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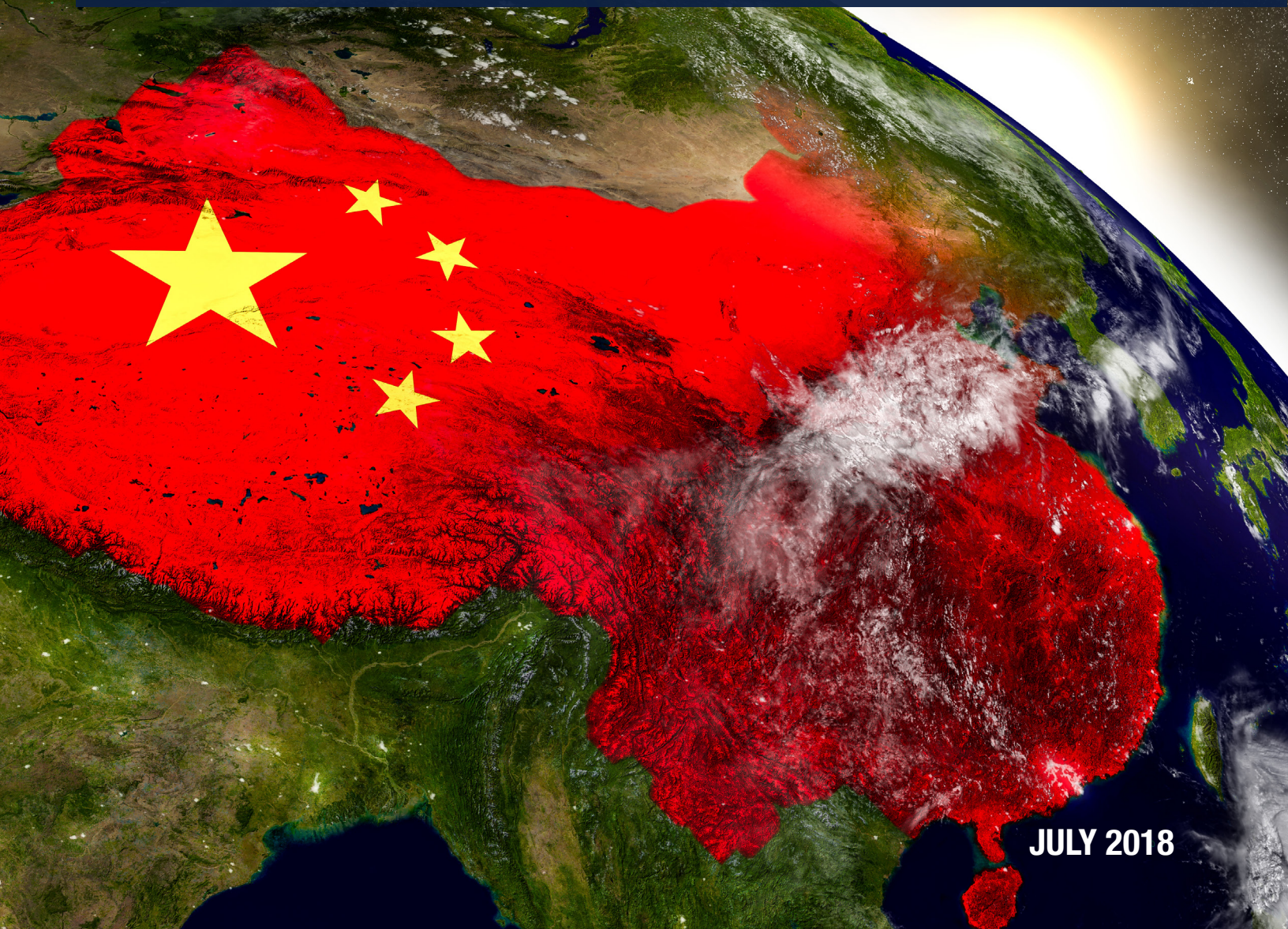
GUIDE TO CHINESE CLIMATE POLICY 2018

BY DAVID SANDALOW



JULY 2018

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INTRODUCTION

In 2017, China was the world's leading emitter of heat-trapping gases by a wide margin. Its policies for limiting emissions will have a significant impact on the global climate for decades to come.

From a historical perspective, China's status as the world's leading emitter is relatively recent. During most of the 19th and 20th centuries, Chinese emissions were modest. Then, in the early part of this century, as the Chinese economy boomed, Chinese emissions began to skyrocket, overtaking those from the United States around 2006. China's cumulative emissions of carbon dioxide since the beginning of the Industrial Revolution are less than half those from the United States or Europe. (Carbon dioxide, the leading heat-trapping gas, stays in the atmosphere for many years once emitted.)

China's leaders have declared that the impacts of climate change "pose a huge challenge to the survival and development of the human race" and that China is "one of the most vulnerable countries to the adverse impacts of climate change."[1] The Chinese government has adopted short- and medium-term goals for limiting emissions of heat-trapping gases and a wide-ranging set of policies that contribute to meeting those goals. Those policies are shaped in part by other objectives, including promoting economic growth, cutting local air pollution and developing strategic industries.

This *Guide* examines Chinese climate change policies. It starts with a review of Chinese emissions. It then explores the impacts of climate change in China and provides a short history of the country's climate policies. The bulk of the *Guide* discusses China's principal climate policies, explaining the policy tools the Chinese government uses to address climate change and related topics. Appendices provide background on institutions that shape climate policy in China.

What are "climate policies"? Monetary and fiscal policies affect emissions and could therefore qualify, as could policies on many other topics. This *Guide* does not catalog all policies that could affect emissions or the climate, but instead focuses on policies most directly related to climate change, including those on energy, transportation, urbanization, forestry, climate adaptation and climate diplomacy.

In choosing policies to focus on, I am guided in part by international convention and in part by governments' extensive reporting on this topic. The Intended Nationally Determined Contributions submitted by more than 160 nations to the UN Framework Convention on Climate Change show a broad international consensus that policies on energy, transportation, urbanization and forestry, among others, are considered "climate policies." The Chinese government's official documents on climate change show the same.

Several official documents are important resources for anyone interested in China's climate policies. Every year the National Development and Reform Commission publishes a report on *China's Policies and Actions for Addressing Climate Change*.[2] These reports provide detailed information on a range of topics. Other key sources for understanding China's climate policies include:

- China's *First Biennial Update Report on Climate Change*, submitted to the UN Framework Convention on Climate Change in December 2016;[3]
- *Work Plan for Controlling Greenhouse Gas Emissions in the 13th Five-Year Plan*, issued by the State Council in October 2016;[4] and
- *China's Intended Nationally Determined Contributions*, submitted to the UN Framework Convention on Climate Change in June 2015.[5]

Several themes run through these documents, including strong support for low-carbon development and commitments to cutting coal use, scaling up non-fossil energy, promoting sustainable urbanization, investing in industries of the future and participating actively in climate diplomacy.

Implementation is fundamental to any policy. This is especially true in China, where policy implementation can be a considerable challenge. Key ministries may fail to coordinate. Resources for enforcement may be lacking. Policies designed to achieve different objectives may conflict. The priorities of provincial leaders may not align with policies from Beijing. For these reasons and more, stated policies—while important—are just part of the picture when it comes to understanding the Chinese response to climate change.

The organization of this *Guide* reflects that. Most chapters start with a section of background facts. This background provides context and can help in forming judgments on the impacts of policies to date and potential impacts of policies in the years ahead. Where implementation has been especially challenging or successful, that is highlighted.

This *Guide* can be read in parts or as a whole. Individual chapters are designed to stand alone and provide readers with information on discrete topics. The *Guide* as a whole is designed to provide an understanding of China's response to climate change and the implications of that response for China and the world.

This is a "living document." Many of the facts and policies it describes will change in the months and years ahead. As that happens, this *Guide* will be updated. The *Guide* will be maintained on a website to be launched in Fall 2018, where content will be revised on a regular basis. New editions of the *Guide* will be released regularly. New and expanded chapters will be included as part of those revisions.

I welcome comments on and updates to the material in this *Guide*. *Please send comments and updates to* *ChineseClimatePolicy@sipa.columbia.edu*.

NOTES

1. People's Republic of China, "Intended Nationally-Determined Contribution" (June 2015) at p.1, http://www4.unfccc.int/ndcregistry/PublishedDocuments/China%20First/China%27s%20First%20NDC%20Submission.pdf; UNFCCC, "First Biennial Update Report on Climate Change" (December 2016) at p.1, https://unfccc.int/sites/default/files/resource/chnbur1.pdf.
2. The October 2017 edition is at http://www.cma.gov.cn/en2014/news/News/201711/P020171122611767066567.pdf.
3. People's Republic of China, "First Biennial Update Report on Climate Change" (December 2016), https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-convention/biennial-update-reports-0.
4. State Council, "Work Plan for Controlling Greenhouse Gas Emissions in the 13th Five-Year Plan" (October 27, 2016), http://www.gov.cn/zhengce/content/2016-11/04/content_5128619.htm. See also Alvin Lin, "China's New Plans Deepen Action on Climate Change" (December 19, 2016), https://www.nrdc.org/experts/alvin-lin/chinas-new-plans-deepen-action-climate-change.
5. People's Republic of China, *Enhanced Action on Climate Change: China's Intended Nationally Determined Contributions* (June 2015), http://www4.unfccc.int/ndcregistry/PublishedDocuments/China%20First/China%27s%20First%20NDC%20Submission.pdf.

PART I - BACKGROUND

TERMINOLOGY

***Gt**—gigaton (a billion tons).*

***CO_2**—carbon dioxide.*

***CO_2e**—carbon dioxide equivalent, a measure used to compare heat-trapping gases based on their warming potential. The CO_2e value of carbon dioxide is 1.*

***Heat-trapping gases**—also commonly referred as "greenhouse gases." The term "heat-trapping gas" more clearly captures the impact of these gases in the atmosphere and will be used throughout this Guide.*

HEAT-TRAPPING GASES

The principal heat-trapping gases emitted by human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NOx) and fluorinated gases (such as HFCs and SF_6). Of these, carbon dioxide is by far the most important, with roughly 76% of the total warming impact of these gases globally. Methane is the second most important, with roughly 16% of the warming impact, followed by nitrous oxides with 6% and fluorinated gases with 2%.[1]

Carbon dioxide emissions are caused mainly by burning coal, oil and gas. Some industrial processes, including cement production, also release carbon dioxide, as does deforestation. Methane and nitrous oxide emissions come from agriculture, the energy sector and elsewhere. The fluorinated gases are used mostly in air conditioning and refrigeration.

The unit "CO_2 equivalent" (CO_2e) is a measure used to compare heat-trapping gases based on their warming potential. One molecule of methane traps roughly 28 times more heat than a carbon dioxide molecule over a 100-year period, for example. Methane is therefore often assigned a CO_2e value of 28. One molecule of nitrous oxide traps roughly 265 times more heat than a carbon dioxide molecule over a 100-year period. Nitrous oxide is therefore often assigned a CO_2e value of 265. The leading fluorinated gases have CO_2e values in the hundreds and thousands.[2]

NOTES

1. IPCC Working Group III, "Climate Change 2014: Mitigation of Climate Change – Summary for Policymakers and Technical Summary (Fifth Assessment Report)" at p.6, https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/WGIIIAR5_SPM_TS_Volume.pdf.
2. See Intergovernmental Panel on Climate Change, "Climate Change 2014: Synthesis, Fifth Assessment Report" at p.87, https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf; G. Myhre et al., "Chapter 8: Anthropogenic and Natural Radiative Forcing" in *Climate Change* 2013: *The Physical Science Basis* at p.714, http://www.climatechange2013.org/images/report/WG1AR5_Chapter08_FINAL.pdf

CHAPTER 1 - CHINESE EMISSIONS OF HEAT-TRAPPING GASES

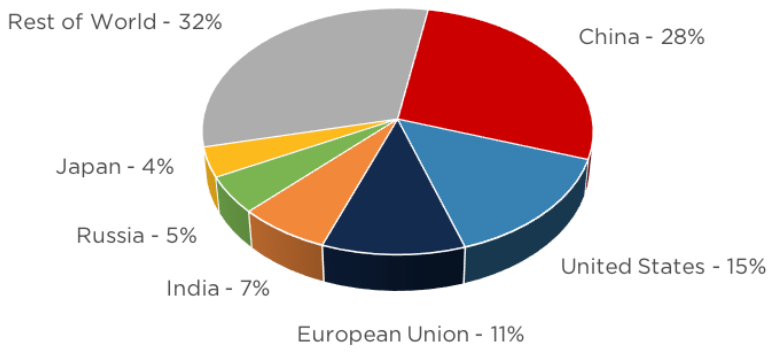
In 2017, China led the world in emissions of heat-trapping gases. Its emissions of roughly 11.7 Gt CO_2e were almost one-fourth of the world total.[1]

This chapter starts by examining China's emissions of CO_2— the most important heat-trapping gas. Following sections discuss China's emissions of other heat-trapping gases, uncertainties in emissions estimates and implications of China's emissions for the global carbon budget.

A. Carbon Dioxide

In 2017, China's emissions of CO_2 from fossil fuel combustion were roughly 9.2 Gt. This was roughly 27% of the world's total. China's CO_2 emissions exceeded those from the United States and European Union combined.[2]

Figure 1-1: CO_2 Emissions 2017



Source: BP Statistical Review of World Energy 2018[3]

Annual emissions are not the only way to measure contributions to global warming. Other common metrics include:

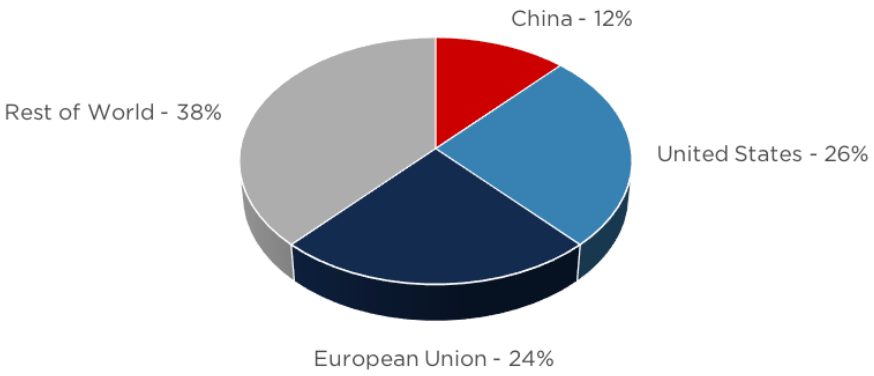
- cumulative emissions over many years,
- per capita emissions, and
- emissions per unit of GDP (often referred to as "carbon intensity").

i. **Cumulative CO_2 emissions.** Once emitted, CO_2 remains in the atmosphere for many years. According to the IPCC, more than two-thirds of a pulse of CO_2 remains in the atmosphere for several decades and 15%–40% remains in the atmosphere for more than 1,000 years.[4] Cumulative emissions over long time periods are an important measure of a country's contribution to current global warming.

One common metric is cumulative emissions since the beginning of the Industrial Revolution in the mid-19th century. From 1850 to 2014, cumulative CO_2 emissions from China totaled 169 Gt—roughly 12% of the global total. Cumulative CO_2 emissions from the United States were 375 Gt (26%) and Europe 334 Gt (23%).[5]

Consistent with this, a study published in *Nature* in 2016 found that Chinese emissions contribute 10% ± 4% of current global radiative forcing. ("Radiative forcing" is a measure of the warming impact of heat-trapping gases.)[6]

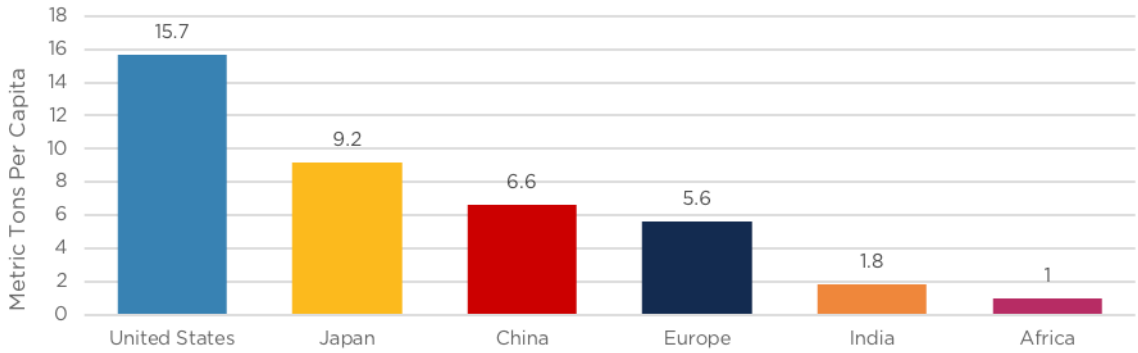
Figure 1-2: Cumulative CO_2 Emissions 1850 to 2014



Source: WRI's Climate Data Explorer[7]

ii. **CO_2 emissions per capita.** In 2017, Chinese CO_2 emissions were roughly 6.6 tons per person—much less than the United States (15.7 tons per person) and less than Japan (9.2 tons per person). China emits more CO_2 per capita than Europe (5.6 tons per person) and much more than India (1.8 tons person) and Africa (1.0 ton per person).[8]

Figure 1-3: CO_2 Emissions Per Capita 2017

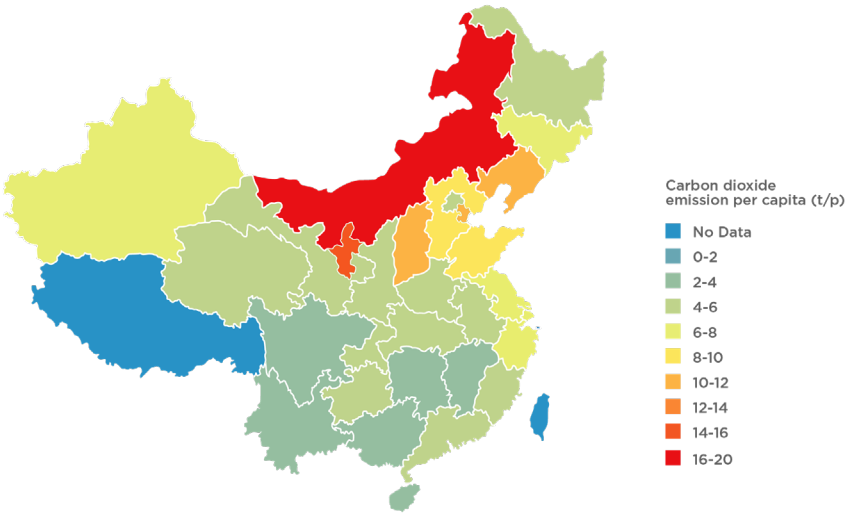


Source: BP Statistical Review of World Energy 2018 and UN department of economic and social affairs (population data)[9]

WIthin China, there are significant regional variations in per capita emissions. The highest per capita emissions come from northern provinces, including Inner Mongolia, Shanxi, Shaanxi and Hebei. These provinces are heavily reliant on coal for power and heating. The lowest emissions came from southern and western provinces, including Sichuan and Jiangxi, where heating demand is less and hydro provides a greater share of the power supply.[10]

There are also significant differences between urban and rural residents with respect to per capita emissions. One study found that Chinese urban residents emit roughly 1.4 times more energy-related CO_2 on average than Chinese rural residents. Another study found that the wealthiest 5.3% of the Chinese population, almost all of whom live in cities, have carbon footprints nearly four times greater than the Chinese average.[11]

Figure 1-4: CO_2 emissions per capita in 2012

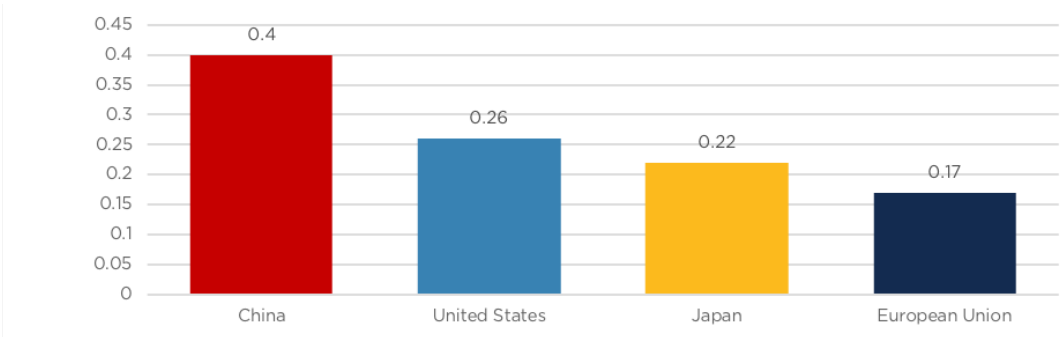


Source: Zhu Liu, China's Carbon Emissions Report 2016[12]

iii. **CO_2 emissions per unit of GDP (carbon intensity).** In 2017, China emitted roughly 0.40 kg of CO_2 per dollar of GDP. The carbon intensity of China's economy has been steadily declining for the past several decades. However, China's carbon intensity remains high in comparison to other major economies, including the United States (0.26), Japan (0.22) and the European Union (0.17).[13]

Chinese emissions per unit of GDP have been falling steadily since 2004. This reflects steady improvement in energy efficiency throughout the Chinese economy, in part driven by goals included in Five-Year Plans.

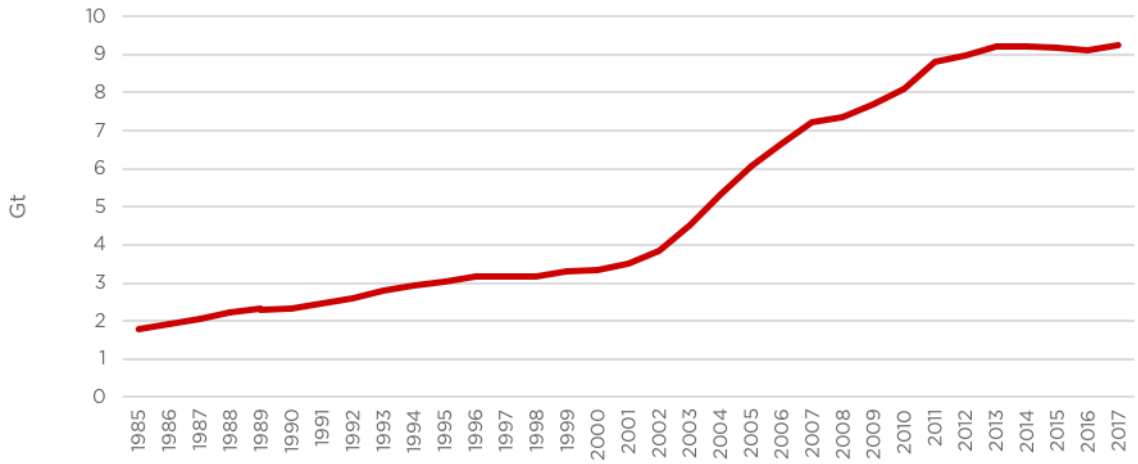
Figure 1-5: Carbon Intensity (kg CO_2 per PPP $ GDP) 2017



Source: BP Statistical Review of World Energy 2018 and IMF, "GDP, current prices, purchasing power parity" (GDP data)[14]

Chinese carbon dioxide emissions tripled between 2000 and 2012, reflecting the country's extraordinary economic growth during that period. Emissions kept growing until 2014, when emissions held almost steady or—according to at least one estimate—declined. This break in the pattern of rising emissions was the result of slowing economic growth, falling demand for coal, growth in hydropower generation due to significant rainfall and increases in solar and wind power. Chinese CO_2 emissions continued to hold roughly steady in 2015 and 2016, with some sources estimating modest increases and other sources estimating modest declines.[15] In 2017 Chinese CO_2 emissions increased, due mainly to growth in coal consumption, with leading estimates varying from 1.4% to 4.1%.[16]

Figure 1-6: China's CO_2 Emissions (Gt) - 1985-2017



Source: BP Statistical Review of World Energy 2018[17]

Most Chinese CO_2 emissions come from the manufacturing, construction and energy sectors. The sectoral composition of CO_2 emissions is as follows:

- Manufacturing and construction sectors: 31%–34%
- Energy sector: 43%–53% (the wide range reflects different categorization schemes by those making the estimates)
- Transport sector emissions: roughly 8%
- Residential and buildings: roughly 5%[18]

This sectoral composition of emissions is much different than in most developed countries. In the United States, for example, roughly 22% of heat-trapping gas emissions come from the industrial sector, 28% from the power sector and 28% from the transport sector.[19]

Land use change and forestry in China are a net sink, sequestering roughly 500 MT or just under 5% of Chinese CO_2 emissions in 2012, according to official Chinese sources.[20]

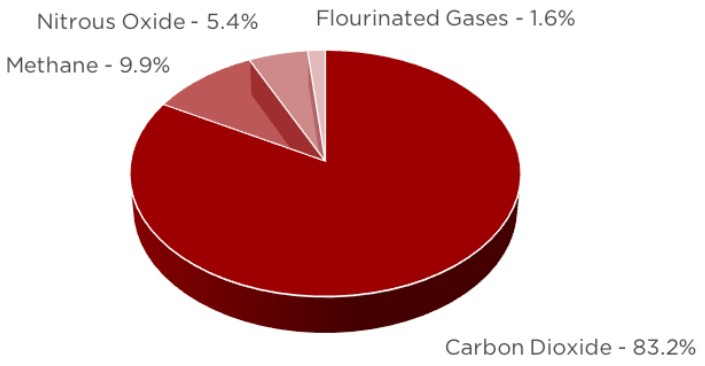
B. Other Gases

China is the world's leading emitter of heat-trapping gases other than carbon dioxide. In 2017, such emissions were likely in the range of 2.0–2.5 Gt CO_2e—roughly one-fifth of total Chinese emissions. (Data with respect to these other heat-trapping gases are not as good or current as data with respect to CO_2, making precise estimates difficult.)[21]

After CO_2, the most significant heating trapping gas is methane. Estimates of Chinese methane emissions for 2012 range from 1.17 to 1.75 Gt CO_2e—roughly 10%–15% of total Chinese emissions of heat-trapping gases. Methane emissions in China come from coal mining, rice farming, waste disposal, livestock production and leakage during production and distribution of natural gas, among other sources.[22]

China is a major producer and consumer of HFCs, a pollutant used in refrigeration and air conditioning with a global warming potential more than 10,000 times greater per molecule than CO_2. China's HFC production in 2010 was 230 million tons, of which 150 million tons was for domestic consumption.[23]

Figure 1-7: China's Heat-Trapping Emissions by Gas (CO_2e) 2012



Source: People's Republic of China, "First Biennial Update Report on Climate Change" (December 2016)[24]

C. Uncertainties in Emissions Estimates

There are significant uncertainties with regard to estimates of Chinese emissions of heat-trapping gases. Although China's data collection systems have improved enormously in the past decade, those systems are not as developed or transparent as such systems in many industrialized countries. In addition, some Chinese data may have systematic reporting biases. Provincial economic and energy data may reflect promotion criteria for provincial officials, which have traditionally weighted hitting GDP targets heavily. The Chinese National Bureau of Statistics has revised its estimates of coal consumption and other energy data several times in the past few years, with significant implications for emissions estimates.[25]

Analysis of these topics in the peer-reviewed literature has grown in recent years. In 2012, a paper in *Nature* found that China's CO_2 emissions calculated on the basis of two official Chinese data sets differed by 1.4 Gt (roughly the annual CO_2 emissions of Japan). In 2015, a paper in *Nature* concluded that previous estimates of Chinese carbon dioxide emissions had been overstated by roughly 10%, due mainly to errors estimating emissions factors for Chinese coal. A 2015 *Science* article highlighted China's unique method for estimating percentages of nonfossil energy. A 2016 *Nature* paper raised questions about previous estimates of a drop in Chinese coal use and related reductions in emissions.[26]

Improving climate data systems is a goal of the Chinese government. In 2014, the National Bureau of Statistics (NBS) and the National Development and Reform Commissions (NDRC) established a 23-member Leading Group on Climate Statistics. NBS also launched "climate change statistical practice pilots" in 15 provinces. The State Council's *Work Plan for Controlling Greenhouse Gas Emissions in the 13th Five-Year Plan* (October 2016) directs provinces and municipalities to "strengthen statistical work on climate change," "improve the greenhouse gas emission measurement and monitoring system" and "promote greenhouse gas emissions data disclosure." The Chinese government's *First Biennial Update Report* and NDRC's *China's Policies and Actions for Addressing Climate Change* (2017) explain the work underway in these areas in some detail.[27]

Many organizations publish data on Chinese emissions of heat-trapping gases.

- The Chinese government provides official emissions estimates in its Biennial Update Reports to the UN Framework Convention on Climate Change. China's First Biennial Update Report, submitted in December 2016, reported on China's National Greenhouse Gas Inventory of 2012. (Chinese government agencies do not publish annual emissions estimates for CO_2 or other heat-trapping gases.)
- Chinese government agencies, including the National Bureau of Statistics, publish estimates of fossil fuel use, electricity consumption and other economic activity, in some cases as often as monthly. The China Electricity Council regularly publishes estimates on these topics as well. English translations of this material are often provided on China Energy Portal. These data and other information are used by experts around the world to estimate Chinese emissions.
- Among the organizations that publish information on Chinese emissions are the International Energy Agency, EC Joint Research Center, World Bank, BP, US Energy

Information Administration, Carbon Dioxide Information Analysis Center, Lawrence Berkeley National Laboratory, Climate Action Tracker, Global Carbon Project, Enerdata, Rhodium Group and World Resources Institute.

Estimates from these organizations vary with respect to scope, timing and many other factors.

- Estimates of CO_2 emissions from fossil fuel combustion are the most common. (These estimates are published by IEA, US EIA and BP, for example.) Some organizations provide estimates of CO_2 emissions from other sources as well (e.g., EC Joint Research Center and Carbon Dioxide Information Analysis Center). A few provide estimates of emissions of all heat-trapping gases (e.g., Climate Action Tracker and World Bank).
- Some organizations (including BP, IEA, Rhodium Group and Climate Action Tracker) provide estimates of emissions from the immediately preceding year. Other organizations provide estimates with more of a time lag.

The table below summarizes recent emissions estimates by some leading organizations.

Figure 1-8: Chinese Emissions of Heat-Trapping Gases (Gt)

Data Source	2012	2013	2014	2015	2016	2017
PRC, First Biennial Update Report[28] *(all gases, minus sequestration from land use change and forestry)*	11.32	-	-	-	-	-
Climate Action Tracker *(all gases)*[29]	10.99	11.39	11.53	11.54	11.52	11.74
EC Joint Research Center[30] *(CO_2 emissions from fossil fuel combustion, cement and other industrial processes)*	9.97	10.50	10.55	10.46	10.43	-
Carbon Dioxide Information Analysis Center[31] *(CO_2 emissions from fossil fuel combustion and cement)*	10.03	10.26	10.29	-	-	-
International Energy Agency[32] *(CO_2 emissions from fossil fuel combustion)*	8.67	9.03	9.0	9.08	8.95	9.1
BP[33] *(CO_2 emissions from fossil fuel combustion)*	8.97	9.20	9.21	9.16	9.11	9.23
Enerdata[34] *(CO_2 emissions from fossil fuel combustion)*	8.6	9.0	9.1	9.1	9.1	9.3

D. Chinese Emissions and the Carbon Budget

According to the Intergovernmental Panel on Climate Change, global CO_2 emissions must be less than a total of roughly 800 Gt in the decades ahead to have a 66% or greater chance of meeting the agreed goal of limiting the global average temperatures increase to 2°C/3.6°F above preindustrial levels.[35] China's emissions will have a significant impact on the world's ability to hit that target. Consider the following:

- If China keeps emitting CO_2 at its current pace, it will use up roughly one-third of this global "carbon budget" by 2045.
- If Chinese emissions (1) increase between now and around 2030 (when the Chinese government has pledged to peak emissions) and then (2) decrease in the years that follow at the same pace at which emissions increase between now and 2030, China will still use up roughly one-third of this global "carbon budget" by 2045.
- If Chinese emissions increase 0.5% per year between now and 2025 and then decrease 1.0% per year between 2025 and 2045, China will use up roughly 30% of the carbon budget.

Of course, industrialized countries emitted far more CO_2 than China in the past century. (CO_2 stays in the atmosphere for many years once emitted.) Industrialized countries are responsible for most of the human-caused CO_2 currently in the atmosphere and, in part for that reason, have agreed to take the lead in cutting emissions in the decades ahead. But however much other countries limit emissions in the decades ahead, Chinese emissions will have a big impact on the global total.

NOTES

1. Climate Action Tracker, "China country summary", https://climateactiontracker.org/countries/china/ (accessed July 12, 2018) (estimating Chinese emissions of 11.7 Gt CO_2e in 2017); J. Olivier, K. Schure and J. Peters, "Trends in global CO_2 and total greenhouse gas emissions: 2017 report," PBL Netherlands Environmental Assessment Agency (December 12, 2017), http://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2017-report (global greenhouse emissions = 49.3 Gt CO_2e in 2016).
2. "BP Statistical Review of World Energy " (June 2018) at p.49 (9.23 Gt, 27.6% of world total) (2018); IEA, "Global Energy and CO_2 Status Report" (March 2018) at p.3 (9.1 Gt).
3. "BP Statistical Review of World Energy" (June 2018) at p.49.
4. Intergovernmental Panel on Climate Change, "Climate Change 2013: The Physical Science Basis" at p.472 (Chapter 6, Box 6.1), http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter06_FINAL.pdf.
5. All figures excluding land use change and forestry. See World Resources Institute, CAIT Climate Data Explorer, http://cait.wri.org/historical (accessed June 24, 2018).
6. The study analyzed the impact of all heat-trapping gases, not just CO_2. See Bengang Li et al., "The contribution of China's emissions to global climate forcing," *Nature* (March 17, 2016), https://www.nature.com/articles/nature17165.
7. World Resources Institute, CAIT Climate Data Explorer (accessed June 24, 2018).
8. See "BP Statistical Review of World Energy" (June 2018) at p.49 (emissions data); United Nations Department of Economic and Social Affairs, "World Population Prospects" (2017) at pp.17ff., https://esa.un.org/unpd/wpp/publications/Files/WPP2017_KeyFindings.pdf (population data). See also Matt McGrath, "China's per capita carbon emissions overtake EU's," BBC News (September 21, 2014), http://www.bbc.com/news/science-environment-29239194.
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CHAPTER 2 - IMPACTS OF CLIMATE CHANGE IN CHINA

A. China's Vulnerability to Climate Change

> "China is among those countries that are most severely affected by the adverse impacts of climate change."— *China's Intended Nationally Determined Contribution* (June 2015)[1]

China is acutely vulnerable to climate change. China's *Third National Assessment Report on Climate Change*—released in November 2015—found that China faces significant threats from sea level rise, severe weather events, glacier melt and more as heat-trapping gases accumulate in the atmosphere. The 900-page report—based on work by more than 500 experts at China's Ministry of Science and Technology (MOST), the China Meteorological Administration (CMA), Chinese Academy of Sciences (CAS), Chinese Academy of Engineering (CAE) and leading universities—found that the average temperatures in China have increased 0.9°–1.5°C/1.6°–2.7°F in the past century, which is more than the global average.[2]

China's vulnerability to sea level rise is especially acute. More than 550 million people live in China's coastal provinces—one of the most densely populated regions on Earth. Millions of people live or work in low-lying areas in major Chinese cities, including Shanghai, Qingdao and Xiamen. The *Third National Assessment Report* found that sea levels off eastern China rose 93 millimeters (3.5 inches) between 1980 and 2012. It found that

- sea levels could rise 40–60 centimeters (16–24 inches) above 20th-century averages by the end of this century, and
- an increase of one centimeter (0.4 inches) could cause the coastline to recede by more than 10 meters (33 feet) in parts of China.

The *Third National Assessment Report* found that such rising seas will significantly increase risks of flooding and storm damage along China's coasts. Another study found that what is now called a "100-year flood event" in Shanghai would become 40 times more likely with one meter (39 inches) of sea level rise.[3]

China is also vulnerable to droughts, heavy rains and heat waves. The *Third National Assessment Report* found that climate change would increase all three. The report found that climate change could extend growing seasons for some crops in northern China but warned that climate change would bring less reliable rains, soils that retain less water, the spread of dangerous pests and shorter growing seasons for many crops. It found that changing rainfall patterns would strain reservoirs and create dam safety challenges, including at the Three Gorges Dam.[4]

Melting glaciers will also create challenges for China. The *Third National Assessment Report* found that China's glaciers shrank 10% between the 1970s and early 2000s and are likely to shrink more in the decades ahead. It highlighted potential geopolitical risks from disputes with South Asian neighbors over transboundary water resources and smaller river flows caused by shrinking glaciers.[5]

A 2018 study found that China is especially vulnerable to river flooding as a result of climate

change. The authors note that costs could be felt throughout global supply chains, many of which depend on goods shipped on China's rivers, and estimate that without adaptation measures economic damage from river flooding in China could increase 80% in the next 20 years.[6]

B. Recent Extreme Weather Events

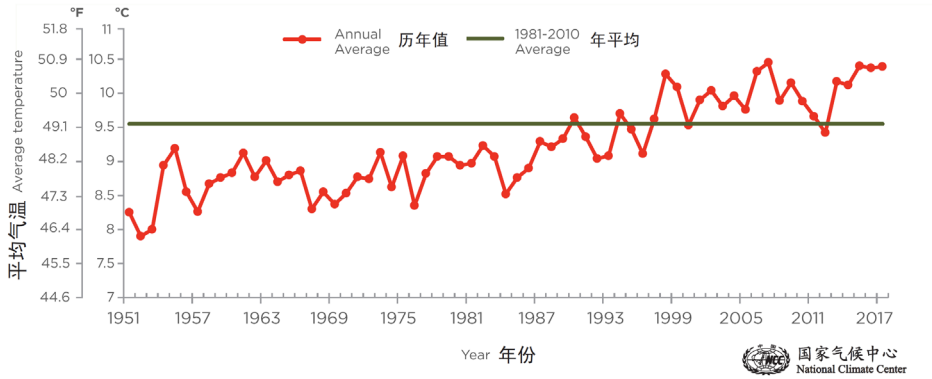
On July 24, 2015, the temperature reached 50.3°C (122.5°F) near Ayding Lake in Xinjiang Province. This was the highest temperature ever recorded in China.[7] Other heat records have been broken in China in recent years:

- On July 20, 2017, Shanghai had its hottest day ever, with the temperature reaching 40.9°C (105°F).[8]
- In 2013, several southern and eastern provinces had the most severe heat wave in at least 140 years. Chinese authorities declared the heat a "level 2" weather emergency—a designation previously used only for typhoons and flooding.[9]
- The warmest years since Chinese scientists began gathering temperature records in the early 1950s are 2015 (first), 2007 (second), 2017 (third) and 2016 (fourth).[10]

Heavy rainfall events in China are increasing in frequency and severity. A 2016 study found that rainstorm days have increased 10% while light rainy days have decreased 13% since 1961. Another study found that rainfall in southern China in 2015 was 50% greater than the 1971–2000 average and that "[t]he rain fell in a series of heavy storms, causing severe flooding in many cities with impacts that included loss of life." In July 2007, the worst rainstorms in 115 years hit Chongqing, causing dozens of deaths and extensive property damage. In July 2012, the heaviest rainfall in 60 years hit Beijing, leaving 37 people dead.[11]

Droughts have also been a problem. In 2017, parts of Inner Mongolia experienced the worst drought on record. In 2016, drought days in northeastern China were 37% above average. In 2007, a severe drought struck parts of southern China. Reservoirs shrank, and parts of the Yangtze River dropped to the lowest levels since records were first kept in the 19th century (probably due not just to drought but to withdrawals).[12]

Figure 2-1: Average Annual Temperatures (China 1951-2017)



Source: China Meteorological Administration[13]

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CHAPTER 3 - SHORT HISTORY OF CHINESE CLIMATE POLICY

Climate change first emerged as a public policy issue in the 1980s, with growing evidence from scientists and calls for action from prominent politicians, including UK Prime Minister Margaret Thatcher and US Senator Al Gore. During this period, China was beginning to implement market-based reforms. Early attention to climate change in China was focused mostly on scientific issues and led by the State Science and Technology Commission. In 1990, the National Climate Change Coordinating Group was established to coordinate work on climate change by government ministries. Members included the State Meteorological Administration (which housed and administered the group), the Ministry of Science and Technology, the Ministry of Energy, the Ministry of Foreign Affairs, and others.[1]

In the early 1990s, China participated in global negotiations to establish a UN Framework Convention on Climate Change (UNFCCC). In the negotiations, China gave high priority to text on "common but differentiated responsibilities"—the principle that all countries are responsible for taking action to prevent climate change but that responsibilities vary based on a country's level of development.

In 1992, Premier Li Peng attended the Rio Earth Summit and signed the UN Framework Convention on Climate Change. The principle of common but differentiated responsibilities was included in the agreement. In his remarks at Rio, Premier Li highlighted several principles, including:

- economic development must be coordinated with environmental protection;
- protecting the environment is the common task of all mankind, but developed countries have greater responsibility; and
- international cooperation on the environment should be based on respect for national sovereignty.

In 1997, China joined more than 100 other nations in adopting the Kyoto Protocol, which imposed emissions limits on industrialized countries but not on China or other developing countries.[2]

In 1998, the National Climate Change Coordinating Group was moved from the State Meteorological Administration to the State Planning and Development Commission (the predecessor to NDRC) as part of a broader governmental reorganization. The move to the State Planning and Development Commission reflected the far-reaching implications of climate change as an issue.

The 10th Five-Year Plan (2001–2005) was the first to mention climate change, affirming the Chinese government's commitment to addressing climate change and other global environmental issues. The plan contained several environmental targets (including for forest cover and air pollutants) but none for climate change or energy efficiency. The Chinese economy grew rapidly during this period, with a massive wave of industrialization but scant attention to energy efficiency, which worsened during the period of the 10th Five-Year Plan (2001–2005).[3]

In 2002, China ratified the Kyoto Protocol. It began actively participating in Clean Development Mechanism (CDM) projects in the years that followed. At the same time, air pollution became an increasingly significant problem in many Chinese cities. Some Chinese

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planners identified renewable energy as an industry with significant growth potential globally. In 2005, the National People's Congress passed the Renewable Energy Law, which set national renewable energy targets and established feed-in tariffs for renewable energy.[4]

The 11th Five-Year Plan (2006–2010) was the first to include a binding target for energy efficiency. The target—a 20% improvement—was implemented in part by assigning energy efficiency targets to each province, with provincial and local leaders accountable for achieving them. Although GDP and other economic targets remained most important to these provincial and local leaders with respect to promotion opportunities, failure to achieve energy efficiency and environmental targets became a potential barrier to promotion for the first time. Evidence emerged that some provincial and local leaders were manipulating energy and environmental data to be seen as hitting their targets.[5]

During the 11th Five-Year Plan (2006–2010), climate change rose rapidly on the agenda of Chinese leaders. Important developments during this period included these:

- In 2006, the Chinese government released its first "National Assessment Report on Climate Change," based on work by more than 20 ministries and government agencies. The report found that climate change posed serious threats to China.[6]
- In 2007, the Intergovernmental Panel on Climate Change (IPCC) released its Fourth Assessment Report, which found that "warming of the climate system is unequivocal" and that most of the recent increase in global average temperatures was probably due to human activities. Chinese experts participated in the IPCC process as Core Writing Team members, reviewers and review editors.[7]
- In 2007, news reports around the world indicated that China had become the world's leading greenhouse gas emitter the prior year.[8]
- In 2007, the National Climate Change Coordinating Group was elevated to become the National Leading Group on Addressing Climate Change (a higher level in the bureaucracy). Some provinces also established Leading Groups on Climate Change.
- In 2007, the Chinese government issued the National Climate Change Program, a 60-page report on Chinese climate policies.
- In 2008, NDRC released its first white paper on climate change—"China's Policies and Actions for Addressing Climate Change 2008."[9]

In late 2008, the global financial crisis struck. Within months, the Chinese government launched an RMB 4 trillion (roughly $600 billion) economic stimulus plan. Some elements, including support for solar power manufacturing, fit well with the growing attention to low-carbon development. However, other elements underscored the far greater priority the leadership attached to sustaining economic growth in the face of a global recession and unprecedented instability in financial markets. The stimulus package included vast energy-intensive construction projects and support for industries heavily dependent on fossil fuels. Environmental regulations were sometimes suspended to facilitate rapid spending. The stimulus package led to emissions increases and slowed progress on energy efficiency across the economy.[10]

The 2009 Copenhagen Conference of Parties (COP) to the UNFCCC received enormous global attention. Just before the conference, China announced its first-ever carbon specific goal: to lower carbon intensity by 40%–45% from 2005 levels by 2020. Premier Wen Jiabao traveled to Copenhagen, where he met with US President Barack Obama and other world leaders. The negotiations were chaotic and the Copenhagen conference was widely considered to be a failure. China and other leading emitters received considerable criticism in the global media for the failure to reach a more ambitious agreement.[11]

In February 2010, in the wake of the Copenhagen conference, top leaders from the Chinese central government and provinces convened for a week-long meeting on low-carbon development. President Hu Jintao, Premier Wen Jiabao and members of the Politburo participated. Later that year, NDRC announced that five provinces and eight municipalities had been chosen for low-carbon development pilot projects.[12]

During 2010, officials in many provinces realized they were at risk of failing to achieve the energy efficiency targets in the 11th Five-Year Plan. To achieve the targets, many officials ordered short-term shutdowns of factories and power plants. The shutdowns provided evidence of the seriousness with which many officials treated the targets.[13]

In October 2010, the Chinese government announced plans to promote seven "strategic emerging industries," including alternative energy, new energy vehicles, and environmental and energy-saving technologies. The government offered financial incentives for investments in these industries and set quantitative targets for each industry's contribution to GDP. Related to this, Chinese policymakers gave increasing attention to promoting the innovative capabilities of the Chinese economy more broadly, focusing on educational and institutional reforms that could promote innovation. In the years that followed, low-carbon development was increasingly seen as part of a strategy for investing in industries of the future and enhancing China's capacities for innovation.[14]

The 12th Five-Year Plan (2011–2015) was the first to include an explicit climate change target. The plan included a chapter on climate change and called for a 17% cut in carbon emissions per unit of GDP (as well as a 16% cut in energy consumption per unit of GDP). To help achieve this target, the State Council released a *Work Plan for Controlling Greenhouse Gas Emissions* during the 12th Five-Year Plan period.[15] Significant developments during this period included these:

- At the end of 2011, the Chinese government chose seven provinces for pilot carbon dioxide emissions trading projects. The projects were launched and implemented in the years that followed, eventually covering more than 10,000 businesses and roughly 6% of China's CO_2 emissions.[16]
- In 2012, low-carbon development, the "green economy" and "ecological civilization" were all heralded by the Chinese leadership at its 18th Party Congress.[17]
- In 2013, the Chinese government released its first *National Climate Change Adaptation Plan*.[18]
- In September 2014, NDRC released the *National Plan on Climate Change* (2014–2020). The plan identified key principles, policies and targets for fighting climate change.[19]

- In November 2014, China and the United States jointly announced steps each country would take to combat climate change agreement during a summit meeting between President Xi Jinping and President Barack Obama. As part of the announcement, China pledged to peak carbon dioxide emissions around 2030 and to make best efforts to peak early. The agreement made headlines around the world (and was widely seen as a catalyst to reaching agreement at the Paris climate conference the next year).[20]
- In June 2015, China submitted its Intended Nationally-Determined Contribution (INDC) to the Secretariat of the UN Framework Convention on Climate Change. In its INDC, China pledged to achieve the peaking of carbon dioxide emissions around 2030, making best efforts to peak early. It also pledged that, by 2030, it would (1) lower carbon dioxide emissions per unit of GDP by 60%–65% from the 2005 level, (2) increase the share of nonfossil fuels in primary energy consumption to around 20% and (3) increase the forest stock volume by around 4.5 billion cubic meters from the 2005 level.[21]

China was an active participant in the Paris climate conference in December 2015. President Xi Jinping participated in the opening ceremony, declaring climate change "a shared mission of all mankind" and joining other world leaders in announcing a commitment to double funding for research and development on clean energy. The Paris Agreement reflected work by the Chinese delegation, led by chief negotiator Xie Zhenhua, to find common ground on challenging issues, including the principle of "common but differentiated responsibilities." Official Chinese news sources reported that China worked closely with other countries during the conference "to ensure the agreement was adopted."[22]

The Chinese government has been unwavering in its support for the Paris Agreement. (The announcement by US President Donald Trump that the United States would withdraw from the Paris Agreement did not change that position.) President Xi Jinping has described the Paris Agreement a "hard-won achievement…in keeping with the underlying trend of global development" and "milestone in the history of climate governance" that "we must ensure is not derailed."[23] In his high-profile remarks to the 19th Party Congress in October 2017, President Xi said, "Taking the driving seat in international cooperation to respond to climate change, China has become an important participant, contributor, and torchbearer in the global endeavor for ecological civilization."[24]

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PART II - DOMESTIC POLICIES

CHAPTER 4 - CLIMATE GOALS

The Chinese government has announced four principal climate goals:

1. to achieve the peaking of carbon dioxide emissions around 2030, making best efforts to peak early;
2. to lower carbon dioxide emissions per unit of GDP by 60%–65% from the 2005 level by 2030
3. to increase the share of nonfossil fuels in primary energy to around 20% by 2030; and
4. to increase the forest stock volume by around 4.5 billion cubic meters from 2005 levels by 2030.

These goals were highlighted in the Intended Nationally Determined Contribution (INDC) China submitted to the UN Framework Convention on Climate Change in June 2015, as well as in other official documents.[1]

The first goal—to achieve peak emissions around 2030 and make best efforts to peak early—was announced by President Xi Jinping in November 2014 at a summit with US President Barack Obama in Beijing. The pledge made headlines around the world, in part because of the setting, in part because the United States jointly announced its own post-2020 climate target in parallel and in part because it was the first time the Chinese government had committed to absolute limits on CO_2 emissions.[2] There is now a considerable literature on China's prospects for meeting that goal, with many analysts projecting that China is likely to achieve peak emissions several years at least before 2030.[3]

The second goal—to lower carbon dioxide emissions per unit of GDP ("carbon intensity") by 60%–65% from the 2005 level by 2030—builds on a similar pledge announced by Premier Wen Jiabao just before the Copenhagen climate conference in 2009. In November 2009, Premier Wen pledged that China would lower carbon intensity by 40%–45% from the 2005 level by 2020. That pledge also made headlines, in part because it was the first time the Chinese government had committed to limit CO_2 emissions.[4]

The third goal—to increase the share of nonfossil fuels in primary energy to around 20% by 2030—was also announced at the November 2014 Beijing summit with President Obama. In light of China's size and projected economic growth, this implies a very substantial increase in renewable and nuclear power capacity in the next decade. An influential 2015 paper projected that 900 GW of new renewable and nuclear capacity (almost equal to the entire power generating capacity of the United States) would be required to meet this goal. In 2016, the share of nonfossil fuels in China's energy mix was 13.3%.[5]

The fourth goal—to increase the forest stock volume by around 4.5 billion cubic meters from 2005 levels by 2030—also builds on a pledge made by Premier Wen Jiabao just before the Copenhagen climate conference. In November 2009, Premier Wen pledged that China would increase its forest stock volume by 1.3 billion cubic meters from 2005 levels by 2020. The 2030 pledge implies an increase in forest cover of about 2–4 times the size of the United Kingdom.[6]

All these goals are implemented through a policy infrastructure that includes Five-Year Plans, guidance documents and regulations issued by relevant ministries, and financial support provided through diverse channels. One common tool is to allocate targets to individual provinces. After Premier Wen Jiabao's 2009 announcement that China would cut CO_2 emissions per unit of GDP 40%–45% from the 2005 level by 2020, for example, that goal was incorporated into the 12th Five-Year Plan (2011–2015) and a number of specific planning documents under the 12th Five-Year Plan. NDRC then allocated subgoals to individual provinces, giving each province a specific target.

NDRC and the National Bureau of Statistics report annually on progress toward these goals.[7]

In addition to these principal goals, the Chinese government sets a number of intermediate or secondary goals related to climate change. For example, in its *Work Plan for Controlling Greenhouse Gas Emissions in the 13th Five-Year Plan* (October 2016), the State Council calls for CO_2 emissions per unit of GDP to be 18% lower than 2015 levels by 2020.[8]

Many Chinese provinces and localities have committed to climate goals as well. As of June 2016, 23 provinces and cities had committed to peaking CO_2 emissions before 2030 as part of China's Alliance of Pioneer Peaking Cities. In December 2017, for example, the city of Wuhan issued a *Carbon Emissions Action Plan* that included a commitment to peak CO_2 emissions by 2022.[9]

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CHAPTER 5 - URBAN AIR POLLUTION

Background

Severe air pollution chokes many Chinese cities. Soot and smog levels exceed national and international health standards, often greatly.

Extreme air pollution events have been common, especially in the winter. A long period of especially severe air pollution in the winter of 2013 gained widespread attention and was labeled an "airpocalypse." Similar incidents occurred in 2014, 2015 and 2016. In January 2017 the Chinese government issued a national red alert for air pollution after dozens of cities across north and central China experienced smog so severe it caused widespread school closings and flight cancellations.[1]

During the fall and winter of 2017–2018, air pollution in Beijing and dozens of other Chinese cities dropped dramatically.

- In November 2017, PM2.5 concentrations in dozens of cities across northern China fell an average of 37% from the previous year. In December 2017, they fell more than 16% from the previous year.
- In January 2018, PM2.5 concentrations in Beijing fell 71% from the previous year to 34 micrograms per cubic meter, meeting China's national air quality standard for the first time. Beijing's Bureau of Environmental Protection said that 25 days during January had good or excellent air quality.

The principal cause of Chinese air pollution is coal combustion (for industrial processes, space heating and power generation). Vehicle exhaust — especially from diesel freight trucks — also plays an important and growing role.[2] The air quality improvements during the fall and winter of 2017–2018 were due mainly to widespread conversion of coal-fired furnaces and boilers to natural gas, as well as temporary administrative closures of heavy industrial facilities in Hebei.[3]

Air pollution is a top concern of many Chinese citizens. In a 2015 national survey, 76% of respondents said that air pollution is a "big problem" and 35% of respondents said it is a "very big problem." The air pollution documentary Under the Dome was viewed more than 300 million times in China before it was removed from Internet platforms four days after its 2015 release.[4]

The health consequences of China's air pollution are significant. One study linked air pollution to 1.6 million premature deaths per year in China. Another study found more than 2.5 billion years of life expectancy are lost as a result of air pollution in northern China alone. Lung cancer mortality rates in Hebei, one of China's most polluted provinces, nearly tripled from 1973–1975 to 2010–2011. A study released in 2017 found that approximately 9% of China's adult population (almost 100 million people) suffer from chronic obstructive pulmonary disease and that air pollution is one of the biggest causes. Research also shows a strong relationship between air pollution and cardiovascular disease in China.[5]

Air Pollution Policies

Cutting air pollution is a priority of Chinese leaders. President Xi Jinping promises to "make

China's skies blue again" and spoke repeatedly about the war against pollution in high-profile speeches at the 19th Party Congress in October 2017 and 13th National People's Congress in March 2018.[6] He identifies cutting pollution as one of three priority "tough battles" for China in the years ahead. (The other two are eliminating poverty and reducing financial risks.)[7] Premier Li Keqiang has spoken about air pollution often. In September 2013, he declared that China would use "iron fists" to combat pollution.[8]

China's first air pollution law dates to 1987. In the decades that followed, China's air pollution laws were mostly ineffective due to sporadic enforcement, low penalties and weak monitoring. Perhaps most importantly, local officials generally lacked incentives to make clean air a priority. Starting around 2007, the Chinese government developed and implemented serious measures to control air pollution in connection with the 2008 Beijing Summer Olympics. However, these measures affected only the Beijing area and were mostly short term (such as shutting down factories before and during the Olympics). By 2009, air pollution in the Beijing area returned to earlier levels.[9]

In September 2013 the Chinese government announced the *Action Plan on Prevention and Control of Air Pollution*, following the horrific air pollution events of the previous winter. The action plan called for a 10% cut in PM10 concentrations by 2017 in cities across China, with more stringent targets in three key regions (Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta). It described "10 tasks" for cleaning the air:

1. Increase efforts in comprehensive control and reduce the emission of multipollutants.
2. Optimize the industrial structure and promote industrial restructuring.
3. Accelerate technology transformation and improve the capability to innovate.
4. Adjust the energy structure and increase the clean energy supply.
5. Strengthen environmental thresholds and optimize industrial layout.
6. Better play the role of market mechanism and improve environmental economic policies.
7. Improve the law and regulation system. Carry on supervision and management based on the law.
8. Establish a regional coordination mechanism and integrated regional environmental management.
9. Establish a monitoring and warning system. Cope with pollution episodes.
10. Clarify the responsibilities of the government, enterprise and society. Mobilize public participation.[10]

From this general guidance, many specific policies and actions have emerged. Measures to control coal burning have been a top priority. They include a ban on new coal-fired power capacity, improved SO2 and NOx controls at coal-fired power plants, and policies to promote alternatives to coal (including natural gas, hydropower, wind power, solar power and nuclear power). Stricter vehicle fuel efficiency and emissions standards have also been adopted. The

Chinese government has led campaigns against the use of fireworks during Spring Festival, a longstanding Chinese tradition, for air quality reasons. (See poster below.)

Other changes include greater incentives for local officials to prioritize air quality, better air pollution monitoring, larger penalties and stricter enforcement. In 2014, Chinese authorities brought roughly 2,000 criminal cases for environmental violations—double the number from the past 10 years combined. In November 2016, more than 1,100 Chinese officials were held accountable for violations of air pollution laws.[11]

China's 13th Five-Year Plan (2016–2020) gives priority to fighting air pollution. In addition to limits on coal consumption, the plan sets quantitative goals for air pollution reduction and air quality, including a 15% cut in SO2 and NOx levels and a requirement that all cities meet air quality standards at least 80% of the time. Monitoring capabilities are enhanced dramatically and each province is required to share air quality information regularly. Targets are set for deployment of hydro, wind, solar and nuclear power.[12]

During 2017, strict policies with respect to coal burning, industrial activities and traffic were announced for the Beijing-Tianjin-Hebei area. These helped produce the record cuts in pollution levels during the fall and winter of 2017–2018. However, natural gas supplies to replace coal in the region lagged, leading to shortages and inadequate heating during parts of the winter.[13]

In May 2018, the Ministry of Ecology and Environment (MEE) reported that all 45 key tasks identified in the 2013 Action Plan on Prevention and Control of Air Pollution had been completed on schedule. According to MEE data,

- between 2013 and 2017, the average concentration of PM10 in prefecture-level cities fell 22.7%; and
- between 2013 and 2017, the average concentration of PM2.5 fell 39.6% in Beijing-Tianjin-Hebei, 34.3% in the Yangtze River Delta and in 27.7% in the Pearl River Delta.[14]

According to MEE data, the average concentration of PM2.5 in Beijing in 2017 was 58 micrograms/cubic meter. Although a significant improvement from prior year levels, this is substantially above levels in US and European cities as well as international health standards.[15]

Relationship to Climate Change

Most measures to fight local air pollution in China also help fight climate change.

Measures to transition from coal to other fuels are central to cutting both urban air pollution and carbon emissions. Policies that promote solar, wind, hydro and nuclear power help achieve both goals since, in contrast to the coal that dominates China's energy supply, those technologies produce almost no local air pollution or heat-trapping gases.

Policies that promote natural gas as an alternative to coal help cut both local air pollution (by 90% or more, depending on the pollutant) and carbon emissions (by roughly 50%). There are two qualifiers:

- First, leaks in the course of production, distribution or consumption of natural gas could significantly diminish the greenhouse gas benefits of using natural gas to replace coal. Methane—the principal component of natural gas—is itself a powerful greenhouse gas. As a

rough rule of thumb, if more than 3%–8% of the natural gas consumed as an energy source leaks, that would cancel the greenhouse gas benefits of switching from coal to natural gas.[16]

- Second, although today natural gas displaces coal in China, in the medium and long terms, natural gas infrastructure could slow deployment of solar, wind, hydro and nuclear power. There may be a trade-off between the carbon emissions reductions natural gas can deliver today by displacing coal and the carbon emissions reductions natural gas could make more challenging in future decades by slowing deployment of renewables and nuclear power.

Policies that promote energy efficiency also reduce both local air pollution and carbon emissions. Policies to promote industrial energy efficiency are especially important, as are policies to improve the energy efficiency of Chinese buildings. China's fuel efficiency standards for vehicles also cut both local air pollution and carbon emissions (as well as reducing China's reliance on imported oil).[17]

China's policies to promote electric vehicles provide significant local air pollution benefits, since electric vehicles do not have tailpipe emissions. There is a debate among experts about the extent to which electric vehicles help mitigate carbon emissions in China, since those vehicles increase power demand from China's coal-heavy electric grid. Some studies have found little if any short-term climate benefit from electric vehicles as a result of this. Others have found modest benefits. In the long run, as China's grid transitions from coal to low-carbon power sources, electric vehicles will have important climate benefits for China and be essential to "deep decarbonization" strategies.[18]

Finally, some technologies for controlling local air pollution are counterproductive when it comes to global warming. Scrubbers on coal plants have important local air pollution benefits but generally increase carbon emissions slightly, since they require energy to operate.[19] More significantly, synthetic natural gas can help reduce local air pollution by moving coal combustion from urban to rural areas but significantly increases carbon emissions. Policies to promote synthetic natural gas are counterproductive when it comes to China's climate goals.[20]

Figure 5-1: Beijing's Air Pollution Every Day for a Year

Source: Zou Yi, (November 2014), https://petapixel.com/2014/11/14/one-years-worth-pictures-highlight-horrible-air-pollution-beijing/

NOTES

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CHAPTER 6 - EMISSIONS TRADING

In December 2017, the Chinese government launched the first phase of a national emissions trading program for carbon dioxide. When fully implemented in the 2020s, the program is expected to cover more than 5 Gt of annual emissions—by far the largest emissions trading program in the world. The extent to which the program will be an important factor in reducing Chinese emissions remains to be determined.[1]

History

Chinese experience with emissions trading dates to at least 2005, when NDRC authorized Chinese companies to participate in the Clean Development Mechanism (CDM), an international emissions trading program run by the UN Framework Convention on Climate Change. China soon became the world's biggest supplier of CDM credits, with more than half the world's CDM projects.[2]

In 2011, the Chinese government announced plans to develop a domestic emissions trading market for carbon dioxide. Over the next several years, pilot programs were launched in seven cities and provinces—Beijing, Shanghai, Chongqing, Shenzhen, Hubei, Tianjin and Guangdong. (See discussion of these pilot programs below.)[3]

As these pilot programs were being launched, Chinese experts conducted extensive research on how best to design emissions trading programs, often drawing on experiences in other countries around the world. Chinese and California state officials began working together on these issues in programs that continue today. Chinese and EU officials began working together as well. In recent years more than 1,500 Chinese emissions trading specialists have received training under a China-EU program.[4]

In 2014, NDRC's Energy Research Institute released a detailed study of emissions trading program design options. The study recommended taking up to 10 years to build "a nationwide market with valid functions, completed structures and smooth operations."[5] Also in 2014, NDRC released its *Interim Measures for Managing Carbon Emissions Trading Rights* to start the process of developing standards for a national carbon trading market.[6]

In September 2015, President Xi Jinping announced that the Chinese government would launch a national emissions trading program for carbon dioxide by the end of 2017. The announcement was made three months before the Paris climate conference, at a summit meeting with US President Barack Obama.[7]

National Carbon Trading Program

In December 2017, NDRC released its *National Carbon Market Development Plan* (*Power Generation Sector*).[8] The document sets forth a three-phase plan:

- Phase 1 ("Basic Infrastructure Establishment"): "Take approximately one year to build unified national systems for emissions data reporting, registration and allowance trading."
- Phase 2 ("Simulated Operation"): "Take approximately one year to conduct mock trading of allowances in the power generation sector."

- Phase 3: ("Deepening and perfecting"): "Conduct spot trading of allowances among participants from the power generation sector… Once the carbon market for the power generation sector is successfully established, the market shall gradually expand to cover other sectors, trading products and trading types."

Power sector entities that emit more than 26,000 tons per year of carbon dioxide are subject to the plan. Carbon dioxide emissions from these entities are roughly 3 Gt per year. (The largest emissions trading program in the world today, run by the European Union, covers approximately 1.8 Gt per year of carbon dioxide.)[9]

Once the emissions trading program is operational (in or around 2020), covered entities will be required to surrender allowances each year to match their emissions. Entities will be allowed to sell surplus allowances and buy allowances to cover any shortfall. The program will be administered by provincial and municipal climate change departments within the Ministry of Ecology and Environment, which assumed responsibility for climate change functions from NDRC in the government reorganization of March 2018. These climate change departments are directed to impose penalties on entities that fail to surrender sufficient allowances.

One important question not addressed in the *National Carbon Market Development Plan* is the level of carbon dioxide emissions that will be allowed. According to press reporting and much commentary, Chinese officials have said that emissions caps will be output based (meaning that as the output of covered entities grows, their emissions caps will grow as well). The *National Carbon Market Development Plan* is silent on this topic.[10]

Pilot Programs Today

China's seven pilot emissions trading programs remain in operation, covering provinces and cities with a total of more than 250 million people. Allowance prices are reported daily.[11]

These pilot programs have several common features. Each is administered by a provincial or municipal government, imposes obligations directly on covered entities, allocates allowances to those entities for free, and covers carbon dioxide but not other greenhouse gases. The programs also have differences:

- Coverage varies (in terms of both types and sizes of businesses).
- Methods for determining allowance allocations vary. (In some pilots, allocations are based on historical emissions, while in others allocations are based on historical emissions intensity.)
- Compliance rules vary. In Beijing, fines are 3–5 times the average market price of an allowance over the past six months for each shortfall allowance. In other pilots, noncomplying businesses are penalized mainly by receiving fewer allowances in the following year.[12]

More than 160 million tons of CO_2 with a value of more than RMB 2.5 billion (roughly US$370 million) have been traded under these pilot programs.[13] In 2018 a leading Chinese expert group released an assessment of these pilot programs. The expert group found liquidity in the

seven pilots to be very low, with transactions accounting for a low percentage of the overall quotas, and that information disclosure needs to be improved. The group found that, in terms of emissions reductions, the Hubei pilot performed best, with 54 million tons of reductions in 2015, with Guangdong and Shenzhen close behind.[14]

According to NDRC's *China National Carbon Market Development Plan* (December 2017), these programs "shall continue to perform their existing roles and gradually transition to a national carbon market when conditions allow."[15]

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CHAPTER 7 - ENERGY EFFICIENCY

"Policies put in place by the [Chinese] government to improve efficiency have been one of the most important factors in limiting the growth of energy-related CO_2 emissions anywhere in the world over the past decade." — *IEA Energy Efficiency Market Report 2016*[1]

Background

China's economy is energy intensive. In 2016, China used 69% more energy per unit of GDP than Japan, 47% more than India and 25% more than the United States. In part, these figures reflect the high share of energy-intensive manufacturing in the Chinese economy. In part, they reflect the legacy of a planned economy and continuing lack of market signals to motivate energy efficiency in some sectors.[2]

The energy intensity of the Chinese economy has improved dramatically in the past several decades. According to the World Bank, between 1980 and 2010, China's GDP increased by 18 times while Chinese energy consumption increased by only 5 times. During this period, the energy intensity of the Chinese economy per unit of GDP fell roughly 70%.[3] Except for several years between 2001 and 2005 when energy intensity increased, gains have been steady.[4] Energy intensity improvements have been especially strong in recent years. According to China's National Bureau of Statistics, Chinese energy use per unit of GDP fell 4.8% in 2014, 5.6% in 2015, 5 percent in 2016 and 3.7% in 2017.[5]

These improvements have been caused by (1) energy efficiency gains within individual sectors (as a result of technological improvements, policy mandates or both) and (2) shifts in economic activity among sectors (in particular shifts from manufacturing to the service sector). According to the IEA, gains within individual sectors have been by far the most important cause of energy-intensity improvements since the year 2000, although structural changes in the economy are expected to play a greater role in the years ahead.[6]

China's energy efficiency gains have had an enormous impact on emissions of heat-trapping gases. According to the IEA, without energy efficiency improvements between 2000 and 2014, Chinese energy-related CO_2 emissions would have been 1.2 GT higher in 2014—13% of China's energy-related CO_2 emissions and roughly the amount of the energy-related CO_2 emissions from Japan that year.[7]

According to the IEA, "Policies put in place by the [Chinese] government to improve efficiency have been one of the most important factors in limiting the growth of energy-related CO_2 emissions anywhere in the world over the past decade."[8] Those policies are described below.

Policies

Improving energy efficiency is a longstanding goal of the Chinese government. Most Five-Year Plans since the 1980s have included energy intensity goals for the Chinese economy.[9] The 11th Five-Year Plan (for the period 2006–2010) contained especially strong provisions,

with a mandatory national target to reduce energy intensity 20% below 2005 levels by 2010. The 12th Five-Year Plan (for the period 2011–2015) contained a mandatory national target to reduce energy intensity 16% below 2010 levels by 2015.[10]

China's current Five-Year Plan continues in this tradition. The 13th Five-Year Plan (for the period 2016—2020) contains a mandatory national target to reduce energy intensity 15% below 2015 levels by 2020.[11]

These targets are implemented through four main tools: (1) annual goals, (2) provincial targets, (3) government spending and (4) regulations and standards.

1. Annual goals. The Five-Year Plan targets for energy intensity are supplemented with specific annual goals. In March 2017, for example, NDRC announced a goal of reducing the energy intensity of the Chinese economy by 3.4% during 2017. (In February 2018, the National Bureau of Statistics reported that energy intensity had fallen by 3.7% during 2017.)[12]

2. Provincial targets. As part of the process for implementing China's Five-Year Plans, each province is required to meet specific energy intensity targets. Under the 13th Five-Year Plan, these targets vary from a 17% improvement (for eight provinces including Beijing, Shanghai and Guangdong) to 10% (for Xinjiang, Tibet and Qinghai). The process of allocating energy intensity targets is overseen by NDRC and reflected in plans issued by the state council. NDRC and other ministries monitor progress toward meeting these targets, releasing quarterly reports on the results. Those results are used to evaluate the job performance of provincial officials and included in the central government's performance management system.[13]

3. Central government spending. The central government spent more than $35 billion on energy efficiency programs during the 12th Five-Year Plan (2011–2015). Provincial governments spent at least $7 billion. These funds were spent on projects to demonstrate energy efficient equipment, upgrade coal-fired boilers, recover waste heat, implement energy managements systems and more. Financial tools used in these projects included direct funding, subsidized loans and credit guarantees. The IEA estimates that Chinese government funding leveraged over $211 billion of private spending on energy efficiency.[14]

   These programs have a long history. During the 11th Five-Year Plan (2006–2010), the central government spent more than $20 billion on energy efficiency programs, leveraging an additional $100 billion in private spending. In the 1980s and early 1990s, more than 200 Energy Conservation Centers were established to help companies conduct energy audits, implement demonstration projects and train energy managers.[15]

4. Regulations and Standards. The Chinese central government has issued dozens of regulations standards to promote energy efficiency across a range of sectors. NDRC, the Ministry of Industry and Information Technology (MIIT), the Ministry of Housing and Urban-Rural Development (MOHURD), the Ministry of Commerce (MOFCOM), and other ministries all have roles. Among the most important are:

a. Efficiency standards for coal-fired power plants. All new coal plants must use supercritical or ultra-supercritical technology. There are longstanding programs to retire small and low-efficiency coal boilers.[16]

b. The Top 10,000 Energy-Consuming Enterprises program. Companies within the program are required to appoint energy managers, prepare energy conversation plans and achieve specific energy consumption targets. These 10,000 companies roughly half of industrial energy demand.[17]

c. Appliance standards and labels. The Chinese government's appliance energy efficiency standards and labeling programs date back many years. More than 220 energy efficiency standards were issued during the period of the 12th Five-Year Plan (2011–2015). NRDC and MIIT each publish catalogs of recommended energy-saving products and promote their use through public education. NDRC runs an Energy Efficiency Leaders program to recognize top products in different categories.[18]

d. Building standards. All new urban residential and public buildings must meet energy-saving design standards established by MOHURD. MOHURD has also developed a Green Building Action Plan, with green building evaluation standards and a labeling program. As of September 2016, roughly 4,500 buildings in China had received green building labels.[19]

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CHAPTER 8 - COAL

Background

Coal Consumption

China uses more coal than the rest of the world combined, with just over half of global consumption. Most of the roughly 3.8 billion tons of coal consumed in China in 2017 was burned for power or heat. Coal is also used as a feedstock in several industries, including chemicals, iron and steel.[1]

In 2017, coal accounted for 60.4% of primary energy and 64.7% of electric power production in China, according to official sources.[2] Coal combustion is responsible for roughly 70%–75% of China's CO_2 emissions.[3]

For decades, coal has helped fuel China's extraordinary economic growth. Between 2001 and 2013, coal consumption in China more than tripled. This played a central role in the growth of the Chinese economy, which grew by almost exactly the same amount during this period.[4] However, coal use also created extraordinary environmental problems. Due in large part to coal burning, some Chinese cities became among the most polluted in the world. Air pollution levels in many cities caused significant health problems.[5]

In 2014, Chinese coal consumption dropped for the first time in 15 years, falling 2.9% from 2013 levels, according to government statistics. Coal consumption fell again in 2015 and 2016 (by 3.7% and 4.7%, according to government statistics). The principal reasons for these declines were (1) policies to discourage coal consumption, (2) a shift in economic activity from manufacturing to the service sector and (3) lower rates of economic growth than in prior years.[6]

In 2017, Chinese coal consumption increased from 2016 levels. Most estimates are in the range from 0.3% to 1.0%. Factors contributing to this growth included a cold winter, hot summer, drop in hydropower productivity and increase in heavy construction activity.[7]

There are considerable uncertainties with respect to data on Chinese coal consumption.

- In recent years Chinese government agencies have revised their official estimates of domestic coal consumption on several occasions. A 2015 revision increased estimates of Chinese coal consumption for the prior decade by up to 17%.[8]
- Aggregate data from provincial authorities generally exceed national figures from the central government, sometimes by as much as 20%. Reasons may include double-counting of coal traded among provinces and inflated figures from provincial officials (whose promotion often depends on hitting GDP targets that have historically been correlated with coal consumption).[9]
- Some Chinese coal consumption statistics are based on tonnage while others are based on thermal content. Trends with respect to each can vary, causing confusion. Estimates of the thermal content of Chinese coal sometimes differ, which can compound the confusion.[10]

Notwithstanding the foregoing, there appears to be broad consensus that China's coal emissions grew steadily until 2013, dropped for each of the next three years and then grew slightly in 2017.

Coal-fired power plants

As of year-end 2017, China had roughly 981 GW of coal-fired electric generating capacity. (This is almost as much electric generating capacity as in the United States from all sources.) China's coal-fired power fleet grew by roughly 35 GW (3.7%) in 2017.[11]

In 2017, China's coal-fired power plants operated at less than 50% of capacity. (Overcapacity is widespread throughout Chinese industry, not just in the power sector.)[12]

China's fleet of coal-fired power plants is among the most efficient in the world. 90 of China's 100 largest coal-fired power plants are ultra-supercritical.[13]

Coal production

China is the world's leading coal producer, with just under half of global production. In 2017, according to official statistics, Chinese coal production increased by roughly 3.3% to reach 3.5 billion tons.[14]

China's proved coal reserves are roughly 138 billion tons—39 years of production at current rates. The main coal-producing provinces are Inner Mongolia, Shanxi and Shaanxi.[15]

Chinese coal imports have fluctuated significantly in the past decade—surging between 2009 and early 2014, falling steeply until early 2016, and then starting to climb again in 2016 and 2017. In recent years China has been the world's largest or second largest coal importer, after India.[16]

Chinese coal production produces methane emissions. In 2005, these emissions were over 135 million tons of CO_2 equivalent (just over 1% of China's current emissions), according to US EPA. Since then, Chinese coal production has increased by roughly 75%. Considerable investments have been made in capturing coal mine methane during this period as well. Current data on methane from Chinese coal mining are lacking.[17]

Policies

Cutting coal use is a top priority of the Chinese government. The many policies for achieving that goal include a national cap on coal consumption, targets for reducing coal's share of the energy mix, requirements to dramatically reduce coal use in many urban areas, investments in coal-to-gas switching, CO_2 emissions standards for power plants and orders to close tens of thousands of inefficient coal-fired boilers.[18]

China's coal policies receive attention at the highest levels of government. In August 2015, Premier Li Keqiang said, "We will strive for zero growth in the consumption of coal in key areas of the country," adding that "environmental pollution is a blight on people's quality of life."[19]

Several Chinese government plans and directives have addressed coal consumption in recent years, with increasingly stringent provisions:

- In 2013, the State Council's *Action Plan for Air Pollution Prevention and Control* called for "managing air pollution by managing coal" as the first of five major themes.
- In 2014, the State Council's *Strategic Action Plan for Energy Development* capped coal consumption nationwide at 4.2 billion tons per year and called for cutting coal's

share of the primary energy mix to 62% by 2020. (That goal was achieved three years early, in 2017.)

- Also in 2014, NDRC released *Interim Provisions on Replacing Coal Consumption with Cleaner Energy Sources in Key Regions*.
- In December 2016, NDRC and the National Energy Agency issued the *13th Five-Year Energy Development Plan*, which calls for coal to provide for no more than 58% of primary energy by 2020.[20]
- In March 2017, the State Council announced plans to phase out, stop construction of and postpone more than 50 GW of coal-fired power generation capacity.[21]
- In July 2017, NDRC announced plans to cancel or postpone construction of 150 GW of coal-fired power generation capacity, close over 20 GW of coal-fired power plants and limit total installed coal-fired generation capacity to 1,100 GW.[22]

These plans and directives, as well as others, require large urban areas to significantly reduce coal consumption in the years ahead. New coal-fired power plants and other industrial projects are banned in many areas, including Beijing and the Yangtze River Delta.[23] In January 2017, the National Energy Administration canceled plans to build 103 coal plants with 130 GW of capacity, including dozens of plants already under construction. From Q1 to Q3 2017, China phased out 2.4 GW of old coal-fired power generation.[24]

These policies have slowed but not stopped new coal plant construction in China. Despite considerable overcapacity in the power sector and central government policies discouraging coal use, new coal plant construction continues:

- In 2016, at least 38 GW of new coal power plants were commissioned.
- In 2017, at least 35 GW of new coal power plants were commissioned.
- As of March 2018, according to one study, roughly 95 GW of new coal power plants were under construction in China and another 116 GW were in preconstruction planning.[25]

These new coal plants reflect the continuing priority GDP targets have in promotion criteria for provincial and local officials, the potential tax revenues new coal plants provide such officials, and the lack of market discipline on many companies in the Chinese power sector.

Chinese coal plants are subject to CO_2 emissions standards. In 2015, large power generation companies were prohibited from emitting more than 650 grams of CO_2 per kWh on average across all their plants. That figure falls to 550 grams by 2020. These standards require Chinese power companies to improve the efficiency of coal production, invest in low-carbon generation or both. In 2016, average emissions across the Chinese electricity system as a whole were 620 grams of CO_2 per kWh. Chinese coal-fired power plants are now substantially more efficient than US coal-fired power plants.[26]

Coal production in China is subject to a tax of 2%–10%, with the exact rate set by individual provinces. In 2015, Inner Mongolia, Shanxi and Shaanxi, which together account for roughly two-thirds of Chinese coal production, set their rates at 8%, 9% and 6.1% respectively.[27]

NOTES

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CHAPTER 9 - RENEWABLE POWER

China leads the world in deployment of renewable power, with more than twice as much capacity as any other nation. Almost 30% of the world's renewable power capacity is in China. In 2017, almost half the renewable power capacity added globally was in China.[1]

More than a third of China's power capacity is renewable. In 2017, roughly 19% of China's power capacity was hydro, 9% was wind and 7% was solar.[2]

In 2017, renewables provided roughly a quarter of the electricity generated in China -- 19% from hydropower, 5% from wind and 2% from solar. (The percentage of electricity generated from wind and solar is less than their percentage of installed capacity for two principal reasons. First, wind and solar power are not available as continually as other power sources, since the wind doesn't always blow and Sun doesn't always shine. Second, wind and solar power projects are sometimes curtailed, meaning they are not used even when they could be generating power.)[3]

Curtailment of wind and solar power is a challenge in China. Curtailment occurs for two principle reasons:

- First, thermal power plants typically have priority over wind and solar plants under electricity dispatch rules. When power systems have excess capacity, as is common in China today, utilization of wind and solar plants can be quite low.
- Second, wind and solar plants are sometimes built without transmission connections. Those transmission connections follow, but sometimes with a lag of months or years.

In 2015 and 2016, curtailment rates for wind and solar power were in the range of 15%–20% nationally, reaching 40% in some provinces. In 2017, curtailment rates dropped to roughly 12% for wind and 6% for solar.[4]

The Chinese government's support for renewable energy dates back to at least the 9th Five-Year Plan (1996–2000), which set targets for "new and renewable energy." In 2005, the Renewable Energy Law set national renewable energy targets and established feed-in tariffs for renewable energy.[5]

The *13th Five-Year Plan on Renewable Energy* was released by NDRC in December 2016. The plan calls for

- increasing the share of nonfossil energy in primary energy consumption to 15% by 2020 and 20% by 2030,
- increasing renewable power capacity to 680 GW by 2020,
- promoting offshore wind development,
- innovating in renewable energy technology,
- reducing renewable power curtailment, and
- scaling up distributed solar generation.

The plan is implemented through many specific policies and measures, including feed-in tariffs and access to capital from government policy banks.[6]

Discussions of the hydro, wind and solar power sectors are below.

A. Hydropower

Background

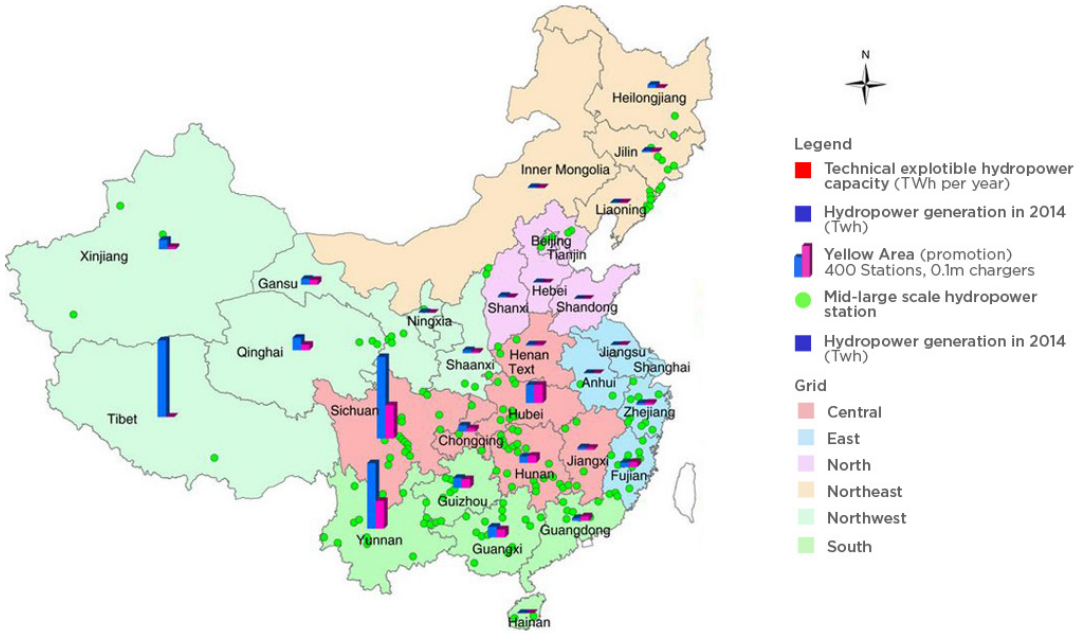
China leads the world in deployment of hydropower. Roughly 30% of global hydropower capacity is in China. China's installed hydropower capacity is more than three times that of any other nation.[7]

China also leads the world in new hydropower construction. In 2017, China installed 9 GW of new hydropower capacity—roughly 40% of the world total. More than one-third of the growth in global hydropower capacity through 2021 is projected to be in China.[8]

The Three Gorges Dam is the world's largest dam, with an installed capacity of 22.5 GW. Located on the Yangtze River in Hubei, the Three Gorges Dam became fully operational in 2012.[9]

Most Chinese hydropower development is in the western and southern parts of the country. Northern China has very little hydropower development. (See map below.)

Figure 9-1: Hydropower Capacity and Deployment



Source: Nature.com[10]

Chinese hydropower production plays an important role in limiting Chinese emissions of heat-trapping gases:

- In 2017, Chinese hydropower produced 1,194 TWh of electricity. If the same power had been produced from coal-fired power plants, those plants would have emitted roughly 1 Gt of CO_2 (using generally accepted international emissions factors).One Gt of CO_2 is roughly 3% of global emissions and more than total CO_2 emissions from Germany.[11]
- The Chinese National Energy Administration (NEA) estimates that, during the 13th Five-Year Plan (2016–2020), hydropower will supply roughly 5,600 TWh of electricity in China. The NEA estimates this will avoid roughly 3.5 Gt of CO_2 (a slightly more conservative calculation of avoided CO_2 than the one just above).[12]

Policies

The Chinese government has a longstanding commitment to expanding the nation's hydropower capacity. Planning for the Three Gorges Dam began in the 1980s, as part of a broader program to use China's hydro resources for development. Chinese hydropower development grew steadily through the 1990s and began to accelerate rapidly in the early part of the last decade. The 12th Five-Year Plan (2011–2015) set forth an ambitious target for hydropower—30% growth in capacity, from roughly 200 GW to 260 GW. This target was exceeded, with China reaching 319 GW of hydropower capacity in 2015.[13]

Hydropower development remains an important priority of the Chinese government. The 13th Five-Year Plan includes a target of 60 GW of new hydropower capacity, to reach a total of 380 GW of hydropower capacity by 2020 and 470 GW of hydropower capacity by 2025.[14] (All figures above include pumped hydro.)

The 13th Five-Year Plan also contains a goal of 40 GW of pumped hydro capacity by 2020 and 90 GW by 2025.[15] In November 2014, NDRC released a paper on pumped storage hydropower plants. The paper stated the following:

- Goals in the next decade include (1) accelerating the construction of pumped hydro plants, (2) more sophisticated and effective regulations and standards, including strategic planning and standardized administrative processes, and (3) bringing in more technical equipment and cutting-edge technology.
- More research is needed on using pumped hydro in connection with solar and wind projects.[16]

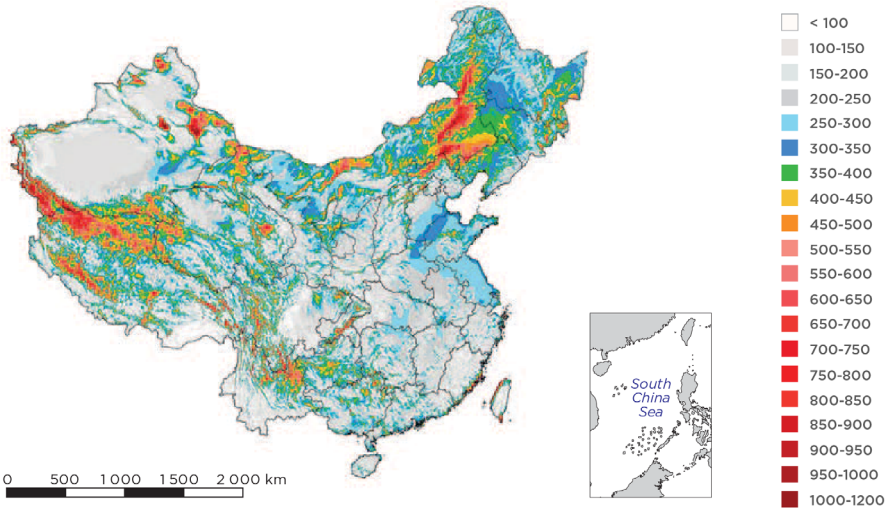
B. Wind Power

Background

China leads the world in deployment of wind power, with more than one-third of global capacity. As of the end of 2017, China had roughly 164 GW of wind power capacity. In recent years China has also led the world in deployment of new wind power, with 15 GW of new installations in 2017 and 19 GW of new installations in 2016. Wind power provided roughly 5% of total electricity generation in China in 2017.[17]

China has significant wind power resources, especially in Inner Mongolia, Xinjiang and other northern and western provinces. (See map below.)

Figure 9-2: China's wind resources: land-based resource potential (WPD ≥ 300 w/m2, 70 m height)



Source: IEA and ERI (NDRC)[18]

Curtailment is a significant challenge for the Chinese wind power industry, although the situation is improving. In 2016, China's wind curtailment rate was roughly 17% nationally, with rates as high as 43% in Gansu and 38% in Xinjiang. In 2017, China's wind curtailment rate was 12% nationally, with Gansu at 33% and Xinjiang at 29%.[19]

Policy

The 13th Five-Year Plan establishes a goal of 259 GW of grid-connected wind power by 2020 (including 5 GW of offshore wind). Each province is given specific deployment goals, including 27 GW for Inner Mongolia, 18 GW for Xinjiang and 18 GW for Hebei. The plan also establishes a goal of 420 TWh of electric generation from wind (which is roughly 6% of China's total electricity generation).[20]

China's feed-in-tariff for wind power dates to 2009. Rates vary by region and are declining slowly. For 2018, rates vary from 0.4 RMB/kWh in the north to 0.57 RMB/kWh in the south.[21]

C. Solar Power

Background

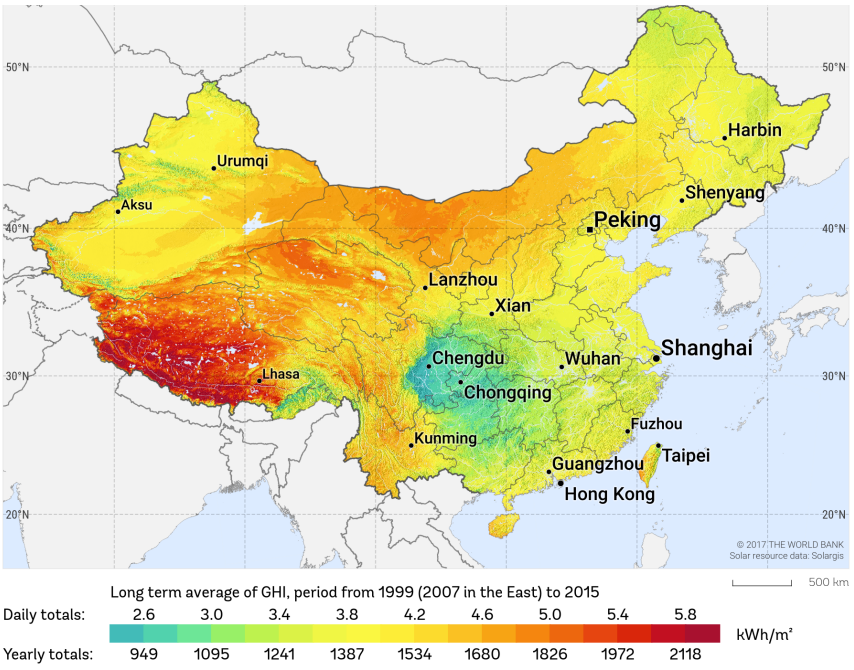
China leads the world in deployment of solar power. Roughly a third of global solar power capacity is in China. In 2017, more solar power capacity was added in China than in the rest of world combined.[22]

China also leads the world in solar manufacturing, as it has for each of the last nine years. In 2017, two-thirds of global solar module production was in China. Chinese manufacturers held dominant positions throughout the solar supply chain.[23]

As of year-end 2017, China has more than 130 GW of installed solar capacity. In 2017, solar accounted for roughly 7% of China's power capacity and 2% of China's electricity generation.[24]

China has excellent solar resources, especially in the western part of the country. (See map below.) However, air pollution may be significantly reducing output from solar panels in some parts of China. One recent study estimated losses of 17%–35% in parts of eastern China, depending on how often PV panels are cleaned.[25]

Figure 9-3: China's Solar Resource



Source: SolarGIS[26]

Curtailment is a significant challenge for the Chinese solar industry, although the situation is improving. In 2017, solar curtailment was roughly 6% nationwide, down from 10.3% in 2016. The problem is especially acute in Xinjiang (22% curtailment in 2017) and Gansu Province (20% curtailment in 2017).[27]

Policy

The 13th Five-Year Plan establishes a goal of 153.6 GW of solar capacity in China by 2020. The plan sets targets for individual provinces, including targets of 12 GW for Hebei, Shanxi and Inner Mongolia.[28]

China has provided feed-in tariffs[29] for solar power since 2011. Those rates have declined steadily since they were first established. For 2017, they ranged from RMB 0.65 to 0.85 (roughly US$0.10 to $0.13) per kWh, depending on the location. The 2017 rate for distributed PV systems was RMB 0.42 (US$0.06) per kWh.[30]

In May 2018, the Chinese government announced major changes to its solar policies. Central government subsidies for the construction of utility-scale and distributed solar projects were withdrawn. Feed-in tariffs were reduced. Local governments were directed to shift procurement to competitive auctions. The changes were seen as an effort to control the cost of solar subsidies (over $15 billion in 2017) and address overcapacity in power markets. Solar deployment in China in 2018 will likely be much lower than in 2017 as a result of these changes.[31]

China's *Five-Year Plan for Solar Energy Development* contains specific goals for solar panel innovation (such as commercialized monocrystalline silicon cells with an efficiency of at least 23% and commercialized multicrystalline silicon cells with an efficiency of at least 20%). The Chinese government spends heavily on research and development for solar power to help meet these and other goals. Much of this funding comes through the Ministry of Science and Technology (MOST).[32]

China Development Bank and other Chinese policy banks have played an important role in providing debt capital to Chinese solar manufacturers and developers. This was especially important in helping the Chinese solar manufacturing industry grow in the years following the financial crisis of 2008, when many solar manufacturers in other countries were unable to secure access to capital.[33]

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CHAPTER 10 - NUCLEAR POWER

In 2017, nuclear power provided roughly 3.8% of China's electricity. The government has ambitious plans to expand China's nuclear generating capacity. Roughly one-third of the nuclear power plants under construction in the world today are in China.[1]

Background

China started building its first civilian nuclear reactor in 1985. The program grew slowly, with three reactors in operation by 2001. The Chinese government launched an ambitious expansion of its nuclear power program in the 10th Five-Year Plan (2001–2005), which called for the construction of eight more nuclear plants. That trend continued in the 11th Five-Year Plan (2006–2010), which called for further expansion of the nuclear construction program and a focus on Generation III technologies.[2]

The Fukushima accident on March 3, 2011, brought the rapid expansion of China's nuclear program to a halt. The State Council ordered an immediate safety review at plants under construction and suspended approvals for new plants, pending a major safety review. In October 2012, a new safety plan was approved, and approvals resumed. In September 2017, the National People's Congress approved an updated nuclear safety plan.[3]

As of June 2018, China had 39 operational nuclear power plants. Most of these plants are located along China's east coast.[4]

Policies

The Chinese government is committed to a significant expansion of its nuclear power industry. NDRC's targets call for increasing nuclear power capacity from roughly 38 GW today to 58 GW by 2020 and 150 GW by 2030. Roughly 20 nuclear power plants are under construction with many more planned, including in inland provinces.[5]

In building its nuclear power fleet, China has imported technology from the United States, Canada, Russia, France and South Korea. The Chinese government aims to localize these technologies and become self-sufficient in reactor design and construction. Chinese policy now mandates using Generation III or more advanced technologies. Nuclear waste is being stored on-site at plants and in temporary storage facilities. The Chinese government intends to develop a closed fuel cycle with reprocessing capabilities for nuclear waste.[6]

Large state-owned enterprises dominate China's nuclear power sector. The major players are China National Nuclear Corporation, China General Nuclear Power Group and China Power Investment Corporation. NDRC, NEA and the National Nuclear Safety Administration play central roles in policy development and regulatory oversight.

The Chinese government identifies its nuclear power policies as part of its strategy to fight climate change.[7] These nuclear power policies have had a significant impact in reducing emissions of heat-trapping gases:

- Carbon dioxide emissions from a nuclear plant are less than 0.5% of those from a coal-fired power plant producing the same amount of electricity, calculated on a life cycle basis. (Coal plants and nuclear power plants play similar roles on electric grids, producing baseload electricity in high volume.)[8]
- That means that a 1 GW nuclear power plant built instead of a coal-fired power plant avoids at least 5–7 million tons of CO_2 per year, depending on plant efficiency and other factors.[9]
- If each nuclear plant in China displaces a coal-fired power plant that might have been built in its place, then avoided emissions from China's nuclear fleet in 2020 would be in the range of 300–400 million tons of CO_2 per year—3–4% of China's CO_2 emissions and roughly 1% of global CO_2 emissions.

Figure 10-1: Nuclear Power Plants in China

Source: World Nuclear Association (June 2018)[10]

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NOTES

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CHAPTER 11 - NATURAL GAS

Background

In 2017, China was the world's third largest consumer of natural gas, behind the United States and Russia. Natural gas accounted for roughly 7% of China's primary energy use—a much smaller share than the global average (23%).[1]

Natural gas consumption in China is growing rapidly. In 2017 natural gas use in China grew by 15%—more than twice the rate of economic growth—due mainly to government policies to help clean the air in China's cities. Annual consumption reached 240 billion cubic meters (bcm). Many forecasts project significant growth in the years ahead.[2]

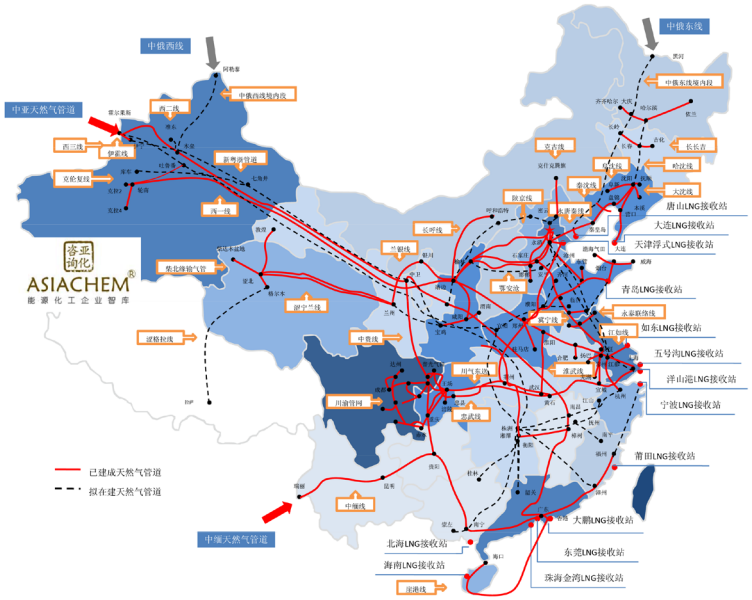
Natural gas in China is used mainly for heating. (Very little natural gas is used in the power sector.) Across much of northern China, a massive conversion of heating infrastructure from coal to natural gas is currently underway. Industrial boilers, district heating networks and building furnaces are being converted. These conversions have helped significantly to cut air pollution, although at times they have run ahead of natural gas supplies. In the winter of 2017–2018, Beijing and surrounding areas had the cleanest air in many years, however natural gas shortages left some industries and buildings without sufficient heat.[3]

China's natural gas comes from three sources: domestic production, pipeline imports and imports of liquefied natural gas (LNG).

- Historically, most of China's natural gas has come from domestic production, almost all from conventional wells. Domestic production more than doubled in the last decade, from approximately 70 bcm in 2007 to 150 bcm in 2017. China's main natural gas producing regions are Sichuan, Xinjiang, Qinghai and Shanxi Provinces.[4]
- China's shale gas resource is the world's largest, however much of the shale gas is very deep, in mountainous areas and challenging to produce. Shale gas production in 2017 was roughly 9 bcm.[5]
- China currently imports natural gas through two pipeline systems: the Central Asia gas pipeline (from Turkmenistan, Kazakhstan and Uzbekistan) and the China-Myanmar pipeline. Total pipeline imports in 2017 were in the range of 42–44 bcm. A natural gas pipeline from the Russian Far East is currently under construction. Known as the Power of Siberia, the pipeline is projected to open in late 2019 and will eventually have 38 bcm per year of capacity.[6]
- In 2017, Chinese LNG imports grew by 47%. LNG infrastructure was severely stressed. New LNG receiving terminals, natural gas pipelines and natural gas storage are under construction to meet rapidly growing demand.[7]

China has more than 64,000 kilometers of long-distance natural gas pipelines, shown below.

Figure 11-1: China Natural Gas Pipeline and LNG Terminal Layout (Updated in May 2016)



Source: Asiachem, http://www.chemweekly.com/

When natural gas is burned for heat or power, it emits roughly half the CO_2 per unit of energy as coal. As a result, natural gas can play an important role in reducing Chinese emissions of heat-trapping gases. However, when natural gas leaks, it becomes a potent greenhouse gas. As a rough rule of thumb, if more than 3%–8% of the natural gas consumed as an energy source leaks, that would cancel the climate change benefits of switching from coal to natural gas.[8]

Policy

Production and Consumption Goals

The Chinese government's coal-to-gas conversion programs in northern China have been especially prominent. The principal purpose of these policies is to improve urban air quality. The 13th Five-Year Plan (2016–2020) identifies reducing CO_2 emissions as an objective as well.[9]

Government targets include these:

- increasing the share of natural gas in primary energy consumption from roughly 7% today to 10% by 2020 and 15% by 2030;
- increasing the share of natural gas in urban dwellings from roughly 43% today to 50%–55% by 2020 and 65%–70% by 2030; and
- increasing the share of natural gas generating capacity in China's power sector from roughly 3.5% today to 5% by 2020 and 10% by 2030.[10]

The 13th Five-Year Plan also calls for increasing domestic natural gas production of unconventional gas, including shale gas and coalbed methane. The current government target for shale gas production is 30 bcm per year by 2020. Several government targets for shale gas production have been missed or revised downward in recent years.[11]

Market Reforms

China's natural gas industry is in the midst of significant reforms.

Historically, the National Development and Reform Commission (NDRC) set natural gas prices by adding production costs, transmission costs and fixed margins. Gas prices were kept high for industrial users to help cover the costs of subsidizing residential gas use. In recent years, a growing percentage of Chinese of nonresidential natural gas sales have been priced based on market value. These price reforms are intended in part to bring down the cost of natural gas for industrial users, encouraging the switch from coal to natural gas.[12]

Structural changes are underway in China's natural gas pipeline network. Historically the Chinese National Petroleum Corporation (CNPC) controlled almost all of China's natural gas pipelines. Several years ago CNPC began transferring pipelines into a subsidiary as part of a plan to establish a separate national pipeline company.[13] In 2016 NDRC reformed pipeline pricing, granting a flat 8% return on investment for interprovincial pipelines and promoting transparency in pipeline costs.[14]

As part of the effort to relieve shortages in natural gas supplies, several private companies are being allowed to build and operate LNG receiving terminals in China.[15]

Environment and Safety Standards

China's 13th Five-Year Plan (2016–2020) emphasizes the importance of protecting the environment when developing natural gas resources.[16] Implementation is left largely to the state-owned enterprises responsible for natural gas production.

China does not have regulations addressing methane leaks from natural gas production. Multiple ministries and industrial associations, including the Ministry of Transport, State Administration of Work Safety and China Natural Gas Standardization Technology Committee, set national safety standards for long-distance transport and local distribution of natural gas.[17]

NOTES

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CHAPTER 12 - SYNTHETIC NATURAL GAS

China's abundant coal resources can be used to produce synthetic natural gas (sometimes called "SNG"). The SNG can be piped into cities, where it produces less local air pollution when burned than coal. However, there are several problems with such a strategy for cutting local air pollution. First, SNG is expensive. Second, SNG requires enormous amounts of water. Third, SNG produces significant amounts of heat-trapping gases—much more per unit of heat or electricity than burning coal directly.[1]

As one Chinese expert said, synthetic natural gas plants "do not reduce emissions. They only shift emissions elsewhere. Actually, they increase emissions."[2]

As of June 2018, five pilot synthetic natural gas projects are operating in China, with a total capacity of just under 6 billion cubic meters per year (bcm/year). Roughly 80 SNG projects with a cumulative capacity of more than 300 bcm are in different stages of the development pipeline. (This is 10 more than were in the pipeline in June 2017.)[3]

Whether these plants will be built is unclear. One source notes that, after 10 years of effort, China's synthetic natural gas industry is still in the "pilot demonstration stage." New projects struggle to receive environmental approvals, with only four granted in 2016. Water source approvals are also a challenge, with only three granted in 2016.[4]

Several five-year plan targets for SNG capacity have been missed:

- The 12th Five-Year Plan set a goal of 15–18 bcm/year of SNG capacity by 2015, however by 2015 only 3.1 bcm/year of SNG capacity had been built.[5]
- The 12th Five-Year Plan also set a goal of 60 bcm/year of SNG capacity by 2020. The 13th Five-Year Plan cut that 2020 target to 17 bcm/year (roughly 4 bcm/year in each of four locations: Xinjiang Huaidong, western Inner Mongolia, eastern Inner Mongolia and north Shaanxi).[6]

In general, governments in coal provinces support synthetic natural gas projects. In May 2017, a 1,279 km synthetic natural gas pipeline project was approved by four provincial governments (Inner Mongolia, Shanxi, Hebei and Tianjin).[7]

In 2017, China's National Standardization Committee began implementing its first synthetic natural gas standard.[8]

The global warming implications of Chinese synthetic natural gas production could be significant. One recent study found that using synthetic natural gas for electricity generation and industrial heat generation produces 40%–70% more CO_2 emissions than directly burning coal. Production of 17 bcm/year of SNG (the 2020 goal in China's 13th Five-Year Plan) would result in roughly 85 million tons of carbon dioxide—almost 1% of China's current emissions and 0.3% of global emissions.[9]

NOTE ON TERMINOLOGY

The language used to describe synthetic natural gas can be confusing.

First, SNG is often referred to as "coal-to-gas" or "coal-to-gas conversion," however the same terms are also used to describe a completely different process: converting boilers and furnaces from the use of coal to the use of natural gas. This latter process – converting boilers and furnaces -- is central to the Chinese government's strategy for fighting local air pollution in northern China. It has huge benefits not only with respect to local air pollution but also with respect to carbon dioxide emissions. It is a completely different process than converting coal itself to synthetic natural gas, although the same terms are sometimes used to describe both.

Second, SNG is also often referred to as "coal gasification." However, the term "coal gasification" is also often used to describe a broader set of processes, including the conversion of coal to chemicals and other products. Synthetic natural gas is in fact just one possible product of coal gasification.

NOTES

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CHAPTER 13 - VEHICLES

Vehicles produce roughly 8% of the heat-trapping gases emitted in China each year.[1] This percentage will increase in the years ahead as the Chinese vehicle stock grows and heavy manufacturing declines as a percentage of the overall economy.

The Chinese government's principal policies with respect to vehicle emissions are fuel efficiency standards and support for electric vehicles. (The Chinese government uses the term "new energy vehicle" to describe vehicles powered by fuels other than petroleum. In the Chinese government's new energy vehicle programs, electric vehicles receive by far the most attention.) This chapter discusses China's vehicle stock, fuel efficiency standards and electric vehicle programs.

A. China's Vehicle Stock

China's vehicle stock has grown at an extraordinary pace in the past several decades, along with the nation's GDP. In 1990, there were approximately 5.5 million registered motor vehicles in China. As of the end of 2017, there were 310 million. That means there is now roughly one registered motor vehicle for every 4.5 people in China. (In the United States, there is almost one registered motor vehicle for every person.)[2]

In 2017, 29 million new motor vehicles were sold in China, making it the world's largest vehicle market by far. (The United States was second, with roughly 17 million vehicles sold.) Of these, roughly 25 million were passenger cars (including 10 million SUVs) and 4 million were commercial vehicles. New motor vehicles sales increased by 3.2% from 2016. SUV sales increased by 13%.[3]

China has more than 100 vehicle manufacturers. Many of these vehicle manufacturers are owned or heavily supported by provincial and local governments. The top 10 Chinese vehicle manufacturers and their sales are shown below:

Name	2017 sales (in millions)
SAIC	*6.92*
Dongfeng Motor Group	*4.12*
FAW Group	*3.35*
Changan Group	2.87
BAIC Group	2.51
GAC Group	2.00
Geely Auto	1.31
Great Wall Motor	1.07
Brilliance Automotive Group	0.75
Chery Automotive	0.67

Source: Chinese Association of Automobile Manufacturers[4]

Traffic congestion is a major problem in many Chinese cities. One recent study found that the average Chinese driver spends nine days a year stuck in traffic. Beijing, Tianjin and Hangzhou were rated the worst cities for traffic congestion.[5]

B. Vehicle Fuel Efficiency

In 2017, the average fuel economy of new vehicles sold in China was roughly 6.29 liters per 100 kilometers (L/100 km).[6] (This is equivalent to 37.4 miles per gallon.) The fuel efficiency of new Chinese vehicles has improved roughly 2% per year on average for the past decade. In recent years Chinese vehicles have become heavier on average, slowing improvements in energy efficiency.[7]

Hitorically, China's vehicle fleet has been among the world's least fuel efficient. For most of the past decade, the average fuel efficiency of passenger cars in China was slightly less than in the United States and Canada, somewhat less than in Mexico, and much less than in Europe and Japan.[8]

The Chinese government requires all new passenger vehicles to meet fuel efficiency standards. According to the State Council, the purpose of these standards is "to ease fuel supply and demand contradictions, reduce emissions, improve the atmospheric environment, and promote the automotive industry and technological progress."[9]

The Ministry of Industry and Information Technology (MIIT) specifically identifies CO_2 emissions reduction as among the "expected social benefits" of its fuel efficiency standards. MIIT estimates that its 2020 vehicle fuel efficiency standards will reduce CO_2 emissions by 113 million tons (as compared to its 2015 standards).[10]

The Chinese government's fuel efficiency standards have two main parts. First, each individual vehicle model must meet specific standards based on its weight. The vehicle fleet is divided into 16 categories by weight for this purpose. These standards were first promulgated in 2005 and have been tightened every few years since.[11]

NOTE ON UNITS

In China and most of the world, the standard measure of vehicle fuel efficiency is liters per 100 kilometers (L/100 km). In the United States, the standard measure is miles per gallon (mpg).

- *When using liters per 100 kilometers (fuel per unit of distance), lower numbers indicate better performance.*
- *When using miles per gallon (distance per unit of fuel), higher numbers indicate better performance.*

This can be confusing. Several websites offer conversion tables, including CalculateMe.com (http://www.calculateme.com/cGasMileage/LitersPer100kmtoMPG.htm) and the Calculator Site (http://www.thecalculatorsite.com/conversions/fuelconsumption.php).

In addition, every vehicle manufacturer must achieve corporate average fuel consumption (CAFC) limits. These limits apply on an annual basis to each manufacturer's new vehicle fleet as a whole. The standard for 2016 was 6.7 L/100 km. The standard for 2020 is 5.0 L/100 km.[12]

Manufacturers are offered several "flexibility schemes" to help meet the CAFC standards. First, manufacturers are allowed to count each electric vehicle (which uses 0 L/100 km) up to five times in determining fleet-wide averages. Second, performance may be averaged over several years, using overperformance in one year to compensate for underperformance in other years.[13]

China's fuel economy standards are established by the Chinese Automotive Technology and Research Center (CATARC) and promulgated by the Ministry of Industry and Information Technology (MIIT).

Enforcement of fuel efficiency standards is uneven, with some experts saying manufacturers face few penalties for failing to comply. MIIT publishes fuel efficiency data for each manufacturer annually. In 2016, 43 manufacturers failed to meet MIIT's standards.[14]

Nevertheless, one analysis found that China's domestic vehicle manufacturing industry as a whole met the government's fuel efficiency standards in 2015. According to the Innovation Center for Energy and Transportation, a nongovernmental organization, the fuel efficiency of the Chinese domestic new vehicle fleet in 2016 was 6.56 L/100 km, well below the government standard of 6.7 L/100 km. (When credits for electric vehicles were removed, the fuel efficiency was 6.83 L/100 km.)[15]

Chinese taxes on the manufacture and import of passenger cars vary by size, with larger cars paying more. This promotes fuel efficiency. There is also a 10% tax on "super-luxury vehicles" (priced above 1.3 million yuan, equal to roughly $190,000). The Finance Ministry says this tax is aimed at encouraging "rational consumption" and promoting energy conservation.[16]

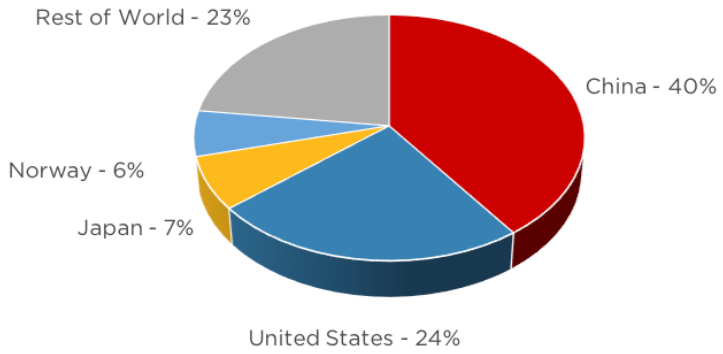
C. Electric Vehicles

In 2017, roughly 794,000 electric vehicles were produced and 777,000 EVs sold in China. Of these, roughly 579,000 were light-duty passenger vehicles, a 73% increase from the prior year. New energy vehicle (NEV) market share reached 2.7% of the light-duty passenger vehicles sold, up 0.9 percentage points from the prior year. (Of these light-duty EVs, 468,000 or 81% were all-electric.) In addition, almost 200,000 commercial medium- and heavy-duty EVs (mostly large buses) were sold in China in 2017. As of year-end 2017, there were more than 1.7 million electric vehicles (light duty and commercial) on the roads in China.[17]

Background

China leads the world in deployment of electric vehicles. At the end of 2017, 40% of electric cars in the world were in China. China dominates global markets for electric buses, low-speed electric vehicles and electric two-wheelers.[18]

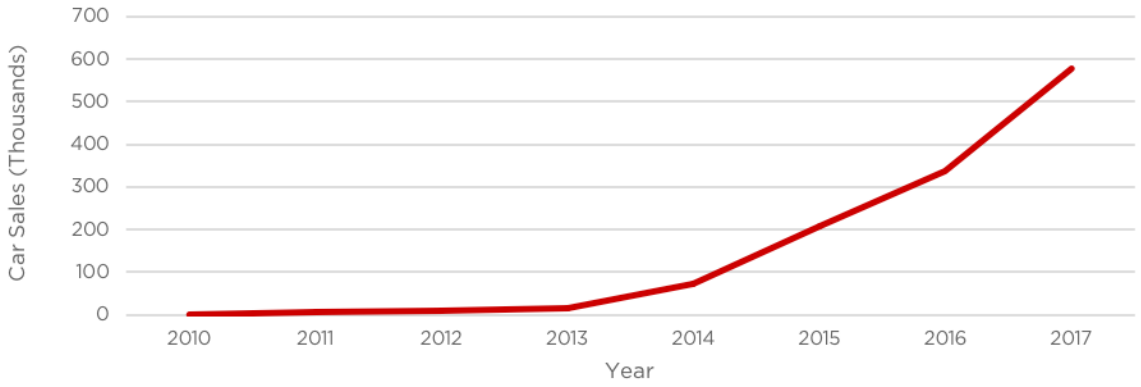
Figure 13-1: Electric Car Stock – December 2017 (3.1 million vehicles total)



Source: IEA, "Global EV Outlook 2018" at p.111 (Table A.1)[19]

In 2017, roughly 777,000 electric vehicles were sold in China. Of these, roughly 579,000 were light-duty passenger vehicles (a 73% increase from the prior year and 2.7% of all light-duty passenger vehicles sold). Roughly 198,000 were commercial medium- and heavy-duty EVs (mostly large buses). As of year-end 2017, more than 1.7 million light-duty and commercial electric vehicles were on the roads in China.[20]

Figure 13-2: Electric Car Sales in China 2010-2017



Source: IEA, "Global EV Outlook 2017"[21]

Electric bicycles are omnipresent in China today. More than 200 million electric two-wheelers are on the roads in China, with roughly 25 million new units sold each year.[22]

Low-speed electric vehicles (LSEVs) are also a growing presence in some parts of China. These LSEVs generally have maximum speeds of no more than 70 kilometers per hour (40 miles per hour), short ranges and lead acid batteries. Roughly 1.2 million–1.5 million were sold in 2016. (These are not counted in tallies of electric vehicles sold.) LSEVs are especially popular in Shandong Province.[23]

The number of EV charging stations in China is growing rapidly. The country's total number of stationary charging points—ports for plugging in electric vehicles—reached 450,000 in 2017, including around 210,000 publicly accessible units. Massive new installation of EV charging stations was underway in China in 2017, with estimates for the amounts to be installed by year-end running as high as 800,000, including at least 100,000 public charging stations.[24]

China has hundreds of auto manufacturers, many of which are owned in whole or in part by provincial or local governments. According to some reports, as many as 200 Chinese auto manufacturers have produced electric vehicles. The quality of these products has been uneven.[25]

In the short term, China's deployment of electric vehicles will have little impact on CO_2 emissions. Because coal dominates the Chinese electric power sector, CO_2 emissions from electric vehicles in China are on average roughly comparable to those from conventional gasoline- or diesel-powered vehicles. (The exact comparison depends on assumptions with respect to the fuel efficiency of conventional vehicles and many other factors. Some studies have found that CO_2 emissions from electric vehicles are currently greater on a life-cycle basis.) However, as coal's role in the Chinese power sector declines, as called for in Chinese government policy and planning documents, electric vehicles have the potential to significantly reduce CO_2 emissions from the Chinese vehicle fleet. In the medium to long term, vehicle electrification will be important in meeting the Chinese government's goals with respect to the transition to a low-carbon economy.[26]

Policies

"Developing new energy vehicles is essential for China's transformation from a big automobile country to a powerful automobile country. We should increase research and development, seriously analyze the market, adjust existing policy and develop new products to meet the needs of different customers. This can make a strong contribution to economic growth."
— President Xi Jinping (May 2014, visiting an electric vehicle factory in Shanghai)[27]

The Chinese government strongly supports electric vehicles. Central government policies include a target of 5 million electric vehicles on China's roads by 2020, EV quotas for vehicle manufacturers and importers, manufacturing subsidies, tax exemptions, government procurement, and support for the construction of electric vehicle charging stations. Many provincial governments also support electric vehicles with preferential access to license plates and other incentives. These policies have three principal goals: to clean the air in China's cities, reduce China's oil import bills and position China for global leadership in a strategic industry.[28]

Under regulations announced by the Ministry of Industry and Information Technology (MIIT) in

September 2017, each vehicle manufacturer and importer will be required to make or import at least 10% electric vehicles starting in 2019. The percentage will increase to 12% in 2020. These regulations apply to any company that manufacturers or imports more than 30,000 vehicles in China. Companies that fail to achieve the required percentages may purchase credits from companies that overcomply.[29]

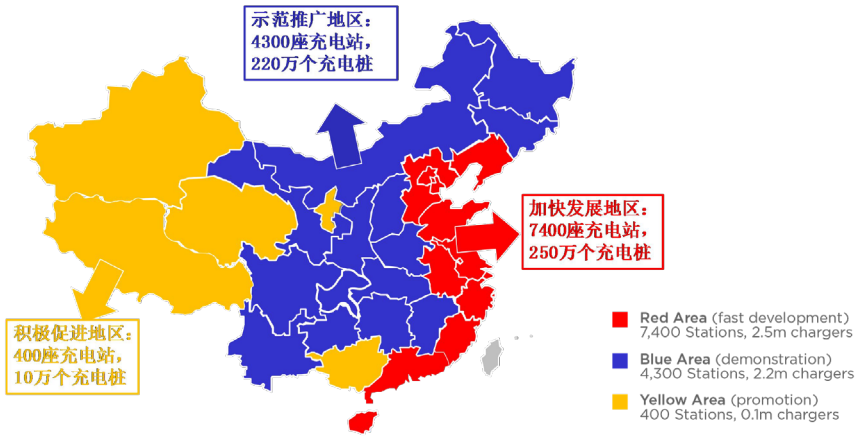
The Chinese government also offers subsidies to manufacturers of electric vehicles in China. These subsidies are roughly $5,000–$7,000, depending on vehicle size. The subsidies are scheduled to be cut 40% in 2019 and eliminated in 2021. In 2016, the Chinese government fined five electric vehicle manufacturers for falsifying records with respect to electric vehicles to collect government subsidies.[30]

The Chinese government exempts electric vehicles from consumption and sales taxes, which can save purchasers tens of thousands of RMB (equivalent to thousands of dollars). It also waives 50% of vehicle registration fees for electric vehicles.[31]

The Chinese government also uses its procurement power to promote electric vehicles. A May 2016 order requires that half of new vehicles purchased by China's central government be new energy vehicles within five years. Beijing's municipal government plans to replace the city's 70,000 taxicabs with electric vehicles.[32]

Electric vehicle infrastructure is central to China's EV program. The Chinese government has announced two goals with respect to deployment of electric vehicle chargers: 800,000 by the end of 2017 and 5 million by 2020. To help meet these goals, the central government subsidizes construction of charging stations, issues guidelines on charging technology standards and provides policy support to municipal governments. China State Grid and China Southern Grid, China's two state-owned electric utility monopolies, both have programs to promote the development of electric vehicle charging infrastructure.[33]

Figure 13-3: Electric Vehicle Charging Infrastructure



Source: NEA, "Guidelines for the Development of Electric Vehicle Charging Infrastructure" (2015 - 2020)[34]

Many Chinese provincial and local governments are very active in promoting electric vehicles. Several municipalities—including Beijing, Shanghai, Guangzhou, Tianjin and Shenzhen—provide license plates immediately at no cost to any purchaser of an electric vehicle. (This is an enormous incentive, since license plates for conventional vehicles can cost thousands of dollars and take years to secure.) Free and preferential parking spaces are also common. Some municipalities—including Beijing and Shanghai—pay local manufacturers subsidies for new energy vehicles (including EVs). Municipalities play a central role in the deployment of electric vehicle chargers. Beijing and Shenzhen have both announced that their entire taxi fleets will transition to electric vehicles within several years.[35]

In pursuing these policies, Chinese government officials are guided in part by earlier efforts to promote electric vehicles that were not entirely successful. In 2012, for example, the Chinese government set a goal of deploying 500,000 electric vehicles by the end of 2015. It reached this goal one year late. That and other problems have led to a series of measures, including increased focus on EV charging infrastructure (to give EV drivers confidence they'll be able to recharge), policies to promote consolidation among EV manufacturers (to help improve the quality of EV products) and efforts to fight local protectionism (to prevent balkanization of the market by favored manufacturers in each province).[36]

Chinese central government policies with respect to electric vehicles are set forth in a number of documents, including:

- *Planning for the Development of the Energy-Saving and New Energy Automobile Industry 2012–2020* (June 2012)[37]
- *Accelerating the Promotion and Application of New Energy Automobiles* (July 2014)[38]
- *Guidance on Accelerating Electric Vehicle Charging Infrastructure* (October 2015)[39]
- *13th Five-Year Plan for National Strategic Emerging Industries*[40]
- *Guidelines for the Development of Electric Vehicle Charging Infrastructure* (2015–2020)[41]

In September 2017, Xin Guobin, a deputy minister at MIIT, said at a news conference that government officials are studying a possible timetable for phasing out sales of gasoline-powered cars in China. This announcement received considerable international attention, however it was not an official statement of Chinese government policy. To date the Chinese government has not announced a timetable for phasing out sales of gasoline-powered cars.[42]

NOTES

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CHAPTER 14 - HFC'S

Background

Hydrofluorocarbons (HFCs) are man-made chemicals used in refrigeration and air conditioning.[1] They were introduced in the late 1980s to replace several chemicals that were damaging the ozone layer. Although HFCs do not damage the ozone layer, they are powerful heat-trapping gases. Some HFCs capture several thousand times more heat than equivalent amounts of carbon dioxide. [2]

Global HFC emissions are small but growing rapidly. Huge numbers of refrigerators and air conditioners around the world today contain HFCs. As these appliances reach the end of their useful lives, the HFCs they contain will leak into the atmosphere. The potential climate change impacts are significant. In the absence of mitigation and control strategies, HFCs could increase global average temperatures by almost 1°F by 2100.[3]

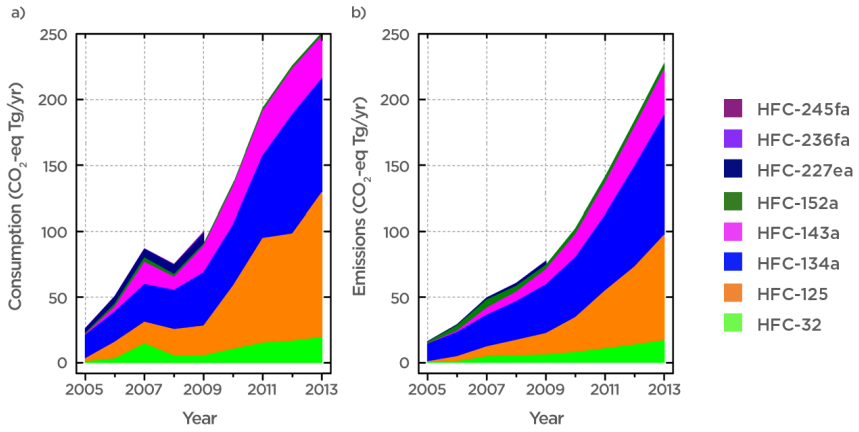
Strategies for reducing HFC emissions focus on finding substitutes that serve similar purposes but trap far less heat when released into the atmosphere. Options include natural refrigerants, hydrofluoroolefins (HFOs) and lower global warming potential HFCs.[4]

HFCs are regulated under the Montreal Protocol on Substances that Protect the Ozone Layer, a treaty dating to 1987. In 2016, parties to the Montreal Protocol adopted the Kigali Amendment, which establishes timetables for significant reductions in the production and consumption of HFCs in the decades ahead. The Kigali Amendment—which will enter into force January 1, 2019—has been hailed as one of the most significant steps the world has taken to fight global warming.[5]

Chinese HFC Industry

China is the world's largest producer and consumer of HFCs. More than 60% of global HFC production is in China. Chinese HFC consumption has grown rapidly, increasing almost tenfold between 2005 and 2013.[6]

Figure 14-1: HFC consumption and emissions in China (2005-2013)



Source: Fang et al., "Hydrofluorocarbon (HFC) Emissions in China" (2016)[7]

Chinese companies manufacture both HFC chemicals and appliances that use them (including refrigerators and air conditioners). Leading Chinese producers and exporters of HFCs include Jinhua Shandong Dongyue Chemical, Sinochem Taicang, Yonghe Fluorochemical and Zhejiang Lantian. Chinese companies also manufacture approximately 70% of global room air conditioners. Leading Chinese manufacturers of room air conditioners include Gree, Midea and Haier.[8]

China's HFC Policies—International

China participates actively in international negotiations on HFCs under the Montreal Protocol. In 2016, China joined 196 other countries in adopting the Kigali Amendment to the Montreal Protocol. The Kigali Amendment sets three timetables for deep reductions in production and consumption of HFCs:

- Most industrialized countries agreed to reduce production and consumption 10% by 2019, with reductions ultimately reaching 85% by 2036.
- Most developing countries agreed to peak production and consumption of HFCs by 2024, with reductions ultimately reaching 80% by 2045.
- Some developing countries in especially hot climates agreed to peak production and consumption of HFCs by 2028, with reductions ultimately reaching 85% by 2045.[9]

China joined the second group of developing countries, committing to peak production and consumption of HFCs by 2024.

HFCs played a high-profile role in China-US diplomacy during the Obama presidency. In 2013, President Xi Jinping and President Barack Obama met for their first full summit in Sunnylands, California. The major announcement at the conclusion of that summit was an agreement by the two countries to work together on HFCs.[10] HFCs received considerable attention at all subsequent Obama-Xi meetings, including President Obama's November 2014 visit to Beijing and President Xi's September 2015 visit to Washington.[11] China has agreements to work cooperatively on HFCs with other countries and groups of countries, including the European Union.[12]

China's HFC Policies—Domestic

The Chinese government is promoting alternatives to HFCs and working to reduce HFC production capacity:

- In 2013, the Ministry of Environmental Protection released a management plan for phasing out HFCs and held meetings about closing down HFC production lines as part of an awareness-raising campaign.[13]
- In 2014, China's National Plan for Climate Change 2014–2020 called on industry to significantly reduce HFC emissions and enhance investment in research and development for HFC alternatives.[14]
- Similarly, the Action Plan for the Development of Energy Conservation, Emissions Reduction and Low Carbon (2014–2015) calls for "strengthen[ing] the management of hydrofluorocarbons (HFCs) emissions, accelerat[ing] the destruction of HFCs

and finding HFCs alternatives." The action plan further states that "during 12th FYP period, China should cumulatively reduce emissions [of HFCs] by 280 million tons of carbon dioxide equivalent."[15]

- In May 2015, NDRC issued a notice asking companies to submit an HFC-23 mitigation plan by year end. NDRC also began offering subsidies for HFC emissions mitigation. Subsidies are set at RMB 4 per ton of CO_2e through 2019, after which they transition to 1 RMB per year.[16]
- NDRC reports that in 2016 it "organized the local commissions to report trifluoromethane (HFC-23) disposed by enterprises…arranged for random third-party verification, and together with relevant ministries, implemented the relevant policies that ensure the normal operation of devices to phase out HFC-23."[17]
- During the 13th Five-Year Plan (2016–2020), the Chinese government is taking several steps to promote R290 (a low GWP HFC substitute) for room air conditioners and commercial refrigeration, including completing the upgrade of at least 20 R290 manufacturing lines and three R290 compressor manufacturing lines.[18]

NOTES

1. HFCS are also used in foams, solvents and other products. Most HFC consumption is for refrigeration and air conditioning.
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3. HFCs are the fastest growing greenhouse gases in much of the world, increasing at a rate of 10–15% per year. Without action, radiative forcing from HFCs could increase as much as 30-fold by 2050, from a forcing of 0.012 W/m2 to as much as 0.40 W/m2. See G. J. M. Velders et al., "Preserving Montreal Protocol Climate Benefits by Limiting HFCs," *Science* 335, no. 6071 (2012): 922–923; White House, "Fact Sheet: The G-20 St. Petersburg Summit," https://www.whitehouse.gov/the-press-office/2013/09/06/fact-sheet-g-20-st-petersburg-summit.
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CHAPTER 15 - LOW-CARBON CITIES

Background

The migration to China's cities during the past several decades may be the largest movement of humanity ever. China's urban population has grown by more than 500 million people since the mid-1980s, mainly due to migration from the countryside. At least six Chinese cities (Shanghai, Beijing, Chongqing, Guangzhou, Tianjin and Shenzhen) now have populations of more than 10 million people. More than 100 Chinese cities have populations of more than 1 million people.[1]

Roughly 54% of China's population now lives in urban areas. By 2030, roughly 70% of China's population—more than 1 billion people—are expected to live in urban areas.[2]

The urbanization of China has significant implications for emissions of heat-trapping gases. The process of urbanization—with the construction of buildings, roads and other infrastructure—is energy intensive and produces significant CO_2 emissions. In addition, urban residents emit more CO_2 per capita than rural residents. One study found that Chinese urban residents emit roughly 1.4 times more energy-related CO_2 on average than Chinese rural residents. Another study found that the wealthiest 5.3% of the Chinese population, almost all of whom live in cities, have carbon footprints nearly four times greater than the Chinese average. (Urban buildings are more energy efficient than rural buildings on average, but this was offset by high emissions from urban industries and the urban transport sector.)[3]

There are significant methodological challenges associated with rigorously comparing CO_2 emissions between cities. Data sets are often poor, and different studies define urban boundaries for purposes of greenhouse gas accounting differently, especially with regard to imported electricity and other energy flows. Nevertheless, a number of studies suggest that some Chinese cities have high per capita CO_2 emissions by global standards, with findings including the following:

- In 2011, CO_2 emissions in Wuhan were 15.2 tons per person and in Shanghai 13.1 tons per person. In 2012, CO_2 emissions in Beijing were 18.2 tons per person (although this figure is likely significantly lower today due to the recent phaseout of coal within Beijing's borders).
- In 2012, CO_2 emissions in Paris were 10.9 tons per person and in New York 6.5 tons per person. In 2014, CO_2 emissions in Tokyo were 4.9 tons per person.

The Chinese figures reflect the presence of CO_2-intensive heavy industry in China's cities.[4]

Policy

The Chinese government promotes urbanization as a matter of policy. The National New Type Urbanization Plan (2014–2020) calls for an additional 100 million people to move from the Chinese countryside to cities by 2020. The Plan states that "domestic demand is the fundamental impetus for China's development, and the greatest potential for expanding domestic demand lies in urbanization." These policies have been reiterated and further developed as part of the 13th Five-Year Plan.[5]

As part of its approach to urbanization, the Chinese government promotes "green development" and attention to "ecological principles" in city planning. China's "eco-cities" programs have a long history, dating back to at least the 1990s. In 2016, the State Council and Communist Party Central Committee released urban development guidelines giving priority to the development of mass transit and calling for "the construction of energy-saving cities." In practice GDP growth has generally been the primary concern of urban planners, but attention to environmental sustainability is often identified in policy documents as an important objective.[6]

In the past decade, low-carbon development has emerged as an increasingly important component of China's green cities programs. In 2008, low-carbon city pilot projects were launched in Shanghai and Baoding. In 2010, NDRC issued the "Notice on Carrying Out Pilots of Low-Carbon Provinces and Cities," calling for dozens of low-carbon city pilots to be launched around the country. Within the next few years, China launched two batches of low-carbon city pilots around the country. In 2012 Su Wei, then Director General of the Climate Change Department at NDRC, wrote,

> China's cities will play an increasingly larger role in...China's efforts to mitigate and adapt to climate change. The economic and technical roadmap for urban development will have important "lock-in effects" on China's future energy demand and GHG emissions, making it essential, in the process of urbanization, to accelerate shifts in economic development patterns; increase the use of low-carbon, energy-saving, and environmentally friendly technologies; and strengthen low-carbon and eco-city development.[7]

In 2016, the 13th Five-Year Plan for Controlling Greenhouse Gas Emissions highlighted low-carbon urban development as a core part of China's strategy for controlling emissions. The Plan calls for low-carbon transit systems, energy efficient urban buildings, methane recovery at municipal landfills and more.[8]

The Chinese government's policies to promote low-carbon cities fall into at least three broad categories.

First, the Chinese government makes extensive use of pilot projects to promote low-carbon urbanization. Pilot provinces and cites are required to prepare low-carbon development plans, establish greenhouse gas emissions statistical systems and enforce greenhouse gas emissions control targets. NDRC monitors activities in these pilots closely and reported on those activities in detail in China's Biennial Update Report (2016). According to the Biennial Update Report, the carbon intensity (CO_2 emissions per unit of GDP) in these pilots fell 19.4% from 2010 to 2014—faster than the national average.[9]

The 13th Five-Year Plan calls for expanding low-carbon pilot projects to 100 cities and roughly 1,000 communities, as well as applying the lessons learned in these pilots more broadly. China's Intended Nationally Determined Contribution (submitted to the UN Framework Convention on Climate Change in 2015) also highlights this topic, saying that China will implement low-carbon pilot projects in cities, towns and communities.[10]

Second, the Chinese government sets specific goals with respect to low-carbon urbanization.

The 13th Five-Year Plan, for example, includes the following goals for 2020:

- Green buildings should account for 50% of new construction in urban areas.
- Carbon dioxide emissions of urban passenger transport vehicles should be 12.5% lower per unit of passenger volume than in 2015.

Such goals are intended to help guide urban planners and may be among the metrics used to evaluate the performance of municipal officials. In some cases, the central government makes funding available to meet such goals, either through grants or preferential financing from the China Development Bank and other policy banks.[11]

Third, the Chinese government participates in a wide range of international programs on low-carbon cities. These include programs between central government ministries and counterparts in other national governments, "sister city" programs between Chinese cities and cities abroad, and programs run by international organizations such as the Climate-Smart, Low-Carbon Cities (CSLCC) program funded by USAID under the US-China Joint Agreement on Climate Change. Such programs facilitate shared learning on best practices and tools for promoting low-carbon urban development. Examples include bilateral programs with the United States, United Kingdom, Germany, Singapore and others, as well as the C40 program (a network of megacities committed to addressing climate change).[12]

China's Alliance for Peaking Pioneer Cities has received considerable attention (and in some respects falls into all three categories just above). The 13th Five-Year Plan encourages cities to strive to peak emissions before the national goal of 2030. At least 23 cities and provinces with 27.5% of China's GDP and 16% of its CO_2 emissions are now part of the program.[13]

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CHAPTER 16 - GREEN FINANCE

The Chinese government strongly promotes "green finance," which the People's Bank of China defines as "financial services provided for economic activities that are supportive of environmental improvement, climate change mitigation and more efficient resource utilization."[1] In September 2016, the People's Bank of China (PBoC) promulgated *Guidelines for Establishing the Green Financial System*—the first time any nation's central bank had issued such guidelines. As host of the G20 in 2016, the Chinese government launched a Green Finance Study Group and included the topic of green finance in G20 communiques for the first time. A recent report found that China "arguably has been the most proactive country in the world in pursuing a coordinated and comprehensive approach to greening its financial system."[2]

China's green finance policies promote investment in a wide range of assets including renewable energy projects, water treatment plants, recycling facilities and mass transit. In 2017, China's green finance policies helped mobilize hundreds of billions of RMB (tens of billions of dollars) for qualifying projects.[3]

PBoC's *Green Bond Endorsed Project Catalogue* includes "clean utilization of coal" as an eligible project category. This has created controversy. International standards for green bond investments do not include coal projects among the eligible categories.[4]

This chapter summarizes and discusses China's green finance policies.

Background

The capital required for pollution control and climate mitigation in China is enormous. PBoC estimates the need at RMB 2–4 trillion (roughly $310–$620 billion) per year. To help mobilize that capital, PBOC issued its *Guidelines for Establishing the Green Financial System* in 2016. In its opening paragraphs, the Guidelines state,

> The establishment of the green financial system requires the internalization of environmental externalities by appropriate incentives and restraints with the support of policies, laws and regulations in the financial, fiscal and environmental areas. It also requires more innovations by financial institutions and financial markets in developing new financial instruments and services, to address the problems of maturity mismatch, asymmetric information and lack of analytical tools for green investment.[5]

The Guidelines call for policies and actions in seven areas:

1. green bonds,
2. green lending,
3. green development funds,
4. green insurance,
5. markets for pollution control rights,

6. local government initiatives, and
7. international cooperation.

Many provincial and local governments have also issued green finance guidance documents. This includes Beijing, Shanghai, Guangdong, Inner Mongolia and Gansu. At least five pilot green finance zones have been set up, where financial institutions receive a variety of incentives to fund clean and low-carbon industries.[6]

Green Bonds

Perhaps the greatest amount of green finance activity in China has been in the area of green bonds. In 2017, RMB 248.6 billion (roughly $37 billion) of green bonds were issued in China (the second highest total of any country, behind only the United States). This was an increase of 4.5% over green bond issuances in 2016, despite a significant drop in corporate bond issuances overall.[7]

In 2017, roughly 30% of China's green bond proceeds went to solar and wind projects, and roughly 22% went to low-carbon transport. Roughly 23% of China's green bond proceeds went to projects that did not meet international green bond standards. This included large hydro projects as well as larger, more efficient coal plants replacing smaller, less efficient ones.[8]

Policies concerning green bonds are set forth in PBoC's *Guidelines for Establishing the Green Financial System* (September 2016), NDRC's *Guidelines for Issuing Green Bonds* (December 2015) and the China Securities Regulatory Commission's *Guidelines for Supporting Green Bond Development* (March 2017). These documents call for guarantees, credit enhancement mechanisms, disclosure requirements and third-party verification. They call on provincial and local governments, as well as rating agencies, to participate actively in establishing a green bond market.[9]

Commercial banks issued more than half the green bonds in China in the past two years. Corporations (including China Three Gorges and Century Concord Wind) issued roughly 20%. Government banks (including China Development Bank and the Agricultural Bank of China) have also been issuers. In 2017, some local and regional banks issued their first green bonds.[10]

In 2016, roughly 2% of total Chinese bond issuances were green bonds. That percentage rose in 2017, as total bond issuances fell and green bond volumes grew slightly.[11]

Green Credit

Green credit is another important part of China's green finance strategies. (The volume of bank lending in China far exceeds bond issuances.) In 2017, roughly 9% of outstanding loans in China were for green projects, including energy efficiency and emissions reduction. PBoC's Guidelines call for "vigorously develop[ing]" green credit with tools such as central bank relending, guarantee mechanisms and securitization. In March 2018, a team from PBoC visited London for talks on ways to securitize green loans for sale to international investors.[12]

China Development Bank's website states that "CDB is one of the earliest advocates of green credit practice in China, which aims to support environmental protection and energy conservation through its designated loans and investments."[13]

Relationship to Climate Goals

Climate mitigation is an important priority within China's green finance policies. PBoC's *Guidelines for Establishing the Green Financial System* and other green finance policy documents specifically highlight the importance of climate mitigation and low-carbon development. In 2017, China's green finance policies helped channel tens of billions of dollars into renewable energy and low-carbon transport projects.[14]

China's policies with respect to the use of green bond proceeds for coal-fired power plants have created controversy. Those policies allow green bond proceeds to be used for coal-fired power plants in some circumstances, such as when larger, more efficient coal-fired power plants replace smaller, less efficient ones. Some see this as consistent with climate mitigation goals, since carbon emissions are reduced in the short term. Others see this as inconsistent with climate mitigation goals, since larger coal-fired power plants tend to lock in carbon emissions for the medium and long term, and less-polluting alternatives may be available.[15]

Work is underway to harmonize Chinese and international green bonds standards. (Leading international standards prohibit the use of green bond proceeds for coal-fired power plants in all circumstances.)[16]

Meeting the climate goals set forth in the Paris Agreement will require trillions of dollars of capital over several decades. China's green finance polices are intended, in part, to help meet that need. Those policies are relatively new and will continue to evolve in the years ahead. How they do so will could play an important role in the world's response to climate change.

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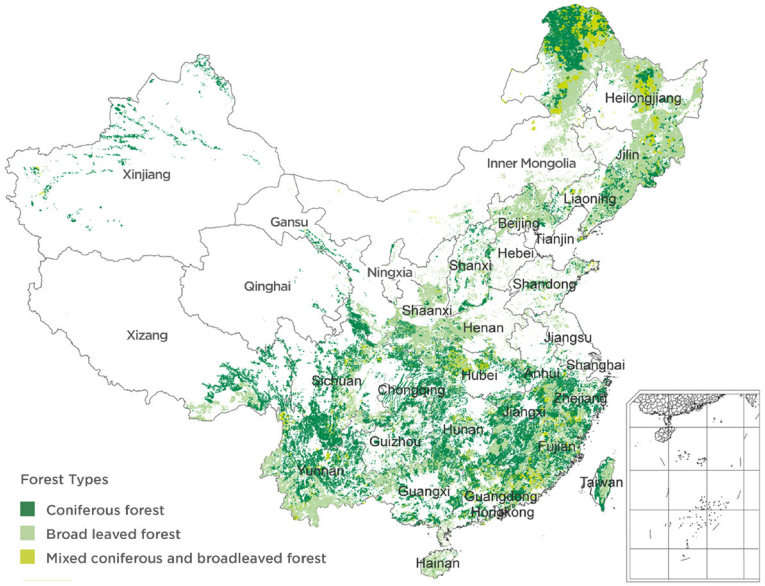
CHAPTER 17 - FORESTRY

Background

Forests cover large parts of southern China, from Fujian Province in the east to Sichuan and Yunnan Provinces in the west. Forests also cover much of China's far northeast. There are fewer forests in the densely populated region between Shanghai and Beijing and almost none in the far western provinces of Xinjiang and Tibet.

Figure 17-1: China's Forest Cover



Source: Shi et al. (2011)[1]

China's forest cover is increasing. There are different estimates of how much, depending in part on the definition of "forest" and other key terms. China's State Forestry Administration reports that China's forest cover grew from less than 13% in 1981 to more than 20% in 2010.[2] A 2011 study found that forest cover in China increased an average of roughly 0.5% annually between 1980 and 2010.[3] A 2017 study found that

> "If 'forest' is defined according to the FAO criteria (including immature and unstocked areas), China's forest cover gains between 2000 and 2010 were larger than the combined area of Germany, The Netherlands, Belgium and Luxembourg. If forest is defined according to China's own criteria..., China has gained an area smaller than size of Germany; and if forest is defined according to what non-specialists would view as forest (contiguous blocs of tall (higher than 5 m) and closed (minimum 50%) crown cover), the detectable gains are smaller than the size of The Netherlands."[4]

NDRC reports that forests covered 21.66% of China's territory in 2016.[5] According to the

National Bureau of Statistics, more than seven million hectares of afforestation were completed in 2017.[6]

The density of China's forest stock is also increasing. The 2011 study cited above found that forest stock density increased an average of 0.44% annually between 1980 and 2010.[7]

Policies

China's Natural Forest Conservation Program is the largest forest conservation program in the world. It includes massive tree-planting programs, an expansion of forest reserves and a ban on logging in primary forests. The Chinese government spends heavily on these forest programs—more than either the United States or Europe and more than three times the global average per hectare. A study released in 2016 found that "the implementation of the National Forest Conservation Program exhibited a significant relationship with forest gain in China during the first decade of the 21st century."[8]

Historically, the goals of China's forest conservation programs included preventing floods and desertification. The current National Forest Conservation Program was launched in the wake of the catastrophic Yangtze River floods of 1998. The Three-North Shelterbelt Program, launched in the late 1970s, is a multi-decade program to plant a 4,500-kilometer wall of trees through the Gobi Desert to reduce sandstorms. Recently the goals of China's forest conservation programs have expanded to include helping fight local air pollution and global warming as well.[9]

China's Intended Nationally Determined Contribution gives high prominence to a forest goal. One of the four principal goals identified in the INDC is "to increase the forest stock volume by around 4.5 billion cubic meters from 2005 levels by 2030."

This goal builds on Premier Wen Jiaboa's 2009 pledge, made just before the Copenhagen climate conference, to increase China's forest stock volume 1.3 billion cubic meters from 2005 levels by 2020. The 2030 goal implies a significant increase in forest cover—about two to four times the land area of the United Kingdom.[10]

To help achieve its forest goals, the Chinese government pledges in its INDC

- "To vigorously enhance afforestation, promoting voluntary tree planting by all citizens, continuing the implementation of key ecological programs, including protecting natural forests, restoring forest and grassland from farmland, conducting sandification control for areas in vicinity of Beijing and Tianjin, planting shelter belt, controlling rocky desertification, conserving water and soil, strengthening forest tending and management and increasing the forest carbon sink; [and]
- "To strengthen forest disaster prevention and forest resource protection and to reduce deforestation-related emissions."[11]

These pledges are reflected in the text of China's *Work Plan for Controlling Greenhouse Gas Emissions in the 13th Five-Year Plan*, issued by the State Council in October 2016. During the 13th Five-Year Plan, the Chinese government aims to increase forest cover from 21.66% to 23%

of the country's total land area. Afforestation programs are under way throughout much of China, including the Lower, Middle and Upper Reaches of the Yangtze River; the Pearl River Basin; the Taihang Mountains; and the Beijing-Tianjin-Hebei region.[12]

NDRC reports that 11.6 million hectares of forests were planted in 2016 and the first half of 2017 and that more than RMB 47.8 billion from the central budget was allocated to forest conservation projects during this period.[13]

Figure 17-2: China's Forestry Development Plan

Source: State Forestry Administration, "China Forestry Development 13th Five-Year Plan"[14]

China's forest programs have the potential to sequester significant amounts of carbon. A 2015 study estimated that since 1973, China's forests had absorbed more than 22 Gt of carbon. A 2016 study estimated that carbon storage in China's forests would reach almost 28 Gt by 2033. This is equal to roughly 10 years of Chinese CO_2 emissions.[15]

Significantly, some of China's forest policies and consumption patterns may exacerbate deforestation in other countries, offsetting the climate benefits of the carbon sequestered in China's forests. Although the Chinese government has expanded forest reserves and banned logging in China's primary forests, China's timber imports are large and growing. The combination of forest conservation within China and growing Chinese timber imports means greater timber production in other countries, including Indonesia, Vietnam, Myanmar and Russia. From a global perspective, this may substantially reduce the climate benefits of China's policies that limit domestic logging.[16]

NOTES

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CHAPTER 18 - ADAPTATION

The Chinese government released its *National Strategy for Climate Change Adaptation* in 2013.[1] The strategy sets forth principles for climate change adaptation, including these:

- "Set priorities. Based on a comprehensive assessment of the impacts and damage of climate change…China should prioritize and focus on adaptation action for vulnerable fields, regions and groups of people."
- "Take the initiative to adapt. Strengthen monitoring and early warning capabilities, in order to reduce losses caused by climate change."
- "Widen the scope of participation. Improve public awareness about adapting to climate change and mechanisms for social participation in climate adaptation."

The strategy also sets out goals, including these:

- Significantly reduce the vulnerability of climate-sensitive areas, regions and populations.
- Significantly strengthen monitoring, early warning capability, disaster prevention and mitigation capacity for extreme weather events.
- Significantly improve climate change fundamental research, observation and forecasting capability.
- Significantly enhance public awareness of climate change.

The Strategy was released by NDRC along with eight ministries and bureaus (the Ministry of Finance, the Ministry of Housing and Urban and Rural Development, the Ministry of Transportation, the Ministry of Water Resources, the Ministry of Agriculture, the State Forestry Administration, the Bureau of Meteorology, and the Maritime Bureau). The strategy highlights the need for capacity building in areas including response to extreme weather events, protection of water resources and prevention of soil erosion.[2]

Since the release of the *National Strategy for Climate Change Adaptation*, the Chinese government has adopted climate change adaptation plans in a number of sectors. These include

- *Action Plan on Climate Change Adaptation in Urban Areas*, released by NDRC and MOHURD;
- *Action Plan for Forestry to Adapt to Climate Change* (2016–2020), released by the State Forestry Administration; and
- *Plan on Building a Meteorological Disaster Information Management System*, released by the Bureau of Meteorology.[3]

The Chinese government has dozens of pilot projects underway to help improve approaches and methodologies for adapting to climate change. The *National Strategy for Climate Change*

Adaptation identified 14 pilot projects to improve climate resilience, including projects on urban infrastructure in Shanghai, soil conservation in Jilin Province and emergency response in Hainan Province. *The Working Plan for Pilot Programs on Climate-Adaptable Urban Development* launched a process in which 30 pilot cities are being selected to implement climate adaptation initiatives. (The goal is that, by 2020, climate adaptation principles will be mainstreamed into development planning processes and urban construction standards in the pilot cities.) The State Oceanic Administration runs pilot projects on disaster risk planning. The State Forestry Administration runs climate change adaptation projects as well.[4]

NOTES

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PART III - FOREIGN POLICIES

CHAPTER 19 - UNFCCC

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Rio Earth Summit in 1992. More than 195 countries are Parties. The UNFCCC is the world's principal multilateral agreement on climate change.[1]

China ratified the UNFCCC in 1993. It has participated in all annual Conferences of the Parties (COPs) under the UNFCCC and many related meetings, with a steadily growing delegation and role.[2]

In discussions under the UNFCCC, China has been a forceful advocate for the principle of "common but differentiated responsibilities." Under that principle, set forth in Article 3.1 of the Convention, all countries are responsible for contributing to solutions to climate change but the nature and extent of those responsibilities vary. In the 1990s, China and other developing countries insisted that they—unlike industrialized countries—should not be subject to binding emissions limits under the UNFCCC. That position was reflected in the structure of the Kyoto Protocol, which was adopted at the third Conference of the Parties (COP-3) in 1997 and entered into force in 2002.

By the time of the Copenhagen climate conference in 2009 (the 15th annual Conference of the Parties of the UNFCCC), China had become the world's largest emitter of heat-trapping gases. At the Copenhagen conference, China pledged to cut CO_2 emissions per unit of GDP 40%–45% from 2005 levels by 2020—its first international pledge to limit CO_2 emissions. China also pledged to increase the share of nonfossil fuels in primary energy consumption to 15% and increase forest cover 40 million hectares from 2005 levels, both by 2020. Premier Wen Jiabao traveled to Copenhagen, where he met with several heads of state in the final, dramatic hours of the conference. The Copenhagen conference was widely perceived to be a failure and all major emitters, including China, received considerable criticism for the meeting's outcome.

In the years that followed the Copenhagen conference, the Chinese delegation to the UNFCCC sought common ground with other countries in the UNFCCC process, including in particular the United States. In 2014, President Xi Jinping and US President Barack Obama made a historic joint announcement on climate change, announcing domestic emissions goals and plans to work together toward a new global climate agreement at the 21st Conference of the Parties of the UNFCCC in Paris in December 2015.

In connection with the Paris climate conference, Parties to the UNFCCC agreed to submit national action plans for addressing climate change (known as Intended Nationally Determined Contributions, or INDCs). China submitted its INDC in June 2015. (It was the first developing country to do so.) In its INDC, China pledged to achieve the peaking of carbon dioxide emissions around 2030, making best efforts to peak early. It also pledged that, by 2030, it would (1) lower carbon dioxide emissions per unit of GDP by 60%–65% from the 2005 level, (2) increase the share of nonfossil fuels in primary energy consumption to around 20% and (3) increase the forest stock volume by around 4.5 billion cubic meters from the 2005 level.[3]

President Xi Jinping joined the opening ceremonies of the Paris conference (COP-21), declaring that "tackling climate change is a shared mission of all mankind."[4] The Chinese delegation

participated actively in shaping the Paris Agreement, which was adopted on December 12, 2015. China ratified the Paris Agreement on September 3, 2016.

In June 2017, following US President Donald Trump's announcement that the United States would withdraw from the Paris Agreement, the Chinese government strongly reaffirmed its commitment to the Paris Agreement. It has reiterated that position on many occasions since. In October 2017, in a high-profile report to the 19th Party Congress, President Xi Jinping said that China is "taking the driving seat in international cooperation to respond to climate change."[5]

NOTES

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CHAPTER 20 - EXTERNAL FINANCING

The Chinese government provides enormous amounts of capital for projects outside China's borders, including power plants, roads and factories. These amounts are likely to grow in the years ahead, in part due to the Belt and Road Initiative. Much of this financing is provided through national policy banks, such as the China Development Bank (CDB) and Export-Import Bank of China (China ExIm), and multilateral development banks, such as the Asia Infrastructure Investment Bank (AIIB) and New Development Bank (NDB or BRICS Bank).

The climate impacts of Chinese external financing are significant.[1] This chapter provides background on the Belt and Road Initiative and China's four main external financing institutions, with a focus on their climate policies and impacts.

A. Belt and Road Initiative

The Belt and Road Initiative (BRI) is the largest infrastructure initiative ever. Under BRI, Chinese entities will provide more than a trillion RMB (hundreds of billions of dollars) to thousands of projects in dozens of countries. The projects include roads, railways, ports, pipelines, transmission lines and power plants. The word "belt" refers to the ancient silk road from China through Central Asia, Iran and Turkey to Europe. The word "road" refers (perhaps confusingly) to a sea route—the "maritime silk road" that started in China and stopped in Vietnam, Indonesia, Malaysia, Sri Lanka, India, Kenya and Djibouti, among other places, before reaching Europe. (See map below.)[2]

Figure 20-1: Belt and Road

Source: Quartz, citing Reuters.[3]

President Xi Jinping announced the Belt and Road Initiative in 2013. In May 2017, President Xi convened a Belt and Road Summit in Beijing, which was attended by 29 heads of state and representatives from more than 60 countries. In his remarks opening the summit, President Xi called the Belt and Road Initiative a "project of the century" that "will benefit people across the world."[4]

Chinese government leaders identify low-carbon development as a goal of the Belt and Road initiative. In his remarks to the Belt and Road Summit, President Xi Jinping said:

> "We should pursue the new vision of green development and a way of life and work that is green, low-carbon, circular and sustainable…We propose the establishment of an international coalition for green development on the Belt and Road, and we will provide support to related countries in adapting to climate change.[5]"

In May 2017, the National Development and Reform Commission (NDRC), Ministry of Environmental Protection, Ministry of Foreign Affairs and Ministry of Commerce (MOFCOM) jointly issued the *Guidance on Promoting Green Belt and Road*.[6] The document highlights the importance of "ecological civilization and green development" and says:

> "We will encourage enterprises to prioritize low-carbon, energy-saving, environment-friendly and green materials and technical processes…We will also guide the businesses to tighten their R&D efforts on key technologies to address climate change."

The Guidance calls on companies participating in the Belt and Road Initiative to

- "promote environmental infrastructure construction and improve green and low-carbon construction and operation," and
- "observe…the laws, regulations, policies and standards of host countries on eco-environment protection, [and] attach great importance to the appeals of the local residents on environment protection."

The Guidance on Promoting Green Belt and Road does not contain enforcement mechanisms. NDRC and MOFCOM, which are mostly responsible for approving overseas investments under the Belt and Road Initiative, have limited experience evaluating the climate or other environmental impacts of projects.[7]

Energy projects are a principal part of the Belt and Road Initiative. The State Council's *Action Plan on the Belt and Road Initiative* (2015) calls for more energy projects, including for "coal, oil, gas, metal minerals and other conventional energy sources" as well as "hydropower, nuclear power, wind power, solar power and other clean, renewable energy sources."[8] Data on overall investment in such projects are limited. One study of external financing by China Development Bank and the Export-Import Bank of China found that, from 2015–2017, those banks provided roughly $43 billion for oil, $20 billion for natural gas, $19 billion for hydro, $15 billion for coal, $3 billion for nuclear and $3 billion for solar and wind projects.[9]

B. Institutions

China Development Bank

China Development Bank (CDB) was established in 1994. According to its website, China Development Bank is "a policy financial institution under the direct leadership of the State Council."[10] Its largest shareholder is the Chinese Ministry of Finance, which owns roughly 36.5% of outstanding shares, and its debt is backed by China's sovereign credit. The China Development Bank invests in infrastructure, basic industries, energy and transport around the world. It provides loans, loan guarantees and a range of other financial tools. Its objectives include promoting economic growth within China and promoting the competitiveness of Chinese entities abroad.

China Development Bank is the world's largest development finance institution. At the end of 2017, its assets were RMB 15.96 trillion ($2.4 trillion) and loan balance was RMB 11.04 trillion ($1.66 trillion). This is more than the assets and loan balances of the World Bank and Asian Development Bank combined.[11]

CDB's website states that "CDB is one of the earliest advocates of green credit practice in China, which aims to support environmental protection and energy conservation through its designated loans and investments."[12] In 2008, CDB began implementing the Equator Principles, a tool to help financial institutions assess the environmental and social risks of projects. CDB has developed the environmental and social risk assessment system for its international projects in accordance with the UN Global Compact principles.

According to CDB's 2017 Annual Report, CDB made RMB 327 billion (about $49 billion) in green loans in 2017, bringing its total green loans outstanding to RMB 1.642 trillion (about $250 billion). "Green loans" include those for energy-saving projects, clean energy, industrial pollution control, circular economy and urban environmental improvement. CDB calculates that its green loan portfolio helps reduce carbon emission by 132 million tons each year.[13]

China Development Bank does not have a separate, stand-alone climate change or low-carbon policy.

CDB is one of the largest financiers of coal-fired power plants in the world. In the past decade it has provided more than $30 billion for coal plants abroad.[14]

China ExIm

The Export-Import Bank of China (China ExIm) was also established in 1994. It operates under the direct leadership of China's State Council and is solely owned by the Chinese government. Like China Development Bank, China ExIm provides loans, loan guarantees and a range of other financial tools. China ExIm supports projects in infrastructure, medical care, education, agriculture and environmental protection around the world.[15]

According to China ExIm's 2016 annual report (the most recent available), China ExIm had RMB 3.33 trillion (roughly US$520 billion) in total assets and RMB 2.38 trillion (roughly $370 billion) in outstanding loans as of December 31, 2016.[16]

China ExIm highlights its policies to promote clean energy and protect the environment. Its website reports that China ExIm "has vigorously supported projects related to energy conservation and emission reduction, environmental protection and circular economy" and that the bank has "intensified support to projects involving new energies such as wind, solar and biomass power." It states that these projects "have produced good economic and social returns."[17] China ExIm also states that it applies environmental standards in all lending, describing a three-stage process:

- "During the loan application review, the compliance and integrity of the project's environmental impact assessment documents and legality of relevant procedures are carefully examined."
- "When loans are being delivered, the energy consumption rate and environmental compliance practice of the borrower are to be kept under scrutiny."
- "In the post-lending management stage, stringent…standards are observed and real-time risk warning management is put in place…"[18]

China ExIm reports that it has carried out exchanges with the World Bank Group, International Financial Corporation and others on environmental assessment.[19]

China ExIm is one of the largest financiers of coal-fired power plants in the world. In the past decade, it has provided more than $25 billion for coal plants abroad.[20]

Asian Infrastructure Investment Bank (AIIB)

According to its website, the Asian Infrastructure Investment Bank (AIIB) is "a multilateral development bank with a mission to improve social and economic outcomes in Asia and beyond." China proposed establishment of AIIB in 2013 and waged a successful diplomatic campaign over several years to bring countries on board as members. AIIB started operations in 2016, with a Beijing headquarters. As of March 31, 2018, AIIB had assets of $19.2 billion and outstanding loans of $4.2 billion (for 24 projects). As of July 2018, 87 countries were members.[21]

The AIIB describes its core values as "Lean, Clean, and Green." Its Environment Framework calls for environmental and social due diligence on all projects, as well as public disclosure of social and environmental risks. AIIB specifically addresses climate change in its Environment Framework, stating that

> The Bank recognizes the challenges presented by climate change and the need to support both mitigation and adaptation measures in a Project facing such challenges. The Bank supports its Clients in their evaluation of both the potential impacts of the Project on climate change and the implications of climate change on the Project. To this end, the Bank plans to prioritize investments promoting greenhouse gas emission neutral and climate resilient infrastructure, including actions for reducing emissions, climate-proofing and promotion of renewable energy.[22]

AIIB released its Energy Sector Strategy in June 2017. The strategy's "Principle 3" is "Reduce the carbon intensity of energy supply." The text states:

- "The Bank will support clients to reduce the carbon intensity of energy to help them achieve their long-term climate goals provided in the Paris Agreement…"
- "The Bank will support and accelerate its members' respective transitions toward a low-carbon energy mix through investments in RE and reduction of carbon emissions from fossil fuels…"
- "The Bank will support clients to develop intermittent RE—hydropower, wind, solar, and other sources—to reduce fossil fuel consumption and increase access to modern energy through decentralized generation, and mini- and micro-grids…"
- "The Bank will focus on supporting and accelerating its members' respective transitions toward a low-carbon energy mix, including lower carbon emissions from fossil fuels… Supported fossil fuel-based generation facilities would be expected to use commercially available least-carbon technology."
- "Carbon efficient oil- and coal-fired power plants would be considered if they replace existing less efficient capacity or are essential to the reliability and integrity of the system, or if no viable or affordable alternative exists in specific cases."[23]

As of July 2018, AIIB had approved 12 projects in the energy sector, including a coal replacement project in Beijing, a natural gas–fired power plant in Bangladesh, a solar PV feed-in tariffs program in Egypt and hydropower projects in Tajikistan, Myanmar and Pakistan.[24]

New Development Bank (NDB or BRICS Bank)

The New Development Bank was established in 2014 by the five BRICS countries—Brazil, Russian, India, China and South Africa. Its headquarters are in Shanghai. Each member country pledged a capital contribution of $10 billion.[25]

The purpose of the NDB is "to support infrastructure and sustainable development efforts in BRICS and other underserved, emerging economies for faster development through innovation and cutting-edge technology." NDB materials say the following:

> The 21st century has brought with it tremendous development. However, this progress has been skewed, insufficient and often harmful to our environment. We will collaborate with Initiatives that drive growth and employment while ensuring environmental protection.[26]

The New Development Bank gives priority to clean energy in its lending. As of July 2018, the NDB had provided 20 loans, seven of which were for renewable energy and energy conservation projects. These seven projects had a cumulative loan amount of $1.4 billion.[27]

NDB's Environmental and Social Framework directly addresses climate change, stating the following in the section on "Core Principles":

> NDB seeks to promote mitigation and adaptation measures to address climate change. Recognizing the sustainable nature of green economic growth and the associated benefits, NDB aims to build upon existing green economic growth

> initiatives and provide support for the new ones at regional, national, sub-national and private sector level. NDB also encourages climate proofing of its infrastructure financing and investments to build resilience to climate change.[28]

In evaluating potential projects, NDB staff are directed to:

> [a]ssess both the potential impacts of the project on climate change as well as the implications of climate change on the project and develop both mitigation or adaptation measures as appropriate. Identify opportunities for no- or low-carbon use, where applicable, and for reducing emissions from the project.[29]

C. Coal-Fired Power Plants

Chinese companies play a significant role in the development, construction and financing of coal plants around the world. With the entry into force of the Paris Agreement, these activities have been a focus of growing research and commentary.

- One study found that Chinese financial institutions supported construction of more than 50 coal-fired power plants abroad between 2001 and 2016. The authors estimate that these power plants release almost 600 million tons of CO_2 per year (more CO_2 than all but seven countries in the world) and that if these plants operate for 30 years on average, lifetime CO_2 emissions from the plants will be almost 18 Gt (roughly half of global emissions in 2017).[30]
- Another study found that between 2000 and 2014, Chinese government entities spent roughly $100 billion on high-carbon projects abroad (coal, oil and gas) and roughly $60 billion on low-carbon projects abroad (mainly hydro).[31]
- In the first half of 2018, media outlets reported on Chinese support for new coal power plants in many countries, including Serbia, Bosnia, Kenya, Pakistan, Bangladesh and Vietnam.[32]
- One study found Chinese involvement in more than 100 coal-fired power plants in planning or under construction in Belt and Road countries as of May 2017. (This included consulting, design, equipment exports, construction and financing.)[33]
- Another study found Chinese coal plant developers behind 68–76 GW of new coal-fired power plants currently in the planning pipeline abroad.[34]

Chinese support for new coal-fired power plants under the Belt and Road Initiative is controversial. Some argue that new coal plants are inconsistent with the climate goals of the Paris Agreement, that renewable power is now cheaper than coal in many locations (especially when health and social costs are included) and that Chinese companies are helping lock in decades of CO_2 emissions outside China's borders. Others argue that coal-fired power is an essential development tool in some countries and that Chinese companies help limit emissions by ensuring that new coal plants use modern, efficient technologies.[35]

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CONCLUSION

Background

Climate change is an immensely challenging policy problem. There are many reasons.

- *First, climate change is caused by invisible, odorless gases.* Human beings depend on our senses for threat detection. Our vision helps us avoid an object hurtling our way. Our smell and taste help us avoid spoiled food. We are less skilled at responding to threats that may be difficult to see, hear, touch, smell or taste.
- *Second, climate change is happening at a pace that alarms many scientists, but can seem slow in the course of day-to-day life.* Scientists warn that the climate is changing at a pace unprecedented in human history.[1] But from day to day, week to week and even year to year, changes can be hard to detect.
- *Third, many impacts of climate change can appear to be the result of other causes.* Climate change increases the frequency and severity of storms, floods, droughts, wildfires and heat waves.[2] Yet all these happen in the absence of climate change as well. It can be easy to dismiss the role of climate change in causing or intensifying such events.
- *Fourth, many solutions to climate change implicate the interests of powerful incumbents.* Many solutions to climate change involve changes to ways some powerful interests have operated for years. Resistance is often strong.
- *Finally, climate change requires collective action to abate.* Climate change is caused by billions of discrete actions across the globe. No group, industry, city, state, province or country can solve the problem on its own. Solutions require cooperation, often in ways that are exceedingly difficult to agree on and implement.

These factors combine to make climate change one of the most challenging problems facing any government.[3]

At the same time, climate change poses huge threats. The Intergovernmental Panel on Climate Change warns with "high confidence" of risks, including:

- "extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services,"
- "drought, flooding, and precipitation variability and extremes,"
- "breakdown of food systems,"
- "death, injury, ill-health, or disrupted livelihoods in low-lying coastal zones,"
- "severe ill-health and disrupted livelihoods for large urban populations,"

- "loss of marine and coastal ecosystems," and
- "loss of terrestrial and inland water ecosystems."[4]

Against that backdrop, how can we best understand the Chinese government's climate policies? How is the world's largest current emitter of heat-trapping gases responding to the immensely challenging yet hugely important problem of climate change?

Chinese Climate Policy: An Assessment

Based on the review of Chinese climate policies in this Guide, I offer five observations:

First, the Chinese government is taking significant steps to address climate change.

These include the following:

Cutting Coal, Scaling Up Low-Carbon Alternatives. The Chinese government is deeply committed to cutting coal use and deploying low-carbon alternatives. China's policies for accomplishing those goals include:

- Five-Year Plan targets for limiting coal use and deploying solar power, wind power, nuclear power and natural gas
- Five-Year Plan targets for improving energy efficiency in the industrial and power sectors
- Many specific measures to help achieve those targets, including incentives and mandates for the conversion of coal heating to natural gas, subsidies for renewable energy and nuclear power, coal plant efficiency standards, green finance programs, and more[5]

These policies have delivered results:

- Coal consumption has fallen 3%–4% since its peak in 2013, even as the Chinese economy has grown roughly 40% during the same period.[6]
- In 2017, China led the world in deployment of wind and hydro power—and installed more solar panels than the rest of the world combined.[7]
- In 2017, consumption of natural gas (which has half the carbon emissions per unit of energy as coal) increased by roughly 15% -- twice the rate of economic growth.[8]
- Roughly one-third of the nuclear plants under construction in the world are in China.[9]

Perhaps most important from a climate change standpoint, as the Chinese economy grew by roughly 40% in the past five years, Chinese CO_2 emissions grew in the range of 0%–3%. For three of those years (2014, 2015 and 2016), according to several estimates, CO_2 emissions fell.[10]

Several factors contributed to these emissions trends, including a shift in economic activity from heavy manufacturing to services. However, the transition from coal to lower-carbon

fuels—driven mostly by government policies—appears to have played a central role. A recent analysis of Chinese CO_2 emissions from 2013 to 2016 noted:

> "Importantly, the reduction in coal consumption occurred despite continued growth of total energy consumption…As coal use decreased, rising energy demand was met by the rapid growth of renewable and nuclear energy, which increased at an average annual rate of…11%."[11]

Similarly, the IEA attributes the partial decoupling of Chinese economic and emissions growth in 2017 to "continued renewables deployment and faster coal-to-gas switching."[12]

Carbon Pricing. The Chinese government is committed to putting a price on domestic carbon emissions. (Outside Europe, only one other national government—Canada's—is committed to doing so.) Seven pilot emissions trading programs for carbon dioxide have been operating since 2013. Based in part on lessons from those pilots, a nationwide emissions trading program for carbon dioxide emissions from the power sector was launched at the end of 2017. Work is underway to extend this program to other sectors.

China's carbon emissions trading program is still young, with basic elements under development. There are important questions about whether administrative machinery can be developed to run the program adequately. But the program reflects a commitment to put a price on carbon emissions and has the potential to be an important tool for limiting Chinese emissions.[13]

Other Policies. The Chinese government has adopted dozens of other policies that reduce emissions of heat-trapping gases. These include policies to:

- improve industrial efficiency;
- improve appliance efficiency;
- improve building efficiency;
- improve vehicle fuel efficiency;
- encourage urban planners to develop mass transit;
- accelerate destruction of hydrofluorocarbons (HFCs), a superpollutant used in refrigeration and air conditioning;
- develop HFC alternatives;
- conserve forests; and
- plant trees on a mass scale.[14]

2030 Peaking Goal. The Chinese government's highest-profile climate change goal is "to achieve the peaking of carbon dioxide emissions around 2030, making best efforts to peak early."[15] Some experts have debated: How ambitious is that goal?

In one respect, the 2030 peaking goal is not especially ambitious. Many forecasts project that

Chinese carbon dioxide emissions are likely to peak several years before 2030. Some forecasts project peaking could occur as early as the first part of the next decade. The 2030 peaking pledge is not a "stretch goal."[16]

On the other hand, these forecasts reflect China's climate policies described in this Guide and assume continued implementation of those policies. The timing of China's CO_2 emissions peak will be the result of an extensive set of climate policies, among other factors.

Furthermore, the peaking of China's carbon dioxide emissions will occur when China's GDP per capita is projected to be in the range of $20,000–$26,000 (depending on when in the 2020s peaking occurs, as well as Chinese economic growth trajectories). By contrast, the peaking of carbon dioxide emissions for the United States happened when GDP per capita was roughly $42,000 per capita (2005), for Japan when GDP per capita was roughly $37,000 per capita (2007) and for OECD countries as a whole when GDP per capita was roughly $31,000 (2007). (All figures are in PPP 2005$.) In this respect the timing of China's emissions compares favorably to other leading emitters in terms of ambition.[17]

In submitting the 2030 peaking pledge to the UN Framework Convention on Climate Change, China's leaders were being conservative, identifying a goal they were highly confident the country could meet. China's ability to fulfill that pledge reflects the important role in China's economy of many policies to reduce emissions. The pledge identifies a metric on which China's level of ambition compares favorably to several other leading emitters.

Public Messaging. In their public statements, President Xi Jinping and other Chinese leaders send the message that climate change is real, that they are serious about addressing it and that doing so is part of China's development strategy. Calls for low-carbon development are common, including President Xi's call for a "green, low-carbon, circular and sustainable way of life."[18] President Xi has said that

> "addressing climate change and implementation of sustainable development is not what we are asked to do, but what we really want to do and we will do well."[19]

At the Paris Climate Conference in December 2015, President Xi said that China will "build a low-carbon energy system, develop green buildings and low-carbon transportation" and that "tackling climate change is a shared mission for mankind."[20] In October 2017, after US President Donald Trump's rejection of the Paris Agreement, President Xi said,

> "taking the driving seat in international cooperation to respond to climate change, China has become an important participant and torchbearer in the global endeavor for ecological civilization."[21]

These themes are repeated in many official documents and speeches.[22]

At one level, public statements of this kind are "just words." Yet such statements can have an impact, in part by establishing a context that shapes policies on high-priority topics, including economic development and urbanization. Such statements also encourage Chinese citizens in many walks of life to help contribute to solutions to climate change. Harnessing the talents of Chinese engineers, scientists, businesspeople and students—among many others—could make a significant difference in responding to climate change.

(There are no climate deniers in the Chinese leadership—or at least none with any observable influence on policy. In part, this reflects a respect for science and scientists that runs deep in Chinese culture. Indeed, Chinese officials have often expressed puzzlement about statements by some US government officials rejecting the global scientific consensus with respect to climate change.)[23]

Second, many Chinese climate policies have multiple objectives. (This is a strength from the standpoint of climate mitigation.)

Chinese official documents identify dozens of policies that help fight climate change, including policies to cut coal use, scale up natural gas and renewables, improve vehicle fuel efficiency, promote sustainable urbanization, and promote forest conservation.[24] Many of these policies have multiple objectives:

- Coal-to-natural gas switching is central to cleaning the air in China's cities.
- Support for solar and wind power is part of a strategy to position China for success in industries of the future.
- Vehicle fuel efficiency programs reduce China's oil import dependence.
- Sustainable urbanization programs help make China's cities more livable.
- Forestry programs help fight flooding and desertification.

Many other governments around the world also identify policies with multiple objectives as "climate policies."[25] In part, this reflects the realities of governance. Important policies rarely have single objectives. In part, it reflects the challenges of climate change as a policy issue, discussed above. Precisely because climate change is such a challenging policy issue, climate policies may be more durable or successful when aligned with other important policy goals.

In his remarks at the Paris Climate Conference, President Xi Jinping said that China has "integrated climate change efforts into [our] medium- and long-term program of economic and social development."[26] Continuing to do so will be central China's success in addressing climate change.

Third, China's governance systems have strengths and weaknesses when it comes to addressing climate change.

The Chinese government sets goals far beyond the time frames of many other governments. Perhaps most notable, the "Two Centenary Goals," first articulated in 1997 and given major prominence starting in 2012, call for China to achieve a "moderately prosperous society" by 2021 and build a "prosperous, strong, democratic, culturally advanced and harmonious" country by 2049.[27] (2021 is the 100-year anniversary of the Communist Party of China. 2049 is the 100-year anniversary of the People's Republic of China.) In addition, for more than 60 years, Five-Year Plans have guided Chinese policy making over multiyear periods. The Chinese government is currently on its 13th Five-Year Plan and will soon start serious preparations for its 14th.

This capacity for long-term planning offers significant advantages in responding to climate change. Solutions to climate change involve fundamental changes to energy systems, many of which require years or decades to fully implement. The Chinese government's demonstrated capacity to establish long-term goals and work successfully to meet them is a significant asset in planning, implementing and sustaining an energy transition.[28]

Other parts of the Chinese governance system are less favorable in this regard.

- In many policy areas, China's implementation and enforcement systems are still in development. Many ministries lack sufficient resources to monitor, let alone enforce, substantive topics within their domains. Although environmental enforcement cases have increased significantly in 2017 and 2018, ensuring compliance with environmental regulations remains a challenge.[29]

- Chinese statistical systems face similar issues. Although China's statistical systems have made enormous strides in the past decade, they too are still in development. Systematic reporting biases can undercut the reliability of results.[30]

These implementation, enforcement and statistical issues create challenges in responding to climate change.

Fourth, some Chinese policies run counter to climate change goals.

Many Chinese policies help reduce emissions of heat-trapping gases, as discussed above. However, at least two sets of Chinese policies do the opposite.

Synthetic Natural Gas. Synthetic natural gas ("SNG") plants convert coal to gas, typically to be piped into cities where the gas produces less local air pollution when burned than coal. The climate change impacts of this process are negative: One recent study found that using synthetic natural gas for electricity and industrial heat generation produces 40%–70% more CO_2 emissions than directly burning coal.[31]

As of June 2018, five pilot synthetic natural gas projects were operating in China. Roughly 80 SNG projects were in different stages of the development pipeline—10 more than in June 2017.[32]

Whether these plants will be built is unclear. New SNG projects struggle to receive environmental approvals, with only four granted in 2016.[33] The plants are also expensive and require enormous amounts of water, which have been significant barriers to construction. Several five-year plan goals for SNG plant construction have been missed. The 12th Five-Year Plan set a goal of 15 billion–18 billion cubic meters per year of SNG capacity by 2015, however only 3.1 billion cubic meters per year of SNG capacity had been built by that year.[34]

Nevertheless, China's 13th Five-Year plan sets a goal of producing 17 billion cubic meters per year of SNG by 2020. (As of June 2018, SNG production was roughly 6 billion cubic meters per year.) If this goal were met, CO_2 emissions from Chinese SNG plants would be roughly 85 million tons per year—almost 1% of China's current CO_2 emissions and 0.3% of global CO_2 emissions.[35]

Overseas Coal-Fired Power Plants. Chinese policy banks and state-owned enterprises are among the largest financiers of coal power plants in the world. Between 2008 and 2017, China Development Bank and the Export-Import Bank of China provided more than $43 billion for coal power plants outside China's border (including more than $15 billion in 2015, 2016 and 2017).[36]

These plants produce very significant amounts of heat-trapping gases. According to one estimate, coal power plants outside China financed by China Development Bank and China ExIm produce almost 600 million metric tons (MMT) of CO_2 each year—more CO_2 emissions than all but seven countries in the world. If these plants operate on average for 30 years each, they will cumulatively emit 17.8 Gt of CO_2—almost half of global emissions in 2017.[37]

Chinese companies are playing important roles in dozens of coal power plants under development around the world today. One study found Chinese involvement (including equipment exports, construction or financing) in more than 100 coal-fired power plants in planning or under construction in Belt and Road countries as of May 2017.[38] Another study found Chinese coal plant developers behind 68–76 GW of new coal-fired power plants currently in the planning pipeline abroad.[39] In the first half of 2018, media outlets reported on Chinese support for new coal power plants in countries including Serbia, Bosnia, Kenya, Pakistan, Bangladesh and Vietnam.[40]

Fifth, China – like all major emitters – will need to do more for the world to achieve its climate goals.

In the Paris Agreement, more than 190 nations agreed to the goal of:

> "Holding the increase in the global average temperature to well below 2°C [3.6°F] above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5° C [2.7° F] above pre-industrial levels."[41]

Before the Paris climate conference, almost all of those nations also submitted national action plans for addressing climate change (known as Intended Nationally Determined Contributions or "INDCs"). However those plans, taken together, do not put the world on a path toward achieving the agreed 2°C [3.6°F] goal, let alone the more ambitious 1.5°C [2.7° F] goal. Estimates vary, but generally find that if all INDCs were implemented global average temperatures would increase in the range of 2.7°-3.7°C (4.9-6.7°F).[42]

To compound the problem, many nations are not fully implementing their INDCs. The European Union, Japan and United States are all at risk of failing to meet their INDC targets and pledges.[43]

Furthermore, most INDCs describe plans only until 2030. For the world to achieve its climate goals, significant action to reduce emissions will be required after 2030. (Indeed the Paris Agreement calls for "rapid reductions" in emissions after a global peak and net zero emissions during the second half of this century.)[44]

For all these reasons, it is clear the world will need to do much more to meet its climate goals. It is also clear that China must play an important role in these efforts, for several reasons.

First and most obvious, China is the world's leading emitter of heat-trapping gases. There is no solution to climate change that doesn't involve China.

Second, China has enormous potential to contribute to solutions to climate change. In the past decade, it played a central role in dramatic cost reductions for solar power – a technology with the potential to significantly reduce power sector emissions around the world in the decades ahead. China's current investments in electric vehicles could play a transformational role for that technology, helping reduce transport sector emissions around the world as well. The Chinese government's focus on innovation and commitment to clean energy could help generate important discoveries and advances with global impacts in the decades ahead.

Third, many countries look to China's development model with enormous interest. Countless countries would like to emulate China's economic miracle. The ways that China "integrate[s] climate change efforts into [its] medium- and long-term program of economic and social development," to once again quote President Xi Jinping, has the potential to be a model for many countries around the world.[45]

Fourth, China's activities abroad have considerable emissions impacts. The extent to which Chinese financial institutions and companies support low carbon infrastructure as opposed to high carbon infrastructure under the Belt and Road Initiative will make an enormous difference in global emissions in the decades ahead.

Finally, China will play an important role in climate diplomacy in the next several years and beyond. As the world considers next steps under the Paris Agreement, the Chinese government's positions and views will be key to shaping a global consensus.

As the world meets the climate challenge in the decades ahead, China's role will be central.

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APPENDICES

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APPENDIX A: GOVERNMENT STRUCTURE

Background

China's government is a party-state system. The Chinese Communist Party chooses the leaders of all government offices and state-owned enterprises. The party and the government are deeply intertwined, with senior officials holding positions in both. Xi Jinping, for example, is General Secretary of the Chinese Communist Party and President of the People's Republic of China. Li Keqiang is the second-ranking member of the Politburo Standing Committee (a party body) and Premier of the State Council (a governmental body).[1]

Within the Chinese Communist Party, the top official is the General Secretary. He chairs the powerful Politburo Standing Committee (PSC), which has varied in size over the years but currently has seven members. The PSC is the inner circle of the Politburo, with roughly 25 members. Just below the Politburo in rank is the party's Central Committee, which has several hundred members and generally meets twice a year. Next is the National Party Congress, which has over 1,500 members and meets every five years. Today the Chinese Communist Party has roughly 88 million members total—roughly 7.5% of the population over 18 years of age.[2]

Within the Chinese government, the top officials are the President and the Premier. The Premier serves as chair of the State Council, which coordinates China's domestic and foreign policy and has been called "China's Cabinet." The State Council's Executive Committee currently consists of the Premier, four Vice Premiers and five State Councilors. 25 ministers, commissioners and other heads of government offices also serve on the State Council, supported by a large bureaucracy.

Chinese ministries and commissions play a central role in formulating policy within their functional domains. This includes the Ministry of Foreign Affairs, Ministry of Finance, Ministry of Science and Technology, Ministry of Land and Resources, State-Owned Assets and Supervision Commission and many more. The National Development and Reform Commission (NDRC) is an especially powerful commission with broad authority over China's economy.

One tool used to coordinate work among top officials is the "leading group." Leading groups bring together key stakeholders on priority topics, help shape consensus and can be located within the party or government. President Xi Jinping heads a number of leading groups, including on foreign affairs, the economy and defense. Members of the Politburo Standing Committee and State Council head leading groups on a range of other topics.

Chinese state-owned enterprises exert considerable influence on Chinese policy making. The leaders of major state-owned enterprises often have rank equal to (and sometimes greater than) the heads of ministries and commissions.

China's legislature is the National People's Congress, with roughly 3,000 members. The National People's Congress meets for two weeks each March to discuss reports from government leaders and approve laws.

China has 34 provinces, including four municipalities with provincial status (Beijing, Shanghai, Chongqing and Tianjin), five autonomous regions (Tibet, Inner Mongolia, Xinjiang, Ningxia and Guangxi) and two special administrative regions (Hong Kong and Macao).

Provincial governments play a key role in governing China, with a rank equal to that of central government ministries. Provincial governments implement policies from the central government but also engage in considerable policy making on their own. Many provincial governments hold substantial ownership stakes in state-owned enterprises and favor their local SOEs with supportive policies. The structure of provincial governments in general duplicates that of the central government, with control exercised by provincial party leaders and provincial ministries exercising considerable authority within their domains.

NOTES

1. With respect to topics discussed in this appendix, see generally Cheng Li, *Chinese Politics in the Xi Jinping Era* (Brookings Press, 2016) at pp.41–76; Kenneth Lieberthal, *Governing China* (W. W. Norton, 2004) at pp.233–242.
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APPENDIX B: KEY PLAYERS

Top-level decision-making on Chinese climate policy is facilitated by the National Leading Group on Climate Change, Energy Conservation and Emissions Reduction, which is chaired by Premier Li Keqiang. Twenty-six ministries and commissions are members.[1]

China's Ministry of Ecology and Environment (MEE) has principal responsibility for climate change policy within the Chinese government. Those responsibilities include

- developing and implementing China's emissions trading program for carbon dioxide,
- coordinating climate change policies with policies on other topics,
- ensuring achievement of climate-related targets in the 13th Five-Year Plan,
- evaluating options for climate-related targets in the 14th Five-Year Plan, and
- representing China in international fora including the UN Framework Convention on Climate Change.

MEE received these responsibilities as part of a government reorganization in March 2018. Before that, the National Development and Reform Commission (NDRC) had taken the lead on climate change within the Chinese government for many years.[2]

Other parts of the Chinese government that play important roles in policies related to climate change include

- the National Energy Administration (NEA), which plays a central role in Chinese policies on fossil, nuclear and renewable energy;
- the Ministry of Foreign Affairs (MFA), which helps shape China's climate change diplomacy;
- the Ministry of Finance, which administers taxes and tax incentives relevant to climate policy;
- the Ministry of Science and Technology (MOST), which provides billions of RMB for research and development on clean energy technologies;
- the Ministry of Housing and Rural and Urban Development (MOHURD), which helps administer green cities and other low-carbon pilot programs; and
- the International Development Cooperation Agency (CIDCA), established in April 2018, which administers foreign aid and development assistance.[3]

Many quasi-governmental institutions and universities provide research and analytic support that informs the development of Chinese climate change policy. They include

- the National Center for Climate Change Strategy and International Cooperation (NCSC), which provides considerable analytic and modeling capabilities on all aspects of climate policy;

- the Energy Research Institute (ERI), which provides considerable expertise on all aspects of energy policy;
- the Development Research Center (DRC), which supports the State Council with research on carbon markets, urbanization, innovation and many other topics related to climate policy;
- the Chinese academies (including the Chinese Academy of Sciences and the Chinese Academy of Engineering), which have deep expertise on topics related to climate science and clean energy technologies; and
- leading Chinese universities (including Tsinghua, Peking and Renmin), with professors in many disciplines playing important roles in advising government leaders.[4]

Chinese state-owned enterprises also play an important role in shaping China's climate policies. Among those most directly affected by Chinese climate policies are the major power companies, electric utilities, oil and gas companies, and coal companies. CEOs of these companies generally have rank equivalent to that of ministers within the Chinese government. Many of them are developing low-carbon technologies with the government's financial support and are key stakeholders in the central government's new emissions trading program.[5]

Chinese provinces play a key role in the implementation of climate policies. Under China's "target responsibility system," many of the central government's key climate and energy targets are allocated to individual provinces, with provincial leaders responsible for fulfilling them. Each province has its own Climate Change Leading Group, chaired by top provincial leaders.[6]

NATIONAL LEADING GROUP ON CLIMATE CHANGE, ENERGY CONSERVATION AND EMISSIONS REDUCTION

Ministerial Members[7]

Ministry of Foreign Affairs

National Development and Reform Commission

Ministry of Education

Ministry of Science and Technology

Ministry of Industry and Information Technology

Ministry of Civil Affairs

Ministry of Finance

Ministry of Land and Resources

Ministry of Environmental Protection

Ministry of Housing and Urban-Rural Development

Ministry of Transport

Ministry of Water Resources

Ministry of Agriculture

Ministry of Commerce

National Health and Family Planning Commission

State-Owned Assets Supervision and Administration Commission

State Administration of Taxation

General Administration of Quality Supervision, Inspection and Quarantine

National Bureau of Statistics

State Forestry Administration

National Government Offices Administration Legislative Affairs

Office of the State Council Chinese Academy of Sciences

China Meteorological Administration

National Energy Administration

State Oceanic Administration

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ACKNOWLEDGEMENTS

This Guide is a team effort.

I am enormously grateful to the many students at Columbia University's School of International and Public Affairs whose research over several years has contributed to this Guide. They include Ella Chen, Celia Cui, Lilian Dong, Du Sha, Guo Xinli, Hua Yue, Krina Huang, Ji Yinghuang, Lan Tianying, Li Mingjun, Li Yijin, Li Yunxi, Lin Yuqian, Liu Sizhou, Sun Yunwen, Sunny Wan, Wang Fang, Wang Jialun, Wang Qingyi, Wang Yue, Wang Yulei, Yang Jinxi, Yang Yinhe, Yu Zheng, Zhang Tuo, Zhao Xijin, Caroline Zhu and Zhu Ruixing.

I'm deeply grateful as well to friends and colleagues who read portions of the manuscript, offering hugely valuable comments. They include Feng An, Maya Ben Dror, Xavier Chen, Michael Eckhart, Tad Ferris, Anders Hove, Mark Levine, Ken Lieberthal, Lynn Price, Varun Sivaram, Xiaopu Sun, Kevin Tu, Vance Wagner, Durwood Zaelke, Zhu Liu and several anonymous reviewers as part of the Center on Global Energy Policy's blind peer review process. Mistakes are of course my own.

Colleagues at the SIPA Center on Global Energy Policy at Columbia make this Guide possible. I'm hugely grateful to Jason Bordoff for his visionary leadership of the Center and many years of friendship. Many thanks as well to Yan Sheng, Du Jingjing, Zhang Xuan, Sally Qiu, Jesse McCormick, Matt Robinson, Megan Burak and Anna Gossett for their tremendous support and assistance.

I'm especially grateful to Dean Merit Janow of the School of International and Public Affairs, whose leadership helps to make Columbia University such an exciting place to study contemporary China.

Enormous thanks to the Hewlett Foundation and Rockefeller Brothers Fund, whose generous financial support makes this Guide possible. More information is available at http://energypolicy.columbia.edu/about/mission.

My deepest thanks go to my parents Terry and Ina, who inspired a love of learning and so much more, to my children Ben, Maya and Holly, who teach me more and more each year, and to the love of my life, my wife Holly Hammonds, for joining me on the journey.

Finally, my thanks to all of you who will read this Guide and send comments or updates to ChineseClimatePolicy@sipa.columbia.edu. This is a "living document." It will be updated and modified on a website to be launched in Fall 2018. New editions will be published regularly. I'm grateful for any and all thoughts or comments you may have.

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