, incentives in generation do not directly lead to greater consumption of renewable energy. The development of renewable energy has to be linked to an increased demand for renewable energy in the main centres of consumption. One of these is central-east China, which has a huge demand for energy and is a critical region for the energy transition.

4. Social aspects of China's energy transition

4.1 Green jobs

According to the United Nations Environment Programme, green jobs refer to positions in agricultural, research and development, administrative, and service activities that contribute to preserving or restoring environmental quality. There are various "green jobs" associated with the renewable energy sector.

Structural adjustments in the power sector have significantly affected the labour market. Experiencing rapid growth in the last decade, the renewable energy sector in China has created new employment opportunities. China installed 65 GW of renewable energy capacities in 2015, which was the largest amount in the world, and employed 35 per cent more people in the clean energy industry than in the oil and gas industries.[61] In the 13th-FYP-period, the renewables industry is projected to create more than 3 million new jobs, hiring a total of 13 million people by 2020.[62] According to the International Renewable Energy Agency (IRENA), by 2050, the global renewable energy industry will add about 19 trillion US dollars to the world economy, and will create about 6 million jobs. China's estimated number of direct and indirect jobs in the renewable energy industry is the highest in the world, as is shown in Table 6.

In contrast to the renewable energy sector, the fossil fuel sector has been losing jobs sharply. The development of renewable energy synchronizes with the decline of fossil fuels. Aiming at the optimisation of the energy structure and improving production efficiency, China has set stricter environmental and energy consumption standards to accelerate the structural adjustment of overcapacity industries. A wide range of enterprises in electricity, coal, and 11 other industries have been shut down. While this helps clean the environment, it has left millions of people looking for new jobs.

For example, after reaching the peak of 5.3 million jobs in 2013, the number of employees in the coal industry declined sharply in the following years, sinking to 3.9 million people in 2016. As the central government is requiring the closure of outdated coal mines at a pace of 500 million tonnes of capacity per year in the 13th FYP, concerns about unemployment are even higher. Unemployment is particularly serious in coal-dependent

Table 6: Estimated direct and indirect jobs in renewable energy worldwide, by industry (10^3).
Data Source: IRENA Renewable Energy and Jobs Annual Review 2016.

	World	China	US	France	Japan	Germany
Solar Photovoltaic	2,772	1,652	194	21	377	38
Liquid Biofuels	1,678	71	277	35	3	23
Wind Power	1,081	507	88	20	5	149
Solar Heating/Cooling	939	743	10	6	0.7	10
Solid Biomass	822	241	152	48		49
Biogas	382	209		4		48
Hydropower (Small)	204	100	8	4		12
Geothermal Energy	160		35	32		17
CSP	14		4		2	0.7
Total	8,079	3,523	769	180	388	644

[61] Data source: https://www.bloomberg.com/news/articles/2016-05-25/clean-energy-jobs-surpass-oil-drilling-for-first-time-in-u-s (Accessed on May 22, 2017).
[62] Data source: The 13th FYP for Energy Development http://www.ndrc.gov.cn/zcfb/zcfbtz/201612/t20161216_830264.html (Accessed on August 21, 2017).

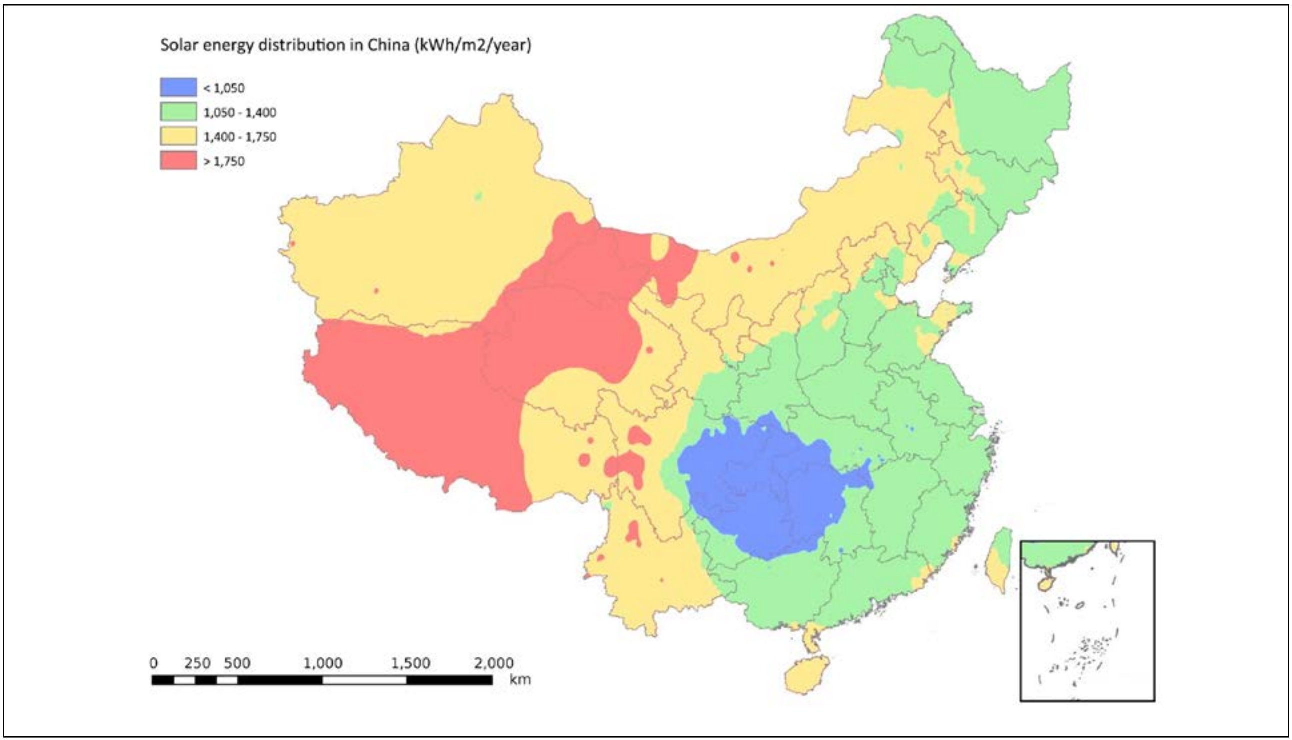

Figure 22: Solar energy distribution in China (KWh/m2/year).
Source: China Wind and Solar Energy Resources Bulletin 2014,

areas, such as Shanxi and Inner Mongolia. Almost half of all coal mines in these areas have suspended or partially suspended their activities as a result of the energy transition. The upgrading of energy industries and the application of new technologies have put older workers, who have more difficulties in finding re-employment, at the greatest risk of losing their jobs.

4.2 Solar PV and anti-poverty projects

China has experienced significant income inequality for a long time. Almost 7.2 per cent of the rural population was still below the national poverty line (1.9 US dollars per day) in 2014.[63] The least developed regions are mainly located in north-western China, which possesses the most abundant solar energy resources in the country (see Figure 22). In order to reduce poverty, China launched the PV Poverty Alleviation Project (PPAP) in 2014, using solar PV to increase the income of poor households in 16 provinces and 471 counties.[64]

PPAP is one of the most important poverty alleviation projects in China. It encourages villagers, especially those in impoverished areas, to install solar PV panels in open spaces, including rooftops, uncultivated hills and slopes, non-arable land, greenhouses, and agricultural facilities (see Figure 23). The electricity generated can be used by villagers or be sold to the grid. Thirty counties in the provinces of Qinghai, Ningxia, Shanxi, Hebei, Gansu, and Anhui are pilots of the PPAP.

The project aims to support more than 35,000 poor villages and 2 million poor households by 2020.[65] The support includes constructing village-collective solar PV stations for each poor village and installing rooftop-

63 Data source: World Bank (2014).

64 Data source: http://www.ndrc.gov.cn/zcfb/zcfbtz/201604/t20160401_797325.html (Accessed on August 12, 2017).

65 The PPAP is conducted by the NEA and the State Council Leading Group Office of Poverty Alleviation and Development (CPAD). The poor counties and households in the PPAP should be certified by the CPAD and identified by municipal governments according to solar resources and economics.

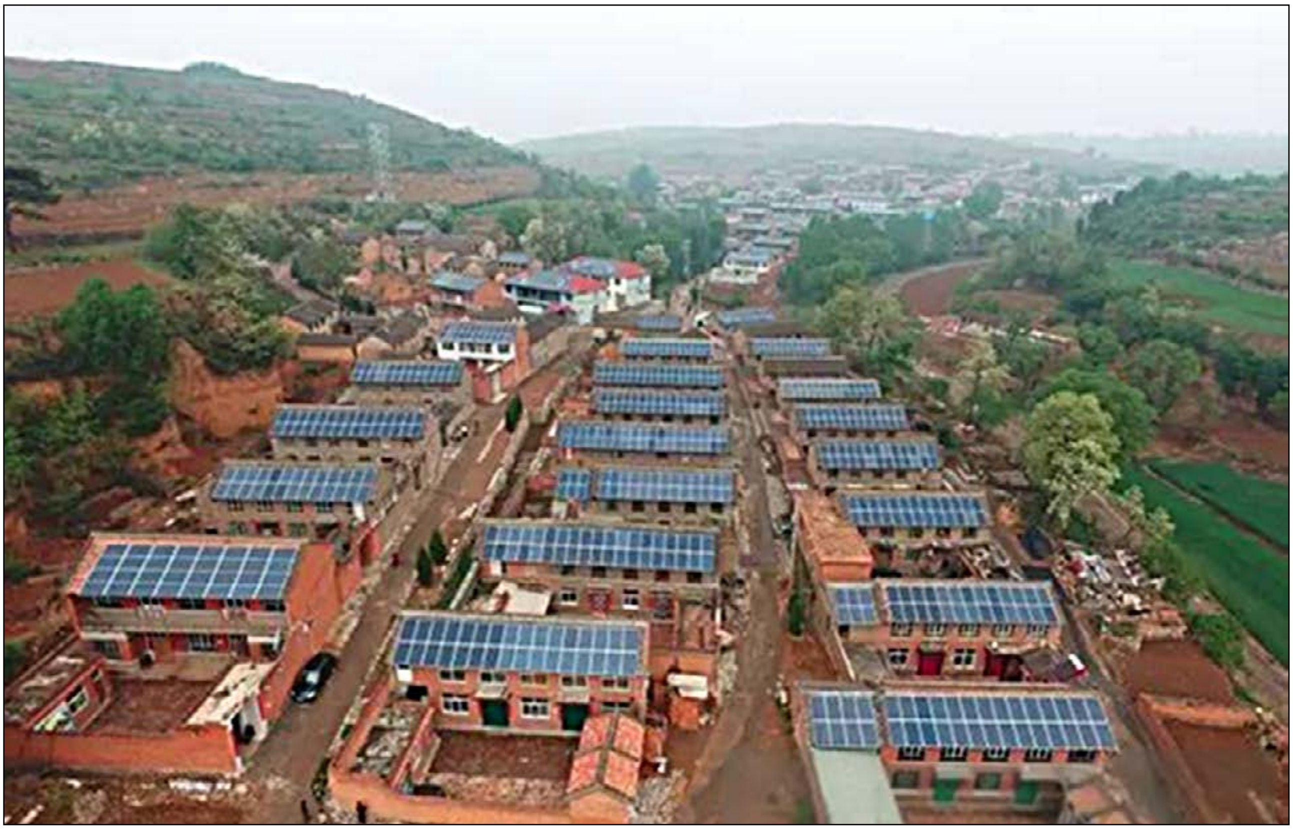

Figure 23: Distributed rooftop solar PV systems.[67]

solar PV panels for each poor household (residential PV project). The aim of the PPAP is to generate more than 3,000 yuan in annual value (about 430 US dollars) for each poor household via solar PV generation. The financial support by the PPAP is mainly from provincial poverty alleviation funds and two Chinese policy banks, the China Development Bank (CDB) and the Agricultural Development Bank of China (ADBC), while the benefits belong to the poor villages and households.[66] In addition, private-sector investment is encouraged to join the PPAP's large-scale PV projects as a source of subsidies, on condition that the property rights or benefits of solar PV stations are shared with the poor villages and households.

The PPAP benefits local people with abundant solar resources, and has already achieved positive results in many pilots. For example, Anhui province had installed 1,108 distributed solar PV systems by the end of 2014, and the scheme is projected to benefit more than 6,000 households by 2020 (Zhao et al., 2016). Chongqing, a direct-controlled municipality, has also witnessed plentiful achievements in the past few years. In 2016, Chongqing invested 4.5 million US dollars to help 1,180 poor households install rooftop-solar PV systems and reached a total installed capacity of more than 3,542 KW.[68] Moreover, China has announced a new round of PPAPs in 14 provinces, with a total installed capacity of 5.1 GW. Governmental funds and private-sector investment are both included, benefiting more than 550,000 poor households in total (see Table 7).

66 China's State Council established three policy banks to manage the government-directed spending in 1994. Policy banks are responsible for financing economic and trade development and state-invested projects.

67 Source: http://www.sz-hua-yang.com/news/news747.html (Accessed on August 21, 2017).

68 Source: http://solar.ofweek.com/2014-10/ART-260009-8120-28892285.html (Accessed on August 21, 2017).

4.3 Negative externalities of renewable energy

China has placed great expectations on renewable energy because of the need for clean and low-carbon development. Nevertheless, we should not neglect the negative impacts of developing renewables. For example, the polysilicon refining industry, the PV cell manufacturing industry, and parts of the solar PV production chain can cause serious water pollution. In addition, wind power can increase people's stress by generating loud noises and disfigure landscapes. Moreover, the construction of numerous wind generators can destroy wildlife's habitats, posing threats to the local ecosystem.[70] Because of these negative impacts, the wind farms located around natural reserves and bird migration routes have inflamed strong public protests.

The wind farm project located in Changdao national natural reserve is a case in point. Changdao is an island county in Shandong province. More than 300 species of birds inhabit or temporarily inhabit it, and 20 of them are protected by the state. In order to protect the ecosystem in Changdao, the China Environmental Protection Foundation (CEPF) in 2016 sued a wind power company called Liankai, which had invested in seven wind generators in Changdao. The CEPF accused Liankai of violating Article 32 of the Regulations on the Natural Protected Regions of China, which provides that "any production facilities are banned in the core and

Table 7: The list of PV poverty alleviation projects (the first batch) [69]

Province	Village-level stations (including residential PV projects)		Large-scale PV projects	
	Scale (MW)	Number of Households (Thousand)	Scale (MW)	Number of Households (Thousand)
Hebei	300	60	550	19
Henan	5	1.5	100	3
Anhui	312	70	300	12
Shanxi	184	30	400	15
Shandong	317	70	800	30
Hubei	58	15	250	20
Shanxi*	66	9.5	200	10
Yunnan	31	9	100	4
Gansu	84	20		
Jilin	165	20	200	8
Jiangxi	540	100	80	3
Jiangsu	35	10		
Hunan	38.4	5		
Liaoning	46	11		
Total	2180	431	2980	125
Liaoning	46	11		
Total	2180	431	2980	125

69 Source: http://zfxxgk.nea.gov.cn/auto87/201610/t20161017_2310.htm
70 Data source: http://www.nature.com/news/the-trouble-with-turbines-an-ill-wind-1.10849 (Accessed on August 20, 2017)

buffer zone of national protected regions." After a series of trials, Liankai lost the lawsuit, and was ordered to tear down all wind generators in Changdao.

Successful cases are rare, however. For example, the lawsuit against the wind farm project in Leigao, a small town in Guangdong Province, failed. The Leigao wind farm project proposed to install 70 wind power generators with a total capacity of 140 MW.[71] Besides abundant wind resources, Leigao also has a large area of mangroves, covering 20,278 hectares. Because the project is only 1.5 kilometres away from the mangrove area, the local public and NGOs such as the China Mangrove Conservation Network (CMCN) are concerned that a wind farm would cause damage to the mangroves and threaten the survival of the black-faced spoonbill and other endangered species. They complained to the central environmental inspectorate, noting that Leigao wind farm had violated a regulation of NEA, namely that "the site selection of wind power should keep away from birds' migration paths." The main controversy was to define whether Leigao is a vital path of bird migration. In the end, the environmental group did not get a positive response.

Nuclear energy, which is an important alternative to fossil fuels, also warrants some special discussion because of its potential risks. Some view it as playing an important part in China's energy transition, yet the anti-nuclear movement is also growing. The perceived risks of nuclear power have been further amplified by the Fukushima nuclear accident in 2011. Researchers found that the accident had dynamic effects on China's real estate markets, with land prices within 40 kilometres of nuclear power plants having dropped by about 18 per cent one month after the nuclear accident. While the impact decreased in the long term, eventually becoming statistically insignificant (Zhu et al., 2016), this suggests that Chinese residents are concerned about the risks of nuclear power, particularly in the short run.

In order to mitigate the public concerns, China has committed to pursue a safe expansion of nuclear capacity, and significantly slowed down the development of nuclear power. China's original plan was to increase nuclear capacity to 70-80 GW by 2020 and to 200 GW by 2030.[72] After the Fukushima accident, all approvals and ongoing constructions of nuclear power plants were brought to a halt pending safety inspections (Bergsager et al., 2013). As a result, the target for 2020 was adjusted to 58 GW and 110 GW by 2030, cutting the projections in half.

71 Leigao wind farm project was invested by Aviation Industry Corporation of China (AVIC).

72 Data source: http://finance.sina.com.cn/roll/20091103/03096914491.shtml (Accessed on August 29, 2017).

5. Policy recommendations

5.1 Collaborative governance for climate change action, air pollution control and the energy transition

There are significant benefits for China in simultaneously tackling the challenges of climate change, environmental degradation, and an energy transition. Massive energy consumption dominated by fossil fuels is the key contributor to carbon emissions and severe air pollution, and the growing concerns about climate change and air quality provide powerful incentives for China's energy transition. Optimizing the energy mix has become one of the most important and urgent steps to combatting climate change and air pollution. An integrated strategy that targets all of these issues is needed. It could also be the most cost-effective approach to addressing these problems.

However, China's governance of climate change, air pollution, and the energy transition is poorly coordinated.

Because of the closer institutional relationship between the NDRC's Climate Change Department and the NEA, it is natural to believe that climate policy would have considerable potential to affect the progress of the energy transition. However, the major push for an energy transition is poor air quality. For most people, air quality is an issue that affects their daily life while climate change is perceived to have a more indirect and long-term impact.

In order to accelerate the energy transition, coordination between air pollution control and energy transition is needed. First, the Chinese government needs to establish a bilateral consultation mechanism in the formulation and implementation of energy transition policies. The data needed for the consultation can be collected by formulating a uniform standard among the various departments, and establishing an accurate system of information collection, storage, and analysis. Secondly, the MEP's (and now the MEE's) role in China's energy transition can be expanded. In particular, the central government can take local utilization of renewable energy into the scope of environmental protection inspections carried out by the central government.

5.2 Reforming China's incentive policies for renewable energy

China has adopted preferential tariff and tax policies to make renewable energy investments profitable. These policies create incentives for the installation of renewable energy capacity but not necessarily for the consumption of renewable energy. As mentioned in section 3.3, due to the preferential treatment of renewables related to the value-added tax and corporate tax, local governments collect less tax revenue from renewables, and thus have reduced incentives to develop renewable energy. In addition, the subsidies for renewable energy have imposed a heavy fiscal burden on the central government. With the growth of the renewables industry, the fund available for subsidies is depleting. The subsidy gap expanded to 6 billion US dollars in 2016.[73] For all these reasons, it is imperative to reform China's incentive policies for renewable energy.

First, remove China's fossil fuel subsidies and adopt market-based instruments, such as an environmental tax and carbon tax, to correct the externalities caused by fossil fuel consumption. Furthermore, abolish the preferential tax policies of renewable energy step by step according to its falling cost.

Second, the era of supporting renewable energy by subsidies should end. As the costs of renewable energy technologies have dropped recently, it is necessary to speed up the mechanism of "tariff degression" to relieve the central government's financial pressure. Moreover, it is necessary to introduce market influence into renewable electricity price formation, especially for renewables that have more potential for technological

[73] Source: http://www.focalsolar.com/2016/09/subsidy-funding-gap-this-year-will-exceed-60-billion-renewable-energy-subsidies/ (Accessed on August 21, 2017).

progress, such as solar energy. The technological progress potential of solar PV can be demonstrated by the electricity price gap between China and Germany. At the end of 2016, the price in Germany (0.08 US dollars per KWh) was only 60% of that in China (0.12-0.15 US dollars per KWh), while China has more abundant solar energy than Germany.

Finally, the renewable portfolio standard (RPS) can be a priority for China's energy sector reform. It can drive the energy transition by promoting renewable energy consumption. The implementation of RPS needs to accommodate the competing interests of different stakeholders, especially provincial governments. The mandatory requirement of the RPS should be imposed on electric power companies and power grids. Since most of those companies are state-owned enterprises, which pursue both political and economic benefits, they may voluntarily enhance the energy transition under political pressure. Nevertheless, the provincial governments can ensure the compliance with the RPS by enhancing provincial renewable energy policies and optimizing the market system.

5.3 Using social policies to ensure equitable transition

The process of an energy transition involves several social justice problems. The impact of the transition from fossil fuels to renewable energy varies across regions and industries. During the energy transition process, the areas with abundant wind and solar power can embrace a promising development opportunity, while the provinces that rely heavily on fossil fuels may suffer quite severe economic losses. Because the new energy industry requires a different set of knowledge and skills than those used in the fossil fuel industry, workers from traditional energy companies may have difficulty in changing jobs.

With the widespread phasing out of outdated capacity, China has announced a series of social policies to resettle laid-off employees. First, enterprises are encouraged to relocate the laid-off employees by job transfer. In addition, employees within five years of the statutory retirement age have the right to retire early. Second, the central government has set up a special fund to support the structural adjustment of traditional industries, which is mainly used for the cost of staff resettlement. Finally, the government has provided technical training for the workforce in the fossil-fuel sectors to prepare them for the structural shift of the labour market. However, these specific social policies mainly target employees in the coal industry, whereas the policy support for the thermal power industry is much weaker. With the acceleration of the "upgrade the large and suspend the small" policy in the thermal power industry, the scope of re-employment policies should definitely be enlarged.

5.4 Enhancing environmental regulations of renewable energy

China has already considered the negative externalities of renewables. Construction of wind power and solar PV must involve an environmental impact assessment (EIA), analysing the potential ecological impacts and feasible mitigation measures. The NEA has issued the technical regulations for EIAs for wind power and PV power stations, and specifically emphasized that the site selection of wind farms should keep away from nature reserves, endangered species, plant reserves, and bird migration paths.

Nevertheless, China still has a long way to go to achieve a sustainable green energy reform. First, the practicality of environmental regulations can be improved by providing detailed support documents. For example, bird migration paths must be defined as a part of China's ecological red line where development is strictly or partly prohibited. Second, clean production should be implemented in the wind power and solar PV industries, as well as the upstream industries. A report found that, in 2012, more than two-thirds of manufacturers of polysilicon, the raw material of solar panels, could not reach the national environmental and energy efficiency standards (Li et al., 2012). Less than 1 per cent of solar PV enterprises have released their corporate social responsibility reports. Therefore, China should bring the wind power and solar PV industries into the state plan for promoting clean production technology, and enhance the environmental supervision with the reform of the environmental management system.[74] Finally, China should promulgate environmental regulations for wind farms and solar PV in terms of construction sites, raw materials, and generation units.

[74] Plans for Clean Production Technology Implementation in the Key Water Pollution Prevention and Control Industry http://www.jneic.gov.cn/art/2016/9/7/art_5702_212162.html (Accessed on August 25, 2017)

6. Recommendations for the FES Office

6.1 Extending the discussion on the efficiency and equality of energy transition

A low-carbon energy transition is a long-term strategy for China. Researchers and scholars tend to focus on strategic targets and technology problems, rather than questions about the efficiency and equality of China's energy transition. FES has already provided a new perspective for analysing the energy transition in terms of its political feasibility as well as its social aspects in this research project. In addition, two other topics deserve the attention of FES:

First, consider linking governance questions related to climate change, air pollution, and the energy transition. Previous studies on the linkage between climate change and air pollution have largely focused on scientific research and political negotiations. Bollen (2010) has demonstrated that there are multiple benefits of collaborative governance of climate change, air pollution, and energy security. Specifically, if energy security policy is integrated with optimal climate change and air pollution policy, the world's oil reserves will not be depleted before the 22nd century. In order to help China achieve an energy transition of high quality and with high efficiency, more research should be conducted in terms of collaborative governance. For example, it is important to identify the relevant actors in the governance of climate change, air pollution and energy transition, and discuss more about the possibilities for and possible forms of collaboration.

Second, introduce cost-benefit analysis into policy formation for the energy transition. An energy transition is a multi-objective decision problem with sometimes competing economic, societal, and environmental goals. The costs and benefits of a policy option can be quantified (monetarily and otherwise), and compared to determine the optimal path of transition. In order to help China optimize its energy transition process, FES could focus on the feasibility of carrying out cost-benefit analyses in China.

6.2 Introducing the successful experience of Germany's energy transition

As a leader in renewable energy development and energy transition, Germany has many successful experiences to share with China. For example, Germany has switched the principal support policy for renewables from feed-in tariffs to auctions. The lowest-bid price of the auction is the basis of the renewable tariff, and the agreement will be in force for at least 20 years. Starting with a pilot auction for ground-mounted solar PV in 2015, Germany introduced further auctions for onshore and offshore wind as well as biomass in 2017.[75] The auctions have successfully driven down prices. Within less than two years, the average price of solar PV fell by almost 40 per cent from 0.11 to 0.07 US dollars per KWh.

The adoption of renewables auctions has contributed to solving the FIT's high financial burden. The experience of Germany's renewables auctions can provide important policy insights for China in terms of how to reduce financial burdens associated with the development of renewables. Therefore, the necessary measures and adjustments for such a development should be identified based on Germany's experience while simultaneously taking China's specific economic and political background into account. Given the close relations of FES and German politics, energy-related think tanks and researchers as well as trade unions, FES can serve as a coordinator of research into renewables auctions and as a link between academic actors from both countries.

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75 Data source: http://energypost.eu/germanys-first-renewables-auctions-are-a-success-but-new-rules-are-upsetting-the-market/ (Accessed on August 25, 2017)

6.3 Conducting more field studies about green jobs

Abundant and accurate information is the basis for analysing the social effects of an energy transition, but reliable and open statistics about the "green jobs" associated with the renewable energy sector are still lacking. China's Ministry of Human Resources and Social Security (MOHRSS) (2010) had a project studying China's green employment in eight power plants in 2010. However, seven years have passed and the data collected by this project need to be updated. In order to facilitate a socially equitable energy transition in China, FES could help to conduct in-depth interviews in the power industry in China and to emphasise the importance of data collection.

6.4 Raising public awareness about the importance of an energy transition

Public pressure has acted as a main driver of the Chinese government's effort to protect the environment. China's attention to air pollution is the best example for this. Since the US Embassy in Beijing started to disclose $PM_{2.5}$ data in 2011, the public has campaigned to create a nationwide $PM_{2.5}$ monitoring network and pollution control plan. This unprecedented case is an example of public participation in policymaking in an authoritarian society (Huang, 2015).

China's transition to renewable energy requires public support. Social perceptions of the energy transition are closely related to the public's environmental awareness, which has a significant relationship with income, education, and information disclosure (Liu et al., 2012). To achieve better public awareness about an energy transition, there is an urgent need for greater risk education and public participation in energy policy decision making in China. Social institutions such as FES can organize research on the short-term and long-term impacts of renewables on the environment and the economy. The research findings can be disclosed to inform the public and facilitate the energy transition.

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