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Rebalancing China's Energy Strategy

Damien Ma

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About the Author

Damien Ma

Damien Ma is a Fellow at the Paulson Institute, focused on investment and policy programs and the Institute's research and think tank activities. He is the co-author of the book, *In Line Behind a Billion People: How Scarcity Will Define China's Ascent in the Next Decade*. He also serves as an adjunct lecturer at the Kellogg School of Management at Northwestern University.

Previously, Ma was a lead China analyst at Eurasia Group, the political risk research and advisory firm. He specialized in analyzing the intersection between Chinese policies and markets, with a particular focus on energy and commodities, industrial policy, elite politics, US-China relations, and social policies. His advisory and analytical work served a range of clients from institutional investors and multinational corporations to the US government. Prior to joining Eurasia Group, he was a manager of publications at the US-China Business Council in Washington, DC. He also worked in a public relations firm in Beijing, where he served clients ranging from Ford to Microsoft.

In addition, Ma has published widely, including in the *Atlantic Monthly, New York Times, Foreign Affairs, The New Republic, Foreign Policy, and Bloomberg*, among others. He has also appeared in a range of broadcast media such as the Charlie Rose Show, BBC, NPR, and CNBC. He also served as an adjunct instructor at Johns Hopkins SAIS. Ma is a term member of the Council on Foreign Relations. He speaks fluent Mandarin Chinese.

Cover Photo: China Daily

Introduction

At a high-level meeting of China's top finance and economics body in June 2014, President Xi Jinping called for a sweeping energy revolution in China, centered on five areas: demand, production, technology, institutional governance, and global markets. The exclusive focus on energy was unexpected for a meeting of the group, which typically deals with general macroeconomic issues.[1] But addressing energy matters at such a meeting also made much sense. In his comments, Xi explicitly linked China's energy security to the country's economic prospects, arguing that a long-term energy strategy would need to align with economic goals.

China's energy policies now and into the near future also need to be anchored in the ambitious economic restructuring agenda that Beijing has embarked upon.

That China's energy structure and its economic model are mutually reinforcing should be obvious. That is because China's development model determines its energy profile.

But China's energy policies now and into the near future also need to be anchored in the ambitious economic restructuring agenda that Beijing has embarked upon, especially since Xi came to power in 2012. The higher priority being placed on environmental goals and the deployment of cleaner energy in the economic reform blueprint unveiled at the Communist Party's Third Plenum in November 2013 will require a different approach to China's complex energy conundrum.[2] Since the plenum, this priority has been underscored in an energy strategy plan (2014-2020) unveiled in November 2014.[3]

Beijing fully understands that in a now gargantuan and complex $10 trillion economy, the effects of energy consumption and production ripple far beyond its borders. China can move global markets and determine global energy prices. And having embedded itself in the global trading system and supply chains, China and the world are inextricably intertwined. China cannot isolate itself from the global economy, nor can the world immunize itself against the effects of what happens in China.[4]

For example, the clouds of pollution dust that are now periodically found on the US West Coast, having blown over from Chinese factories manufacturing products for the global market, is just one of many illustrations of how China's energy and environmental challenge is no longer just China's problem. Other countries are deeply affected by China's energy and economic choices.

Moreover, China's large scale means that although it may view itself as a "developing" economy that has barely reached middle-income status, its resource and energy footprint is already enormous and akin to that of the world's leading advanced economies.

To put it another way, China's global impact has raced ahead of its own self-perception. And this means that China, despite the government's protestations, cannot behave like a typical developing country when it comes to its energy development. This is especially so since China has already surpassed the United States in both total carbon emissions and energy consumption. China and other emerging markets like India will be the principal contributors to emissions and energy demand growth over the next decades, while the United States and most of the advanced economies are likely to move in the opposite direction.

For these reasons, Chinese policy is premised on an understanding of the gravity of the country's energy and environmental woes. Beijing is confronting these with a sense of urgency.

Indeed, the surprise US-China climate change announcement at the Asia-Pacific Economic Cooperation forum (APEC) in November 2014, in which China declared that it plans to peak its emissions by 2030, is yet another indication that Beijing is moving away from behaving like a typical developing country on the global stage.[5] The public announcement of such a target date also signifies Beijing's intent to take significant unilateral actions to curb its energy and carbon footprint.

But any assessment of what Beijing can achieve in the medium term needs to be tempered by a realistic understanding of the fact that economic growth, and therefore energy demand growth, still needs to continue for decades. And it is not yet clear whether a more consumption-driven Chinese economy will help facilitate an energy transition or simply alter the character of China's energy consumption.

The bottom line is this: China will have to determine how to keep growing while simultaneously reducing environmental and resource costs and emissions. That is because the latter will undermine the former, if left unattended. But no silver bullet exists for such a monumental task. It will take a variety of solutions, among them technology, smart policies, and various market incentives, to shift China's energy profile in a meaningful way. And any forecast of China's energy scenarios, even for the next five years, must account for a large dose of uncertainty, not least because of spotty data and the rapid changes in the economy.

This paper, which inaugurates a new series of "Paulson Papers on *Energy and Environment*" from the Paulson Institute, is intended as a "scene setter" that frames and examines the current state of China's energy structure and some of the existing proposals to reshape its energy landscape through 2020. Subsequent papers in this series will focus on various aspects of China's energy and environmental conundrum, providing analyses of different sectors and technologies or offering diverse views on policies that are germane to the major issues that China faces in this realm.

This paper does not offer specific prescriptions or solutions, but rather lays out the core elements of China's energy strategy now and into the near future. The assessment will conclude with a brief discussion of the linkage between Beijing's energy strategy and its international stance on climate change—a position that is largely a manifestation of its domestic energy and economic concerns.

Coal Declines, But Remains King

The nature of China's energy consumption is determined in large part by its economic growth and its development model. By now, it is well known that China has become an industrial and export powerhouse in what seems an impossibly short period of time, especially compared to previous industrializing giants such as Great Britain and the United States. In a span of about 15 years—roughly from the end of the Asian financial crisis in the late 1990s to today—a sprawling heavy industrial base has sprung up in China, particularly steel, aluminum, and cement.

The growth of industry has also been a determining factor in China's overall energy profile.

Take steel, for example. In 1997, China produced about 10 million tons more steel than the United States. But by 2012, Chinese annual steel production—about 716 million tons—was eight times that of US production, constituting 46 percent of the world's steel production.[6] In addition, China is the producer of 45 percent of the world's aluminum and nearly 60 percent of its cement.[7]

Although these industries have been beset by severe overcapacity in recent years, Beijing built them up deliberately to feed one of the most stellar economic booms since World War II. After it entered the World Trade Organization (WTO) in 2001, China managed an impressive decade of GDP growth, peaking around 14 percent in 2007. That boom was anchored in an economic model that had two basic pillars: fixed asset investment (for example, pubic works infrastructure and housing) and becoming a producer that exported to the world.

Embedding itself in the liberal global trade regime symbolized by the WTO served Beijing's economic strategy of creating a formidable production-oriented economy. A large surplus labor pool and an enormous industrial base were needed to support exporters and manufacturers, whose products were destined for foreign markets rather than China's domestic market.

Chinese industry capitalized on the needs of downstream manufacturers by supplying them with necessary inputs like aluminum and cement. It also exported its own products—usually at lower cost—into the global market, occasionally leading to conflicts with international trade partners, including the United States. It would hardly be an exaggeration to claim that the last 10 to 15 years were a golden age for Chinese industry.

But the growth of industry has also been a determining factor in China's overall energy profile. Breaking the analysis down by sector, it becomes clear that Chinese industry has been the predominant driver of the country's energy consumption, even compared to other emerging markets (see Table 1).

While Europe and the United States have the most balanced energy profiles across sectors, China has been even more unbalanced than India when it comes to the share of industry in energy demand. In 2011, China saw energy consumption growth of 7 percent on the back of a massive stimulus that financed industry and disproportionately supported an infrastructure boom to stave off economic catastrophe.

That same year, China produced 696 million tons of crude steel, which required burning 570 million tons of coal, up 6.3 percent from the previous year.[8] Once again, industry may have benefitted, but that did little to improve, and may have even exacerbated, the disequilibrium in China's energy profile.

The sheer scale of industrial production in China's economy has several other important knock-on effects on its energy needs. For one, a massive industrial base has meant that it is very difficult to regulate from Beijing, and to separate the relatively energy efficient and cleaner players from the dirty and highly polluting ones. As a result, China reversed its achievements of the 1990s in reducing energy intensity. Instead, the 2000s saw the economy become more energy intensive (see Figure 1). [An increase in energy intensity—the amount of energy it takes to generate one unit of output/GDP—means that as China's economy grew, energy use required to support that growth became increasingly inefficient.]

Another implication of China's energy guzzling industries is that the energy mix became heavily tilted toward coal, one of

Table 1. Energy Consumption by Sector, 2011

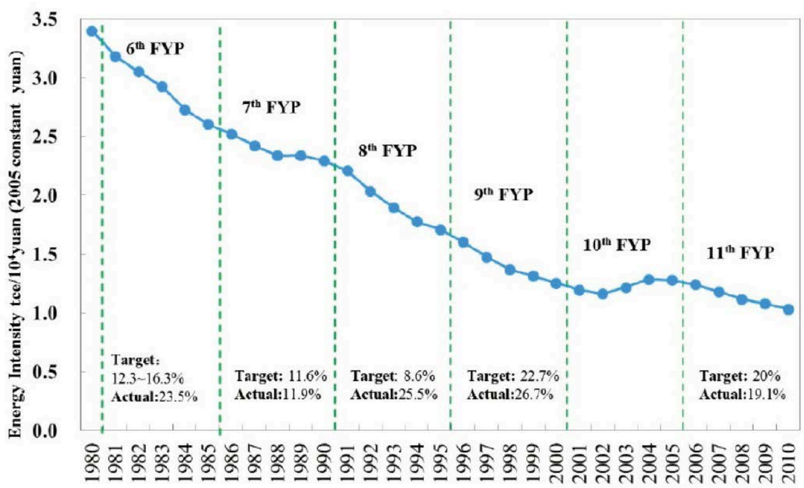
	China	India	Russia	OECD Europe	Japan	United States
Energy Consumption by Sector (percent share)						
Industrial	72%	68%	53%	38%	44%	34%
Residential & Commercial	14%	16%	27%	31%	31%	27%
Transport	14%	16%	20%	31%	25%	38%
Total Consumption (Quadrillion BTUs)						
	78	17	22	59	15	73

Source: US EIA International Energy Outlook 2011.

the only abundant domestic resources in the country. Still hovering around 70 percent of its total energy consumption, China today remains effectively a coal-based economy.

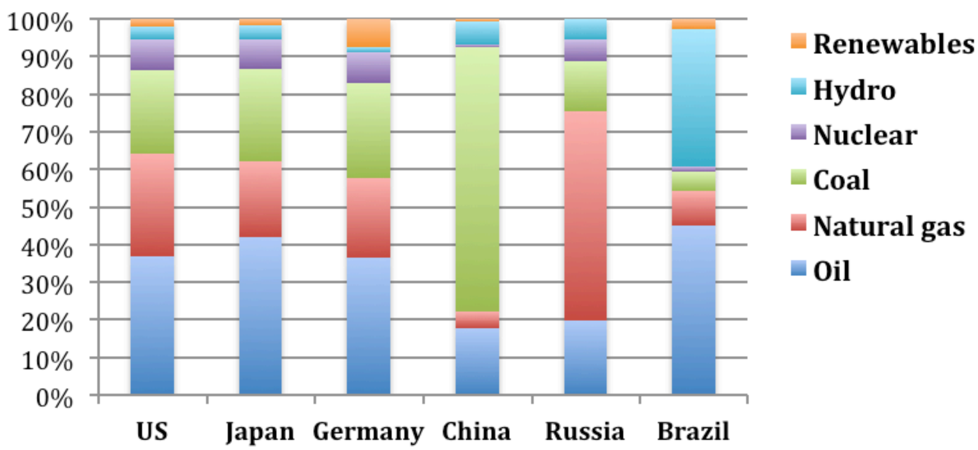
To be sure, coal has figured prominently as one of the primary energy inputs that powered other nations through industrialization. Therefore, China's appetite for coal at this stage of its development isn't a surprise. What is striking, however, is just how sharply China's energy mix is skewed toward coal, especially when compared to other major economies (see Figure 2).

Figure 1. Energy Intensity Trend Since the 6th Five-Year Plan



Source: Presentation from Qi Ye, Climate Policy Initiative, Tsinghua University.

Figure 2. Energy Consumption By Fuel Across Countries



Source: BP Statistical Review of World Energy, 2012.

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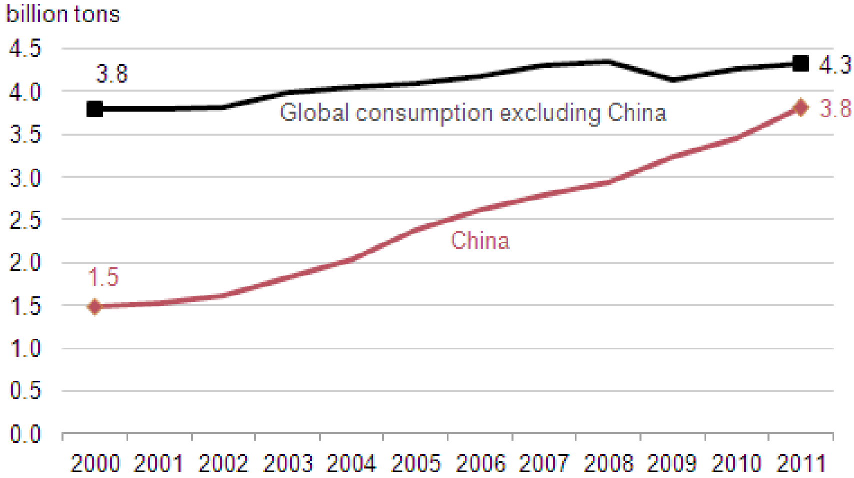
Figure 3. China's Total Coal Consumption



Source: EIA.

Table 2. Coal's Dominance in China's Power Generation

	2006	2007	2008	2009	2010
Total production (bn tons)	2.3	2.5	2.7	3.0	3.2
Consumption in power generation (bn tons)	1.2	1.3	1.3	1.4	1.6
Share in power generation	53%	51%	49%	47%	49%
Total installed power capacity (GW)	623.7	718.2	792.7	874.1	966.4
Coal-fired installed capacity (GW)	483.8	556.1	602.9	651.1	709.7
Share of coal-fired installed capacity	83.3%	83.3%	81.2%	81.8%	80.8%

Source: Coal Economy Research, Annual Report on China's Energy Development, 2012.

When placed next to fellow BRICS countries, such as Brazil and Russia, China's outsized reliance on coal stands out. Already, the Chinese economy consumes nearly as much coal as the rest of the world combined (see Figure 3). The majority of power generation in China relies on coal, and the steel industry consumes large amounts of coking coal, a specific type that is of higher caloric content.

Indeed, coal makes up about two-thirds of the fuel used for power generation in China.[9] According to Chinese estimates, the share of coal in power generation in 2012 may have been as high as 75 to 77 percent (see Table 2).[10] In comparison, that figure is about 40 percent in the United States. But reducing coal to that level in the United States took decades to achieve, and the decline has accelerated recently because of

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fuel switching to natural gas in the US power sector.[11]

As the US experience demonstrates, dramatically reducing the share of coal in the energy mix can take decades, particularly for continental-sized economies that require substantial and reliable base load power. Since China's energy needs will be on the upswing for decades, with another 472 GW of new installed power capacity coming on line from 2015-2020 (at an average growth rate of 5.8 percent), the centrality of coal in the energy mix will not diminish quickly.[12] Another projection from Bloomberg New Energy Finance expects installed capacity growth to average 5 percent through 2030, which translates into 88 GW of additional capacity a year—this is equal to adding roughly one United Kingdom's worth of power capacity every year.[13]

Therefore, any reasonable, or even somewhat optimistic, scenario should expect coal to account for at least 60 percent of China's energy mix in the foreseeable future, and it will most likely be somewhat higher.

But the consequences and costs of such a production-intensive and coal-reliant economy are dramatic and stark. Pollutants from coal-fired plants, whether they be sulfur dioxide (SO2) or PM 2.5, are choking urban China. Repeated occurrences of "airpocalypse" have become emblematic of the considerable downsides of a coal-based economy.[14] More than a decade into China's industrialization, the environmental, and potential public health, costs are no longer an abstraction but a grim reality.

The scale of the challenge ahead is enormous and more complex. Imposing some constraints on coal use is already a major part of Chinese policy. But Chinese policymakers will also need to adjust to an economy whose energy profile could well shift from producers (steel plants, manufacturers, and so on) to consumers (a rising Chinese middle class and its growing car culture), especially if Beijing succeeds in its effort at economic rebalancing. In other words, a more consumption-driven Chinese economy will invariably require a different approach to managing China's energy consumption.

China's "Everything but Coal" Strategy

More than at any time over the last decade, the Chinese government is now reckoning with the serious environmental problems that have become daily experiences for the average Chinese. The economic reform plan unveiled at the Third Plenum in November 2013 incorporated a clear emphasis on sustainable development and better management of resource consumption.

China's top leadership, too, has embraced a strategy to more aggressively diversify away from coal, improve industrial energy efficiency, and invest billions in clean energy and pollution mitigation. For the most part, the current strategy is focused on the supply side, although demand-side efforts are emerging as a new focal point. Much of this has been put forth in the recently released 2014-2020 energy strategy action plan.[15]

Much of China's effort to date to address emissions and promote energy efficiency hinges on limiting the growth of coal use.

Supply Side Approach: Less Coal …

Much of China's effort to date to address emissions and promote energy efficiency hinges on limiting the growth of coal use and, by extension, clamp down on its downstream user—namely, heavy industry.

And targeting coal is absolutely necessary since industrial coal is the single largest contributor to pollutants and greenhouse gas emissions, accounting for some 90 percent of China's SO2 emissions and 70 percent of its CO2 emissions, acording to some estimates.[16] A key headline target through 2020, then, is to put a cap on total coal consumption at around 4.2 billion tons, which is slightly higher than the 4 billion ton cap that is supposed to be met by 2015.[17] Whether China can meet the 2020 goal will be determined, in many ways, by whether it can first meet its 2015 coal consumption target.

One way the government is dealing with coal is to forcibly shut down smaller, dirtier producers and consolidate assets into what are expected to be more efficient and large-scale coal bases. During the 12th Five-Year Plan (FYP) period, the goal is to eliminate 400-plus small coal producers, equal to about 20 million tons of capacity. Meanwhile, 63 percent of Chinese coal will come from 10 mega producers of 100 million tons capacity each and 10 large producers of 50 million tons each. Total coal production could be potentially capped at 3.9 billion tons by 2015.[18]

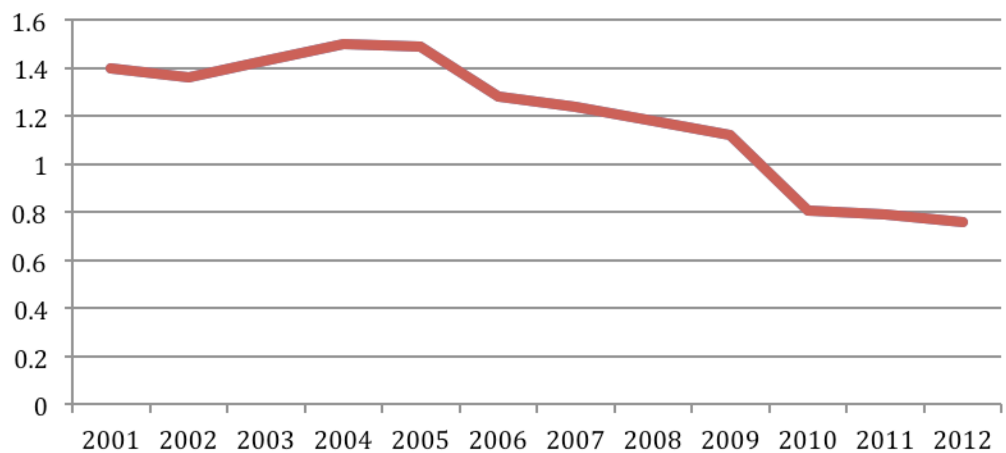
Another initiative is to raise the cost of resources such as coal and oil by imposing a higher resource tax. In fact, the Chinese Ministry of Finance in October 2014 took just such a step by imposing a 2 to 10 percent resource tax based on value (the previous tax based on volume was virtually meaningless because it was so low).[19] This will negatively affect a coal industry that has already suffered a tremendous blow from China's growth slowdown and various policies aimed at forcing producers to exit the market.

Measures taken to curtail the scope and role of heavy industry are informed by a similar administrative approach. They too aim to forcibly shutter small and dirty plants and mandate industrial consolidation to create super-producers with scale and improved efficiency.

This process began as far back as the 11th FYP in 2006, but unrelentingly robust economic growth through 2011 made it quite challenging to meaningfully control industrial energy consumption. Nonetheless, China has made noticeable strides in reducing energy intensity, more or less meeting its stated targets in the 11th FYP (see Appendix for 12th FYP energy and environment-related targets). Still, it took then-Prime Minister Wen Jiabao to lead an eleventh-hour, "iron hand" campaign for those targets to be met.[20]

But these achievements also obscure a subtlety, which is that China's energy intensity improvements to date appear to be flatlining, suggesting that the current approach of shutting down plants and ordering local authorities to comply with energy targets may soon hit its limits (see Figure 4). Put differently, most of the low hanging fruit to achieve energy efficiency in industry may soon be picked. And some of the data at the industry/plant level seem to bear this out (see Tables 3a, 3b, and 3c).[21]

Figure 4. China's Energy Intensity is Declining (tons of coal equivalent/10,000 yuan)



Source: China Energy Statistical Yearbook 2013, NBS.

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It appears that for medium to large power plants, China's coal consumption efficiency is nearly on a par with that of Japan, an advanced economy that is typically considered to be highly energy efficient. Even in its heavy industries, such as steel and cement, China has made progress toward converging with Japan.

... But More of Everything Else

Still, because the Chinese coal industry faces significant volatility, many inside and outside China seem to believe that the curtains are closing on the prosperous era of coal, an industry that coasted on the country's wave of staggeringly broad and fast-paced industrialization.

Table 3a. Total Coal Consumption Rate for Power Plant in China and Japan*

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
China**	392	379	363	343	342	332	322	320	312	308	305
Japan**	317	315	303	301	299	300	297	294	294	295	295

*units in gram standard coal/Kwh
**For China, only includes 6 MW and above power plants; for Japan, includes average of nine major electricity companies
Source: China Electricity Council; The Institute of Energy Economics, Japan; Handbook of Energy and Economic Statistics 2013 Edition, Japan.

Table 3b. Energy Consumption for Steel in China and Japan*

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
China**	997	976	784	732	729	718	709	697	681	675	674
Japan	629	656	646	640	627	610	N/A	612	N/A	N/A	N/A

*units in kg of standard coal/ton of production
**only includes medium to large size steel companies
Source: China Iron and Steel Association; Journal of Energy Society of Japan; Japan Steel Association.

Table 3c. Energy Consumption for Cement in China and Japan*

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
China	201	199	183	178	172	168	161	148	143	138	136
Japan	123	124	126	127	126	118	N/A	N/A	119	N/A	N/A

*units in kg of standard coal/ton of production
Source: National Bureau of Statistics; China Cement Association; Journal of Energy Society of Japan; Japan Cement Association.

Figure 5a. Expected Installed Power Capacity by Source, 2015

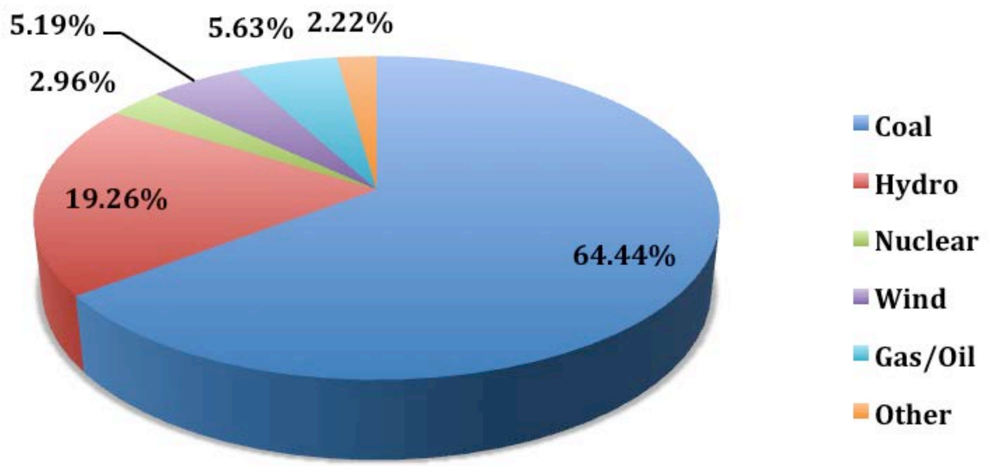
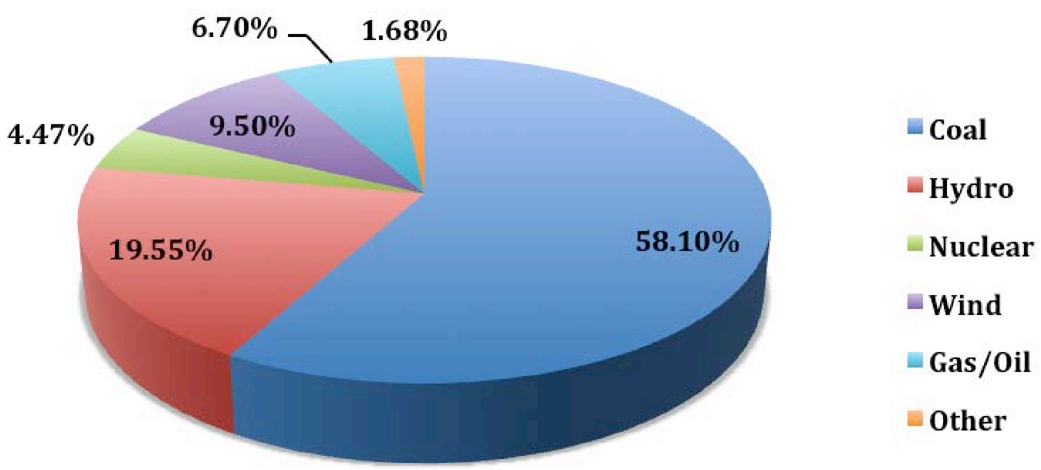


Figure 5b. Expected Installed Power Capacity by Source, 2020



Source: China Electricity Council, 2011.

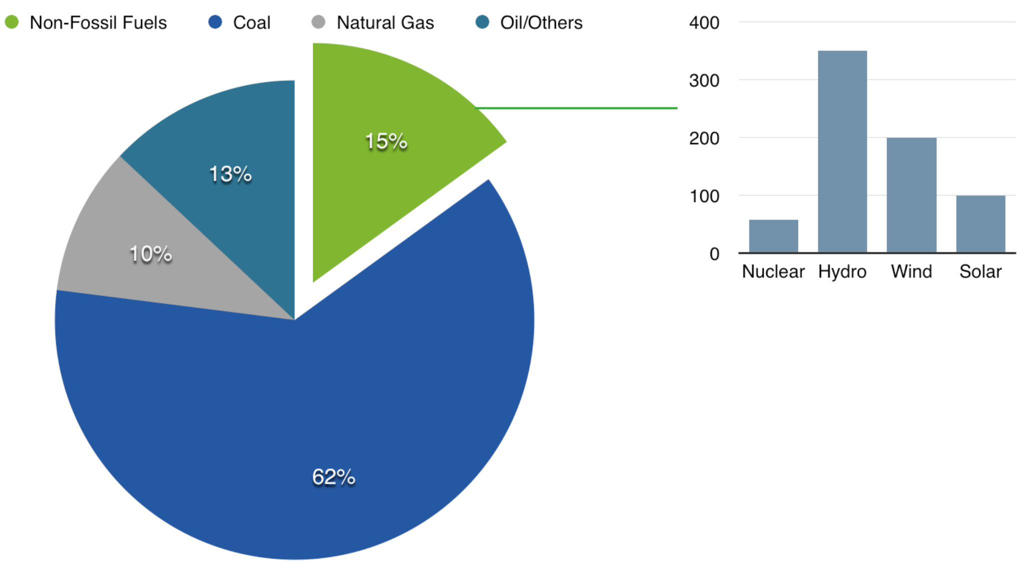
China's gradual exit from this intense industrialization and high growth phase will have implications for a range of global commodity prices, from coal and iron ore to copper. For market participants and investors, then, the end of this era will also mean the close of the "super cycle" of commodity prices, underwritten by what has long seemed to be insatiable Chinese demand.

This means that the relative decline of coal in China's general energy mix and in the power sector, in particular, will yield a corresponding ramp up of just about every other energy resource—particularly natural gas, hydropower, nuclear power, and renewables (see Figures 5a and 5b). If China meets its aspirational targets for deployment of these resources, it is clear that some of the biggest beneficiaries will be wind, gas, and nuclear.

Indeed, the 12th FYP calls for having non-fossil fuels account for 11.4 percent of China's energy mix by 2015 (the other two macro targets are cutting energy intensity and carbon intensity by 16 and 17 percent, respectively).[22] By 2020, or at the end of the 13th FYP cycle, the share of non-fossil fuels is expected to reach 15 percent and carbon intensity to have been cut by 40 to 45 percent from 2005 levels.

What is more, the three macro energy targets noted above have, for the first time, been deemed to be "binding." And this means that, in political terms, they "must" be met. Putting such a mandate in place essentially guarantees that

Figure 6. China's Potential Primary Energy Mix By Source, 2020*



*biomass not included.
Source: State Council 2014-2020 Energy Strategy Plan; author estimates.

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Beijing will have to support the expansion of a more diverse basket of energy sources. At least through 2020, China intends to aggressively deploy non-coal energy resources, with the expectation that coal would fall to 62 percent of the overall energy mix. If this aspiration is realized, then China's overall energy mix could look something like Figure 6.[23]

If the above energy mix rebalancing scenario is realized, two of the most promising areas of growth will almost certainly be natural gas and renewables. Each deserves a brief discussion in terms of how they will figure in China's energy strategy.

Bullish on Gas

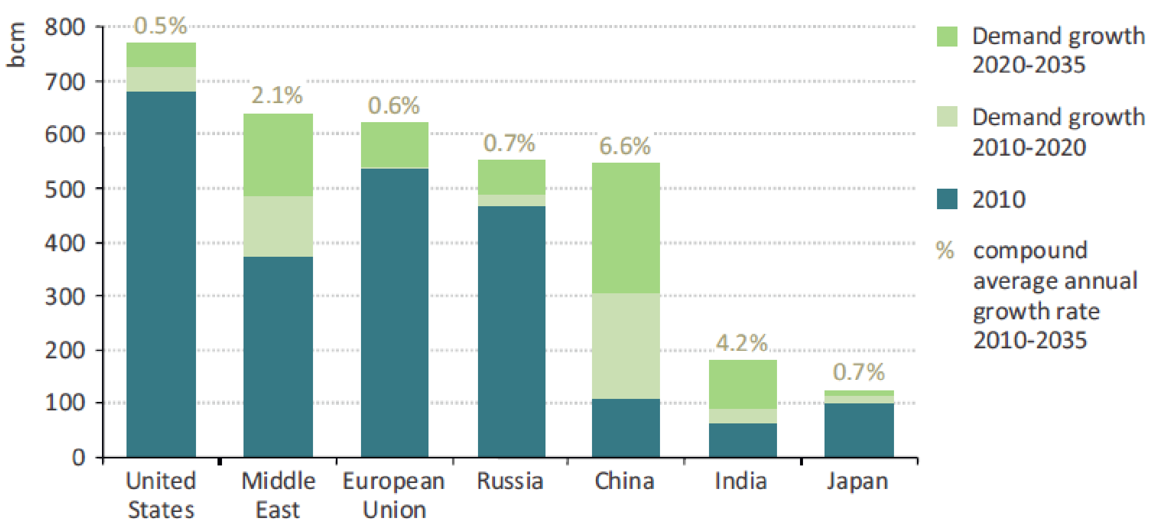
Natural gas will be especially pivotal to this story. There is increasing market consensus that Chinese natural gas demand will balloon over the next decade, which has led some to go so far as to proclaim that the era of coal is yielding to a golden age of gas in China.

Such hyperbole aside, there are indeed strong reasons for optimism that gas will get a significant boost in China's energy mix, not least of which is strong political support.

Natural gas is not carbon-free by any means, yet it is cleaner than burning coal and oil. It is, therefore, viewed as an important factor in reducing air pollution and emissions and as a "bridge fuel" in China's transition to cleaner energy.

One historical precedent that may apply to today's Beijing, for example, is the way that London grappled with its

Figure 7. Natural Gas Demand in Select Regions in the New Policies Scenario



Source: IEA World Energy Outlook 2012.

severe pollution in the 1950s. The rapid introduction of gas into the city's energy mix to replace coal apparently had a marked effect in curtailing pollution.[24] From an energy security perspective, China still has the potential to tap its domestic reserves in the future, using gas—unlike oil—to hedge against growing energy import dependence.

The potential for natural gas growth is enormous since it is today only about 4 to 5 percent of China's energy mix, far lower than the world average of around 20 percent. By 2015, China anticipates doubling natural gas in its energy mix to 8 to 9 percent, or between 230-260 bcm of gas consumption in total volume.[25]

While estimates vary on the total demand figures, virtually all projections see rapid growth. According to the BP Energy Outlook, China will contribute 23 percent of the increase in global gas demand and is expected to reach European Union's 2010 gas consumption level by 2030.[26] As Figure 7 underscores, China, while starting from a low base, will be by far the biggest share of gas demand growth over the next decade.

Chinese domestic production, however, is unlikely to keep up with robust demand growth, which has been expanding at nearly 20 percent since 2010. Already, China imports about one-third of its gas, a trend that is unlikely to abate in the near term.[27] While initial optimism abounded that China's vast domestic reserves of unconventional resources such as shale gas could fill the gap between supply and demand, the shale play is likely to disappoint in the medium term.

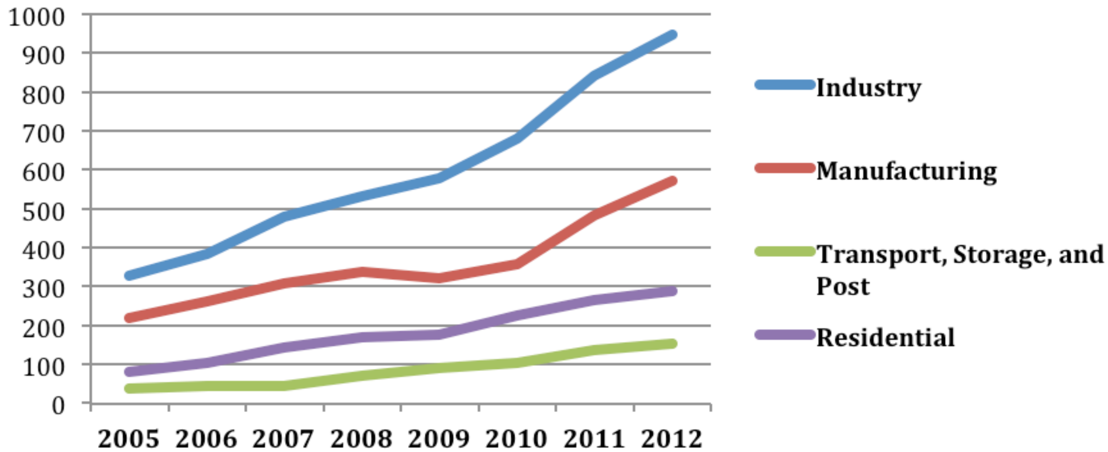
For a variety of reasons, including cost of extraction, different geologies, and technology limitations, the anticipated "Chinese shale boom" has thus far turned out to be a disappointment.[28] In fact, China has pared back its shale gas production target for 2020 to 30 bcm (from a previous target that was as ambitious as 100 bcm),[29] equal to the 2020 production target for coal-bed methane, another abundant unconventional gas resource. As a result, China will increasingly rely on global supplies in the foreseeable future, from suppliers as far flung as Australia and Russia, to meet its burgeoning demand.[30]

Another reason to be bullish on the rising prominence of gas in the energy mix is that China's macroeconomic restructuring effort is conducive to the growth of natural gas. For instance, after years of delay, Beijing finally began in late 2011 to liberalize gas prices to encourage domestic production and to unify the natural gas pricing regime across the country. Market-based pricing could in turn help spur more robust domestic production of unconventional resources such as shale, since some analysts estimate that it can cost four times as much to drill a well in one of the Chinese shale formations as it does in the United States.[31]

Urbanization, the centerpiece of China's growth strategy through at least 2020, will also support natural gas because urban residential demand has been a major driver of gas consumption (e.g., Chinese households almost exclusively cook with gas stoves). And taking a chapter from the US experience with fuel switching, the Chinese government has started to lend stronger support behind efforts to introduce more gas into the power sector (see Figure 8 and Table 4).

Between 2005 and 2012, residential gas consumption ballooned some 260 percent, outpacing the consumption growth rate in industry. That trend is likely to pick up for the residential sector on the back of urbanization and as industrial growth slows down.

Figure 8. Natural Gas Demand Drivers (100 million cubic meters)



Source: China Energy Statistical Yearbook 2013, NBS.

Table 4. Potential Installed Power Capacity, 2015

Fuel type	2010 (GW)	2015 (GW)	Ave. annual growth (%)
Coal	660	960	7.8
Hydro	220	290	5.7
Nuclear	10.8	40	29.9
Natural gas	26.4	56	16.2
Wind	31	100	26.4
Solar	0.86	21	89.5
Total		**~1490***	

*Total figure likely also includes biomass and other sources that are not listed in the document.
Source: State Council, 12th FYP on energy.

Expected natural gas demand for the power sector should also see significant growth, although in absolute terms, the amount of gas in power generation will be a fraction of coal. But if these targets hold, China could be using more natural gas than nuclear (~40 GW) for power generation by 2015.

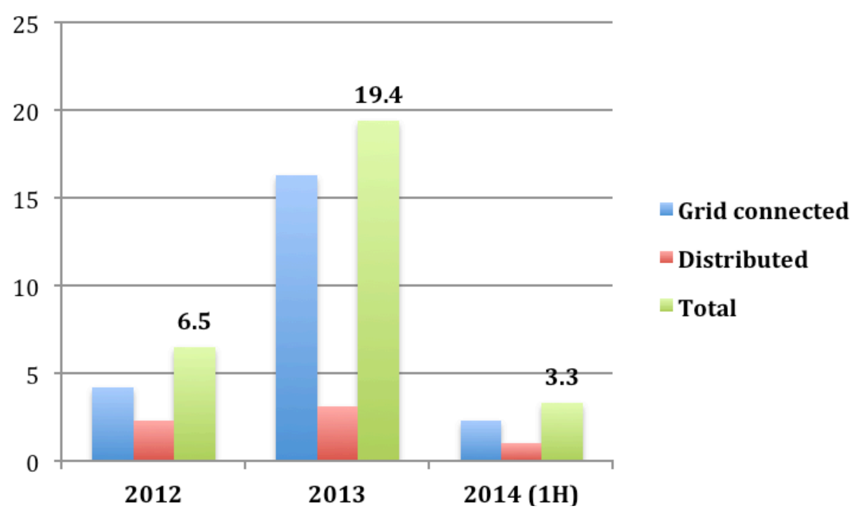
Renewables Rising

Renewables, although just a tiny fraction of the total energy mix, are being promoted alongside gas as supplementary cleaner energy sources. It would be unrealistic to assume that solar and wind will comprise a significant share of China's overall energy consumption in the foreseeable future, but Beijing is clearly backing the expansion of renewable energy supplies. In fact, China was one of the fastest growing wind power markets for several years starting in 2006, and it is also adding a tremendous amount of solar, albeit from a very low base.

Both solar and wind went through a period of overheating in the last few years, and the young industries are still unwinding from that bout of market volatility. The solar industry seems to be slowly recovering from demand contraction in foreign markets. It was overly exposed to foreign demand, since 95 percent of Chinese solar products were exported. Wind, too, was overbuilt, as a large portion of the installed capacity was not connected to the grid and therefore was not generating any electricity.

Precisely for these reasons, the Chinese government hopes to buoy these

Figure 9. Total Installed Solar Capacity (GW)[32]



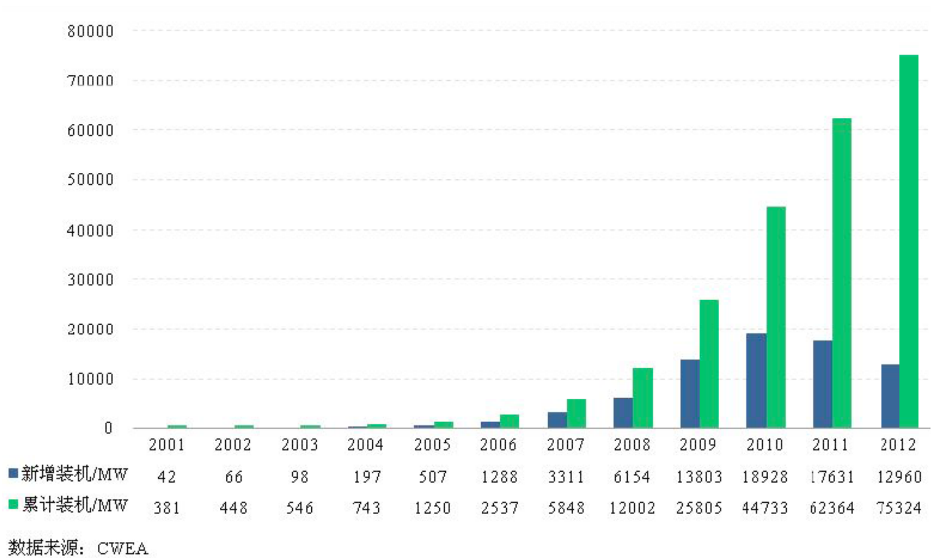
Source: National Energy Administration, NDRC.

industries by turning toward domestic demand. Just in the last few years, China has become one of the largest solar markets in the world. The ostensible target in the 12th FYP is to have a total installed solar capacity of 21 GW by 2015, which was raised three-fold from the initial proposal.[33] Yet by the end of the first half of 2014, China had already exceeded that goal with about 22 GW installed—3 GW more than the total solar capacity in the United States (see Figure 9).[34]

An important policy change has been the central government's embrace of distributed power generation, which allows for increasing rooftop solar installations and growth of solar in rural areas, where connecting to main power grids is difficult. For instance, the data reflect the gradual rise of distributed solar installation, with Zhejiang province near Shanghai leading the way. Moreover, Beijing is also intent on creating more utility-scale solar, particularly in far-flung regions such as Xinjiang, that will eventually be connected by ultra-high voltage transmission lines to send power to dense population centers.

Wind power in China had been expanding aggressively before solar entered its current period of rapid growth. Even though the sector is beset by overcapacity, with some of the leading players like Sinovel still losing money, wind power is nonetheless expected to see significant growth through 2020. At its current, albeit slower, pace of installation, China will

Figure 10. Total Wind Power Installed Capacity (GW)[36]



Source: China Wind Energy Association, 2013.

almost certainly meet its 12th FYP goal of having 100 GW of wind capacity by 2015—that is more than double the total nuclear power capacity coming online (see Figure 10).[35] However, it remains to be seen what share of this new capacity will be grid connected and producing power.

With 76 GW of wind power already installed, China is also gradually moving to establish offshore wind capacity. In 2012 alone, China added 46 turbines off the coasts of Fujian, Jiangsu, and Shandong provinces, bringing its total offshore wind capacity to 389 MW. Although miniscule in comparison to overall wind capacity, that figure already makes China the world's third-largest offshore market, after Denmark and Great Britain.[37]

It is clear that China is chipping away at the dominance of coal to achieve several objectives simultaneously. First, it can pave the way for new energy sectors like solar and wind. Second, boosting every other fuel from natural gas to nuclear will have enduring and positive effects as Beijing strives to meet emissions targets and reduce pollution. Third, imposing higher taxes on dirtier energy resources can be a vehicle to provide local governments with a new revenue stream. Ultimately, transitioning out of the industrialization, or production-intensive, phase of development should help restrain energy consumption growth.

However, the current approach is almost exclusively on the supply side, utilizing a combination of top-down administrative actions. It is simply easier for Beijing to shutter plants and dirty factories and to boost the supply of cleaner energy sources than to affect the behavior of nearly 1.4 billion consumers of energy, whose wealth and needs differ drastically from person to person, family to family, and place to place.

But if China succeeds in rebalancing its economy to a more consumption-oriented growth model, then it will also have to rebalance its energy strategy to focus on demand-side management solutions.

Managing Demand: Old and New Tools Needed

To this day, China continues to view itself primarily as a relatively poor developing country. While many outside China point to its aggregate energy use, Beijing consistently touts the fact that its per capita energy consumption is still much lower than advanced economies.[38] Both happen to be true, which is why the Chinese government has historically concerned itself with supplying enough energy for the entire country and has hardly focused on managing end-user consumer demand.

Yet at the same time, energy demand is rising rapidly among the Chinese urban middle class as they buy cars and homes. As noted above, residential

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demand will be a key driver of natural gas consumption as urbanization progresses. Indeed, energy consumption tends to shift from industry to the residential and transport sectors as the economy becomes predominantly driven by services and consumption. That has been the experience for virtually all advanced economies (see Table 1 again).

As the 13th FYP cycle approaches in 2016, Beijing will have to increasingly pivot from primarily tackling supply-side and production-related energy policies to crafting incentives that will manage consumer energy demand. This is, frankly, a taller order than pushing de-industrialization, in part because of the vast differences in economic wellbeing across China, suggesting that policies will have to be localized or anchored in specific regional conditions to reflect the huge divergences in energy usage patterns and consumption levels across China.

Demand-side management in China will require a diverse set of policies and solutions and will necessitate more reliance on market-based tools.

Demand-side management in China, therefore, will require a diverse set of policies and solutions and will necessitate more reliance on market-based tools. One such powerful and broad-based tool is market pricing for energy—a tool that would be consistent with the headline declaration from the Third Plenum that the market should henceforth play the “decisive” role in allocating resources in the Chinese economy. Another area that requires attention is transport, since, much like the United States, rising car ownership in China, and the fuel used to power those vehicles, could mean another explosion in energy consumption.

The Price Is (Not Quite) Right

But energy pricing is exceptionally complex in China. The challenge is not simply a matter of liberalizing prices across the board, since commodities such as coal have been subject to market prices since the 1990s. Domestic natural gas prices, too, are starting to become more liberalized and are essentially linked to oil prices, thus moving toward convergence with the market.[39] However, when it comes to midstream and downstream electricity prices, the Chinese state continues to intervene, and a partially reformed power sector means that China’s electricity prices remain distorted.

Although electricity prices for some industries can appear in line with similar industries in advanced economies,[40] a complex web of cross-subsidization and local protectionism means that the actual cost of energy for industry is likely lower than it should be. According to Chinese estimates, when compared to Organization for Economic Cooperation and Development (OECD) countries’

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electricity prices for industry, China is more or less in the middle.[41] For example, Italy had the highest price at $0.28/Kwh and South Korea the lowest at $0.06/Kwh ($0.07/Kwh for US), while China's was $0.092/Kwh, roughly equal to the OECD average of $0.11/Kwh.

But it is unclear whether these prices reflect the full cost of investment or other externality costs, since local governments have every incentive to provide cheap land and discounted energy inputs to local industry and power generators. As far back as 2005, the National Development and Reform Commission (NDRC) formed a task force to examine the electricity tariff system and found that, for example, the cost of desulfurization in a typical 300 MW coal power plant is 0.88-2.8 yuan/kg but the environmental charge for SO2 emissions was only 0.21-0.63 yuan/kg.[42] Therefore, it was much cheaper to simply pay the SO2 fee than install desulfurization technology, which would have increased the electricity tariff in a more liberalized market.

In short, one of the important ways to rationalize power pricing is to have electricity tariffs reflect truer costs of the investment and other internalized costs.

On the other hand, China's residential electricity prices are more distorted and significantly below those of OECD countries.[43] At $0.074/Kwh, China's residential electricity tariff is less than half the OECD average of $0.158/Kwh.

One major reason for this discrepancy is a legacy of the socialist planning era, during which a Chinese government that was perennially fearful of stoking inflation artificially kept consumer end-user electricity prices low.

This meant that the NDRC didn't allow power generators to raise tariffs freely and also controlled the price at which distributors sold electricity to Chinese consumers. Several power blackout crises in the mid-2000s, when economic growth was soaring and power demand peaking, can be partly attributed to this distortion. As coal costs rose (and these costs were market-based), power generators could not raise their prices. Instead, some simply decided to idle their plants in a bid to force the government to raise prices.

Rationalizing end-user electricity prices and allowing power generation costs to be reflected in those prices will be an important step in managing energy demand. Beijing has already taken some steps to move toward a tiered pricing scheme in which a certain set of consumers, primarily the urban middle class, will pay relatively more for electricity than their rural counterparts.[44] And recently, tiered pricing has also been implemented for certain segments of heavy industry.[45]

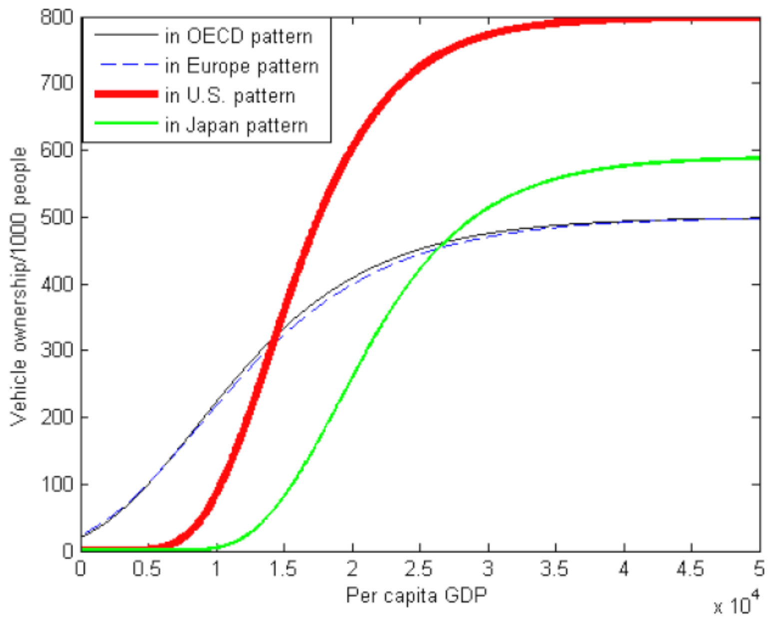
Meanwhile, although it is still a long way off, many in China have advocated more enduring and significant reforms of the power sector—for instance, allowing power generators to negotiate directly with end users based on market prices, separating power generation assets from transmission assets, and introducing more competition into this state-dominated sector. Such reforms could potentially even lower electricity prices in the future. Either way, these kinds of steps would give the market a more powerful role in managing energy demand.

A Billion Cars on the Road?

Amid the global economic recession of 2010, China became the world's largest auto market. Chinese consumers bought nearly 10 million passenger vehicles that year, and China is projected to be the world's largest car market by 2020, according to the management consultancy McKinsey & Company.[46] The growth of vehicles is in part responsible for China becoming 60 percent dependent on crude oil imports today. How and to what extent the auto market grows in China will certainly have profound impacts on consumer energy demand.

Many factors will determine the path that China takes in promoting or curtailing its vehicle fleet growth, including per capita income, infrastructure, energy security, and pollution, among others. But two chief aspects will overwhelmingly determine how the transport sector will shape

Figure 11. China Vehicle Ownership Projection Under Different Paths*



*Per Capita GDP in USD$10,000
Source: Wu, Zhao, and Ou.[47]

China's future energy demand: the vehicle penetration rate and the type of fuel that will fill those vehicles.

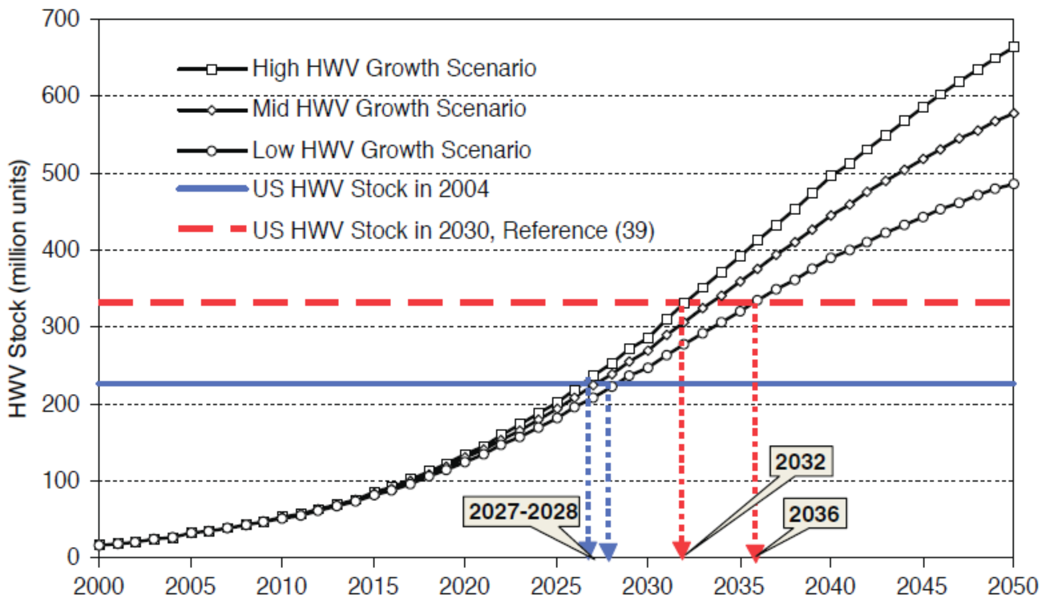
There are compelling reasons that argue for either very significant vehicle penetration or else a more modest penetration rate in China, making it quite challenging to project the most likely scenario with any certainty.

In favor of the "very high penetration" projection are factors such as a highway network that is now larger than that of the United States, a government that supports the domestic auto industry, and a growing car culture among the Chinese who view ownership as a rite of passage into middle class status.

But the "modest penetration" scenario has strong underlying evidence as well: the government's concern about energy security, the unusual density of Chinese cities, the simultaneous promotion of an extensive passenger rail network, and increasing urgency to tackle pollution. Put another way, whether China takes the American, European, or Japanese path to car ownership will have significant implications for its future energy demand (see Figure 11).

The above projection from experts at Tsinghua University suggests that vehicle penetration in China will peak at about 500 vehicles/1,000 people, equal to European levels and far below the 80

Figure 12. Total Stock of Vehicles in China Through 2050



Source: Huo, Wang, Johnson, and He.

percent in the United States. Even so, a lower penetration rate in China still means a tremendous amount of total vehicles because of sheer population size. Indeed, a scenario from Argonne National Laboratory sees total vehicle stock in China hitting above 600 million by 2050 (see Figure 12).[48]

Even under the low-growth scenario, China will have hundreds of millions more vehicles on its roads than in the United States, where personal vehicle ownership growth appears to be slowing in recent years.[49] Whether these vehicles will be powered by gasoline or electricity cannot be determined at this point, particularly given that electric vehicles (EVs) are only starting to gain some commercial viability. But assuming a very generous EV penetration rate of perhaps 30 to 40 percent by 2030, the additional numbers of internal combustion engine vehicles will still have a sizable impact on CO2 emissions and general air pollution.

Focusing on more stringent fuel economy, as the Chinese government has been doing, will be an important component of limiting energy demand and emissions from the transport sector. And these policies are also intended to drive auto manufacturers to improve their technology and efficiency or face elimination. Beijing has, in fact, long desired to consolidate the country's fragmented auto sector, although with limited success thus far, into a few powerful, advanced players.

Beijing implemented a fuel economy standard as early as 2004, which increased passenger vehicle fuel efficiency by 9 percent from 26 mpg to 28.4 mpg in 2006.[50] China has also proposed Phase IV of its fuel economy standard, which essentially converges with the stricter European standard.[51] And if fully enforced by 2020, that standard could save up to 149 million tons of CO2 by 2030, according to an ICCT estimate.[52] Whether the standard will be enforced, however, remains an open question.

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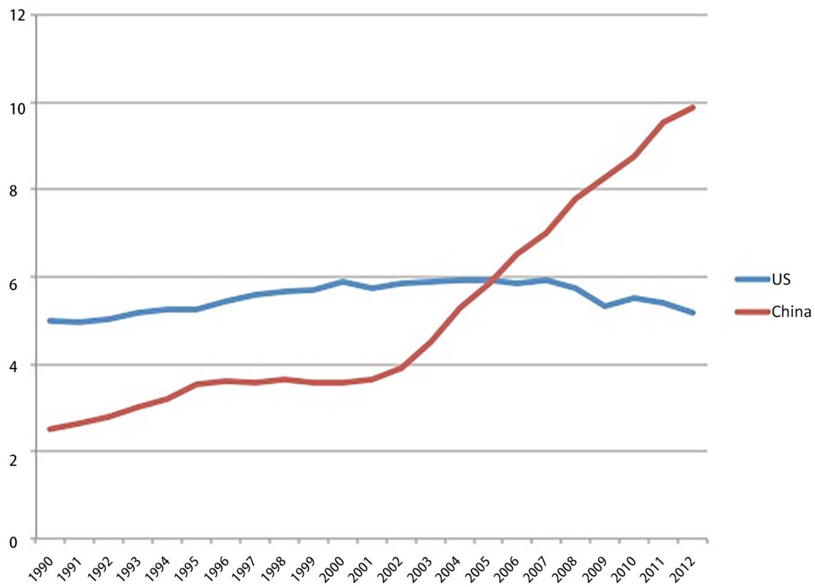
Climate Change: National Priorities Still Paramount

For China, the effects of climate change could exacerbate its resource scarcity and lead to unforeseen consequences and environmental crises. Consequently, Beijing at the policy level has always taken climate change seriously, especially now that China has become the world's largest carbon emitter. Although China still claims that advanced economies should shoulder historical responsibility for emissions, China will now be responsible for much of the growth in emissions in the foreseeable future (see Figure 13).[53] Estimates vary, but China is indisputably the world's largest emitter at this point and contributes to perhaps as much as 30 percent of global emissions.

In one of the most serious demonstrations of China's commitment to address climate change, Beijing and Washington jointly agreed to separate unilateral actions to curb emissions on the sidelines of the November 2014 summit of the APEC forum, with Beijing planning to peak emissions around 2030. This announcement was important and positive in a few respects.

For one, both countries set some boundaries and parameters heading into the Paris climate negotiations in 2015 and staked out clear positions. At

Figure 13. Historical Emissions from US and China (in billion tons)



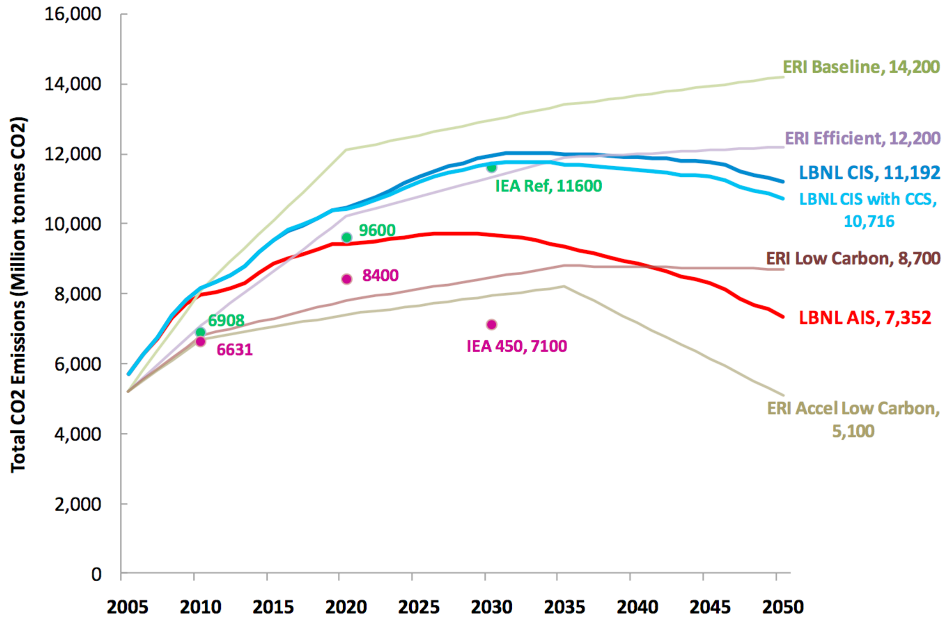
Source: PBL Netherlands Environmental Assessment Agency.

the same time, by making a joint public announcement with the United States, China seemed to be signaling that it is willing to take on greater responsibility, while separating itself from (and possibly alienating) other developing countries, including India and Brazil.

Irrespective of how the politics play out during the 2015 Paris negotiations, China's position on climate change, much like that of the United States, still reflects its domestic economic, energy, and environmental priorities. Its proposals on the global stage tend to be heavily informed by policies and actions that largely align with its own domestic economic development and energy strategies. For instance, China made headlines on the eve of the Copenhagen climate conference in 2009, when it announced that it intended to cut carbon intensity by 40 to 45 percent by 2020, but that target was already being incorporated into the 12th FYP.[54]

Similarly, the APEC announcement was likely informed by China's upcoming 13th FYP, as well as Beijing's thinking about objectives for the 14th and 15th FYPs that will carry through to 2030. For instance, if Beijing announces a national cap and trade program or a carbon tax, as some anticipate, that will likely be because these are measures that have already been incorporated into China's economic plans.

Figure 14. China's Carbon Emissions Trajectory Under Various Scenarios*



*AIS = Accelerated Improvement Scenario; CIS = Continued Improvement Scenario
Source: Lawrence Berkeley National Laboratory.

Indeed, the 2014-2020 energy strategy noted earlier bears this out: if China reaches 15 percent of non-fossil fuels in its primary energy mix, that should translate into more than 700 GW of installed renewable resources (see Figure 6 again). This already puts China within grasp of the lower end of its proposed renewables target of 800-1000 GW of installed capacity by 2030.[55] Moreover, different projections of China's emissions peak, both from China's own Energy Research Institute and US experts, show a number of paths that make 2030 realistically achievable, if not earlier (see Figure 14).[56]

This is not particularly surprising, as China and the United States are the two major powers that still do not have a fully integrated, national-level climate change policy. Instead, each is pursuing separate but largely complementary actions to address domestic energy issues, which will nonetheless have direct and positive effects on emissions reduction.

As demonstrated above, China has outsized and unique energy challenges that it must address, while ensuring that such actions do not derail its economic growth. China still has about one-third of its labor force working on farms, and these people need to be brought into the middle class. But even within such a framework of balancing reasonable economic growth with reducing its carbon footprint, Beijing can still achieve significant results simply by pursuing its current strategy to the full extent.

If China can diversify away from coal aggressively and at a faster pace than it currently anticipates, that alone will drive major changes in its energy profile, directly affecting its contribution to global emissions reduction. The immediate battle against air pollution requires many of the same policies and actions that are also effective in tackling emissions. They are, in short, mutually reinforcing.

Whether China signs on to any global accord on climate change will be important but ultimately may not be sufficient in addressing the monumental challenge. As China constitutes roughly 13 percent of the global economy and will almost certainly be the largest contributor of greenhouse gases over the next decade, its effective execution of a major energy and economic transition will be central. It will undoubtedly have profound, and positive, effects on the global energy and emissions landscape.

Conclusion

President Xi may well aspire to foment an energy revolution in China, but in the foreseeable future, it is more likely to be an energy evolution. China's path forward is more or less clear, yet the scale of its energy challenge is daunting. What is more, from Beijing's vantage point, balancing the competing priorities of economic growth and an energy transition will be a tall order. But trading one off against the other involves making a false choice. After all, refashioning China's economic model should facilitate a rebalancing of its energy profile as well. These two priorities align, rather than diverge.

China's path forward is more or less clear, yet the scale of its energy challenge is daunting.

Beijing's clarion call for addressing air pollution is a proxy for pushing forward an energy agenda that would also be embraced by the Chinese public. "Climate change" may be an abstraction to the average Chinese, remote from their daily lives, but the suffocating smog that chokes Chinese cities is not. And yet the basic sources of these two problems are the same—they are severe symptoms of an energy-intensive, inefficient, and coal-based industrial economy.

Imposing significant constraints on industry and controlling the growth of coal could have some immediate downsides to an economy that is already slowing down. But it can also be a catalyst for new industries and sectors to flourish, such as cleaner energy sources like natural gas, environmental technologies, and energy services. And the fact that the services sector recently became a bigger contributor to growth, surpassing the secondary, or industrial sector, may suggest that China can sustain growth even with weaker heavy industrial activity.

For all its energy and environmental woes, China also has a unique advantage: More than most developing countries, it has the capacity and willingness to deploy technologies quickly and drive down their costs rapidly. Moreover, China can address the vast majority of its problems by deploying existing technologies rather than inventing new ones.

But it will take more than technology for China to achieve its energy goals. The commitment and political capital behind economic restructuring need to be maintained, while more creative and sophisticated policies will also be required, including rationalizing and marketizing energy prices. An energy approach that has been biased toward prioritizing supply will need to be adjusted to further incorporate incentives that manage demand as Chinese consumption behaviors change.

For the first time in at least a decade, the sense of urgency to deal with a highly unbalanced and distorted energy structure is palpable. Stresses in the Chinese economic system are accumulating and could end up stalling growth in the future, particularly if an energy or environmental crisis materializes. In the end, Beijing may yet hold fast to "differentiated responsibilities" when it comes to climate change, but it will be fully responsible for shepherding its own economy and energy system onto a more sustainable footing.

Appendix: China's Efficiency and Pollution Targets (2011-2015)[57]

Energy consumption per unit of industrial value added	2010	2015	Change
Coal consumption for power generation (gram/kwh)	NA	NA	-21%
Power generators' electricity usage rate	333	325	-8%
Grid line electricity loss rate	6.33%	6.20%	-0.13%
Energy consumption per ton of steel (kg stan coal)	6.53%	6.30%	-0.23%
Aluminum ingots electricity consumption (kwh/ton)	605	580	-25
Copper smelting energy consumption (kg stan coal/ton)	14013	13300	-713
Crude refining energy consumption (kg stan coal/ton)	350	300	-50
Ethylene energy consumption (kg stan coal/ton)	99	86	-13
Synthetic ammonia energy consumption (kg stan coal/ton)	886	857	-29
Caustic soda energy consumption (kg stan coal/ton)	1402	1350	-52
Cement clinker energy consumption (kg stan coal/ton)	351	330	-21
Plate glass energy consumption (kg stan coal/weight box)	115	112	-3
Paper/cardboard energy consumption (kg stan coal/ton)	17	15	-2
Paper pulp energy consumption (kg stan coal/ton)	680	530	-150
Ceramics (kg stan coal/ton)	450	370	-80
	1190	1110	-80
Construction			
Residential building retrofit in northern regions that require heating (100 million sq m)			
Implementation of "green" building standards in urban new builds	1.8	5.8	4
	1%	15%	14
Transportation			
Rail transport per unit payload energy consumption (ton stan coal/mn ton converted km)			
Transport vehicle per unit turnover energy consumption (kg stan coal/mn ton converted km)	2.01	4.76	-5%
Transport ships per unit turnover energy consumption (kg stan coal/mn ton converted km)	7.9	7.5	-5%
Civil aviation per unit turnover (kg stan coal/ton km	6.99	6.29	-10%
	0.45	0.428	-5%
Public entities			
Construction of public entity energy consumption (kg stan coal/sqm)	23.9	21	-12%
Public employee energy consumption (kg stan coal/person)	447.4	380	15%
End user appliance/equipment efficiency			
Coal-fired boilers (operational efficiency)	65%	70~75%	5~10%
Three-phase asynchronous motors (design efficiency)	90%	92~94%	2~4%
Passernger vehicles average gas consumption (liter/100 km)	8	6.9	-1.1
Residential airconditioner (efficiency ratio)	3.3	3.5~4.5	0.2~1.2
Refrigerator (efficiency index)	49%	40~46%	-9%
Residential water heater (heaing efficiency	87~90%	93~97%	3~10%

Pollutant reduction targets	2010	2015	Change
Industry (10,000 tons)			
Industrial COD emissions	355	319	-10%
Industrial SO2 emissions	2073	1866	-10%
Industrial ammonia emissions	28.5	24.2	-15%
Industrial ammoniz oxide emissions	1637	1391	-15%
Coal-fired electricity SO2 emissions	956	800	-16%
Coal-fired electricity ammonia oxide	1055	750	-29%
Steel SO2 emissions	248	180	-27%
Cement ammonia oxide emissions	170	150	-12%
Papermaking SO2 emissions	72	64.8	-10%
Papermaking ammonia emissions	2.14	1.93	-10%
Textile printing and dyeing COD	29.9	26.9	-10%
Textile printing and dyeing ammonia	1.99	1.75	-12%
Agriculture			
Agro COD emissions	1204	1108	-8%
Agro ammonia emissions	82.9	74.6	-10%
Urbanization			
City wastewater treatment rate	77%	85%	8

Source: 12th Five-Year Plan on Energy Efficiency and Pollution Reduction.

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