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Transforming the Power Sector in Developing Countries

The Critical Role of China in Post-Paris Implementation

Dr. Robert F. Ichord, Jr.

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Cover photo: Carlos Barria/Reuters. A worker inspects solar panels at a solar farm in Dunhuang, 950km northwest of Lanzhou, Gansu Province, September 16, 2013.

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EXECUTIVE SUMMARY

The global transformation of the electric power sector will be one of the key factors determining the success of the 2016 Paris Agreement on climate change in curbing greenhouse gas (GHG) emissions. Since the International Energy Agency projects that almost 90 percent of world growth in electricity generation in 2014-2040 will occur in the developing and non-OECD (Organisation for Economic Co-operation and Development) countries, increasing investment in clean energy and changing the electricity mix in these countries are of critical importance. China's role will be central, accounting for an estimated one-third of future electricity growth in the non-OECD countries.[1]

This report is the second in the Atlantic Council series *Transforming the Power Sector in Developing Countries*, which analyzes key countries within a "meta" strategic framework. It focuses on China, the world's largest electric power system, largest GHG emitter, and second largest economy in the world. And, as far and away the globe's biggest coal producer and consumer, China faces enormous challenges in addressing its growing environmental problems and diversifying its fuel and electric power generation mix. Encouragingly, the Chinese government has made a serious commitment to reduce the role of coal and carbon dioxide intensity in its economy and China's positive role in the Paris process prompted other developing countries to participate in the agreement.

The Chinese government under President Xi Jinping has charted a policy to reform the electric power sector and increase the share of non-coal sources in the power mix. As part of the transition to cleaner, more efficient sources, the government has begun restructuring the energy sector by opening up a power system dominated by major coal generators and introducing more market-based pricing. The relative slowdown in economic growth over the past few years has created both a barrier and an opportunity to advance this plan. Demand for electricity has slowed, particularly in large industry, reducing coal demand and creating substantial excess capacity. Major new capacity additions in wind, solar, hydro, and nuclear have further reduced coal demand and exacerbated the surplus condition. This situation has created tensions in various regions over the dispatching of power and the economic impact of coal mine closures and reduced generation revenues. The government and state banks have pumped money into key industries to sustain production and encourage expansion of overseas energy project development through the state's so-called policy banks.

This report discusses these key challenges and some of the policy directions the Chinese government might consider following. Suggested priority actions include rationalization of the thermal power generation capacity, improved transmission access for renewables and cross-provincial electricity trade, more economically driven power dispatch, limits on financing for bankrupt companies, a shift in the lending profile for international energy projects to cleaner sources, continued unbundling of the monopolistic power structure and movement to third-party access, and facilitation of private investment in alternative generation and green bonds. A key recommendation is to consider introducing a carbon tax—as the International Monetary Fund has suggested as a more efficient and effective option—as opposed to the current plans for a national emissions trading system open to bureaucratic manipulation and corruption.

The Chinese government was somewhat open to working with the Barack Obama administration on aspects of these issues. The new Donald Trump administration should recognize that the United States has mutual commercial, economic, and political interests in continuing an engagement with China in this sector.

1 International Energy Agency, *World Energy Outlook 2016* (Paris: Organisation for Economic Co-operation and Development, 2016), 552, 584, 600.

INTRODUCTION

This is the second in a series of Atlantic Council reports on the transformation of the electric power sector in the developing and non-OECD (Organisation for Economic Co-operation and Development) countries and its implications for the success of the Paris Agreement on climate change, ratified by the United States and China in September 2016 and signed by 124 other countries to date.

China's role in the global transformation process toward clean energy and in the implementation of the Paris Agreement, which entered into force on November 4, 2016, is huge. It has become increasingly clear that the Chinese leadership has made a profound political and financial commitment to dealing with both its domestic environmental problems and the global challenge of climate change. China and the United States' joint announcement of their commitments to reduce emissions and China's announced intention to peak its carbon dioxide (CO_2) emissions by 2030 were instrumental in galvanizing support, particularly in the non-OECD world, for the Paris Agreement and the submission of serious, aspirational nationally determined contributions (NDCs) for mitigation and adaptation. At the time of this writing, however, the election of Donald Trump as president of the United States and his critical statements and actions related to both climate change policies and relations with China have introduced uncertainty and concern over the future of the Paris process and the role of the two largest economies and CO_2 emitters.

China is the largest emitter of greenhouse gases (GHGs) and the biggest producer and consumer of coal in the world. China accounted for an estimated 47.7 percent of global coal production in 2015 and 50 percent of its consumption.[2] The International Energy Agency (IEA) estimated that in 2014, coal provided 66 percent of China's primary energy, 84 percent of its power sector primary energy, and 57 percent of the industrial energy supply.[3] Chinese CO_2 emissions exceeded 8.6 gigatons (GT) in 2014, which amounted to about 25 percent of global energy-related CO_2 emissions in that year.

Despite its economic ascension in recent years, China's gross domestic product (GDP) per capita on a PPP (purchasing power parity) basis was only $13,400 in 2015, or about 75 percent of the world's average.[4] Further economic growth is a critical objective for Chinese leaders, implying large future increases in energy consumption. Given its massive role in global emissions, now and into the future, China's actions to move toward a cleaner fuel mix, particularly in its power sector, are critical. By applying the framework of the first strategy paper in this series, *Transforming the Power Sector in Developing Countries: A Strategic Framework for Post-Paris Action*,[5] this paper delves into some of the factors affecting change in China's power sector and suggests some key policy directions and related actions that the Chinese government and other interested actors should consider to accelerate the transformation.

The world economy has certainly felt the effects of the slowdown in Chinese economic growth over the past two years. But even the official GDP growth number of 6.9 percent for 2015 and estimated 6.7 percent in 2016 entail large increases in energy demand with significant impacts on global energy markets and GHG emissions. BP estimates that China accounted for the largest increment of world primary energy demand of any country in 2015 and continued as the largest net crude oil and product importer.[6] Crude imports increased further during 2016 as China ramped up supplies from Iran after sanctions were removed.[7] Energy market analysts and policy makers around the world will be watching closely to see how quickly the combination of slower growth and policies to diversify and improve energy efficiency can change the trajectory of Chinese GHG emissions.

2 *BP Statistical Review of World Energy* (London: British Petroleum, June 2016), 32-33.

3 International Energy Agency, *World Energy Outlook 2016*, 598.

4 "China GDP Per Capita PPP: 1990-2016," Trading Economics.

5 Robert F. Ichord, Jr., *Transforming the Power Sector in Developing Countries: A Strategic Framework for Post-Paris Action,* The Atlantic Council, Global Energy Center, 2016.

6 *BP Statistical Review of World Energy*, June 2016, 2 and 19.

7 Dan Strump and Jenny W. Hsu, "Asia Soaks Up Iranian Oil," *The Wall Street Journal*, October, 10, 2016, C3.

THE CHALLENGE

China is at a historic turning point in the development of its economy and energy system. The structural change in its economy and movement away from the heavy industry model is creating enormous pressures on businesses and labor as well as challenges for the energy transformation process. The massive electric power sector in China, the largest in the world with over 1,500 gigawatts (GW) of installed capacity[8] (compared with 1,100 GW in the United States[9]), will play a central role, and the nature and pace of its movement away from coal will be decisive for both the Chinese and world economies. The following sections identify key dimensions of the power transformation challenge.

Meeting Growing Energy Demands and Changing the Fuel Mix

Chinese leadership has articulated a rapid diversification strategy based on increasing energy efficiency; expanding the use of renewable energy, nuclear energy, and natural gas; and reducing coal use and emissions from the resource through carbon capture and sequestration (CCS). There is growing evidence that Chinese coal production and use may peak earlier than expected. Production reportedly declined in 2014, 2015, and 2016 (see figure 1, p. 4).

Electricity growth rose only 0.5 percent in 2015 as consumption fell in heavy industry.[10] This low rate of growth is surprising given the reported 6.9 percent growth in GDP, implying the economy may be weaker than the statistics imply. But official government estimates for January–August 2016 show a rebound in the electricity growth rate to 4.2 percent.[11] The structure of the Chinese economy is changing and the government has stressed the need to move to a more sustainable economic growth model with greater efficiency, innovation, and orientation toward services. Services were reported to have increased to 56.9 percent of GDP in the first quarter of 2016.[12] This trend seems to be reflected in the growth in electricity consumption in the light industry, tertiary industry, and residential sectors in 2015. The increased electricity consumption in 2016 was highest in these sectors and was spurred by demand for air conditioning as well as an expansion in manufacturing. Residential demand in August 2016 grew by an amazing 19.9 percent.[13]

"The structure of the Chinese economy is changing and the government has stressed the need to move to a more sustainable economic growth model. . ."

Improving Governance and Transparency

The Chinese energy sector is run by a huge, state-run bureaucracy and is dominated by extremely large, mainly state-owned companies. The transparency and openness of management in the sector is limited. The slowdowns in economic growth and energy demand have created an unprecedented excess capacity in the energy, construction, and engineering fields. The government announced plans to lay off 1.8 million workers in the coal and steel industries as a result and is developing programs to deal with displaced workers. But despite the Chinese government's announcement to cut steel capacity by 150 million tons by 2020, steel exports were at record levels during the first six months of 2016 and in June were 23 percent higher than in June 2015.[14]

The extent to which there will be domestic political backlash from the economic slowdown will become evident soon. We have clearly seen political

8 "China's Power Generation Fell in 2015, for the First Time since 1968," Enerdata, January 21, 2016, http://www.enerdata.net/enerdatauk/press-and-publication/energy-news-001/chinas-power-generation-fell-2015-first-time-1968_35800.html.

9 Paul Zummo, *America's Electricity Generating Capacity, 2015 Update*, American Public Power Association, 2015, 1.

10 Adam Rose and Kim Coghill, "China's 2015 Power Consumption Up 0.5 Pct Year on Year," Reuters, January 17, 2016.

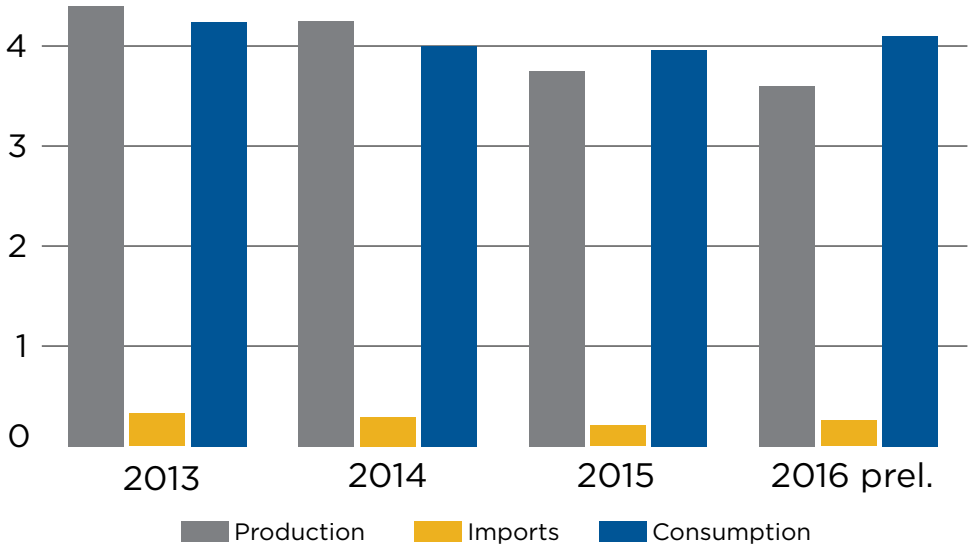
11 Yawen Chen, Kevin Yao, and Christian Schmollinger, "Update 2 – China's August Power Consumption Rises on Hot Temperatures – NDRC," Reuters, September 14, 2016.

12 Xin Zhiming, Wang Yanfei, and Ma Si, "Economy Stabilizing, Figures Show," *Washington Post*, China Daily Supplement, April 27, 2016, H5.

13 Ibid.

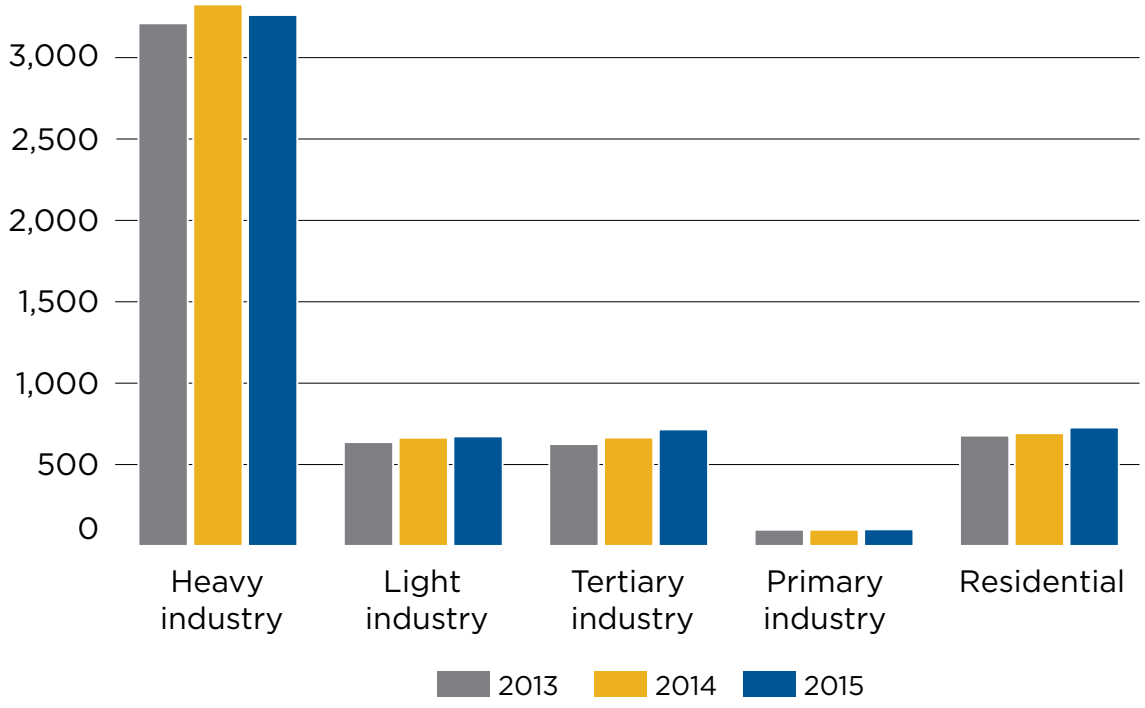
14 "China's Steel Exports Jump to Second Highest amid Tensions," Bloomberg, July 13, 2016.

Figure 1. Estimated Chinese Coal Production, Imports, and Consumption 2013-2016 (preliminary) (billion tons)



Sources: Chinese coal data vary widely and the government has revised the numbers for past years. Overall coal production appears to be declining, though imports and consumption were slightly higher in 2016 preliminary statistics.
This table is drawn from a number of sources: David Stanway and Himani Sarkar, "China to Close More Than 1000 Coal Mines in 2016: Energy Bureau," Reuters, February 22, 2016, http://www.reuters.com/article/us-china-energy-coal-idUSKCN0VV0U5; Ayaka Jones, "Recent Statistical Revisions Suggest Higher Historical Coal Consumption in China," US Energy Information Administration, September 10, 2015, http://www.eia.gov/todayinenergy/detail.php?id=22952&src=email;Meng Meng and Richard Pullin, "Update 1 – China 2016 Coal Imports Jump 25 Percent—Customs" Reuters, January 13, 2017, http://af.reuters.com/article/idAFL4N1F31KA; Fang Cheng and Chen Aizhu, "China Coal Output Extends Decline Despite Government Call to Reopen Mines," Reuters, November 14, 2016, http://www.reuters.com/article/us-china-economy-coal-output-idUSKBN1390GP.

Figure 2. Chinese Electricity Consumption, 2013-2015 (billion kilowatt hours)



Source: "China's 2015 Power Consumption Up 0.5 Pct Year on Year," Reuters, January 17, 2016.

ramifications from industry declines in certain coal-producing regions of the United States, United Kingdom, and recently Germany, as well as other countries. Moreover, the United States and European Union have already reacted to Chinese trade dumping actions, especially with respect to Chinese low-price steel exports; the United States, for example, has imposed new tariffs and strongly urged China to curtail subsidized steel production and exports at the June 6-7, 2016, US-China Strategic and Economic Dialogue in Beijing.[15]

Tackling Environmental and Social Problems

The environmental, health, and social consequences of the extensive and inefficient use of coal in power and industry[16] have been enormous. Of the 362 cities monitored in the first three months of 2016, 310 failed to meet national standards for 2.5 parts per million particulates—those small enough to be hazardous to human health—in the air. On December 16, 2016, China issued its first red alert in Beijing and environmental officials advised twenty-three other cities to issue red alerts as well due to intense air pollution. The red alerts require schools, hospitals, and businesses to cut production and services, and consumers to limit vehicle use.[17] The serious threat to health from air, water, and soil contamination has created a political imperative for the Communist Party leadership to chart a radically different energy reform strategy. International focus on climate change has intersected with these domestic political forces to increase the level of ambition of the reforms. China's potential and its government's desire to be a dominant player in the global clean energy economy are also important policy drivers.

Achieving Power Sector Financial Viability

The Chinese government has provided enormous subsidies to the energy and power sector and the large and inefficient state-owned companies are now dealing with a serious overcapacity situation and a lack of coordination among generators, transmission, and distribution entities. One study estimates subsidies to coal alone at $5.8 billion in 2013, including tax relief, investment, compensation for mine closures, value-added tax rebates, and other direct payments.[18] The leadership faces the challenge of rationalizing the sector and increasing financial transparency while simultaneously bringing in new capital.

15 See "2016 US-China Strategic and Economic Dialogue US Fact Sheet – Economic Track," Press Center, US Department of the Treasury, June 7, 2016, https://www.treasury.gov/press-center/press-releases/Pages/jl0485.aspx.

16 "China's Air Pollution Shifts West in First Quarter 2016," *The Straits Times*, April 20, 2016.

17 Christian Shepherd, Clarence Fernandez, and Tom Hogue, "China Wants 23 Northern Cities Put on Red Alert for Smog," Reuters, December 16, 2016.

18 "Subsidies to Coal and Renewable Energy in China," International Institute for Sustainable Development, November 2, 2015, https://www.iisd.org/gsi/renewable-electricity-subsidies/subsidies-coal-and-renewable-energy-china.

STRATEGIC PRIORITIES

Creating a Sound Policy, Legal, and Regulatory Framework

Issue: China's power system needs a more market-based and less politically and administratively driven regulatory framework to reduce emissions and energy intensity.

Discussion: Over the past two years, the Chinese government has taken a number of important policy steps toward transforming the power sector. In addition to China's announcement that it intends to peak CO_2 emissions by 2030, the National Energy Administration (NEA) ordered in April 2016 a halt to construction of new coal power plants in thirteen provinces and delays for already-approved projects in a further fifteen provinces.[19] NEA also placed a moratorium in 2015 on new coal mines in China for a period of three years and announced a plan to close a thousand small mines. In early 2017, NEA ordered the halt of one hundred coal projects in eleven provinces.[20]

Energy price reform is a priority area under the current 13th Five Year Plan (2016-2020). The National Development Reform Commission (NDRC) plays a lead role on pricing issues and its tariff office sets key fuel, wholesale, and retail electricity prices. NDRC has been trying to liberalize oil, gas, and electricity prices by introducing more market mechanisms with a goal of instituting reforms by the end of 2017, but policies have exhibited considerable inconsistency. For example, wholesale gas prices were increased to stimulate domestic production but subsequently were lowered 25 percent to encourage greater consumption. In general, the drop in international energy prices and domestic oversupply have led to a downward adjustment in prices, although coal prices have recently been rising. NDRC has stated its desire to move towards "netback market value prices," in which benchmarks are established and pegged to the prices of alternative fuels. This approach is being tested in Guangdong Province. The "Further Strengthening the Institutional Reform of the Electric Power Industry" Document #9, released by the State Council in March 2015, calls for continued regulation of transmission and distribution prices and their separation from generation and wholesale prices while concurrently providing latitude for generators to negotiate prices directly with major consuming industries.[21]

Energy pricing policy is and will increasingly be intertwined with environmental regulations. President Xi Jinping announced China's intention to develop a national emissions trading system in 2017 during his meeting with US President Barack Obama in September 2015.[22] China carried out pilot trading programs from 2013 to 2015 in Beijing, Shanghai, Tianjin, Chongqing, Guangdong, Hubei, and Shenzhen. Local authorities were given flexibility in developing these CO_2-only cap and trade schemes, which varied in terms of industrial sector coverage and implementation details. A paper by Zhong Xiang Zhang of the Australian National University indicates the pilots covered 38-57 percent of CO_2 emissions across the regions, included 1,919 entities, and issued 1.2 billion in CO_2 allowances.[23] He comments that developing a national system would involve a "daunting challenge to decide which sectors are to be covered under emissions trading, how to set their emissions caps and allocate permits among companies covered within sectors, and how to enforce compliance of regulated entities."[24]

In addition to these challenges, there are risks associated with implementing a cap and trade system. There is a clear possibility that such a complex system would be open to manipulation and corruption, not to mention the problems experienced in other cap and trade systems such as the Emissions Trading System in Europe (e.g., too high a cap, generous allocations of permits, no consistent rising carbon price, companies passing on costs to consumers).[25] Given the enormous

19 Hao Feng, "China Puts an Emergency Stop on Coal Power Construction," The Diplomat, April 7, 2016.

20 Josephine Mason, Vyas Mohan, and Tom Hogue, "In Latest Move, China Halts More Than 100 Coal Power Projects," Reuters, January 17, 2017.

21 Liu Xiying and Kong Lingcheng, "A New Chapter in China's Electricity Market Reform," Energy Studies Institute Singapore, Policy Brief, March 21, 2016.

22 Angeli Mehta, "China Launches National Wide Emissions Trading Scheme," Chemistry World, October 6, 2015, https://www.chemistryworld.com/news/china-launches-nationwide-emissions-trading-scheme/9025.article.

23 Zhang Xiang Zhang, "Carbon Emissions Trading in China: Evolution from Pilots to a Nationwide Scheme," Australian National University Working Paper 1503, April 2015.

24 Ibid.

25 Numerous articles describe the ETS problems. See, for example, Will Denayer, "Why the Market Approach Fails to Lower Greenhouse Gas Emissions. Part 2: The Failure of the EU Emissions Trading System," Flassbeck Economics International, May 12, 2016, http://www.flassbeck-economics.com/why-the-

Photo of a coal-fired power plant in Shuozhou, Shanxi, China. *Photo credit:* Kleineolive/Wikimedia.

potential for problems in managing a national trading system, it may be important to consider President Xi's current high-profile campaign to crackdown on corruption, which has involved at least some energy officials.[26]

A cap and trade system is also not the most impactful policy option. The International Monetary Fund has concluded that a carbon tax or a tax on coal use are the most effective policies for reducing CO_2 emissions, and that an emissions trading system applied to the power sector and large industry would have only about 60 percent of the environmental and 50 percent of the fiscal impact of carbon and coal tax policies.[27]

Policy Recommendation: Before implementing a bureaucratic, complex national emissions trading system prone to corruption, China should consider a simpler, more transparent carbon tax. A tax would generate revenues that could be used to further improve energy efficiency and support other clean energy initiatives.

Establishing an Efficient Institutional and Market Structure

Issue: China has an inefficient power market that needs fundamental restructuring and improved, transparent governance to promote competition and non-discriminatory access for renewable energy generators.

Discussion: China's largely coal and hydropower energy system is dominated by big state-owned companies with strong ties to regional, provincial, and municipal interests. Given the vested interests of these companies in the coal industry, reforming this entrenched structure to accommodate renewables

market-approach-fails-to-lower-greenhouse-gas-emissions-part-2-the-failure-of-the-eu-emissions-trading-system/.

26 "China Says 300,000 Punished for Corruption," CBS News, March 6, 2016, http://www.cbsnews.com/news/china-300000-punished-for-corruption-in-last-year/.

27 Ian Parry, Baoping Shang, Philippe Wingender, Nate Vernon, Tarun Narasimhan, *Climate Mitigation in China: Which Policies Are Most Effective?* IMF Working Paper 16/148, International Monetary Fund, July 2016.

and private involvement will be difficult. Five large state-owned generation companies were formed after the government broke up the monopoly as part of the unbundling of transmission and distribution from generation in 2002. These five companies have major coal power assets and now generate 566 GW (39 percent of total capacity in 2015) and account for up to 50 percent of China's power output. Below is a breakout of these companies, plants, and capacity.[28]

1. China Huaneng Group: 130 plants with 110 GW
2. China Huadian Group Corporation: 70 plants with 123 GW
3. China Datang Corporation: 68 plants with 120 GW
4. China Guodian Corporation: 94 plants with 123 GW
5. China Power Investment Corporation: 65 plants with 90 GW

These companies are seeking to maintain their influence by moving into renewable energy ventures. Some of these companies, like China Datang, have established hydro and other renewable energy plants and have subsidiaries for diversification purposes and for international operations. Other companies, e.g., Three Gorges and Sinohydro, concentrate on hydro. Three main companies are leading the nuclear area: China National Nuclear Corporation, China General Nuclear Power Corporation, and the China Power Investment Corporation.

Two transmission companies, the State Grid Corporation of China (SGCC) and Southern Power Grid, were created to provide separate management over the high-voltage transmission system. Inner Mongolia has its own grid company. Including the Southern Power Grid, there are six regional/provincial grid companies that, along with municipal entities, own and operate most of the distribution networks in their localities.[29]

With the release of State Council Document #9 on Power Reform, the Chinese government signaled its intention to introduce some significant structural changes in the power system, i.e., create more competition among generators, allow private participation in distribution and retail, direct contracts between generators and industry, foster greater inter-regional trade, and integrate renewables into the system. Although implementing regulations are under development, companies are reportedly already being formed to position themselves for roles in distribution. This development seems to follow the path of the earlier Chinese opening of gas distribution to private companies.

A key priority is therefore to develop a detailed electricity market design that will spell out the interaction between and among generators, grid companies, and distribution and retail operators in a way that will move toward a more competitive system and away from the state-dominated single-buyer model. Whether this is politically possible given the depressed state of the power/coal industry remains to be seen.

Policy Recommendations: The central government should more fully unbundle the energy system and establish a bilateral contracts market to begin moving away from the single-buyer system. The government should establish stronger regional system operators, independent from the dominant state generators, that can formulate transparent, appropriate market rules and trading platforms for their regions to foster economic dispatch, improved transmission and load planning, and cost-reflective pricing.

Achieving a Cleaner and Resilient Generation Mix

Issue: Overcapacity and electric transmission system bottlenecks—as well as grid access problems for renewable generators—are slowing the transition to a cleaner energy mix.

Discussion: China's NDC target calls for not only peaking emissions by 2030, but also reducing CO_2 intensity (CO_2 emissions per unit of GDP) by 60-65 percent by 2030 from 2005 levels and increasing non-fossil fuel energy production to 20 percent by 2030. The Chinese government has charted a policy to greatly expand renewable energy, nuclear, and hydro power use. Despite these plans, the IEA still projects substantial coal capacity growth in its New Policies Scenario (see figure 3). This scenario has total electricity generating capacity growing from 1,382 GW in 2014 to 2,612 GW in 2030 with coal increasing by 268 GW and still representing 43 percent of total capacity.[30] China added 71 GW of new thermal, mainly coal, generating capacity in 2015.[31] But it is certainly

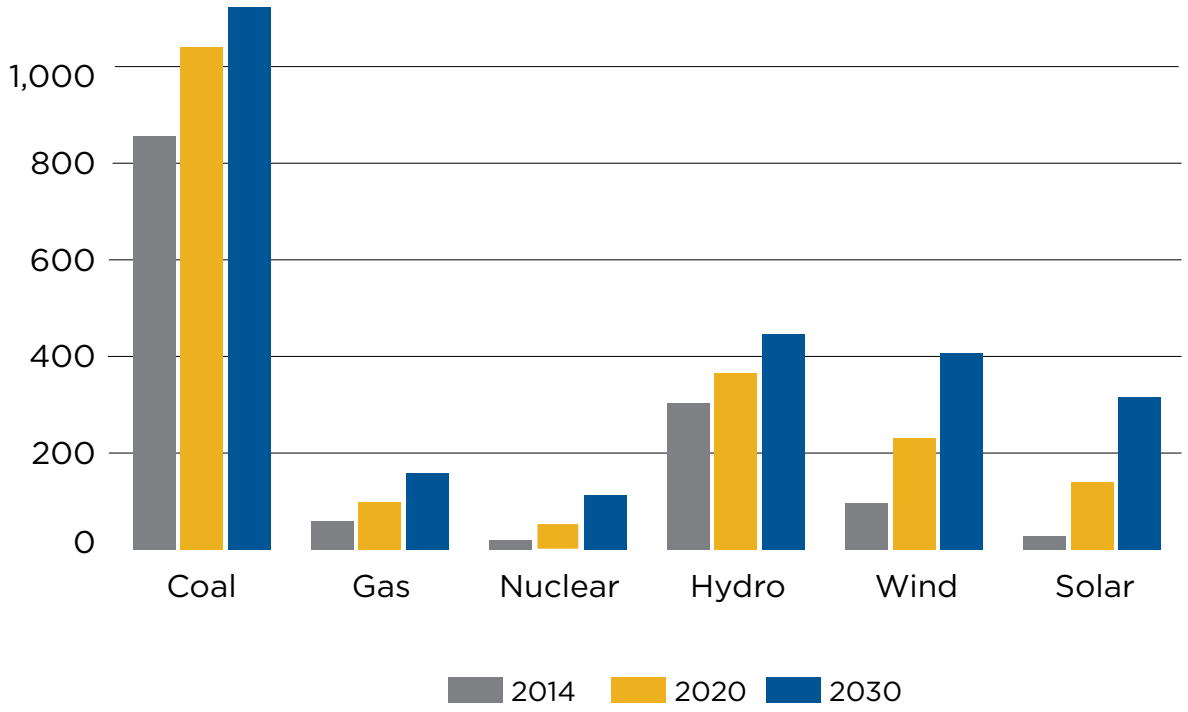
28 See company websites: www.cdt.com.cn; www.cgdc.com.cn; www.eng.chd.com.cn; www.chng.com.cn; www.eng.cpicoro.com.

29 *China's Power Sector: A Backgrounder for International Regulatory and Policy Advisors*, The Regulatory Assistance Project, February 2008, 5, http://www.raponline.org/wp-content/uploads/2016/05/rap-chinapowersectorbackground-2008-02.pdf.

30 International Energy Agency, *World Energy Outlook 2016*, 600.

31 "China's Electricity Mix: Changing So Fast That CO_2 Emissions May Have Peaked," Energy Post, March 1, 2016.

Figure 3. Projected Changes in China's Electricity Mix IEA New Policies Scenario 2016 (GW Capacity)



Source: IEA World Energy Outlook 2016, p. 600.

possible, though probably unlikely, that annual electricity growth will be lower than the 2.2 percent assumed in this scenario.

Nevertheless, hydro, wind, and solar capacity and generation are projected to grow significantly. The increase in Chinese renewable energy investments in 2015 was a world record—with 32.5 GW of wind and 18.3 GW of solar added from a Bloomberg estimate of $110.5 billion in investment.[32] Grid-connected solar grew by 73.7 percent to reach 43.18 GW and grid-connected wind increased by 33.5 percent to a total of 129.34 GW.[33]

Together with hydro and nuclear use, the expansion of wind and solar caused thermal generation to fall in 2015 by 2.7 percent (see table 1). However, though wind and solar accounted for 8.5 percent of installed capacity in 2015, they supplied only 4.7 percent of electricity output due to grid access problems and lower efficiency. Transmission constraints have been a major problem. As a result of these issues, wind curtailment has been increasing, averaging 8 percent in 2014, 15 percent in 2015, and an estimated 19 percent during the first nine months of 2016. It was higher in some provinces like Gansu (46 percent); Xinjiang (41 percent); Jilin (34 percent); and Inner Mongolia (23 percent).[34] NEA placed some projects on hold in 2015.

The recent Five Year Plan for Power now targets 110 GW of solar and 210 GW of wind by 2020, a reduction from previous targets of 150 GW for solar and 250 GW for wind. The rate of investment slowed significantly in 2016 and was down 50 percent during the first quarter of 2016 compared with the previous quarter.[35] Besides the slower economy, some incentives, like the onshore wind feed-in-tariff, expired at the end of 2014. Preliminary Bloomberg estimates for 2016 show that while wind additions of 24-25 GW were lower than in 2015, commissioned solar photovoltaic (PV) of 26.5 GW was higher.[36]

State Council Document #9 on Power Reform, released in March 2015, also highlights the need for improved system planning to respond to both the

32 "Clean Energy Defies Fossil Fuel Price Crash to Attract Record $329 BN Global investment in 2015," Bloomberg New Energy Finance, January 14, 2016.

33 "China's Electricity Mix," Energy Post.

34 Brian Spegele, "China to Put a Little Less Energy into Clean Power," *The Wall Street Journal*, December 5, 2016, A9.

35 "China Lull Behind Quiet Quarter for Global Clean Energy Investment," BNEF News, April 19, 2016.

36 Michael Liebreich, "A Year of Hectic Change and Off-Target Predictions," Bloomberg New Energy Finance, Review of the Year, December 13, 2016.

Table 1. Chinese Electricity Generation 2014, 2015

	2014 TWh	2015 TWh	% Change	TWh Change	% Share 2014	% Share 2015
Thermal	4359.7	4242	-2.7	-117.7	75.3	73
Hydro	1072.8	1126.4	5	53.6	18.5	19.4
Nuclear	132.5	170.8	28.9	38.3	2.3	2.9
Renewables	228.2	271.4	18.9	43.2	3.8	4.7
Total	**5793.2**	**5810.6**	**0.3**	**17.4**	**100**	**100**

Source: "China's Electricity Mix: Changing So Fast That CO2 Emissions May Have Peaked," China National Bureau of Statistics, Institute for Energy Economics and Financial Analysis Calculations, in Energy Post, March 1, 2016. Units in Terawatt hours (TWh).

changing structure of the economy and the more complex, diverse sources of energy supply. The heavy industrial nature of China's development has matched China's highly centralized, baseload coal and hydro–dominated power system. In 2015, primary and secondary industry accounted for about 74 percent of total electricity generation of 5.81 trillion kilowatt hours (kWh). Heavy industry's share was 59 percent of the total. The residential sector represented only 13 percent and light industry and commercial most of the remainder. With increasing urbanization[37] and accompanying growth of demand in the services and residential sectors, the system will need more peak and flexible capacity.

Improved planning is needed to better integrate renewable energy into the grid, move to a market-based dispatching system, and incorporate stronger demand-side management (DSM) measures (see sections below on China's DSM pilots). In the past, the system has not operated on a least-cost basis. It has been characterized by a hierarchical system of dispatch—from national to regional, provincial, prefecture, and county levels—that has sought to maintain equal operating hours at the provincial level regardless of the thermal efficiency of the units.[38] With growing overcapacity in power plants, the capacity utilization of the thermal power plants fell in 2015 to below 50 percent. There are also limits in terms of the net transfer capacity between regions so the advantages from inter-regional trade have not been fully realized. As noted above, authorities have curtailed the dispatch of renewable energy plants in some areas due to grid limitations and SGCC officials have publicly admitted there has been a lack of proper planning.[39]

A key element of the emerging strategy for dealing with this changing demand structure and generation mix is to make huge investments in the transmission grid. Bloomberg reports that SGCC plans to increase spending 28 percent to $350 billion over the 2016-2020 Economic Plan period.[40] SGCC has gone to international financial markets to finance its expansion program, raising one billion euros in two Eurobond tranches in 2015.[41] China is a world leader in ultra-high-voltage, direct-current transmission (UHVDC) and SGCC has offered a vision of developing a UHVDC system not only for China but for the larger Eurasia region, even connecting with Europe. It is also working on connecting large renewable systems into high-voltage lines. SGCC announced the successful integration of a 5 MW wind turbine in September 2015.

China is continuing to place a major emphasis on hydro, hydro pumped storage, and the coordination of hydro and renewables to enhance system reliability. The connection between SGCC and hydro generators was recently strengthened when Three Gorges Hydro assumed a 30 percent ownership share in SGCC. A new hybrid solar-hydro complex at Longyangxia Dam on the Tibetan plateau, which includes a 320

37 "China Lays Out Population Forecast," *The Wall Street Journal*, January 26, 2017, A7. Chart in article suggests that urbanization percentage will increase from 53 percent to about 70 percent by 2030.

38 See Fritz Kahrl and Jim Williams, "China's Electricity System, A Primer on Planning, Pricing, and Operations," E3 at ethree.com, slide presentation for a description of the dispatch hierarchy, no date.

39 Feifei Shen, "China's Grid Operator Blames Bad Planning for Idled Renewable Energy," Renewable Energy World, April 1, 2016, http://www.renewableenergyworld.com/articles/2016/04/china-s-grid-operator-blames-bad-planning-for-idled-renewable-energy.html.

40 Aibing Guo, "State Grid to Boost Spending Plan 28% to $350 Billion," Bloomberg, January 21, 2016.

41 Bo Kong and Kevin Gallagher, *The Globalization of Chinese Energy Companies: The Role of State Finance* (Boston: Boston University, 2016), 7, https://www.bu.edu/pardeeschool/files/2016/06/Globalization.Final_.pdf.

"The International Renewable Energy Agency (IRENA) estimates that 45 percent of China's power generation facilities are located in areas of high water stress"

MW solar PV farm (with plans to increase to 530 MW) and a 1,280 MW hydro peaking station, has also been integrated into the grid.[42] Although comprising only 20 percent of total installed capacity, hydro is important regionally and in terms of system stability. Forecasted growth is slower for hydro, with a target of 350 GW by 2020 compared with current capacity of 319 GW. Environmental concerns exist over the expansion of hydro since dams—which alter ecosystem functioning—are being proposed for ecologically fragile Tibetan regions and the upper Yangtze River and there are concerns about downstream flooding. China Huadian Corporation recently announced the start of construction on the huge 1.2 GW Suwalong Dam at the intersection of Mangkam County in Tibet and Batang County in Sichuan despite substantial idle hydro capacity in this region due to transmission constraints and lower demand.[43] The situation is complicated by seasonal and cyclical variations in river flows that have led to the building of coal plants to ensure supplies during the dry season in some provinces. A major drought in 2011 forced many hydro plants to close. But the combination of large hydro facilities bringing power to major load centers via UHVDC lines is appealing to some policy planners.[44]

China is preparing for the changes in the structure of consumption by implementing demand-side pilot programs and developing plans for electric vehicles. The country announced a plan to develop twenty thousand charging stations as part of the overall national effort to move toward electric vehicles to reduce pollution in urban areas.[45]

China's provinces vary considerably in terms of their resources and renewable energy plans. Most have goals to reduce CO_2 intensity and diversify into renewables.[46]

Pressure on water resources is also driving Chinese energy diversification efforts. The power sector is currently responsible for 12 percent of Chinese water withdrawals. The International Renewable Energy Agency (IRENA) estimates that 45 percent of China's power generation facilities are located in areas of high water stress and that a 26 percent share from renewables in 2020 could reduce water use by 42 percent.[47]

A major growth area is expected to be offshore wind. Some provinces, like Jiangsu, have very favorable offshore wind potential. China announced a target of 30 GW in offshore installed wind capacity by 2020 and 52 GW by 2030, but Bloomberg indicates progress has been slow in this challenging new field. China was expected to add only 335 MW in 2015, bringing total offshore wind capacity to 911 MW.[48] NEA raised the feed-in tariff for offshore wind in 2014 to give companies a greater incentive to exploit this significant resource potential.

China is also making efforts to ramp up its nuclear program. It has thirty reactors in operation, twenty-four reactors under construction (26.76 MW), and plans to build six to eight plants a year until 2020 to increase capacity to 58 GW. There is international concern about the speed of this effort and the safety implications, and this goal is unlikely to be met. The government issued a white paper in 2015 that identified needed key improvements in nuclear safety regulations and emergency response preparedness, and construction problems and equipment quality concerns have seriously delayed the completion of eight reactors.[49] Chinese companies are moving aggressively in their pursuit of international nuclear markets, as discussed below. The setbacks in building the new domestic units, however, call into question not only whether nuclear, which accounts for only about 3 percent of domestic electricity generation at present,

42 Mathis Rogner, "Case Study, Solar PV-Hydro System at Longyangxia, China," International Hydropower Association, August 28, 2015.

43 Li Jin, "China Starts Construction of Tibet's Biggest Hydropower Plant on Upper Reaches of Yangtze River," *South China Post*, April 30, 2016.

44 Beth Walker and Liu Qin, "The Hidden Costs of China's Shift to Hydropower," The Diplomat, July 29, 2015.

45 Guo, "State Grid to Boost Spending Plan 28% to $350 Billion," footnote 40.

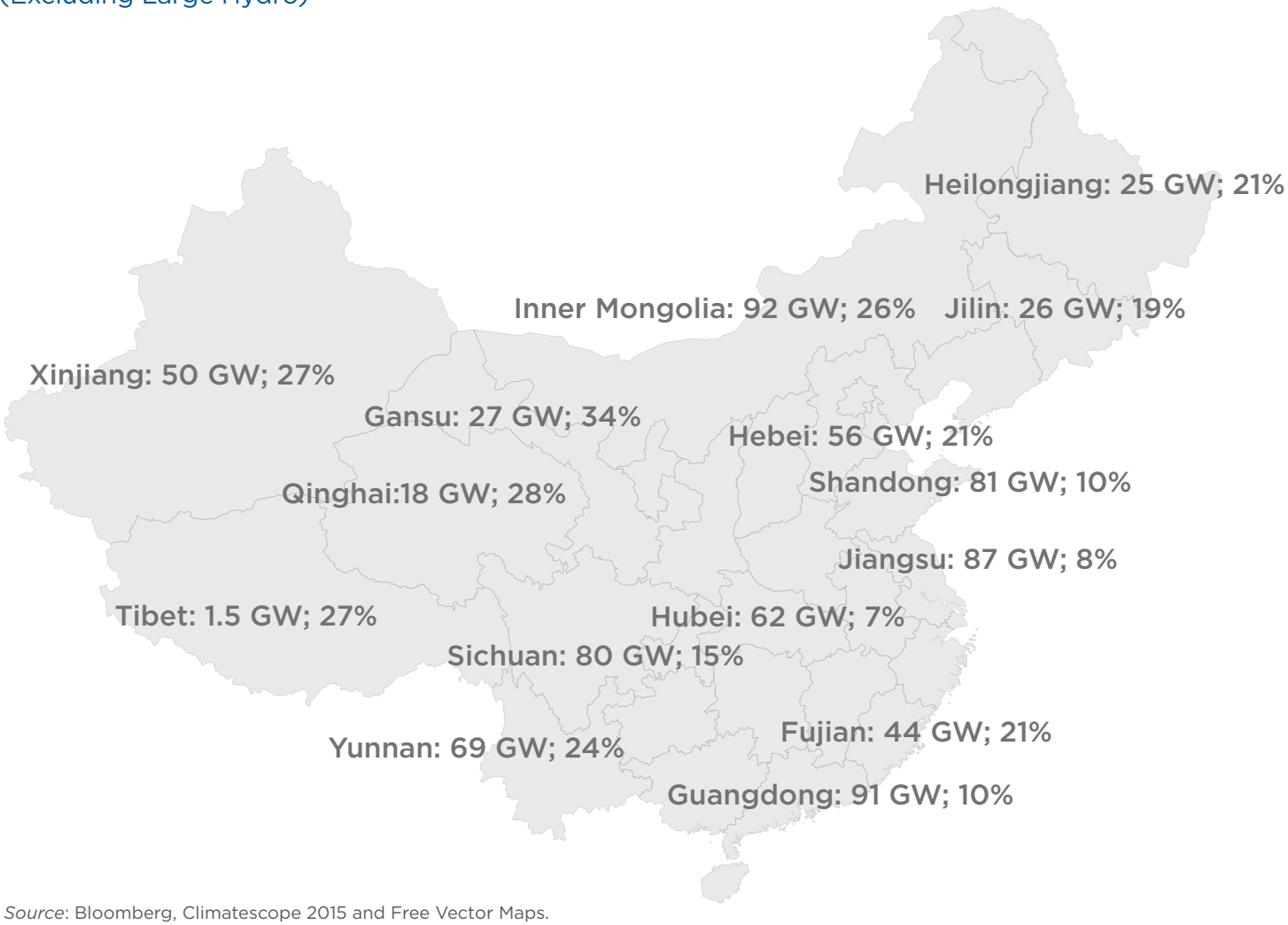
46 See Bloomberg New Energy Finance, *Climatescope 2015*, for a discussion of the situation in fifteen Chinese provinces.

47 Adilya Zaripova, "IRENA: Renewables Can Help China Reduce Water Use in Power Sector," *pv* magazine, March 9, 2016.

48 "China Set for GW-Scale Offshore Wind Market in 2016," Bloomberg New Energy Finance.

49 The State Council, People's Republic of China, Full Text of China's Nuclear Emergency Preparedness, www.english.gov.cn, January 27, 2016; For a current review of setbacks in China's nuclear program, particularly in the imported AP1000 and EPS units, see Steve Thomas, "China's Nuclear Power Plans Melting Down," *The Diplomat*, October 29, 2016.

Map 1. Installed Power Capacity in Select Chinese Provinces and Percentage of Renewables Use (Excluding Large Hydro)



Source: Bloomberg, Climatescope 2015 and Free Vector Maps.

can reach the 8-10 percent share foreseen in 2030, but also whether these problems will hamper China's international nuclear expansion efforts.

The diversification strategy also calls for increased development of natural gas for power. The current role of gas in the power system is very limited. Capacity was only 42.7 GW in 2013 with thirty billion cubic meters (bcm) of consumption (17 percent of domestic gas consumption). Besides pollution from larger coal plants, much of China's air pollution comes from coal burning from low-emission sources, i.e., small, inefficient boilers with inadequate controls and residential coal burning for heat in winter.[5051] China has moved to shut down these sources in a number of cities as natural gas systems can provide both electricity and heat to small industries and municipal facilities. Urban gas distribution networks are being expanded, especially in northern coastal cities where residential gas use for heating has increased.

According to the US Energy Information Administration, China added 12 GW of gas capacity in 2014 and is working to accommodate an additional 18 GW. Coal plants in the Beijing area are being replaced with 2.7 GW of gas.[51] China has seen a steady increase in domestic gas production as well as an expansion of liquefied natural gas (LNG) imports. Xiaojie Xu from the Chinese Academy of Sciences forecasts increasing gas supplies from imported LNG (90 bcm in 2030); pipeline imports (increases from 31 bcm to 80 bcm); and domestic shale gas beginning to come in at 6.5 bcm.[52] But the current lower-than-expected

50 [51] Brian Spegele, "Beijing's Plan for Cleaner Heat Leaves Villagers Cold," *The Wall Street Journal*, January 26, 2017, A7.

51 "China Country Brief," US Energy Information Administration, May 15, 2015.

52 Presentation by Xiaojie Xu at Center for Strategic and

demand for gas has resulted in substantial unused capacity in LNG regasification terminals and a drop in LNG imports in 2015.[53] China's natural gas production also slowed in 2015 to its lowest rate in ten years (2.9 percent) given the weak market and low gas prices.[54] Nevertheless, some energy policy experts, including at the NDRC, see gas as an essential element of China's future energy mix given constraints on coal, nuclear, and renewable development.[55]

Policy Recommendation: China should urgently rationalize its thermal generation capacity, which operated at less than 50 percent in 2015, by closing older and inefficient units. It should expand inter-regional transmission transfer capacity, and ensure China National Grid and lower voltage systems are not discriminating against clean energy generators (both renewables and natural gas) in dispatch and the provision of grid access.

Expanding Electricity Access to the Poor and Rural Areas

China is almost totally electrified so this area is not the strategic priority it is in other developing countries. In previous decades China invested heavily in extending power lines to villages and providing distributed renewable systems. The Township Electrification Program from 2001 to 2005 involved installing renewable energy systems (solar, hybrid wind, and small hydro) and mini-grids in these areas; the central government provided $293 million and eleven provincial governments allocated $437 million for these efforts.[56] The Countryside New Power Program in 2006 sought to complete universal electrification but some areas were not reached until the end of the 2011-2015 Five Year Plan, when the government allocated RMB 19.87 billion to connect the remaining 1.491 million households to the grid. These households were mainly located in remote areas of Tibet and Xinjiang.

International Electricity Cooperation and Collaboration with Neighbors on Regional Electricity Networks and Markets

Note: This section varies from the overall strategic framework of the first report (which in this strategic element stressed only collaboration with neighbors) and seeks to take into account China's extensive overseas power sector involvement and the strong interests of Chinese domestic power technology and engineering industries, especially given domestic surplus capacity, in expanding export markets.

Issue: The Chinese government is continuing to support its companies in overseas coal plant construction with subsidized financing packages.

Discussion: The regional and international dimensions of China's electricity transformation are of increasing significance from an energy security, economic development, and climate change perspective. Chinese energy companies have expanded their activities in almost every region and energy subsector over the past several years. While Chinese oil and gas and hydro companies (e.g., Sinopec and Sinohydro) have been active overseas for many years, there has been a recent surge of Chinese involvement in the renewables, nuclear, and electricity transmission areas.

From a climate change standpoint, Chinese overseas expansion in renewables, nuclear, and electricity transmission is generally welcome given the large capital investment requirements in the non-OECD countries and the difficulty of attracting investments in these perceived high-risk environments. But there are environmental, safety, and social and political issues that have characterized these ventures.

Chinese involvement in large hydro projects in Latin America, Africa, and Asia has attracted criticism from both international and domestic environmental groups for inadequate environmental and social impact evaluation and a lack of transparency and community involvement.[57] The case of the $3.6 billion Myitsone Dam project in Myanmar is perhaps the most notable example. The Myanmar government has halted the project due to persistent local opposition, but the Chinese are hoping the new government of Aung San Suu Kyi will change the country's position on this and other infrastructure projects.[58]

International Studies, Washington, DC, April 5, 2016.

53 Michael Lelyveld, "China Natural Gas Market Stalls as Prices Fall," Radio Free Asia, February 29, 2016.

54 Adam Rose and Christian Schmollinger, "Update 1 – China's 2015 Natural Gas Output Growth Slowest in at Least 10 Years," Reuters, January 19, 2016.

55 Energy Research Institute of the National Development and Reform Commission, "Policy Study: Gas-Fired Power Generation in China (Synthesis)," Understanding China's Energy Landscape, March 2016, http://www.understandchinaenergy.org/policy-study-gas-fired-power-generation-in-china-synthesis-report/.

56 "China's Mini-Grids for Rural Electrification," Case Study, United Nations Economic and Social Commission for Asia and the Pacific, no date.

57 See, for example, Vanessa Lamb and Nga Dao, "Perceptions and Practices of Investment: China's Hydropower Investments in Mainland Southeast Asia," paper presented at Chiang Mai conference in June 2015.

58 "China Seeks a Fresh Start in Myanmar," *The Wall Street Journal*, June 10, 2016, A10.

The Three Gorges Dam on the Yangtze River, China. *Photo credit:* Rehman/Wikimedia.

Chinese hydro companies, according to the nongovernmental organization International Rivers, are involved in 330 projects in seventy-four countries. Major companies include Sinohydro, China Datang Overseas Investment Co., China Huaneng Group, Gezhouba International, China Huadian Corp., China Three Gorges Corp., and PowerChina Resources. They are supported by the China Export-Import Bank and China Development Bank (the so-called policy banks).[59] One of the largest projects is the 1,500 MW Coco Coda Sinclair project in the Amazon Basin in Ecuador. It is reported that $1.68 billion of the originally estimated $2.6 billion is financed by the Chinese Export-Import Bank with Sinohydro as the implementer.[60]

In the nuclear arena, China aims to be a global leader. Its projects span the non-OECD regions and are particularly focused on Argentina, South Africa, Romania, Turkey, Saudi Arabia, and Pakistan. One important recent deal is an agreement with Argentina in November 2015 to finance and build two nuclear reactors, one a $6 billion CANDU 6 reactor and the other a Chinese Hualong One design. The China National Nuclear Corporation, which operates two CANDU 6 reactors at its Qinshan plant in Zhejiang Province, is the lead Chinese company in the deal. China is also building two CANDU reactors at Chernovoda in Romania, involving a reported $7.7 billion package with China General Nuclear Company as the lead.[61] China is looking to market overseas the Hualong One reactor, which is based on the relatively new Chinese ACP1000 design, which has been approved by the International Atomic Energy Agency. China is constructing two Hualong units in Pakistan near Karachi. The projects are being financed with $6.5

59 "China's Global Role in Dam Building," International Rivers, https://www.internationalrivers.org/campaigns/china-s-global-role-in-dam-building.

60 "Coca Codo Sinclair Hydroelectric Project, Ecuador," Power Technology, 2016, http://www.power-technology.com/projects/coca-codo-sinclair-hydroelectric-project/.

61 "Argentina and China Sign Two Reactor Construction Agreements," World Nuclear News, November 16, 2015.

billion from the China Export-Import Bank to Pakistan through a twenty-year loan.[62]

Chinese solar and wind companies are advancing as well in almost all the non-OECD regions. Data covering 2002-2012 show 124 investments in thirty-three countries; investment in just fifty-three of these projects totaled $40 billion.[63] The pace of involvement has picked up since 2012. Surplus industrial capacity inside China has been an important driver of power sector infrastructure projects around the world. Key markets of focus have included Brazil and South Africa, which have undertaken auctions for substantial wind and solar capacity. A growing number of ventures are being pursued in sub-Saharan Africa, notably in Kenya, Ethiopia, Tanzania, and Ghana. China took early advantage of Chile's major energy import dependence and excellent solar resources to launch solar photovoltaic projects. With funding from the China Development Bank, Hong Kong–based Sky Power committed in 2012 to invest $900 million in developing ten 30 MW PV plants throughout Chile. More recently, Sky Solar entered into a joint venture with US company Hudson Clean Energy Partners to develop a 44 MW PV installation in the northern Atacama Desert where power is needed for the mining industry and there is no main grid connection. They will also team up for projects in Uruguay.[64] As in the nuclear area, China is focusing its investment efforts in Argentina where SINOWIND Technologies is developing the 200 MW El Angelito wind farm in Patagonia for an estimated $440 million.[65]

A key question for the future as we look at China's overseas electricity sector involvement is how its policy of supporting coal power will evolve. China's extensive support for overseas coal power projects has come under scrutiny given the OECD countries' growing resolve to stop government financing for new coal projects. One estimate concludes that the Chinese financed between $21 and $38 billion in overseas coal power projects over the past ten years and that they have as much as $72 billion allocated to coal plants in the pipeline.[66] India, Indonesia, and Vietnam have been traditional destinations for Chinese efforts in coal power. But other countries—including Pakistan, Bangladesh, Philippines, Thailand, and even Georgia—are looking at coal to meet growing electricity demand. There has been speculation that China's concept of the New Silk Road includes an interest in building infrastructure to export coal from the large coal deposits in Xinjiang to Central Asia; the Chinese have had a presence in Kazakhstan's coal power sector for years. The Chinese have been leaders in building high-efficiency super- and ultra-critical coal units as well as in developing CCS plants, and the country is planning to replace older coal units with more efficient, CCS-ready plants domestically. But if domestic policies to limit new coal plant development are maintained, there is likely to be pressure from Chinese industry on the government to continue to support the export of Chinese goods and services in the coal sector.

Policy Recommendation: The Chinese government should phase out financing for overseas coal power projects without CCS and ensure financing for overseas power projects is on commercial, non-subsidized terms and uses a reasonable carbon price in considering viability. Chinese policy banks should reorient their funding to give greater priority to renewables and natural gas projects.

Attracting Domestic and International Investment and Financing

Issue: While China needs large investments in alternative, clean energy sources to transform its coal-dependent power sector, the government continues to prop up state companies in the coal, steel, and other heavy industry sectors, thereby contributing to the overcapacity problem and inflating wasteful and polluting coal production and generation.

Discussion: The business press and international financing community have been quite focused on the state of the financial sector in China. China's banking system is clearly under stress—debt has ballooned to over 250 percent of GDP and corporate debt has reached levels (145 percent of GDP) that have prompted warnings from the IMF.[67] Debt has skyrocketed as a result of both slower economic growth and Chinese government policies that condone expanding wealth management mechanisms to obtain higher returns on capital, policies that have spurred the rapid growth of the so-called "shadow banking system."[68] The government has also allowed the state-

62 "China Loans Pakistan $6.5 Billion for Nuclear Plants," Agence France-Presse, January 2, 2014.

63 Xiaomei Tan, Yingzhen Zhao, Cliffwood Polycarp, Jianwen Bai, *China's Overseas Investments in the Wind and Solar Industries: Trends and Drivers* (World Resources Institute, 2013), 3.

64 "Sky Solar and Hudson Clean Energy Partners Announce Strategic Partnership to Fund Up to $100 Million into Solar Projects," Globe Newswire, September 21, 2015.

65 "Argentina and China Sign Wind Power Deal," China Business Council for Sustainable Development, February 8, 2015.

66 Morgan Hervé-Mignucci and Xueying Wang, "Slowing Growth of Coal Power Outside China: Role of Chinese Finance," Climate Policy Initiative, November 25, 2015.

67 Mark Magnier, "IMF Warns China on Corporate Debt," *The Wall Street Journal*, June 13, 2016, A10.

68 See Special Report on Finance in China, *The Economist*, May 7, 2016.

dominated banks to continue to lend to financially troubled enterprises to maintain growth. To address these issues, the Chinese government announced in October 2016 it would introduce a debt relief plan involving debt-equity swaps, and the biggest Chinese banks are setting up subsidiaries to buy and manage the swaps.[69]

Unlike many other non-OECD countries, Chinese state energy industry utilities have fared reasonably well financially due to major government support and an ability to issue bonds on both domestic and international markets.[70] Although residential tariffs have been kept low, industrial tariffs of about 11 US cents per kWh have been reasonably high and the grid companies have been able to keep a substantial share of the revenues. In addition, the government has supported the renewable energy industry during times of major oversupply or curtailment; for example, the China Development Bank and the Chinese Export-Import Bank have funded exports of photovoltaics and wind systems. The economic slowdown is certainly having a serious financial impact on both fossil fuel and renewable energy companies. It remains to be seen how the adjustment program will unfold, but it appears that the state is continuing to bail out the generating and mining companies as President Xi seeks to foster short-term growth leading up to the 19th Congress of the Central Committee of the Communist Party in October 2017.

On a positive note, the government seems to want to attract greater private financing—it is opening its substantial domestic bond market to foreign companies and considering allowing international investment houses to open their own companies (as opposed to requiring joint ventures). Although the government is clamping down on the recent flood of capital outflows, there is considerable interest in the "green" bond market and the beginnings of commercial and bank ventures to finance renewables. The People's Bank of China is taking a lead role and has set up a Green Finance Committee, which has developed guidelines for sustainability-focused bond issues by financial institutions. NDRC has released its own guidelines for non-financial institutions.

China is playing a leading role in the rapid expansion of the worldwide green bond market, accounting for 33 percent of the $25.3 billion in bonds issued as of June 2016.[71] These issuances included a $5.4 billion bond by the Shanghai Pudong Development Bank and a $1.55 billion bond from the Fujian Industrial Bank. The chief economist of the People's Bank indicated in March 2016 that China may issue $46 billion in green bonds by the end of 2016.[72] Nevertheless, it appears from a new report[73] that China fell short of this target—$36.2 billion or 39 percent of global green bonds were issued in 2016, mainly by commercial banks (82 percent) like the Shanghai Pudong Development Bank. Corporate bonds were a significant 16 percent of the total. However, some investors are questioning whether these bonds meet international standards for green bonds since they include clean coal and related transmission projects.

"China is playing a leading role in the rapid expansion of the worldwide green bond market, accounting for 33 percent of the $25.3 billion in bonds issued as of June 2016."

The transformation of the Chinese electricity sector will require large capital investments. The IEA's *World Energy Outlook 2016* estimates under its New Policies Scenario that generation investment will reach about $1 trillion between 2015-2025 and an additional $797 billion will be needed for transmission and distribution. The renewables share of generation financing is projected to be $666 billion. In the *World Energy Outlook 2015*, 30 percent of the $641 billion in renewable investment is forecast to be in hydro—the rest is projected to support wind, solar, and bioenergy.[74]

69 Lingling Wei, "China Lays Out Loan-Relief Plan," *The Wall Street Journal*, October 11, 2016, C3; Fan Yu, "Chinese Bank Unveil Debt-to-Equity Swap Arms," *The Epoch Times*, November 27, 2016.

70 See Bo Kong and Kevin Gallagher, *The Globalization of Chinese Energy Companies: The Role of State Finance* (Boston: Boston University, 2016), for a discussion of the growing reliance of Chinese energy companies on bond financing.

71 Lianting Tu, "China Approves $15 Billion of Green Debt in Pollution Fight," Bloomberg News, June 7, 2016.

72 Vincent Shaw, "China Aiming for $46 Billion Green Bonds in 2016," *pv* magazine, March 29, 2016.

73 "China Green Bond Market 2016," Climate Bonds Initiative, January 2017.

74 International Energy Agency, *World Energy Outlook 2016*, Table 6.5, 264; International Energy Agency, *World Energy Outlook 2015 (*Paris: Organisation for Economic Co-operation and Development, 2015), Table 9.5, 371.

It appears that policy and development banks as well as supranational banks are likely to get into this market. Bloomberg reports that major generating companies are developing asset-backed securities deals, such as the $152 million security transaction by the renewable subsidiary of Shenneng Nanjing Energy Holding Co. involving a 200 MW solar farm and a financial guarantee from the parent company, which is involved in hydro and coal projects.[75]

Local governments may also emerge in this market. Already, they are active in financing demand-side energy efficiency projects through pilots that were started in 2011. Under these pilots in major cities like Beijing, Suzhou, Tangshan, and Foshan, localities were able to pay demand-side management costs in a few ways: through a city utility surcharge, via revenues obtained by charging more to energy-intensive industries, and through a joint central and provincial government fund. Local grid companies are also getting involved. A pilot in Shenzhen developed a revenue cap regulatory approach that decoupled revenues from sales. This approach is being expanded to Ningxia, Anhui, Yunnan, and Hubei Provinces.[76] The NDRC and the Ministry of Finance issued the National DSM Platform Management Rules in 2014 that provided a framework for greater transparency and guidelines for verification and certification. In 2015, the priority of DSM was given further policy endorsement and financing for energy service companies and the number of third-party suppliers is increasing. In 2016, the United States and China launched a Building Energy Efficiency and Green Building Fund for $3.05 billion, involving US and Chinese companies.[77]

Policy Recommendation: China should clamp down on domestic state bank lending and bond issuances for state power companies with poorly performing assets due to coal plant overcapacity and slower demand. The green bond market should be encouraged but rules on allowable projects should be changed to focus on renewables and energy efficiency rather than "clean coal."

75 "Solar-Backed Bond Opens New Path for Renewable Energy Financing," Bloomberg News, February 2, 2016.

76 Barbara Finamore, "China Power Sector Reform Plans Aim to Boost Energy Efficiency and Renewables," Natural Resources Defense Council, May 25, 2015.

77 "Building Energy Efficiency and Green Development Fund Launches First Projects," Paulson Institute, June 20, 2016.

CONCLUSION

China's energy transformation efforts are unprecedented in their size and speed. These changes along with slower economic growth contributed to the apparent flattening of global CO_2 emissions in 2015. As China is the world's largest GHG emitter, its changing energy mix and strong political commitment to move to a more environmentally sustainable economic path offer hope that the trajectory of GHG emissions can be altered to meet the targets set in Paris. The International Energy Agency paints an optimistic picture for China to peak emissions before 2030 and exceed 20 percent non-fossil fuels.[78] The world has clearly benefited from the huge Chinese state subsidies for solar and wind, which have created export surpluses that have helped drive down prices for these renewable energy technologies.

"China has an opportunity to continue the development of commercially viable renewable and gas power industries that, together with nuclear and hydro, would allow China to steadily reduce its GHG emissions"

China's power sector, the largest in the world with over 22 percent of global installed capacity in 2014,[79] will play a critical role in this broader transformation process. This report puts forward a few core recommendations for how China could accelerate the transition toward a cleaner energy system. In particular, introducing a carbon tax would further the movement toward an improved electricity regulatory and market system that would facilitate the diversification to include low-carbon energy sources. Powerful political and local actors with interests in continuing the coal-based economy will no doubt challenge these reforms, especially if excess capacity conditions continue.

However, China has an opportunity to continue the development of commercially viable renewable and gas power industries that, together with nuclear and hydro, would allow China to steadily reduce its GHG emissions. But, even if China continues down this path, rationalizing existing thermal capacity to weed out old and inefficient plants will be critical to the successful growth and incorporation of these new clean power technologies.

Despite the continuing debt problems of the inefficient state-dominated Chinese banking system, the outlook is for private sources of financing to become more important as China continues to open its banking system and scale up its green bond market. With increasing urban and income growth, electricity demand will very likely continue to increase, albeit at a slower rate due to energy efficiency improvements. Will the energy price as well as other regulatory and market reform measures be sufficient to attract the investment needed in generation, distribution, and end use to meet this changing level and structure of demand? Will state investment in developing a stronger transmission backbone facilitate access for renewable energy while at the same time maintaining reliability? And will the government prioritize gas-fired generation, as well as renewables and nuclear, in the future energy mix despite the need for increased gas imports? These basic questions will play out in the broader context of the historical tension that Chinese leaders have faced in promoting development for its huge population on one hand and, on the other, maintaining order in this large and diverse polity. The measures by President Xi to consolidate power ahead of the 19th Communist Party Congress in 2017 can be seen as a reaction to growing social and economic tensions and cleavages. Will more nationalistic policies halt or roll back some of the steps that have been made towards a more open investment climate?

The full ramifications of the apparent slowdown in Chinese domestic coal production and the domestic political and economic adjustment process in the coal, steel, and major industries are not yet clear. This issue is of special concern with respect to policies and commercial efforts by Chinese coal and power companies to (1) shift coal power construction away from population centers to remote western regions in China and (2) continue building coal plants overseas.

78 IEA, *World Energy Outlook 2016*, 313.

79 IEA, *World Energy Outlook 2016*, 552 and 600.

Will they be driven to continue supporting the export of coal plants, even if ultra- or supercritical designs, and undercut international efforts to mitigate CO_2 emissions? The aggressive Chinese leadership on green finance in the 2016 G20 Summit is a positive sign.

On the non-fossil fuel side, it is becoming increasingly clear that Chinese companies, with major support from the state policy banks and an array of Chinese-backed international and regional funds,[80] are assuming an increasingly dominant position in the hydro, solar, wind, and nuclear subsectors of the non-OECD world. US companies and those from other OECD countries will face strong competition in these markets and may find it necessary to develop strategic alliances to stay in the game. Chinese involvement in non-OECD markets will be examined in future briefs on individual countries and regions.

Finally, despite the uncertainties surrounding President Trump's policy on climate change, the United States has important commercial and technological interests in encouraging the rationalization and diversification of the Chinese power sector and seeking more market openness and receptivity to involvement by US energy, technology, and financial companies in China's large and growing energy system. Cooperation in this sector can perhaps offset some of the other serious, emerging political, military, and trade tensions in the broader US-China relationship.

80 See Kevin P. Gallagher, Rohini Kamal, and Yongzhong Wang, *Fueling Growth and Financing Risks: The Benefits and Risks of China's Development Finance in the Global Energy Sector* (Boston: Boston University, Global Economic Development Initiative Working Paper 002, May 2016).

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