China Energy
A Guide for the Perplexed

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Contents

Introduction

Henry Kissinger: Many visitors have come to this beautiful, and to us, mysterious land.

Premier Zhou Enlai: You will find it not mysterious. When you have become familiar with it, it will not be as mysterious as before.

—July 9, 1971, Beijing (National Security Archives)

China's energy profile provides a window into its economic soul. It tells us much about what China does, how fast it is doing it, and how efficiently. Energy is also a finite global commodity, demand and supply for which affects us all both in terms of the costs of running our nations, firms and households, and in terms of the environment that surrounds us. So for financial analysts trying to gauge the effect of China's rise on world prices, for policymaking realists formulating responses to China's emergence, and for economists and political scientists seeking to understand the workings of China's economy behind the veil of international cooperation departments in Beijing, a clear understanding of China's energy sector dynamics is important.

The urgency to acquire that understanding is clear: In 2001 China accounted for 10 percent of global energy demand but met 96 percent of those needs with domestic energy supplies; today China's share of global energy use has swelled to over 15 percent and the country has been forced to rely on international markets for more of the oil, gas, and coal it consumes.[1] Between 1978 and 2000 the Chinese economy grew at 9 percent while energy demand grew at 4 percent. After 2001, economic growth continued apace, but energy demand growth surged to 13 percent a year. It is this fundamental shift in the energy profile of China's economic growth that has created shortages at home, market volatility abroad, and questions about the sustainability of China's trajectory. China is now the world's second-largest energy consumer and is set to become the leading source of greenhouse gas emissions as early as the end of 2007.[2]

Despite its importance, China's energy profile has been hard to make sense of for those whose jobs don't entail watching the sector full time. It is in flux, changing quickly in its constant effort to keep up with the rest of the economy. It is a fusion of plan and market forces, formal regulation and seat-of-the-pants fixes, central intentions, and local interests. And while retail consultants can trawl through supermarkets in Shanghai counting cereal boxes to measure trends, in energy many key metrics are obscured by national security considerations or habits of secrecy at state-owned enterprises.

The purpose of this policy analysis is to make visible the internal dynamics of the Chinese energy situation, which most observers glimpse only second hand as the impact of demand on world markets, the behavior of Chinese firms abroad and the effect of Chinese emissions on the global environment. Our hope in doing so is to facilitate energy policy cooperation between China and other countries, more rational conception of and reaction to China's energy behavior by markets and governments, and more effective prioritization of the energy reform agenda in China, the United States, and elsewhere.

The analysis is divided into four sections:

What's driving demand: An explanation of the internal dynamics fueling China's energy needs. Our key point: It's not air conditioners and automobiles that are driving China's current energy demand but rather heavy industry, and the mix of what China makes for itself and what it buys abroad. Consumption-led demand is China's future energy challenge.

[1] See BP (2006), the *China Statistical Yearbook* from the National Bureau of Statistics, and *China Customs Statistics* from the General Customs Administration. The latter two as well as all other Chinese statistics used in this analysis (unless otherwise indicated) have been collected via CEIC Data Company Ltd., a commercial statistical database provided by ISI Emerging Markets. Henceforth, all figures accessed in this manner will be referenced as CEIC data followed by the source publication or government agency.

[2] The International Energy Agency (IEA 2007b) sees China surpassing the United States in 2009. Most recent estimates by the US Carbon Dioxide Information Analysis Center move that date up to 2007.

China's energy supply system: An explanation of the policies, institutions, and markets China relies on to meet its demand. Our key point: China's energy system is increasingly unsuited to manage demand in a secure manner, and for the medium-term Beijing and other countries will need to work-around that system with second-best solutions.

Global impacts: An accounting of the external implications of China's energy choices in light of the systematic analysis of demand and supply dynamics. Our key point: While the roots of China's energy profile are a domestic matter, the shoots and leaves affect the vital interests of others, and we all have a legitimate basis to be "nosy neighbors" when it comes to China's energy needs.

Conclusions and the policy agenda: By starting from a holistic understanding of China's demand and supply fundamentals, both policymakers and civil society groups can play an even more positive role on the China energy agenda. Our key point: China's energy challenge is rooted in systemic conditions that go beyond the energy sector per se, and therefore energy policy alone will not provide the answers. Coordinating energy analysis with the broader policy agenda on macro and external imbalances is essential. Yet while structural adjustment is necessary to address root causes, given the conflicting pressures China's leaders face the international community must be realistic in working to mitigate negative impacts, building international energy regimes that include China, and exploring policy options not dependent on Beijing's readiness to proceed in an optimal manner.

China is the focus of this analysis. However, the reader should understand that despite the enormity of the China energy challenge, the United States is still a bigger consumer of energy despite having less than one-quarter the population. US culpability does not obviate the need for critical analysis of China—the biggest contributor to the planet's energy profile at the margin. The lessons learned in thinking about China may soon have to be applied to India as well. While this report is written about China *for* US and other Western analysts and policymakers, and not *about* the US energy footprint, the US and Chinese economies are of course profoundly related in terms of the distribution of production and shared interest as energy consumers. Much of the energy China consumes is used to make products sold to the rest of the world, thus replacing energy demand in other countries. As such, the basis for reforming China's energy sector may well include equally profound changes in the United States and elsewhere.

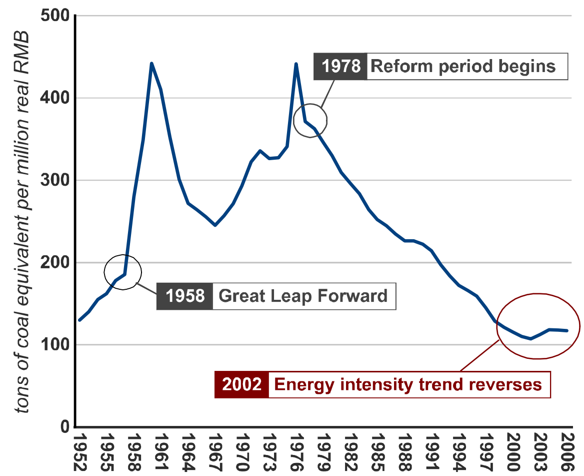
1 What's Driving Demand

THE EVOLUTION OF ENERGY DEMAND IN CHINA

On the eve of the reform in late 1970s China had an energy demand profile impaired by years of central planning and ideological failures. Rather than choosing a development strategy in line with its natural endowments (rich in labor, poor in capital and technology) as Japan, Hong Kong, Taiwan, and others had done, Communist Party leaders ignored their comparative advantage and dragged China—kicking, screaming, and sometimes starving—in pursuit of Soviet-style industrialization. In fits and starts over 30 years, the country's economic resources were directed out of agriculture and into energy-intensive industries like steel and cement. Between 1949 and 1978, industry's share of economic output grew from 18 to 44 percent and the amount of energy required to produce each unit of economic output tripled (figure 1).[3] Running counter to what China's resource base could support, this command and control approach created tremendous inefficiency and hence, ironically, the potential for catch-up growth later.

In 1978 leaders began to unleash that potential. Faced with the prospect of another wave of famine as an agricultural sector with fewer people and resources failed to keep up with the government's industrial vision, Beijing let farmers "catch their breath" by relaxing production targets, raising prices and increasing the autonomy of farming collectives. The results were dramatic. With market incentives farmers increased output. The early 1980s saw rural residents with more time on their hands, cash in their pockets and freedom to choose how to use it. Much of the new-found wealth was invested into township and village enterprises (TVEs) targeted at the sector where China would most naturally be productive: labor-intensive light manufacturing. These TVEs became an engine of economic growth and the opening salvo in a sectoral shift away from energy-intensive industry that shaped China's energy footprint for the next 20 years.[4]

Figure 1: Energy Intensity of the Chinese Economy (1952-2006)



Source: CEIC from China Statistical Yearbook

In addition, the reform period brought changes within heavy industry that further improved the energy intensity of Chinese growth. Economic incentives—the right to aspire to and keep profits—were introduced where there had previously been only planned mandates. Awareness of bottom-line profits improved the focus on top-line expenses, including energy. And as enterprises were becoming more aware of the impact of energy costs on profitability, their energy bills were growing as the result of partial liberalization of oil, gas and coal prices. The introduction of limited competition for both customers and capital, not just from other state-owned enterprises (SOEs) but from a growing private sector, made energy cost management all the more important. Domestic market competition was augmented by integration with competitive global markets. Falling trade barriers brought pressure on SOEs from energy-efficient foreign

[3] CEIC data from the *China Statistical Yearbook.*

[4] For more on energy dynamics in China's reform period, see Kenneth Lieberthal and Michel Oksenberg, *Policy Making in China : Leaders, Structures, and Processes* (Princeton, N.J.: Princeton University Press, 1988). On the launch of reforms in general, see Barry Naughton, *Growing out of the Plan : Chinese Economic Reform, 1978-1993* (New York, NY: Cambridge University Press, 1995), Susan L. Shirk, *The Political Logic of Economic Reform in China*, California Series on Social Choice and Political Economy ; 24 (Berkeley: University of California Press, 1993), Barry Naughton, *The Chinese Economy : Transitions and Growth* (Cambridge, Mass.: MIT Press, 2007), Kenneth Lieberthal and David M. Lampton, *Bureaucracy, Politics, and Decision Making in Post-Mao China*, Studies on China ; (Berkeley: University of California Press, 1992), Nicholas R. Lardy, *Integrating China into the Global Economy* (Washington, D.C.: Brookings Institution Press, 2002), Nicholas R. Lardy, *China's Unfinished Economic Revolution* (Washington, DC: Brookings Institution, 1998), Kenneth Lieberthal, *Governing China : From Revolution through Reform*, 2nd ed. (New York: W. W. Norton, 2004).

companies, but also allowed them to acquire the energy efficient technology their competitors enjoyed. Rapid economic growth enabled China to integrate this technology quickly, significantly improving the efficiency of the country's capital stock. [5]

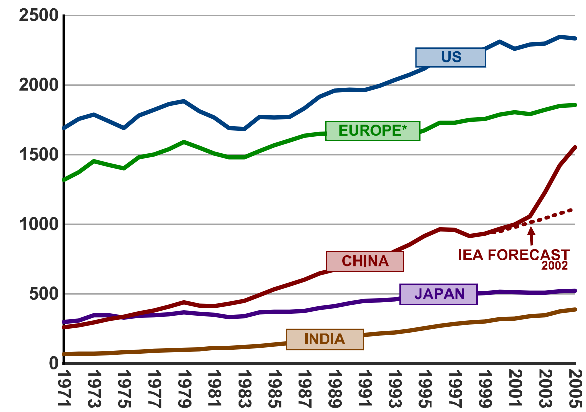
By 2000, Chinese economic activity required two-thirds less energy per unit of output than in 1978 (see again figure 1). Energy intensity improvement on this scale was unprecedented for a large developing country, and meant that China in the year 2001 was 10 percent rather than 25 percent of global energy demand.

THE CURRENT DEMAND PICTURE

Starting the new millennium in 2001, China's leaders expected that the pattern of energy intensity improvement achieved over the previous 25 years would continue. Reform was largely an accepted reality, and was assumed to presage further energy efficiency. Centrally orchestrated conglomerate-building ambitions had been scaled back with the Asian financial crisis, which tarnished the national champion model. The decision to join the World Trade Organization (WTO) had been made, locking in greater market contestability inside China and the importance of comparative advantage. Most energy forecasters at home and abroad assumed that the structural adjustment away from energy-intensive heavy industry toward lighter industry would stick. Further, the economy's GDP was expected to grow at a rate of 7 to 8 percent—fast but not furious (Zhou and Levine 2003). Both the Chinese government and the International Energy Agency (IEA) predicted 3 to 4 percent growth in energy demand between 2000 and 2010 (figure 2).

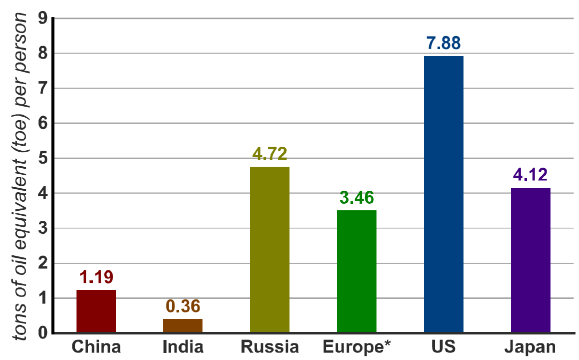
Both missed the mark by a mile. The economy grew much quicker than anticipated, but the real surprise was a change in the energy intensity of economic growth. Energy demand elasticity (the ratio of energy demand growth to GDP growth) increased from less than 0.5 between 1978 and 2000 to 1.5 between 2001 and 2006.[6] Energy consumption grew four times faster than predicted to over 15 percent of global demand in 2006 (nearly twice as large in absolute terms as forecast in most 2002 estimates). Yet on a per capita basis, China's energy demand remains relatively low (figure 3).

Figure 2: Energy Demand (mtoe)



Source: BP Statistical Yearbook 2006, IEA WEO 2002. Excludes biomass and waste.
*Europe refers to OECD Europe.

Figure 3: Per Capita Energy Demand (toe, 2005)



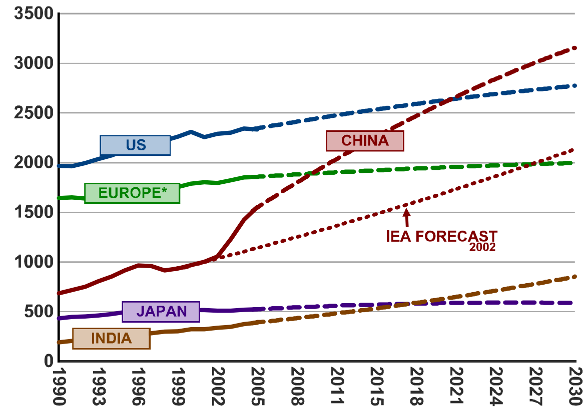
Source: BP Statistical Review and Economist Intelligence Unit (EIU)
* Europe here refers to OECD Europe

This upside surprise not only shocked domestic and international energy markets (discussed in greater depth later on) but also has prompted a fundamental reassessment of China's, and thus the world's, energy future. The IEA has raised their China 2030 forecast by 1.2 billion tons of oil equivalent (a 63 percent upward revision)—more than India's total projected demand for that year (IEA, *World Energy Outlook 2006*) (figure 4). Under this scenario, China will account for 20 percent of global energy demand, more than Europe and Japan combined, and easily surpass the United States as the world's largest energy consumer.

[5] Analysis of what contributed to China's reduction in energy intensity can be found in Karen Fisher-Vanden et al., "Technology Development and Energy Productivity in China," *Energy Economics* 28, no. 5-6 (2006), Fuqiang Yang et al., "A Review of China's Energy Policy," (Lawrence Berkeley National Laboratory, 1995), Jin-Li Hu and Shih-Chuan Wang, "Total-Factor Energy Efficiency of Regions in China," *Energy Policy* 34, no. 17 (2006)., Lynn Price et al., "Industrial Energy Efficiency Policy in China," in *ACEEE Summer Study on Energy Efficiency in Industry* (2001), Karen Fisher-Vanden et al., "What Is Driving China's Decline in Energy Intensity?*," *Resource and Energy Economics* (2004), Richard F. Garbaccio, "Price Reform and Structural Change in the Chinese Economy: Policy Simulations Using a CGE Model," *China Economic Review* 6, no. 1 (1994).

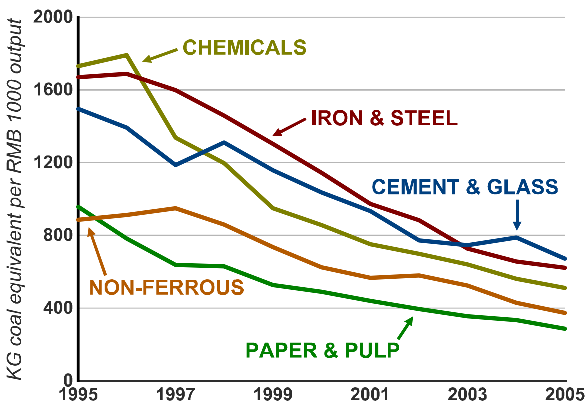
[6] CEIC data from the *China Statistical Yearbook.*

Figure 4: Energy Demand Forecasts (mtoe)



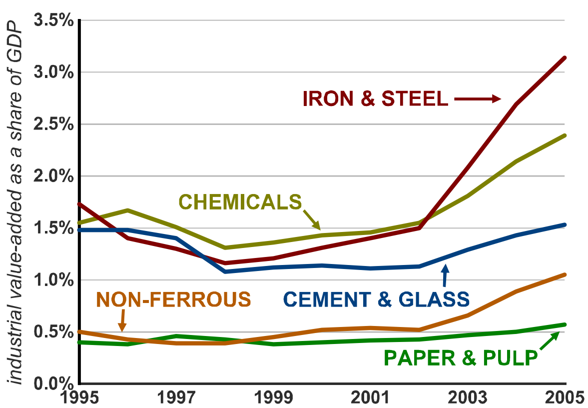
Source: BP Statistical Yearbook 2006, IEA WEO 2002, IEA WEO 2006. Excludes biomass and waste. *Europe refers to OECD Europe.

Figure 5: Energy Intensity by Industry



Source: CEIC from China Statistical Yearbook

Figure 6: Industry Output as a Share of GDP



Source: CEIC from China Statistical Yearbook

What caused China's two decade history of energy intensity improvements to change course? Many China watchers assume that the recent evolution of China's energy profile reflects growth in consumption and transport, for instance air conditioning and personal cars. This is not correct. Consumption-led energy demand will be the major driver in the future and is already significant in absolute terms, but the main source of today's growth is energy-intensive heavy industry.

Industrial energy efficiency has continued to improve over the past six years: Every new steel mill is more efficient than the last (figure 5); but the structural shift away from heavy industry toward light industry has reversed, and a new steel plant—no matter how much more efficient than its peers—uses substantially more energy than a garment factory (figure 6).

Though these "twin culprits" are important, one is primary and the other secondary in understanding the present picture. We profile these demand drivers below, explore the factors behind them, and look at how they will shape China's energy footprint going forward.

INDUSTRY-LED DEMAND

Industry accounts for over 70 percent of final energy consumption in China today, while the residential, commercial and transportation sectors account for 10, 2, and 7 percent, respectively.[7] This is high by either developed or developing country standards (figure 7). In part it reflects the role of industry in the Chinese development model (figure 8), as opposed to India which has taken a more services-heavy approach. Yet industry as a share of China's GDP reached its current high of 48 percent two other times, in the late 1970s and the early 1990s, when investment booms also created a surge in industrial activity (Lardy 2006). Is it the case then that energy-intensity booms arise whenever there is an investment boom in China?

From an energy standpoint, the current investment cycle is different: China is now making for itself, rather than importing from abroad, more of the energy-intensive basic products (such as steel and aluminum) used to construct the roads and buildings investment pays for. China now accounts for 48 percent of global cement production, 49 percent of global flat glass production, 35 percent of global steel production, and 28 percent of global alumi-

[7] CEIC data from the *China Energy Statistical Yearbook*. This figure, as those used throughout this analysis, excludes consumption of biomass fuels like wood and crop waste. The use of such fuels is difficult to quantify and unlikely to increase much in absolute terms as China develops.

num production (figure 9).[8] Some of this has been a migration of energy-intensive industry from other parts of the world, not only to meet Chinese demand but for export to other markets. The energy effects of investment cycles are changing (in fact worsening), underscoring an important insight: booming investment and booming investment into energy-intensive heavy industry are increasingly the same thing. The implication of this is that energy problems cannot be fixed with energy policy reform alone, but require financial system and other reforms more broadly. In his companion paper on "Rebalancing Economic Growth," for the *China Balance Sheet* series, our colleague Nicholas Lardy discusses the challenges of rationalizing financial intermediation in China.[9] In the section immediately below, we consider the role of finance—among other factors—in promoting energy-intensive industry growth.

Why is a country that grew rich for 25 years utilizing comparatively abundant resources (labor) shifting back toward industries that rely on scarce and strained resources (energy, raw materials, capital, and technology) and that create relatively few jobs? Is it the result of coordinated industrial policy by Beijing or simply firms seeking to maximize profits? Has comparative advantage shifted from labor-intensive to energy- and capital-intensive manufacturing? Based on a review of the literature, analysis of the macroeconomic and industry data available and primary research interviewing Chinese and foreign business leaders, industry analysts, government officials, academics and activists, we can postulate a number of things.

In general, the changing composition of China's industrial structure is less the result of concerted national aspirations (as it was under Mao Zedong) as competition among provinces, counties and cities to grow GDP, the capital stock, tax revenue and corporate profits. The rules of competition are set not just by Beijing, but also by local interests, including individual state-owned heavy industrial enterprises. And regardless of who sets the rules, the reality of how they are implemented is almost entirely a local matter. [10]

Figure 7: Energy Demand by Sector (2005)

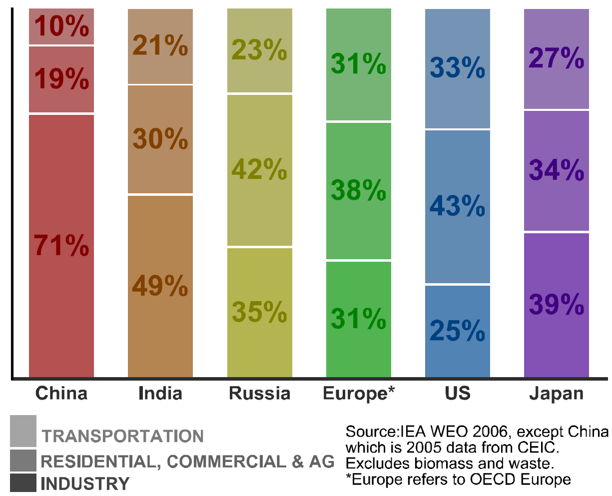
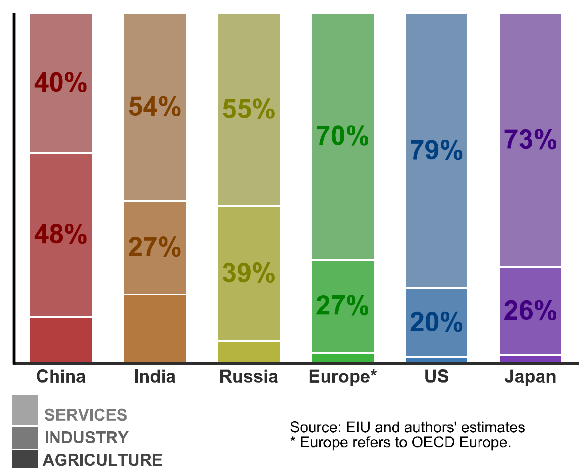


Figure 8: GDP by Sector (2005)

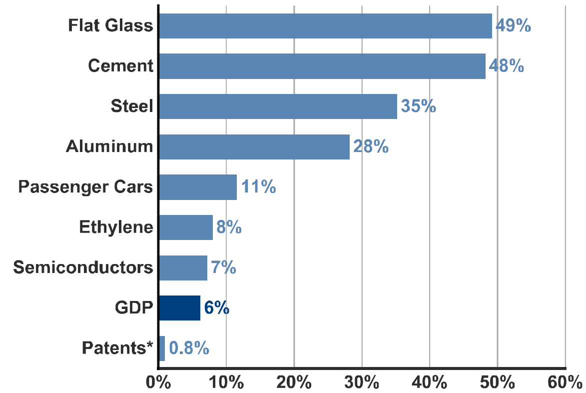


[8] Michael Taylor, "Energy Efficiency and Co2 Reduction Opportunities in the Global Cement Industry" (paper presented at the IEA-WBCSD Cement Industry Workshop, IEA, Paris, 4 September 2006). Pilkington, "Flat Glass Industry - Summary," http://www.pilkington.com/about+pilkington/flat+glass+industry/default.htm.; International Iron and Steel Institute, www.worldsteel.org; Abare Economics, www.abareconomics.com. CEIC data from the *China Statistical Yearbook.*

[9] Nicholas R. Lardy, "China: Rebalancing Economic Growth," (Washington: Peterson Institute for International Economics, 2007). This adds to Lardy's seminal work, *China's Unfinished Economic Revolution* (1998), which dealt in detail with problems in financial intermediation.

[10] Barry Naughton's recent textbook *The Chinese Economy* (2007, 347) argues: "The development of a market economy in China has shaped the economy in complex and sometimes apparently contradictory directions that are far different from what a central planner would ever have envisaged." Andy Wedeman's *From Mao to Market* catalogues many of the intraprovincial trade wars that still go on but through industrial policy tactics rather than outright roadblocks. Scott Kennedy's recent work demonstrates the extent to which firms and their industry associations now drive industrial policy, rather than industrial policy disciplining them (Scott Kennedy, *The Business of Lobbying in China* (Cambridge, Mass.: Harvard University Press, 2005).

Figure 9: China's Share of Global Production (2006)



Source: CEIC, USPTO, IEA, Pilkington, IISI, USGS, Comtex, and author's estimates
* Refers to share of US Patents awarded to foreign countries

Within this context of competition, economic incentives explain much of the industrial buildout. On the profit side, after tax earnings in energy-hungry industries have been good (thanks to huge depreciation on new investments, absence of dividend payment to the government for SOEs, transfer payments, and other factors).[11] Ranging from 4 to 7 percent in steel, glass, chemicals and cement in recent years, heavy industry profits have risen from near-zero in the late 1990s to a level comparable to their light industry counterparts.[12] With China modernizing over 170 cities of more than 1 million people, certainly there is a large domestic market for basic materials, and supply was squeezed by breakneck growth since 2001. But with overcapacity arising almost as soon as the first profits, the ability to sell surplus production into international markets has been critical to maintaining margins.

Contributing to strong profit is the fact that important costs associated with energy intensive industry are low in China. Land—a key input—is often deeply discounted and brokered by local governments. Costly investments to protect public goods including air and water are often not enforced. Construction time is short and labor costs very low. These conditions generally apply to all industry; however they are particularly valuable in the energy-intensive segment where fixed investment costs are large.

Distortions in the financial system take the sting out of the fact that heavy industry is usually capital intensive. Not only are margins high, but SOEs have not had to distribute them to their shareholders (the State!), leaving them with plenty to reinvest. When it comes to borrowing, banks can lend at a nominal 6 to 7 percent to state firms (often lower under a variety of development promotion schemes) because they pay depositors only 2.8 percent for one-year deposits.[13] Importantly, the risk of foreclosure if investments turn out to be stupid—a potent incentive to be careful about comparative advantage elsewhere—barely applies for state firms in China.

Energy

Energy prices in China, once highly subsidized, have largely converged with world prices over the past 30 years. Yet an accurate assessment of what any specific firm pays for coal, gas, oil or electricity can be difficult due to local idiosyncrasies in pricing, dual supply channels for many legacy SOEs, arrears (both permissioned and not) and other factors. Chinese prices for raw energy commodities including coal and natural gas can be significantly cheaper than in the Organization for Economic Cooperation and Development (OECD), particularly in interior provinces close to resource deposits. For coal, this results not from subsidization but rather low extraction costs in areas isolated from international markets. As transportation bottlenecks ease, coke prices will continue to converge upwards with world prices. Natural gas prices, on the other hand, have been tightly controlled by Beijing which, facing pressure from the Middle East in attracting and maintaining gas-intensive industries like petrochemicals, has attempted to keep industrial gas prices competitive with those in other developing countries. But as this approach has failed to induce the development or importation of sufficient quantities of natural gas to meet burgeoning demand, domestic prices have increased.

For electricity, the form in which Chinese industry receives more and more of its energy, prices appear high

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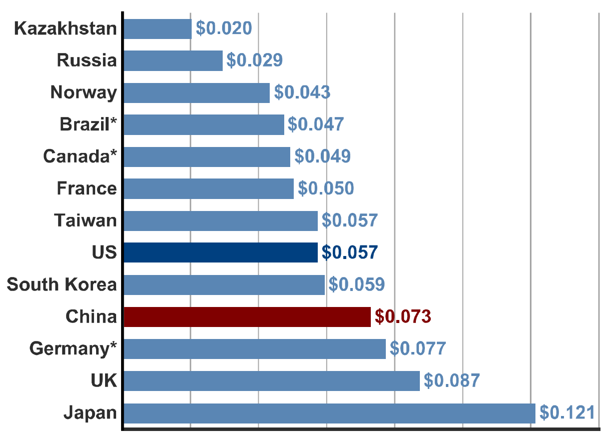
[12] CEIC data from the *China Statistical Yearbook*. For opposing views on how good profits really are in recent years, see Louis Kuijs, William Mako, and Chunlin Zhang, "SOE Dividends: How Much and to Whom?," in *World Bank Policy Note* (Washington: World Bank, 2005), Weijan Shan, "The World Bank's China Delusions," *Far East Economic Review* (2006), Weijian Shan, "China's Low-Profit Growth Model," *Far Eastern Economic Review* 169, no. 9 (2006), Bert Hofman and Louis Kuijs, "Profits Drive China's Boom," *Far Eastern Economic Review* 169, no. 8 (2006), Jonathan Anderson, "The Furor over China's Companies," in *Asian Focus* (Hong Kong: UBS, 2006). and David Dollar and Shang-Jin Wei, "Das (Wasted) Kapital: Firm Ownership and Investment Efficiency in China," in *IMF Working Paper* (International Monetary Fund, 2007)., which, though pointing to the superiority of private management over SOEs in China, reports very solid profits almost across the board.

[13] As of March 2007, household deposits were reported at $2.04 trillion and enterprise deposits at $1.46 trillion. Rates reflect March 2007 hikes.

compared with both other developing and developed countries (figure 10). Based on our conversations with Chinese business leaders and industry analysts, however, it is likely that many industrial enterprises do not bear the full cost implied by national average figures from the Statistical Bureau. The National Development and Reform Commission (NDRC) sets electricity tariffs province-by-province based on the recommendations of local pricing bureaus that answer to local officials. While NDRC would like to see a rationalization in energy pricing to reduce overall energy consumption, it is hindered by local social and economic development concerns. Energy-intensive firms in China typically consume more energy per ton of output than their peers in the OECD (on average, 20 to 40 percent more, according to some estimates [He 2006 and Wan 2006]), and are thus sensitive to electricity price increases (as well as gas and coke prices). Recent efforts by NDRC to raise prices for the most energy hungry industries have been met with provincial resistance,[14] and even when the price increases stick, non-payment can be a significant issue.[15]

Figure 10: Electricity Prices for Industry (USD per kilowatt-hour, 2005)



Source: EIA and CEIC from NDRC Price Monitoring Center. *2004 data.

Environment

Energy in China is at or near international price levels, but this is based on excluding associated environmental costs.[16] Over 80 percent of the country's electricity is generated from coal. Less than 15 percent of these coal power plants have flu gas desulphurization (FGD) systems (used to remove SO_2 from emission streams) installed and even fewer have them running.[17] Operating an FGD system requires a 4 to 8 percent reduction in production efficiency and therefore contributes marginally to a higher electricity price. If all the power plants in China installed and operated FGD systems, average electricity tariffs could rise by as much as 15 to 20 percent.[18] Industries that burn coal directly (such as steel and cement) are subject to sulfur taxes, but these are generally too low to reduce pollution. Other air pollutants, such as nitrogen dioxide and mercury are largely unregulated. And regulated or not, enforcement generally falls to the provincial and local governments, which must balance environmental concerns against economic growth priorities. In the absence of a stronger environmental regulator, like the Environmental Protection Agency (EPA), that balance is skewed toward near-term economic growth as industry warns of a loss of competitiveness to the province next door (and therefore jobs and tax revenue) if environmental enforcement is ratcheted up.

Land and Construction

In China, land is not privately owned in perpetuity, but owned and allocated by the government on the people's behalf. While private land ownership does not exist, long-term leases do (generally 50 years) and are bought and sold between both individuals and enterprises. In more developed urban real-estate markets like Beijing and Shanghai, there is little difference between these land-leases and an ownership deed. They are priced at market terms and transferred between holders with little interference from the state. Outside the urban commercial and residential real estate markets, however, land transfers are largely government domain. Local officials can appropriate farm land to create industrial parks. While they are required to compensate farmers, the amount paid is typically determined by the agricultural, not the industrial, use value. The effect is that in order to attract new industrial investment, local officials have the ability to price land well under what a firm would pay elsewhere in the world. Industrial users will in the future pay taxes to these governments, farmers will not. While land use prices are

[14] "China Halts Preferential Electricity Pricing of 14 Provinces," *Asia Pulse*, 17 April 2007.

[15] We thank Scott Roberts of MIT for this point.

[16] In 2004 and 2005 transport fuel prices—gasoline and diesel—were an exception to this. These have, for the time being, converged with international prices, and in any case were a minor component of industrial energy costs.

[17] Estimates for the amount of power generation capacity with FGD installed range from 60GW to 90GW out of a total base of 622GW.

[18] Calculated based on the share of total power generation coming from coal, the amount of FGD already installed and running, and the current tariff increase allowed for power plants that run FGD systems.

rising in coastal areas, new swaths of farmland are being offered for industrial use in China's interior and heavily discounted to lure investment.

In extensive interviews with directors of energy intensive firms expanding operations in China, the land cost advantage was emphasized. So too was the lower cost and time required for construction. Localities often contribute generously to groundwork—grading, infrastructure build out, and clustering related segments of the value chain. Relocating existing residents, carrying out environmental impact assessments, and other steps are accelerated in China to a degree not found elsewhere. Labor costs in construction are dramatically lower in China than in to the OECD world. An aluminum smelter that would take 3-4 years to build in the United States at high labor and ground preparation cost can be constructed in China in under a year and much lower daily cost.[19]

Capital and Consolidation

China's financial system does not exist in order to bankroll over-deployment of the nation's wealth into energy-intensive industry, either statutorily or in terms of the aspirations of central leaders. In fact senior leaders are exerting themselves to reduce the energy intensity of the economy. Nonetheless, the outcome has been just that: too much capital going to build out energy guzzling capacity. This is often rational from a financial perspective because the costs associated with operating such industries are low, because excess capacity can be exported without fear of normal exchange rate effects, and because borrowers are mostly state-owned firms and hence loan officers at state owned banks bare little career risk in making loans to them. Further, foreign industrial firms are willing to join in many projects, contributing promising technology and back-linkages to developed markets.

Industry seeking investment finds a sympathetic audience at the local and provincial level even while central authorities are leaning against approvals in sectors where they see—with the advantage of a national perspective—overcapacity. Beijing, through the NDRC and other entities, has formally tried to curb lending to steel, aluminum, cement, and other industries in recent years. They have tried to prevent lending to new firms in the automobile sector, force consolidation by financial takeover in steel, coal and other sectors, and raise borrowing costs for energy-intensive industries in general. But in most cases, financing of additional capacity has continued, while little of the unauthorized capacity is ever shut down.

Since 1998, profit margins on an earnings before tax (EBT) basis[20] have recovered from less than 1 percent to between 4 and 7 percent for China's energy hungry industries (table 1). In fact, last year, profits margins in metals, glass, chemicals and cement exceeded those in textiles, apparel, furniture and electronics. The aluminum industry has seen a particularly dramatic increase in profitability with EBT margins increasing from 5 to 14 percent in the past four years. Recent survey work by David Dollar and Shang-jin Wei, which calculates return on investment in 12,400 firms across the country, supports the trends seen in sector-wide official profit data. Since 2002, iron and steel profits have surpassed those in most light industries (Dollar and Wei 2007).

Table 1: Industrial Profit Margins (on an EBT basis) (percent)

Industry	2006	2002	1998
Heavy Industry			
Iron & Steel	5.2	4.6	0.8
Nonferrous Metals	6.8	3.2	–0.8
Cement & Glass	5.3	3.7	–0.4
Paper & Pulp	5.2	5.0	1.8
Basic Chemicals	5.6	4.0	1.0
Light Industry			
Textiles & Apparel	3.9	3.1	0.2
Furniture Manufacturing	4.4	4.0	3.7
Computers & Telecom	3.3	4.8	4.3
Electronic Machinery	4.7	5.0	2.6

Source: CEIC. Calculated as pretax earnings divided by total sales revenue.

Some debate whether China's firms are truly profitable. Gross corporate earnings, return on equity, net margins, and gross margins give significantly different answers. Shan Weijian of TPG Newbridge, an investment firm, has argued that the value of debt-to-equity swaps and bank recapitalization has exceeded the entire pre-tax profits of the industrial sector since 1999—suggesting zero profitability but for lax bank financing on a gargantuan scale. This suggest that the direction China is headed is wrong, but does not contradict the instinct to pile into these industries at the microeconomic level. For explaining the gold rush into heavy industry the debate about which margin best reflects performance may matter less than the reality that cash flows are huge and growing

[19] Based on conversations with both US and Chinese aluminum industry analysts, January and February 2007.

[20] Calculated as earnings before tax divided by total sales revenue.

dramatically, putting industry in a position to exert even more power and influence.

A corollary is that if banks are told not to lend or must charge prohibitively higher rates, many of China's biggest SOEs have sufficient retained earnings that they can pay their own way. And there is little alternative to reinvesting: enterprise deposits in the banking system—like household deposits—receive minimal interest. Again there is debate about whether these retained funds reflect massive depreciation allowances rather than profit, and again it does not matter for our purposes here. Likewise, the argument that such funds should be distributed to shareholders, which means the government itself, is compelling, and may come to pass soon helping to soak up liquidity and fund social expenditures, but it is not presently the case and anyway would likely not be retroactive.[21]

Rising profit impedes Beijing's effort to rationalize resource allocation. The National Development and Reform Commission has sought for several years to consolidate the steel industry, not only to reduce energy consumption but also to create national champion steel companies that can compete with firms in Japan, South Korea, Europe and the United States in higher value-added products. Yet the number of steel enterprises doubled between 2002 and 2006 as firms saw profit opportunities and piled in. The largest three of China's 7000 steel companies, while world-scale, accounted for only 14 percent of the country's total production in 2005. Compare this with Japan, South Korea and the United States, where the top three companies each control well over half of the market (table 2). China's steel industry is Balkanized, with each province promoting its own local champion. Attempts by Beijing to encourage consolidation in the industry meet resistance from provincial and local officials loath to see their firms absorbed by companies from next door.

Similar phenomenon exists in other energy-intensive industries. At the end of 2006, China had 381 aluminum companies, 3,388 paper and pulp companies, 2,982 glass companies, 5,210 cement companies and 20,083 chemicals companies (table 3). And despite government attempts to force consolidation, these industries have instead seen further fragmentation as rising profits and provincial encouragement prompt more players to enter the market.

This pile-on would have created profit-eroding overcapacity were it not for the export safety valve. China's metals companies in particular have been able to clear their inventories and remain profitable by selling to overseas markets, accounting for a big chunk of China's $177 billion trade surplus in 2006. In 2002 China's steel imports exceeded exports by 450 percent. In 2006 exports exceeded imports by 230 percent, making China not only the world's largest steel producer, but also the largest exporter. Today the iron and steel industry in China is responsible for 16 percent of total energy consumption, compared with only 10 percent for all the households in the country combined (figure 11).

Table 2: Global Steel Industry, Market Share and Industry Concentration (2006)

Country	Production	Share	Top 3 Firms*
	crude, million s of tons	*percent of global*	*percent of national*
China	422	34.6	14.1
Europe**	198	16.3	44.7
Japan	116	9.5	69.3
United States	99	8.1	59.7
Russia	71	5.8	55.1
South Korea	48	4.0	85.8
World	1,219	100.0	—

Source: CEIC, IISI, and company annual reports. *Share of domestic production from the three largest companies in 2005. ** refers to EU25.

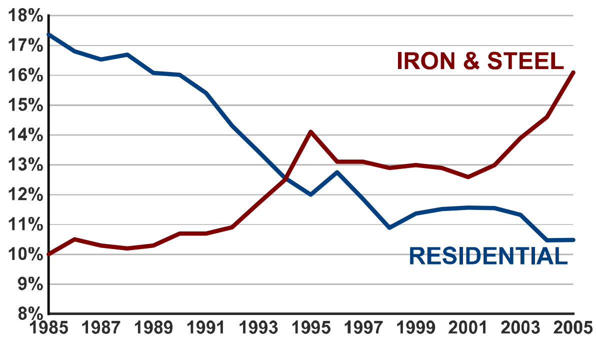
Table 3: Industry Concentration (number of firms in China)

Industry	2006	2004	2002*
Iron & Steel	6,959	4,947	3,551
Nonferrous Metals	2,798	1,766	1,332
Cement Production	5,210	5,042	4,656
Glass & Glass Products	2,982	2,205	1,739
Paper & Pulp	3,388	3,009	2,606
Chemical Materials	20,083	15,172	12,481

Source: Beijing Kang Kai Information & Consulting from ISI Emerging Markets. *2002 number is from a February 2003 survey.

[21] SOE dividend payments to the government is a hot topic at present, and likely to transpire, in some form, in the coming years. See Barry Naughton, "SASAC Rising," *China Leadership Monitor*, no. 14 (2005).

Figure 11: Share of Total Energy Demand, Iron & Steel Industry vs. Household Sector



Source: CEIC from China Statistical Yearbook

Aluminum production, in which China now also runs a trade surplus, consumes more energy than the commercial sector, and production of chemicals, in which China still runs a trade deficit, but a shrinking one, consumes more energy than the transportation sector. Taken together, China's heavy industry today consumes 54 percent of the country's energy, up from 39 percent only five years ago.

The bottom line: Capital allocation is a methadone drip keeping an energy intensive market structure going when it should be allowed to go through painful withdrawal. The consequences of making ill-considered investments in energy intensive sectors must be permitted to bite.

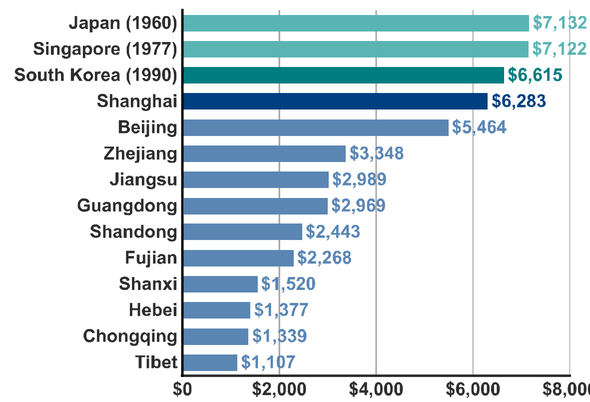
CONSUMPTION-DRIVEN DEMAND

While an investment led shift in China's industrial structure is causing a surge in energy demand, Chinese households are reaching income levels at which energy-intensive consumer goods, like air conditioners and automobiles, are within reach. Historically, when countries reach $5,000 per capita GDP, the commercial and transportation sectors start to surpass industry as energy demand drivers. China's per capita GDP today is $2,000, up from about $200 in 1978. But in more affluent coastal provinces, per capita GDP has surpassed the $5000 mark (figure 12). Shanghai and Beijing, with a combined population of over 33 million, are at the same per capita level as South Korea in 1990. And Tianjin, Zhejiang, Jiangsu and Guangdong, with a population of 225 million, are not far behind.[22]

This emerging middle class is more likely to work in an office than in a factory and, easily able to satisfy their food and shelter needs, have money left over to spend on a consumer goods and services. If making the steel and glass to build office buildings and shopping malls is China's current energy challenge, lighting heating and cooling those malls and offices is China's future energy challenge. Today, the commercial sector accounts for less than 3 percent of total energy demand in the country. That share is set to expand as a function of rising incomes and a growing service sector. While nationally services only account for 40 percent of economic activity, in places like Beijing, Guangdong and Shanghai, their share is much higher and thus commercial demand is already shaping those cities' energy needs (figure 13).

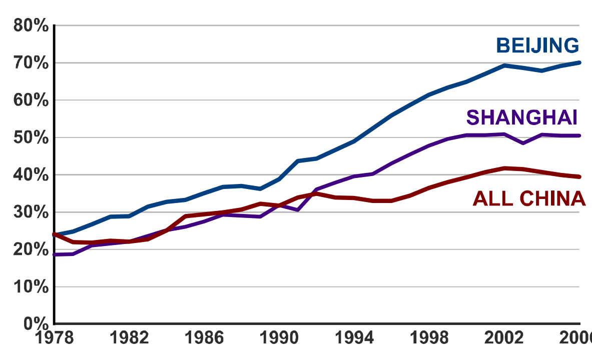
Similarly, the cement and asphalt for highways driving today's investment-led energy demand is paving the way for tomorrow's consumption-led energy demand. The number of passenger vehicles on the roads has doubled since 2002 to more than 25 million, with over 5 million new cars sold in 2006 alone.[23]

Figure 12: Per Capita GDP by Province (real 2005 USD)



Source: WDI and CEIC from China Statistical Yearbook. Population is from Chinese census data.

Figure 13: Service Sector as a Share of GDP, Select Provinces/Municipalities and China as a Whole

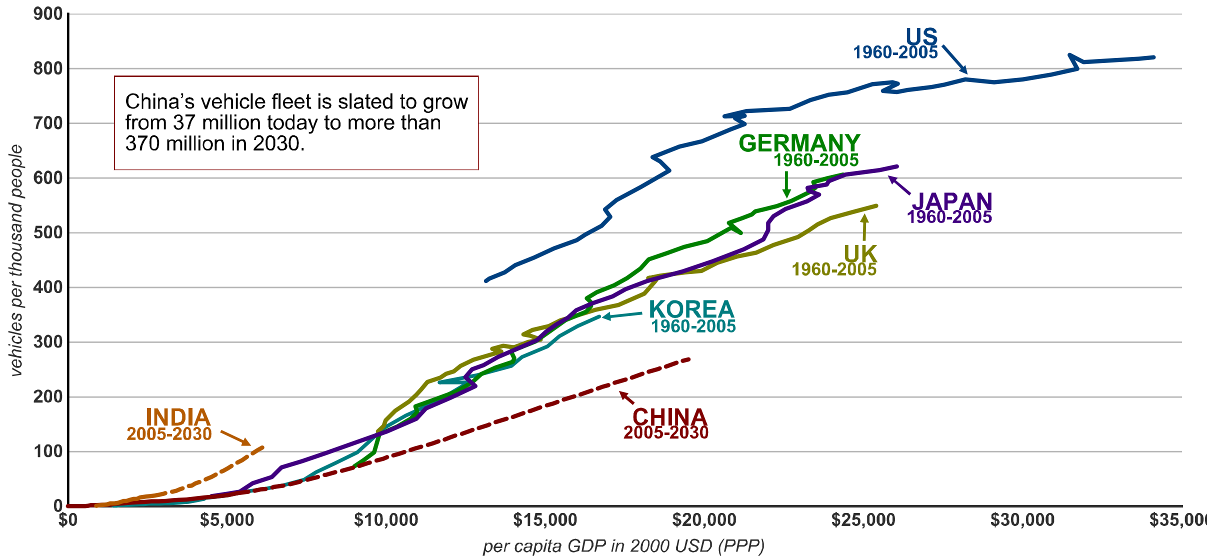


Source: CEIC from China Statistical Yearbook

[22] CEIC data from the *China Statistical Yearbook.*

[23] CEIC data from the Ministry of Communications. These figures refer to passenger vehicles only.

Figure 14: Vehicle Penetration as an Income Function, including China and India Projections to 2030



Source: Dargay, Gately and Sommer (University of Leeds)

While the vehicle fleet in China is still less than 20 percent as large as the United States, the gap is narrowing.[24] Based on experience elsewhere, car sales in China are set to grow faster than GDP until income levels reach about $20,000 per capita. Global projections from the Institute for Transportation Studies at the University of Leeds show China's total vehicle fleet (including trucks) growing 10 fold over the next 25 years from 37 million to more than 370 million cars and trucks (figure 14) (Dargay, Gately, and Sommer 2006).

It is certain that as China gets richer, a greater share of the country's energy demand will come directly from consumers in the form of heating, cooling, lighting and transportation (as opposed to indirectly via infrastructure construction). As Lardy (2007) discusses, a range of options may be used to accelerate the growth of consumption as a weight in China's economy and growth. We take the view that

1) at best a swing back to consumption will be more gradual than the shift *into* heavy industry has been, due to China's political economy and the vested interests now tied up with the status quo;

2) the sunk costs and long life cycles of energy intensive capital investments will incline local authorities to run them as long as possible to recover costs, for the sake of the financial system; and

3) shifting government-directed resources away from energy-intensive industry (like pipelines and ports) and toward social service investments that support consumption (healthcare, education) will not necessarily reduce the absolute value of energy-intensive investment. Trigger-happy global investors have earmarked hundreds of billions of dollars for China exposure, and given further reforms to China's financial markets already anticipated (for instance municipal bond markets)¸there is ample private capital both in China and outside with an appetite for further investment in infrastructure and industry.

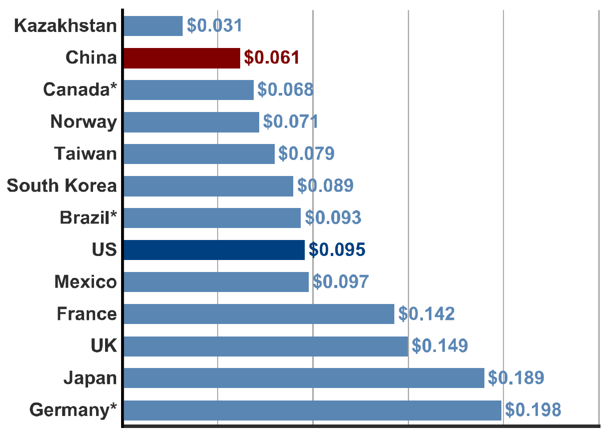
For a considerable period therefore we foresee consumption growth as additive to investment, rather than substituting for it. The rebalancing of China's growth more toward consumption-led growth is entirely desirable from an economic standpoint, but is no panacea for the country's current energy headaches. Increased consumption will bring challenges of its own, and the scope of those challenges is quickly getting locked-in by investment decisions made today.

Each year, over 10 million people are reclassified from rural to urban, most of them moving physically to new places and homes. Building out the commercial and residential real estate to accommodate them (as well as the needs of existing urban residents looking to upgrade their quality of life) amount to a full 23 percent—$270 billion

[24] US vehicle statistics are from the US Department of Transportation's Bureau of Transportation Statistics, available at www.bts.gov.

in 2006—of China's fixed investment.[25] The urban planning and building code surrounding this construction determines how much leeway China will have to alter its energy profile in the future. And with several more decades to go before China reaches the urbanization level of Latin America, this secular driver is here to stay awhile. To date energy efficiency concerns in building China's cities have ranked below cost and timeframe considerations. In addition, the economic distortions underlying domestic steel, aluminum, glass and cement production shield construction companies from the full energy cost (including environmental externalities) of the materials they select. And as residential electricity tariffs are highly subsidized (see figure 15) there is little incentive on the part of consumers to demand the construction of more energy efficient apartment blocks.

Figure 15: Electricity Prices for Households (USD per kilowatt-hour, 2005)



Source: EIA and CEIC from NDRC Price Monitoring Center. *2004 data.

After real estate, the second largest destination for fixed-asset investment is in transportation infrastructure, totaling roughly $140 billion in 2006.[26] And as with real estate, how this money gets spent is shaping the energy profile of China's transportation sector in the years ahead. At present more than half of this investment goes into building highways and less than 20 percent into railways, thus laying the groundwork for explosive automobile growth outlined above.

Efforts to develop mass-transit alternatives are hampered on several fronts, not least by the political economy of the auto industry. Despite Beijing's desire to see the emergence of a select group of national champion auto companies, the industry remains highly fragmented. At present there are 33 companies, scattered among 21 provinces, manufacturing passenger vehicles.[27] In the cut-throat competition between these firms, provincial officials are under pressure to ensure that their local champion has a big enough local market to make it competitive against the company next door.[28]

As automobiles will inevitably be a major part of how China moves people in the years ahead, reducing the energy intensity of automotive transport is essential. Notable improvements have already been made, such as engine displacement taxes and fuel efficiency standards. And in the medium term, some see China as having potential to leapfrog traditional vehicle technology and be earlier movers on alternative like hybrids or hydrogen fuel cells. While the fact that China's auto sector is still in its infancy provides more flexibility in how the future vehicle fleet is built out, we don't see the necessary economic and policy foundations in place, at present, to make such a leap. To date domestic firms have sought to replicate existing vehicle designs rather than create new ones. Weak intellectual property rights undermine the likelihood that foreign innovators will drive costs down through localization in China to the degree needed to make their next generation vehicles "cheap" to the Chinese. On top of this, price controls for gasoline and diesel (discussed on more depth in the following section) have reduced demand for alternatively fueled cars on the part of consumers. In an effort to inoculate consumers against the inflationary effects of rising oil prices, Beijing also removes the incentive to either drive less or switch to a more fuel-efficient car.

[25] CEIC data from the *China Statistical Yearbook.*

[26] CEIC data from the *China Statistical Yearbook.*

[27] "A Profile of China's Automotive Industry " *Xinhua News Agency* 3 March 2007.

[28] For an excellent example of barriers to cross-province auto consolidation, see Keith Bradsher, "Too Many Chinese Cars, Too Few Chinese Buyers. So Far," *The New York Times*, 18 November 2006.

2 China's Energy Supply System

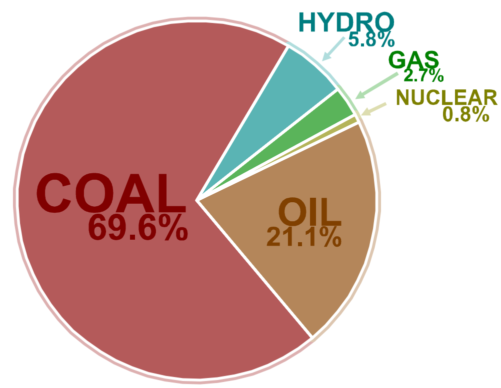
From 1978 to 2001, China's economy was able to grow eight-fold without putting significant strain on the country's energy resources. Institutional reform and price liberalization during this period encouraged more efficient use of coal, oil and natural gas. Demand for these fuels grew at an average annual rate of 4 percent while the economy grew at 9 percent.[29] As a result, until the mid-1990s China was not only able to produce enough energy to fuel its own development, but had enough for export.

Since then the coincidence of an investment-led shift back into heavy industry and the nascent take-off in consumer-driven demand has taken its toll on the country's energy supply system. Demand for coal, on which China relies for 67 percent of its energy needs (figure 16) has grown 12 percent annually since 2001. Oil demand has grown by 9 percent and natural gas by 15 percent over the same period (figure 17). This change in the energy intensity of Chinese economic growth surprised Beijing as well as the rest of the world. Neither government regulators nor market participants were prepared deal with such a demand surge. Over the past five years domestic energy shortages, increased import dependence, price volatility and deteriorating environmental quality have raised the profile of China's energy policy both at home and abroad.

To date, energy sector reforms have lagged those in the rest of the economy. The coal, power, oil and gas industries remain torn between plan and the market. Competition has been introduced into some parts of the energy value chain (such as coal extraction and power generation) but state-owned monopolies/oligopolies remain dominant in others (power distribution and most of the oil and gas sectors). Upstream prices have mostly been liberalized, but downstream prices remain largely controlled. A small number of bureaucrats try to plan supply while markets are determining more and more of the demand. The result is a market structure and pricing system that favors supply expansion rather than demand management, and a regulatory framework that attempts to control that expansion through ham-fisted administrative measures rather than market-oriented price signals.

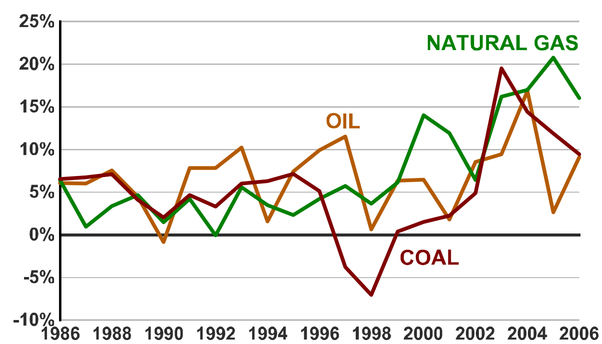
In this section we provide a brief overview of China's oil, gas, coal and electric power industries and how the existing policy system is inadequate for addressing China's surging demand and the energy insecurity and environmental degradation that come with it.

Figure 16: China's Energy Supply by Fuel (2005)



Source: CEIC from China Statistical

Figure 17: Annual Energy Demand Growth by Fuel



Source: CEIC from China Statistical Yearbook

FORMAL ENERGY POLICY INSTITUTIONS

Under the planned economy, energy policy in China did not exist separate from industrial policy. The State Planning Commission (SPC) in Beijing determined how much energy would be needed to achieve industrial objectives set out in five-year plans and allocated investment and set procurement prices accordingly.[30] It then fell to the State Economic Commission to insure that the industrial ministries in charge of coal, oil, gas, and electricity

[29] CEIC from *China StatisticalYearbook*

[30] Structures changed over the prereform period; this depiction applied on the eve of reform in the late 1970s. The definitive study of the bureaucratic dynamics of the period is Lieberthal and Oksenberg, *Policy Making in China : Leaders, Structures, and Processes*.

production met their targets. By the early 1980s, it was clear that this command-and-control approach was failing to meet the country's needs. To improve the efficiency of energy production and allocation, Beijing began a series of reforms, first in oil and gas and then in coal and power, to convert government energy ministries into state-owned enterprises (Yang et al. 1995). Prices were partially liberalized, incentives were gradually introduced and competition was allowed in certain areas. By the end of 2002, all energy production and delivery in the country was being carried out by companies rather than bureaucrats, and these firms were making investment decisions based *largely* on market, rather than political, considerations.

While taking the Ministries of Coal, Petroleum, and Electric Power and turning them into state-owned enterprises did much to improve the efficiency of energy supply, it also created an energy policy vacuum in Beijing. Most of the industry expertise that was once housed inside the industrial ministries is now a part of the nation's energy companies. In its place are a handful of bureaus and committees with a great deal of authority on paper (and increasing professionalized) but insufficient tools and resources to make effective policy. Erica Downs describes the result as "ineffective institutions and powerful firms", meaning that "energy projects and agendas are often driven by the corporate interests of China's energy firms rather than by the national interests of the Chinese state" (Downs 2006).

Today most of the formal government mechanisms for shaping energy outcomes in China reside within the powerful NDRC, the successor to the State Planning Commission. Most importantly the NDRC's Energy Bureau is required to approve energy projects of any meaningful size, its Price Bureau has control over what firms can charge for gasoline, diesel, natural gas and electricity, and its Industry Bureau sets industry policy affecting the country's energy-intensive firms. The NDRC also has a Bureau of Resource Conservation and Environmental Protection which is charged with achieving the State Council's ambitious (and unlikely) energy efficiency targets.[31] Other government agencies with a lesser role include the Ministry of Land and Resources which manages resource extraction licensing, the Ministry of Commerce which oversees energy import and export licenses, the Ministry of Finance which is tasked with collecting taxes, fees and levies and the State Environment Protection Agency (SEPA) China's environmental watchdog. The Rail Ministry is critical to moving coal and chemicals around the country.

What China does not have (since 1993) is a Ministry of Energy to help formulate and implement a cohesive energy policy. Attempts have been made to create one in the past, but have failed in the face of opposition from other ministries and state energy companies (Andrews-Speed 2004). In 2005, the State Council created an Energy Leading Group composed of vice ministers and ministers, along with the State Energy Office, which is intended to serve as a sort of secretariat to the Leading Group and is led by the NDRC's Ma Kai. With the Leading Group meeting only twice a year (as far as we know from public announcements) to establish guiding principles for the energy sector and the Energy Office at risk of becoming beholden to industry interests, it is unlikely that either will have a significant impact on the governance of the energy sector.[32]

As a whole, the energy policymaking apparatus has too few people at the national level[33] and the wrong set of tools to deal with the energy challenges of a large, diverse economy. The Energy Bureau is staffed with fewer than 100 people, many of whom come directly from industry.[34] The State Energy Office has even fewer (between 30 and 40) and focuses on fairly academic matters.[35] Compare this with the United States, where 110,000 people are employed at the Department of Energy (though many perform R&D functions done in other institutions in China). Over 600 of DOE's staff are dedicated to statistical collection, analysis and forecasting alone as part of the Energy Information Agency.[36] The result is an energy regulator forced to rely on the regulated for policy recommendations (the research staff at the State Grid Cor-

[31] Other officers at NDRC have some role in energy as well. A brief description of the NDRC's administrative structure can be found at http://en.ndrc.gov.cn.

[32] A great discussion of these institutions can be found in Downs (2006); we supplemented published sources with a number of industry interviews.

[33] Staffing at provincial-level Development and Reform Commissions add significantly to the nationwide energy bureaucracy headcount, though their priorities are not always aligned with Beijing's.

[34] The most recent publicly announced staffing figure for the energy bureau was from Su Yu, "Hang Shi Nengyuan Zhanlue: Nengyuanban Maitou Jixing 150 Tian [Forging an Energy Strategy: The State Energy Office Quietly Works Hard for 150 Days]," *Diyi caijing ribao [First Financial and Economic Daily]*, 31 October 2005. which put the number at 57. Conversations with officials in Beijing suggest that the staff level has since increased to around 100.

[35] Interviews with industry leaders and academics who have advised or participated in Energy Bureau and State Energy Office activities, Beijing, 2007.

[36] U.S. Department of Energy, *Performance and Accountability Report Highlights: Fiscal Year 2006* (Washington: U.S. Department of Energy, 2006). EIA figures are from www.eia.doe.gov. Both DOE and EIA numbers include both federal employees and contract employees.

poration, for example, is larger than that of the Energy Bureau). And the basket of tools at NDRC's disposal (administrative and price controls) are less and less suited for dealing with today's Chinese economy.

INFORMAL CHANNELS OF INFLUENCE

In addition to the limited formal mechanisms of energy policymaking, the government influences developments in the energy sector through informal channels. While it is true that China has powerful energy firms, firm behavior can be affected by state influence. In addition to privatized, listed arms, most of China's leading energy companies have centrally owned group level holding companies nominally held by the State-owned Assets Supervision and Administration Commission (SASAC), representing "the people" who are majority shareholders in these large, state-owned energy enterprises (Naughton 2005). While SASAC has thus far been a relatively passive "owner", it has the potential to exert a great deal of influence over these firms, particularly if SOEs are required to start paying dividends to the state (which they currently do not do).[37]

More importantly, the senior-most executive leadership of these firms is determined by the Ministry of Personnel (MOP), which has the power of appointment and dismissal. The MOP is fully aligned with the interests and politics of the Communist Party, and lies at the core of party power and discipline. As energy companies are too strategic to staff cavalierly, and as there are few career energy bureaucrats with both knowledge of the sector and the proper party credentials, MOP tends to select industry professionals for these leadership positions. Yet most of these professionals also view their posts as stepping stones to future careers in the real pinnacle of power in China: government officialdom. As a result, industry leaders must balance policy objectives and party politics with pure profit and loss calculations in making firm-level decisions.

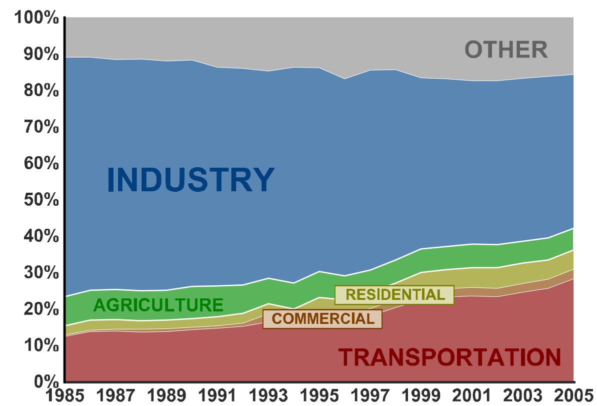
While the power to appoint and dismiss provides MOP and the party with the ability to shape industry, making industry leadership a political position (the chairmen of some of the largest energy companies hold a vice minister–level rank) the system provides industry with a seat at the table in shaping policy.

[37] For discussion of China's dividend policy for state-owned enterprises, see Kuijs, Mako, and Zhang, "SOE Dividends: How Much and to Whom?.", Shan, "The World Bank's China Delusions.".

OIL AND GAS

Oil currently meets 21 percent of Chinese energy needs, up from 17 percent in 1990 (absolute growth of nearly 5 million barrels per day from 2.3 in 1990 to 7.2 in 2006).[38] In oil, as in coal, gas and power, industry is the largest consumer in absolute terms, compared with the United States, where transportation accounts for two-thirds of total oil demand (EIA 2006). Yet with the number of motor vehicles on the roads doubling over the past five years, transportation is the most important factor at the margin, accounting for 42 percent of the *growth* in oil consumption since 1995 (figure 18). In recent years, automobiles have been joined by petrochemical production and oil-fired power generation in driving petroleum demand.

Figure 18: Composition of Oil Demand by Sector



Source: CEIC from China Statistical Yearbook

Natural gas plays a much smaller role than oil, accounting for only 3 percent of all energy consumed. Yet demand is growing, driven by the country's fast-growing chemicals industry and an urbanization-led need for clean household heating and cooking fuel (see again figure 17). In 2005, production of raw chemicals accounted for 32 percent of all gas demand, followed by the residential sector at 17 percent.[39] Despite hopes of a take-off in gas-fired power generation (see the section on Coal and Power below), the few natural gas turbines in the country were responsible for a meager 4 percent of demand, slightly more than the transportation sector at 3 percent.

Supply

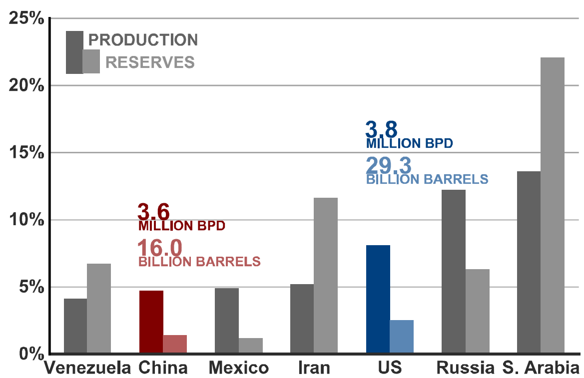
As the fourth largest petroleum producing country outside of the Middle East (after the United States, Russia,

[38] CEIC data from the *China Statistical Yearbook.*

[39] CEIC from the *China Statistical Yearbook.*

and Mexico) (BP 2006), China has a well-developed oil and gas supply industry (figure 19). A net oil exporter until 1993, China was a major supplier of crude oil to the rest of East Asia during much of its history. In fact, in the late 1970s industrial planners in Beijing hoped that doubling production would allow them to finance their dreams of industrialization and modernization with oil riches. Failure to find the new oil fields required for this vision helped precipitate economic reform. While domestic production has increased modestly with the development of some offshore and western fields, China's relatively meager proven reserves suggest that annual oil output is near peaking at the current 3.7 million barrels per day. [40]

Figure 19: Annual Oil Production and Proven Reserves for Top Six Producers (2005)



Source: BP Statistical Review

Gas production is still increasing, but not fast enough to satisfy demand growth. Industry forecasts suggest that China will need around 200bcm of natural gas per year by 2020, a four-fold increase from current levels.[41] While there have been encouraging new discoveries offshore, in Sichuan Province, and in the Erdos Basin, China will need to import significant amounts of gas. China's first shipment of liquefied natural gas (LNG) arrived at a receiving terminal in Guangdong Province in summer 2006 from Australia's Northwest Shelf project, in which the China National Offshore Oil Corporation (CNOOC) has a stake. CNOOC has signed two additional LNG supply agreements, one with BP's Tangguh project in Indonesia and the other with Malaysia's Petronas (to supply terminals in Fujian and Shanghai respectively).[42] Given the price and availability of additional contracts in Asia, China will not be able to meet its medium-term gas needs through LNG alone. A number of potential pipelines from Russia and Central Asia are under discussion, but both the economics and politics of these projects are challenging.[43]

Market Structure

Domestic upstream production is controlled by three companies, all of which were at one time parts of government ministries. The largest, in terms of production, is the China National Petroleum Corporation (CNPC), which was formed as a ministry-level SOE in 1988 out of the upstream assets of the Ministry of Petroleum Industry. CNPC is the world's fifth largest oil producing company, ahead of Exxon, BP, Chevron, and Shell (table 4). The China Petroleum and Chemical Corporation (Sinopec), formed in 1983 out of the downstream assets of the Ministry of Petroleum Industry and Ministry of Chemical Industry, has a much smaller upstream portfolio (ranking 30th globally in oil production) but is dominant in the refining sector. In terms of revenue, but not profits or production, Sinopec is larger than CNPC. CNOOC is the smallest of the three by all measures and was established in 1982 to develop China's offshore resources in cooperation with international oil companies (IOCs).[44] CNOOC, which unlike its sisters does not have ministry rank, is almost exclusively an upstream company with the exception of a refining and petrochemicals joint venture with Shell (table 5). A fourth state-owned oil company, Sinochem, has a limited presence upstream (mostly overseas) but a noteworthy trading, refining, and chemicals portfolio. Other smaller independent firms play a significant role in logistics, transport, storage, and refining.

Competition

While each of these companies was originally given a discrete market segment, competition among them has

[40] International Energy Agency, *Medium-Term Oil Market Report: Update*, 2007.

[41] Erica S. Downs, "China," in *Energy Security Series*, ed. Brookings Institution (Washington, DC: Brookings Institution, 2006). table on comparative natural gas demand forecasts).

[42] "China Seals LNG Supply Contract for Shanghai Terminal," *Gas Matters*, 4 December 2006.

[43] Based on conversations with oil and gas industry officials in China. A good synopsis of the pipeline projects currently under consideration can be found in "China's Foreign Plans Have a Long Way to Go," *International Gas Report*, 26 February 2007.

[44] For an excellent discussion of institutional change in the energy sector, see Lieberthal and Oksenberg, *Policy Making in China : Leaders, Structures, and Processes*, Yang et al., "A Review of China's Energy Policy."

grown over the past decade. In an attempt to create competitive, vertically integrated oil and gas companies, Beijing forced CNPC and Sinopec to swap some assets in 1998, giving Sinopec a decent-sized upstream portfolio, CNPC refineries, and a distribution network.

Table 4: World's Largest Oil and Gas Producers by Output (2005)

Rank	Company	Mboe
1	Saudi Arabian Oil Co	4148.83
2	Gazprom	3313.35
3	National Iranian Oil Co	1810.74
4	Petroleos Mexicanos	1666.23
5	PetroChina Co Ltd (CNPC)	1040.51
6	Exxon Mobil Corp	983.32
7	Sonatrach	904.36
8	Kuwait Petroleum Corp	892.44
9	Petroleos de Venezuela SA	817.6
10	Total SA	732.24
19	BP Plc	485.05
23	Royal Dutch/Shell	421.93
26	ChevronTexaco Corp	384.44
30	Sinopec	314.68
33	ConocoPhillips	281.47
38	CNOOC Ltd	210.99

Source: IHS Inc.

Table 5: Snapshot of China's Big 3 (2006)

	CNPC	Sinopec	CNOOC
Operating Statistics			
Crude Oil Production (tbpd)	2,140	800	633
Natural Gas Production (bcm)	44.2	7	8.8
Refinery Throughput (tbpd)	2,207	2,938	NA
Financial Statistics			
Revenue ($ billions)	101.1	133.5	15.2
Profits ($ billions)	23.2	8.48	5.9
EBT Margins (percent)	22.9	6.4	38.9
Employees (thousands)	1,589	730	37

Source: Company press releases, Xinhua News Agency Refers to group level company, not the listed subsidiary. Crude oil converted at 7.33 barrels per ton.

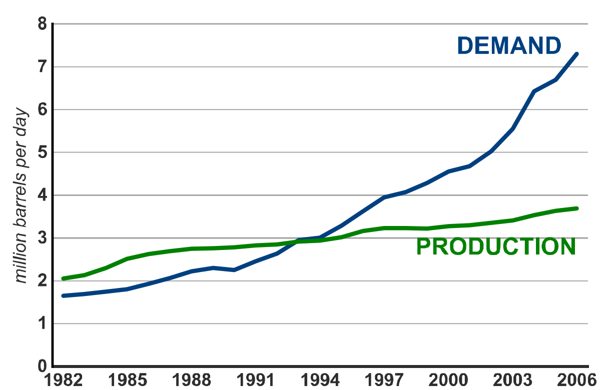
While the two companies still maintain regional strongholds (CNPC in the north and Sinopec in the south), there is growing cross-regional competition (and competition internationally, discussed further below). Sinochem and CNOOC are quickly expanding their onshore downstream activities as well.

All four state-owned oil companies also now have subsidiaries listed in Shanghai and Hong Kong. While the majority of the shares in these publicly traded companies are still owned by the parent group, their listing has injected additional profit incentive into the energy sector and bolstered competition among firms in an effort to increase revenue. When profit-seeking is at odds with political guidance from Beijing, the oil companies seek to influence the policymaking process in their own interests. The clearest example of this is the tug of war between the oil companies and the government over product pricing.

Pricing

With limited reserves and relatively flat domestic production, China now relies on international markets for nearly half of the oil it consumes (figure 20). Growing exposure to global crude prices that are liberalized and volatile is straining China's oil pricing system. Fearful of passing inflation to an increasingly automobile-oriented and vocal middle class, as well as to low-income farmers and taxi drivers, Beijing maintains tight control of gasoline and diesel prices. As the price China paid for its imported crude doubled between 2004 and 2006 refiners—unable to pass the cost to consumers—lost money with each barrel processed. In 2006 the refining industry as a whole lost over $5 billion (Beijing Kang Kai Information & Consultancy Co Ltd. 2006). While CNPC lost the most in absolute terms, the burden was greatest for Sinopec, as it had less upstream revenue which with to offset its refining losses.

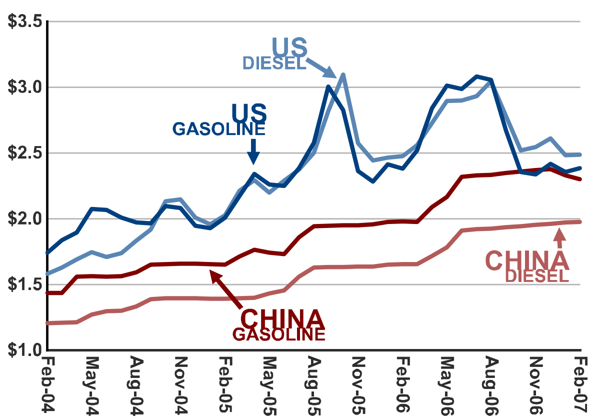
Figure 20: China's Domestic Oil Production and Total Demand



Source: CEIC and IEA and author's estimates.

The impact would have been worse if these state-owned oil firms had not used connections and dominant market positions to lobby for increased gasoline and diesel prices. First in March and then in May 2006, as crude costs swelled, CNPC and Sinopec cut back on loss-making refining, creating spot shortages in some high-demand areas like Guangdong and Zhejiang Provinces. As stories of long lines at gas stations and farmers unable to get enough diesel to work their land filled the press, NDRC acquiesced and raised prices 3 to 5 percent in March and another 10 to 11 percent in May (figure 21). While downstream profits have suffered from high crude price, upstream profits have grown dramatically. Beijing responded in spring 2006 by enacting a windfall tax on all domestic oil production above a certain price and used some of that revenue to compensate farmers and cab drivers for their more expensive diesel and gasoline bills. By the end of 2006, however, crude costs had fallen enough to put the country's refiners back in the black and a third expected price increase was averted. In fact, in early January 2007, Beijing slightly lowered the price of gasoline and diesel. The government is likely to continue adjusting prices as needed to balance the interests of the companies with the interests of consumers and is unlikely to fully liberalize prices in the near term.

Figure 21: Gasoline and Diesel Prices in the United States and China (2004–07)



Source: CEIC, EIA and author's estimates

For natural gas, prices are set by Beijing but vary by province and sector. In most provinces, residential users pay the highest price, followed by chemical producers, power generators, and fertilizer manufacturers. Prices for the chemical industry are subsidized to make the industry competitive with the Middle East—the alternative place to put new chemical industrial facilities. Prices for power generation are kept low to promote some substitution of this clean fuel for coal, but the market is not clearing (demand is not being met). And gas prices for fertilizer are subsidized out of concern for the country's farmers.

In a tight gas market, the price structure creates an incentive for CNPC and Sinopec to supply residential customers at the expense of industry, particularly if that industry is a chemical park operated by the competition. Several of these parks, built by one of the Chinese oil majors in partnership with large foreign chemical companies, have had difficulty ensuring reliable supply at the government-stipulated price. The foreign companies have been forced to lobby provincial and national officials to keep the gas turned on. Many are also looking at developing coal-derived alternatives to natural gas as a more dependable feedstock.

Expanding Overseas

With limited opportunities to increase upstream production domestically and thin or negative margins on downstream activities because of price controls, Chinese oil companies have sought to boost reserve holdings, production, revenue, and clout by expanding overseas. This development has garnered substantial attention in both business and policy circles abroad. The political dialogue that has surrounded this domestically has been well-covered by others (Downs 2004, 2006; Lieberthal and Herberg 200) and the implications for international markets and global energy security is covered in the next section. For the purposes of our discussion here, the point we wish to emphasize is that the domestic resource endowment and industry structure create a market incentive for Chinese oil companies to expand their upstream portfolios overseas.

In fact, in recent years it is more likely that the companies, rather than government officials, are the real force behind any "going out" policy. CNPC, Sinopec, and CNOOC have used political clout to get supportive high-level state visits, access to subsidized capital, or development assistance money designated for infrastructure projects. This sometimes contradicts Beijing's desire to sink additional investment into mature, less profitable fields at home in order to prop up declining domestic production.[45] Chinese oil companies argue that increasing their overseas business bolsters China's energy security for the same self-interested reasons US corn growers to champion the cause of energy independence through ethanol.

COAL AND POWER

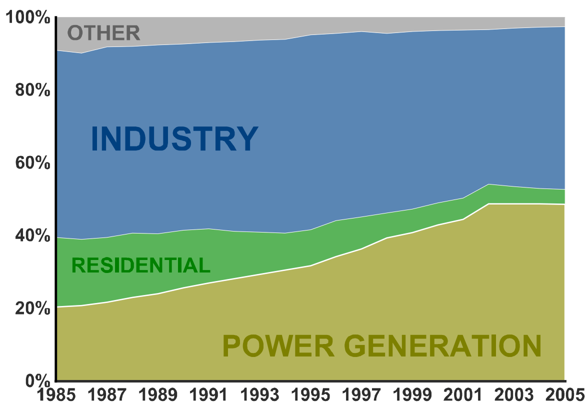
While China's oil and gas sector gets the most attention internationally, the coal and power sectors have the big-

[45] Based on conversations with Chinese petroleum industry officials.

gest impact on the country's energy security, economic vitality, and environmental sustainability. While down from a post-reform high of 76 percent in 1990, coal still meets over two-thirds of China's energy needs. In 2006 that translated into 2.4 billion tons of coal demand, nearly twice the amount consumed just six years ago. China is easily the world's largest coal market, double the size of the United States. Over 75 percent of the demand growth in recent years has come from the power sector, as electricity demand boomed and alternative fuel sources for generating that electricity (hydro, natural gas, wind, and nuclear) failed to keep pace (figure 22).

Of the 50 percent of coal not consumed by the power sector, the majority is sold directly to industry for use in boilers, coking ovens and on-site ("inside the fence") power generation. Household coal consumption, which accounted for 20 percent of total demand in 1985, has dropped to 4 percent as China's residents move into homes equipped with gas and electricity for cooking and heating.

Figure 22: Coal Demand by Sector (share of total)

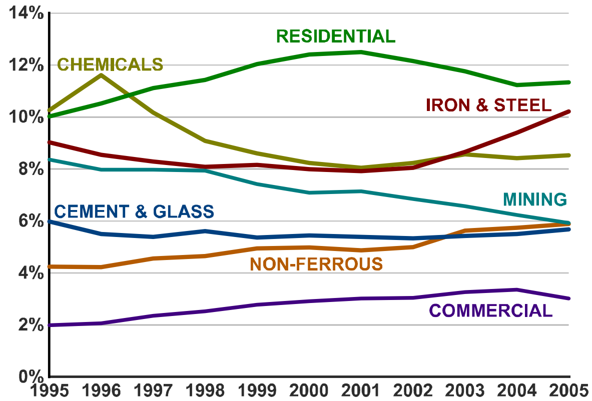


Source: CEIC from China Statistical Yearbook and author's estimates

Driven by the electrification of both household and enterprise energy use, the Chinese economy has created as much new demand for power since 2000 as the total demand for power in France, Germany and the UK combined.[46] In 2006 alone China added over 100GW of new capacity, equivalent to the entire installed base of Africa.

Like the coal used to generate it, the lion's share of the country's electricity is consumed by industry, with 10 percent going to iron and steel production alone (figure 23). Households account for 11 percent of demand, down slightly from a high of 12.5 percent in 2001. The commercial sector, which uses between 15 and 20 percent of the electricity in OECD countries, accounts for only 3 percent of Chinese demand.

Figure 23: Electricity Demand by Sector (share of total)



Source: CEIC from China Statistical Yearbook

Supply

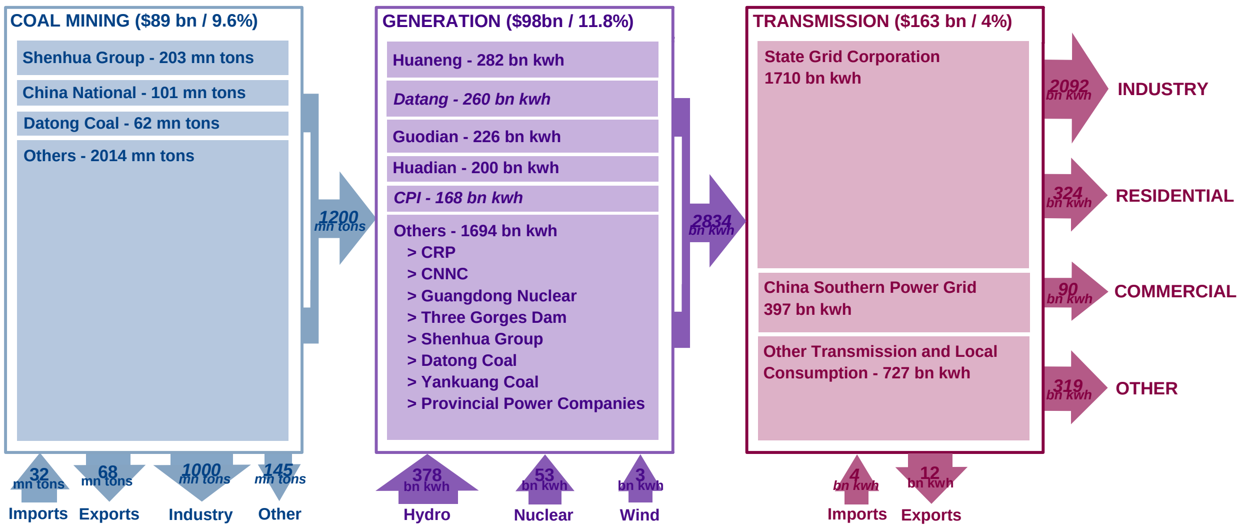
China relies on coal because it has this resource greatest abundance. Compared with only 1 percent of the world's proven oil and gas reserves, nearly 13 percent of all the known mineable coal still in the ground is in China.[47] Through most of its history, tapping these reserves has allowed China to remain energy independent. But energy independence does not mean energy security. Having coal in the ground is one thing. Being able to mine it, move it, and burn it quickly, cleanly, and in large enough quantities to clear the market is another. The latter requires efficient industry structures, good data, responsive pricing signals, and effective regulation.

China's coal and power sector falls short on all counts. When double-digit electricity demand growth broke out starting in 2002, the result was coal shortages, power outages, spikes in oil demand, and a rapid deterioration in the quality of the country's air. This has created a sense of energy insecurity of domestic origin that, for most Chinese, is more immediate and more important than concerns over growing dependence on imported oil.

[46] CEIC data from the *China Statistical Yearbook*; BP plc., *Statistical Review of World Energy 2006.*

[47] Ibid.

Figure 24: The Electricity Value Chain (2006 revenue / EBT profit margin) (figures in italics are estimates)



Market Structure

Unlike oil and gas, the coal industry in China is highly fragmented. Production shortages in the late 1970s and early 1980s forced Beijing to allow local private and collectively owned mines to enter what had been a state-dominated industry. As these small mines were free to sell all their output at market rates while the state-owned mines were forced to sell at the plan-specified price, the small mines' share of national production climbed dramatically during the 1980s and 1990s (Andrews-Speed 2004; Yang et al. 1995). Today the top three state-owned coal companies, while world-scale, account for less than 15 percent all domestic production. Shenhua Coal, the biggest of the three, is now the world's largest coal company yet accounts for less than 9 percent of the domestic market (figure 24). The power generation industry is more consolidated than coal extraction, but less so than oil and gas. Like other parts of the energy sector, electricity production and transmission was controlled by a government agency before the reform period. The same energy shortages that forced Beijing to loosen its grip on coal production in the 1980s prompted reforms in the power sector. Local and provincial governments, and even private and foreign companies, were given the right to invest in power generation (but not transmission). In another wave of reforms in 1997, the Ministry of Power and Industry was converted into the State Power Corporation of China (SPCC), which in turn was dissolved in 2002. SPCC's generation assets (46 percent of the national total) were divided among five power producers, all SOEs (see figure 24). The distribution assets (90 percent of the national total) were split between two companies, the State Grid Corporation (SGC) in the north and the China Southern Power Grid (CSG) in the south (IEA 2006). These distributors are massive enterprises, the first and tenth largest utilities in the world, with $110 billion of revenue together in 2005.[48]

Today the five power producers spun off from the SPCC plus two state-owned nuclear power companies generate nearly half of the country's electricity. With the exception of a few large coal companies like Shenhua that have power assets and the Three Gorges Project Corporation, the remainder is generated by provincial, local and privately owned companies. While some competition has developed in power generation, transmission remains controlled by the SGC and CSG duopoly. All five state-owned independent power projects, and several of the large coal companies, have publicly traded subsidiaries. As in the oil and gas industry, a large portion of the shares are held by the parent company. Neither of the grid companies have listed arms, though CSG is considering an initial public offering in the near future.[49]

Pricing and Profits

Since the 1980s China has gradually liberalized coal pricing. As with many other goods a two-tiered price system was created, one set by NDRC for plan-allocated quotas

[48] Fortune Magazine's *Global Fortune 500* available at http://money.cnn.com (accessed 19 March 2007)

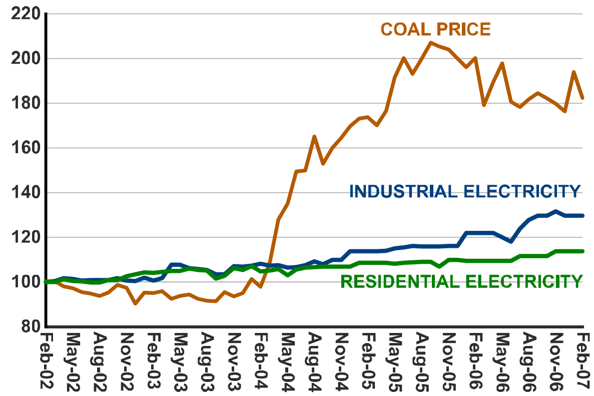
[49] "Shanghai Sharemarket Expected to Double IPO Value in 2007, May Beat HK," *AFX Asia*, 4 January 2007.

and the other set by the market for all demand outside the plan. Over the past 20 years, the plan price has rationalized and the amount of coal produced outside the plan has grown. At the beginning of 2007, the two-tier system was completely abolished and all coal, both contract and spot, must now be negotiated at market rates (although it remains to be seen how much "legacy behavior" will remain).[50]

Electricity prices, however, remain tightly controlled by NDRC's Price Bureau. Unlike more developed electricity markets, China has no separately determined transmission tariffs. NDRC determines both the price at which the generators can sell power to the grid and what the grid can charge different categories of users. NDRC sets these price schedules province by province in consultation with local price bureaus and attempts to strike a balance between the interests of various parties affected by the regime. Provincial officials lobby for end-user pricing low enough to keep their industries viable and citizens happy. The power generators lobby for an on-grid tariff high enough to cover their fuel costs and ensure that the sector is profitable enough to make the necessary investments. In the middle are the grid companies, stressing to NDRC that enough margin needs to shake out between the two prices to finance a $130 billion buildout of the nation's transmission network between 2006 and 2010.[51]

It's difficult to pinpoint exactly how rents are allocated across the electricity value chain by the current system because of the complexity and opacity of end-use pricing and transmission costs. The demand surge over the past three years shrank coal inventories and doubled spot prices. In response NDRC enacted a price pass-through mechanism whereby electricity tariffs could be raised by 75 percent of coal price increases. Yet according to available data, electricity prices have only risen by 20 percent on average since the beginning of 2004 (figure 25). This put stress on power generation profits, which, for the industry as a whole, fell from 11.7 percent in 2003 to 9.6 percent in 2004 (Beijing Kang Kai Information & Consultancy Co Ltd. 2007b). Industrywide, coal mining profits rose from 5.7 to 8.4 percent (Beijing Kang Kai Information & Consultancy Co Ltd. 2007a). As coal prices flattened out during the second half of 2005, power generation profits recovered to 11.8 percent by the end of 2006. Looking at specific publicly traded companies (for which the profit data is more reliable), the trend is even more pronounced (table 6).

Figure 25: Coal and Electricity Price Growth (index of nationwide averages, Jan 2002 = 100)



Source: CEIC from China Statistical Yearbook. Export coal price is used as a proxy for the spot market price.

Table 6: Net Profit Margins for China's Publicly Traded Coal and Power Companies (percent)

Company	2006	2005	2004	2003	2002	2001
Coal Mining						
Shenhua	31.6	29.9	22.6	10.8	7.5	—
Yanzhou		25.0	29.8	20.0	19.2	19.9
China Coal		11.1	10.1	1.0	—	—
Power Generation						
Huaneng	15.6	12.2	17.7	23.2	21.2	21.9
Huadian	9.0	8.0	10.4	12.9	15.3	19.6
CPI	13.3	15.2	19.2	20.8	—	—
CRP	28.1	48.2	68.9	120	—	—
Datang	14.4	13.1	16.9	18.2	17.5	22.0

Source: Thomson Financial.

How much money the grid companies really make is less clear. Looking just at the gap between the published national average on-grid price and end-user prices, and the grid appears to be in a position to make huge profits. Yet the reported transmission industrywide data show meager 2006 profits of 4 percent, up from 1.6 percent in 2004. While the quality of this data is spotty (the grid is a state-owned monopoly with an incentive to underestimate profit), interviews with both company officials and industry analysts suggests that the grid is able to collect less from end-users (either because of reduced rates or nonpayment) than the published rate tables would suggest.

[50] Based on interviews with several power generation companies in 2007. See also "Beijing Scraps Coal Round," *Power in Asia*, 18 January 2007.

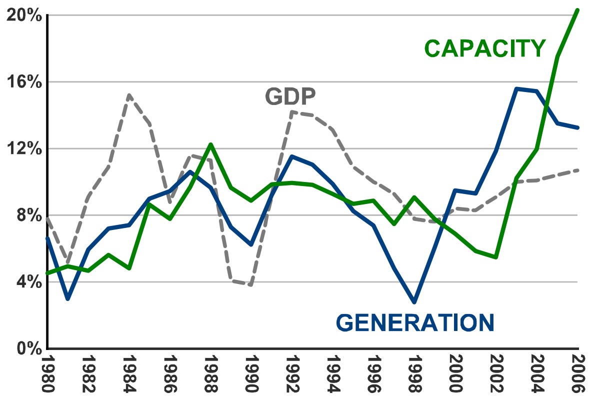
[51] Based on interviews with grid company officials in January and February 2007.

Market Regulation

What is clear is that the current electricity market structure and pricing regime aren't working for the country as a whole. In the absence of market price signals, NDRC attempts to accurately forecast demand, approve new supply accordingly, and tweak prices so that everyone has enough money to build the needed capacity. So far the record for this approach has been less than glowing. For China's power sector, the reform period has been marked by volatile capacity swings between surplus and shortage (figure 26). The past four years have been particularly painful. NDRC, seeing a glut of power in the market, issued a three-year moratorium on new power construction in 1999 (IEA 2006; Andrews-Speed 2006). When demand took off in 2002, supply fell short, and blackouts were endemic. Desperate for new power, local official drove the construction of 140GW of new capacity without NDRC approval. Industry stocked up on diesel and fuel oil to run private generators, contributing to a 16 percent spike in oil demand in 2004.[52] And while supply and demand have since come back into balance thanks to a doubling of installed power generating capacity since 2002, the factors that created the shortage haven't changed. NDRC is already fretting about a coming supply glut based on their conservative economic growth forecasts, and is reining in power plant construction.

Yet the current pricing system is not compatible with serious demand-side management. NDRC has started to raise electricity rates for more energy-intensive users, but the largely state-owned heavy industry sector lobbies local and provincial officials to ensure that the price hikes are gradual enough to keep their businesses viable. The energy companies would like to make more money, but not if it means raising prices to demand destroying levels. With strong corporate interests on both the supply and demand sides pushing for capacity expansion, it's left to comparatively weak economic bureaucrats and environmental regulators to advocate demand management. This means that despite the government intention to see consumption brought under control, the stage is set for another upside demand surprise, and all the coal shortages and power blackouts that go with it, in a few years' time.

Figure 26: Annual Growth in Power Generation, Capacity and GDP



Source: CEIC from China Statistical Yearbook, LBL, SGCC and CEC. Chart derived from IEA's China Power Sector Reforms (2006)

Environmental Control

The political economy of the power market and the policy tools used to manage it also hinder efforts to address environmental consequences. Pulverized subcritical coal-fired power technology currently accounts for 80 percent of all power generation (China has only recently introduced more efficient supercritical technology). The remainder is mostly hydropower, with nuclear, natural gas and renewables constituting less than 2 percent each (figure 27).[53] The dominance of coal in meeting the country's electricity needs is taking its toll on the nation's air quality. Annual sulfur dioxide (SO_2) emissions, the principal cause of acid rain, have grown by 30 percent since 2000. According to environmental regulators, SO_2 caused over $60 billion in direct economic damage in 2005.[54] Harder to quantify are the welfare loss in respiratory problems, premature mortality, and the declining quality of the physical environment.

Concerned with the social and political risks associated with environmental deterioration, Beijing has taken steps to reduce power-sector air pollution. An SO_2 pollution levy was enacted in the late 1970s (Jiang and McKibbin 2002) but was either too cheap, too narrow, or too weakly enforced to discourage power plants from polluting. While SEPA, China's environmental watchdog, periodically threatens to close plants that don't comply

[52] Based on interviews with industry officials in China during January and February 2007.

[53] CEIC data from the *China Statistical Yearbook*; the China Electricity Council (www.cec.org.cn).

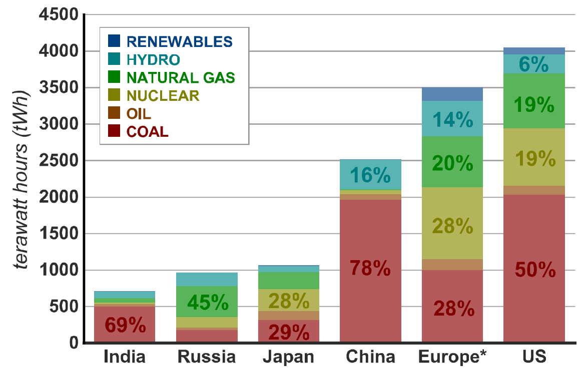
[54] "500b-Yuan Loss from Sulfur Cloud," *South China Morning Post*, 4 August 2006, "SEPA Lifts Ban on Two Power Firms after They Fulfill Ruling " *Industry Updates*, 19 March 2007.

with existing regulations, its enforcement power is limited (though growing).[55] Recently the sulfur levy was increased but, more importantly, was coupled with a market-based incentive: If plants installed FGD systems, NDRC would allow them to add the cost of installation and operation to the price they can charge the grid companies for power.

The results so far have been fairly encouraging. More than half the FGD capacity in existence was built in 2006 under this system. It is still too early to tell whether regulators will be successful in ensuring that power plants operate these FGD systems now that they have them installed. Also Chinese FGD systems tend to operate at lower removal efficiency than those used in the OECD (70 to 80 percent compared with 98 to 99 percent in Japan).[56] And while this approach to SO_2 control is gaining traction, no such regime exists for coal-fired power's other air pollutants, including nitrogen dioxide, particulate matter, mercury, and CO_2.[57]

The move from coal to cleaner alternatives faces several challenges. New hydropower projects encounter political resistance (from displacing people—over 23 million already) and declining water resources.[58] Nuclear power plants have long construction lead times (even in China, since the usual corners cannot be cut in nuclear) and still involve lengthy negotiations with foreign firms. Under current electricity pricing schedules, natural gas is not a competitive fuel source for power generation in most of the country[59] in the absence of more severe pollution penalties or increased demand from residential and commercial consumers.[60]

Figure 27: Power Generation by Fuel Type (2005)



Source: IEA, EIA, BP Statistical Review, CEIC and author's estimates
* Europe here refers to OECD Europe

Wind power is becoming cost-competitive in certain areas, particularly with the passage of a renewable energy law in 2005, and China has become one of the world's largest markets for wind turbines, adding 1,000MW of capacity in 2006.[61] Yet at under 1 percent of total installed power generation capacity, wind has a long way to go before it can make a significant dent in China's overall power demand. The situation isn't helped by the boom and bust cycle of capacity construction in China. During a period of shortage, Chinese firms reach for technology that will get the most power on the grid in the shortest time frame. This almost always means pulverized coal.

[55] For more background on environmental governance in China, see, among others, Elizabeth Economy, *The River Runs Black : The Environmental Challenge to China's Future* (Ithaca: Cornell University Press, 2004).

[56] We thank Peter Evans for this point. See his seminal work on Japanese green aid to China (mostly in the form of FGD systems) can be found in Peter C. Evans, "Japan's Green Aid Plan: The Limits of State-Led Technology Transfer," *Asian Survey* 39, no. 6 (1999).

[57] Based on conversations with environmental regulators, NGOs and power companies.

[58] "China Feb Reservoir Volumes Fall 3.5 Pct Yr/Yr," *Reuters News*, 1 February 2007. The displaced persons statistic is from Premier Wen Jiabao's March 2007 Work Report to the National People's Congress.

[59] Natural gas–fired power is economic in some coastal provinces where the cost of delivered coal is high and there is more peak demand.

[60] A power grid that serves a large number of residential and commercial users, such as in affluent coastal provinces, needs to dispatch additional electricity during peak demand hours. If a higher tariff is charged during these periods (called "time-of-use" pricing), than natural gas-fired power, which is easier to turn on and off than coal-fired power, can be competitive even at a higher price per unit of energy content. Yet even when the economics work out, gas availability remains a challenge as industrial users who have no alternative to natural gas are often given supply priority.

[61] We thank Scott Roberts of MIT for this point.

3 Global Impacts

China's energy markets and policies, as they exist today, are failing to reliably supply the country's explosive demand growth or adequately address its environmental consequences. And the same market distortions and policy shortcomings that create supply shortages, price volatility, and air pollution inside China impact energy markets and environmental quality outside China. Blackouts resulting from poor planning and management in the domestic power sector send ripples through international oil markets. Retail price controls, coupled with a growing sense of energy insecurity at home, have prompted Chinese oil companies to search for investment opportunities abroad. The skewed capital, land, and environmental costs that have caused given China such a large global market share in heavy industry has also made the country a leading source of sulfur pollution regionally and greenhouse emissions globally. If these costs right themselves in the years ahead, some heavy industry will no longer be viable in China and global metals and chemicals markets could be shaken up once again as excess Chinese capacity is subtracted.

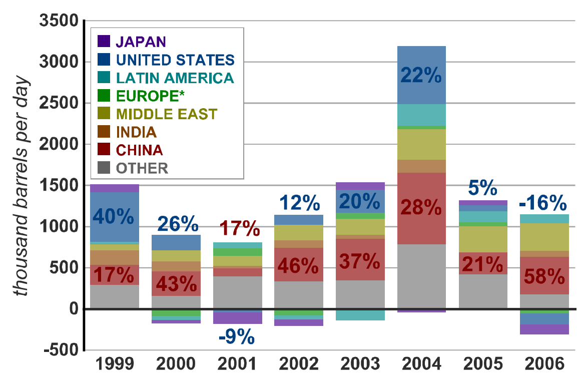
WORLD ENERGY MARKETS

The most visible impact of China's growing energy demand outside its borders is in upstream energy commodity markets. Going from one of Asia's largest energy suppliers to one of the world's largest energy importers in little more than a decade, China is a major force at the margin in global oil, gas, and coal trade flows. In addition to the sheer magnitude of China's buying on these markets, the volatility of demand, a paucity of good data, and the nature in which Chinese energy companies buy and invest have made policymakers and business leaders in other parts of the world anxious.

Oil and Gas Markets

With domestic extraction flattening out, China relies on international oil markets for a growing share of the crude oil it consumes. And every year China needs more and more oil. In 1993, when imports exceeded exports for the first time, China was the world's fifth largest oil consumer, accounting for 4.5 percent of total global demand (BP 2006). Today China accounts for 8.7 percent of global demand and has surpassed Japan as the world's second largest oil consumer after the United States. China's impact on international oil trade is even greater than its share of global demand in absolute terms suggests: At the margin, over a third of global demand growth over the past five years came from China (figure 28).

Figure 28: Global Oil Demand Growth by Country or Region



Source: 1999 to 2003 from BP Statistical Review. 2004 to 2006 from IEA Oil Market Report March 2007. *Europe refers to OECD Europe.

This explosion in Chinese demand surprised international markets as much as it surprised Beijing. In an already tight market it was the surprise more than the demand itself that helped push up oil prices. At the turn of the century, both Chinese planners and foreign observers assumed that oil demand would continue to grow half as fast as GDP, as it had done for the previous two decades. They were wrong on two counts: The economy grew more quickly than expected and the oil intensity of economic growth increased unexpectedly. This surprise was a result of investment-led more than consumption-led demand. While auto sales have outpaced most estimates, the real shock came from the unexpected surge in heavy industry. Industrial demand pushed China's oil needs beyond what was anticipated both directly (in the consumption of naphtha and other feedstocks) and indirectly (in fuel used for back-up generators).

Month-to-month and year-to-year volatility in demand further increase China's impact on oil markets. In 2004 blackouts created a spike in the amount of diesel and fuel oil industry purchased for back-up power generation, pushing up apparent oil demand growth[62] to 16

[62] As Chinese companies don't release inventory data, apparent demand here refers to refinery throughput plus net import of refined products.

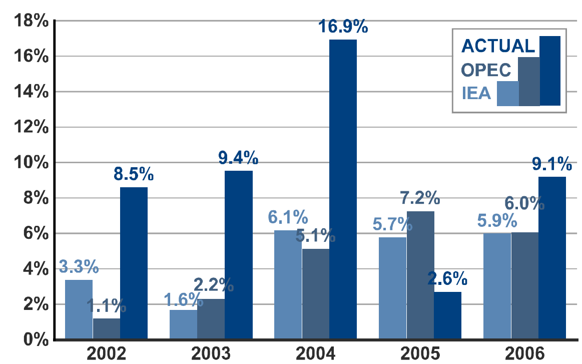
percent, from 11 percent the year before.[63] In 2005 demand growth fell to 3 percent due to new coal-fired power capacity coming online and a drawdown in corporate inventories of oil as firms tried to wait out what they thought were temporary price hikes. Crude prices went from $42 to $70 per barrel that year (partially in response to Chinese demand in 2004) but domestic retail gasoline and diesel prices only increased 15 percent.[64] As refining operations lost money, oil companies cut back purchases and drew down inventories. Because Chinese companies do not publish inventory data, outside observers including the International Energy Agency (IEA) assumed that a decline in apparent demand was the result of weak underlying demand, and that 2004 was an anomaly.

Markets were therefore surprised again in the beginning of 2006 when crude imports skyrocketed as Chinese oil companies took advantage of a dip in the market to replenish depleted inventories. Once oil prices rebounded, the oil companies again choked back refinery throughput to minimize losses and put pressure on the government to raise the downstream prices they could charge. When the retail price increases arrived (once in March and once in May), Chinese firms cranked up refinery production and drew down inventories. This cat and mouse game between the oil companies and the government over prices, coupled with the fact that China buys most of its oil imports on the spot market, creates a great deal of month-to-month volatility (figure 31). The pricing system has also created a booming independent refinery business, where smaller-scale firms further cloud the demand picture by processing fuel oil or stolen domestic crude to clear the market when the Chinese oil majors refuse to import and refine at a loss. These factors makes forecasting Chinese oil demand an even more challenging endeavor (figure 29).

While its impact has been felt most in oil markets, China could become a significant factor in the natural gas trade in the years ahead. At present China only imports 3 billion cubic meters (bcm) of gas per year in the form of LNG—less than consumed in the United States every other day. Another 6 bcm has been contracted and will start arriving in 2009.[65] Though domestic pricing for LNG has been a major hurdle to ramping up supply this far because China has refused to match market prices, the price that the Shanghai LNG terminal reportedly will pay for gas indicates that more affluent coastal provinces might be ready to compete for contracts at market rates.

An alternative means of importing gas is by pipeline from Russia or Central Asia. The possibility of doing so has been on the agenda during most meetings between Chinese leaders and their gas-rich neighbors. For Russia, raising the prospect of China as an alternative gas market is useful in negotiations with Europe. For Kazakhstan, Turkmenistan, and Uzbekistan, China represents an alternative to piping their gas through Russia. Yet while economics on China's more affluent coast are starting to make LNG look attractive, prices in the country's interior make the cost of the pipelines currently under discussion difficult to accept.

Figure 29: China Oil Demand Growth Forecasts vs. Reality



Source: Start of year forecasts from IEA and OPEC Monthly Oil Market Reports. Actual demand is from China Statistical Yearbook via CEIC, except for 2006 with is from a recent announcement by NDRC.

Coal Supply and Power Generation

Even for coal, China is looking to international markets to meet domestic demand. With 13 percent of the world's proven reserves, China was the world's second largest coal exporter until 2003.[66] Since then, China has nearly halved the amount of coal it sells overseas as strong domestic demand has outpaced production. In fact, in January 2007, China became a net coal importer as coastal provinces turned to Indonesian and Australian coal, which is comparable to domestic production in price once transportation is included. Chinese coal companies are also actively seeking to set up mining operations in Mongolia and elsewhere to ship coal back home. The volatility of China's coal trade impacts global seaborne coal prices and

[63] International Energy Agency, "Oil Market Report," 13 February 2007.

[64] Crude prices are forward-month WTI contacts as traded on the NYMEX. Domestic retail gasoline and diesel price data is from the National Development and Reform Commission Price Monitoring Center.

[65] Refers to the Fujian and Shanghai LNG receiving terminals. See section 2 of this analysis for more detail.

[66] United Nations Commodity Trade Statistics Department, "UN Comtrade Database," (2007).

makes it difficult for other coal-producing countries to decide whether to make large investments to expand mine capacity.[67]

When domestic production falls short or transportation bottlenecks emerge, China's coal markets affect the world via electricity shortages that roil fuel oil demand and disrupt light manufacturing value chains (as discussed above). But Chinese firms are also looking to import mine-mouth power from Russia and Mongolia to alleviate shortages in some Northern grids, creating a potential power export opportunity for niche players.

China is also poised to become a major exporter of coal-fired power technology. The IEA, in its recent *World Energy Outlook*, estimates that the world will add 4,890GW of generation capacity over the next 25 years.[68] Much of this will be in the developing world where cost is an overarching concern. And Chinese equipment providers, who have large economies of scale domestically as the result of the explosion in electricity demand, are situated to offer pulverized coal-fired technology at a substantial discount to cleaner technology from US, European, or Japanese firms.[69] Thus the market economics that have made it difficult to improve the environmental profile of power generation in China may make it difficult to do so in the rest of the developing world.[70]

ENERGY SECURITY AND OVERSEAS INVESTMENT

The domestic price controls that create volatility in the way Chinese oil companies buy crude from the international market also create an incentive for them to invest overseas. And a growing sense of energy insecurity at home caused by supply shortages and price volatility creates political support for that impulse (see discussion in previous section). What type of impact this investment has on international energy security has been a topic of great debate, particularly in the wake of CNOOC Ltd.'s aborted bid to acquire California-based Unocal in 2005 and the growing international attention paid to CNPC's investment in Sudan.

Much has been written on this topic already.[71] Our contribution, based on interviews with both Chinese and foreign petroleum industry officials, addresses three economic questions central to Chinese oil company activities overseas: where they invest, how they invest, and where they sell the oil. We do this through the lens of the domestic economic and political foundation established above.

Where They Invest

Table 7 shows the geographic distribution of upstream investments by Chinese national oil companies (NOCs), and which of these investments are currently producing oil. Given economically comparable projects, China's firms make decisions about where to spend their money based on three considerations: technical capabilities and (to a lesser extent) the compatibility of the oil in the ground with the refineries back home; the presence of competition from IOCs; and an assessment of political risk.

Crude oil comes in different types and must be matched with appropriate refineries. China's large domestic oilfields, like Daqing and Shengli, produce a crude that is relatively low in sulfur (sweet), and in Daqing's case relatively high in API gravity (light).[72] The refinery capacity built to support these fields is geared toward this type of oil. This is one reason why China imports far less Persian Gulf oil (which is high in sulfur) than its neighbors in East Asia (figure 30). Instead, China buys more of the lighter sweeter crudes that come from Asia and West Africa. The same considerations shaping crude oil buying influence the direct investment decisions of China's oil companies abroad, assuming they intend to sell the oil to refineries back home.

For some of the first overseas investments by Chinese firms, these were the primary considerations. Since then,

[67] We thank Scott Roberts of MIT for this point.

[68] International Energy Agency, *World Energy Outlook 2006* (Paris: Organization for Economic Co-operation and Development).

[69] "Chinese Power Equipment Makers Target Asia to Compensate for Domestic Slowdown " *Global Power Report*, 22 February 2007.

[70] We thank Peter Evans at Cambridge Energy Research Associates for this point.

[71] See especially WoodMackinzie, "The Impact of Asian NOCs on the Upstream M & A Market," (2006), Peter C. Evans and Erica S. Downs, "Untangling China's Quest for Oil through State-Backed Financial Deals," in *Policy Brief #154* (Washington: The Brookings Institution, 2006). Erica S. Downs, "The Chinese Energy Security Debate*," *The China Quarterly* 177 (2004).; Xiaojie Xu, "Chinese NOC's Overseas Strategies: Background, Comparison and Remarks," (James A. Baker II Institute for Public Policy, Rice University, 2007), Kenneth Lieberthal and Mikkal Herberg, "China's Search for Energy Security: Implications for U.S. Policy," *NBR Analysis* 17, no. 1 (2006).; and Steven W. Lewis, "Chinese NOCs and World Energy Markets: CNPC, Sinopec and CNOOC," in *The Changing Role of National Oil Companies in International Energy Markets* (James A. Baker II Institute for Public Policy, Rice University: 2007).

[72] API stands for American Petroleum Institute.

China's ability to refine its equity production at home has become gradually less important (indeed most of it is not shipped back home, as discussed below). Today, Chinese oil companies are more constrained in their selection of blocks on which to bid by their upstream technical ability rather than their refinery stock. Chinese firms are quite adept at exploration and development in geological formations abroad similar to those found in China. Some of these (such as complex faulted block reservoirs and certain heavy oil deposits) are relatively challenging and thus pro of these (such as complex faulted block reservoirs and certain heavy oil deposits) are relatively challenging and thus provide the Chinese majors with an advantage in bidding projects.[73]

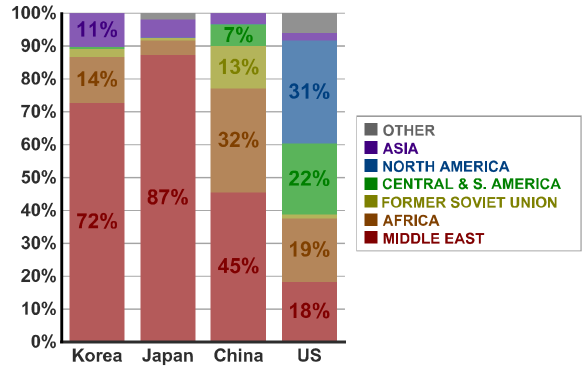
Table 7: Global Presence of Chinese Oil Companies (2006)

	CNPC	Sinopec	CNOOC
Africa			
Countries invested in	8	6	4
Producing oil in	3	2	0
Total equity production (tbpd)	180	9	0
Middle East			
Countries invested in	3	4	0
Producing oil in	3	1	0
Total equity production (tbpd)	30	1	0
Former Soviet Union			
Countries invested in	3	3	0
Producing oil in	3	1	0
Total equity production (tbpd)	250	40	0
East and Southeast Asia			
Countries invested in	4	2	4
Producing oil in	3	0	2
Total equity production (tbpd)	30	0	35
North and South America			
Countries invested in	4	3	1
Producing oil in	4	2	0
Total equity production (tbpd)	70	40	0

Source: Author's estimates based on conversations with oil company officials and market analysts. Excludes China.

Yet in other areas, such as deep offshore, Chinese NOCs are at a significant disadvantage vis-à-vis the IOCs. Much of the unexplored oil and gas acreage remaining worldwide not already controlled by the NOC of an oil-rich country is of a type for which Chinese companies are less suited (and thus less competitive in head-to-head bids with IOCs), Chinese firms often seek sites such as Sudan, Iran, or Syria, where the IOCs are either prohibited from investing or hesitant to do so out of fear of host-country political risk or damaging negative publicity.

Figure 30: Oil Imports by Region of Origin (2006)



Source: EIA, China General Customs Administration, MITI, Korean Customs. Korean data is Jan-Nov 2006.

Chinese NOCs are less worried about public perceptions associated with such investments, though both CNPC and Sinopec have chosen to keep their most sensitive operations under the auspices of their parent group companies, rather than their publicly traded subsidiaries. And in terms of political risk, Chinese firms appear less concerned than their Western IOC peers that a host country will one day decide to nationalize their assets. In part this is because Chinese firms are new to the game and have yet to endure such an ordeal. They also face lower investment hurdles overall (see below) and can thus accept a higher risk premium. At the same time, there are indications that some in China responsible for foreign affairs are less agnostic about the damage to China's new, hard-won "soft power" that could come from a narrow "you give us the oil, we give you the money" attitude that is great for vested authoritarian elites but not necessarily great for average citizens in developing nations desperate for reform.

Chinese investment in countries that Western firms avoid may create political, strategic, or human rights challenges, but it does not threaten international energy security per se. This is an important distinction to make. In fact, it could be argued that such investment actually enhances energy security by bringing oil to market that would not have been developed otherwise.

How They Invest

Both business leaders and policymakers have raised concerns about *how* Chinese oil companies make their in-

[73] We thank K. F. Yan at Cambridge Energy Research Associates for this point.

vestment once they have chosen where to place their bets. Are they competing on a level playing field with the IOCs? Where does their financing come from? What political support are they able to draw upon to secure a deal?

On the question of cost and source of financing, the answer varies by company. Well-known is the case of CNOOC's attempted acquisition for Unocal in 2005, where the smallest of the three Chinese oil majors was able to secure $7 billion in cheap state financing as part of its $18.5 billion bid (Evans and Downs 2006). Yet this example is not representative of most overseas investments by Chinese firms. In order to make an offer that was more than half the entire market capitalization of the company, and more than double its annual revenue, CNOOC had proposed to borrow heavily from the state-owned banks. This is certainly not the case for CNPC, whose 2006 profits alone totaled $24 billion.[74] And as CNPC is not required to pay dividends to the state, the only alternative for investing that money is in mature and expensive domestic production or in bank deposits that yield a nominal 3 percent. With less of an opportunity cost, CNPC is able to accept a lower investment hurdle than a BP or a Chevron, whose shareholders would rather take their money and reinvest it elsewhere if the company can't deliver double-digit returns.

With only $9 billion in profits in 2006 and a great deal of downstream investment to be made, Sinopec lies somewhere between CNOOC and CNPC in its ability to bank-roll overseas deals out of its own pocket. And even when these firms do have to take out a loan, there is no shortage of banks eager to offer capital for oil exploration and production, as it has been the most profitable sector of the economy in recent years.[75]

More nebulous is the role that government-supplied tied aid plays in helping Chinese firms secure deals in developing countries. The most famous example is the $2 billion soft loan extended by China's Export-Import Bank to Angola for infrastructure projects in 2004, which international observers claim prompted the Angolan government to award an oil concession to Sinopec at the Indian Oil and Natural Gas Commission's expense (Evans and Downs 2006). This "good-will gesture" was followed up in the summer of 2006 with another $2 billion infrastructure loan announced during Premier Wen Jiabao's visit to Angola as part of a seven-nation African tour.[76] It is hard to quantify exactly how important these loans, and the high-level political delegations that arrive to announce them, are in the investment success of Chinese oil companies now or in the future. Much has been written about the attractiveness of Chinese capital that comes with no governance strings attached for African leaders. But many are discovering that some of the promised investment never materializes and when it does comes with few jobs for their citizens. The loans to Angola, for example, require 70 percent of the construction work to be done by Chinese companies (which generally bring with them their Chinese employees). In addition, a bilateral trade agreement usually comes part and parcel with the financial assistance, thus opening poor African nations to Chinese manufacturing exports.

Most of the largest IOCs have, of course, also benefited from similar support at one point or another in the past, and (perhaps ironically, given some griping) even in some of the same countries Chinese firms are investing in today. What is more important is that their home governments (e.g., the United States) have made great efforts to discipline and reduce these noncommercial interventions. One reason is profit-oriented: When all buyers add inducements beyond market rates in a negotiation, then they are all worse off; stopping such self-defeating cost-escalation requires that individual countries are restrained from "beggaring their neighbors."[77] Another motive is developmental: Overinflation of the natural resource export sector clearly can retard socioeconomic development, creating both humanitarian problems and political risk problems that can become flashpoints for conflict. Efforts to prevent unhealthy investment competition on the buy side are discussed in the policy conclusions section.

Where They Sell the Oil

Concerns about China's overseas oil investments are fed by the idea that China's NOCs are locking up resources through equity deals[78] and thus taking oil off the market and out of reach for other buyers. Underlying these con-

[74] Winnie Lee, "CNPC Earned $23.85 Billion Profit in 2006, up 5.7%," *Platts Oilgram News*, 24 January 2007.

[75] CEIC data from the *China Statistical Yearbook.*

[76] Benoit Faucon, "China Makes Headway in Angola with Multiple Trade Ties," *Dow Jones International News*, 30 November 2006, "China's Exim Bank Grants Angola US $2bln Credit," *China Knowledge Press*, 23 June 2006.

[77] For an excellent discussion, see Peter C. Evans, "International Regulation of Official Trade Finance: Competition and Collusion in Export Credits and Foreign Aid" (Massachusetts Institute of Technology, 2005).

[78] Equity deals refer to standard industry production sharing agreements where the foreign oil company is given the right to sell a specified share of the oil it produces. Nothing about the equity deals that Chinese firms have signed is fundamentally different from those signed by their IOC peers.

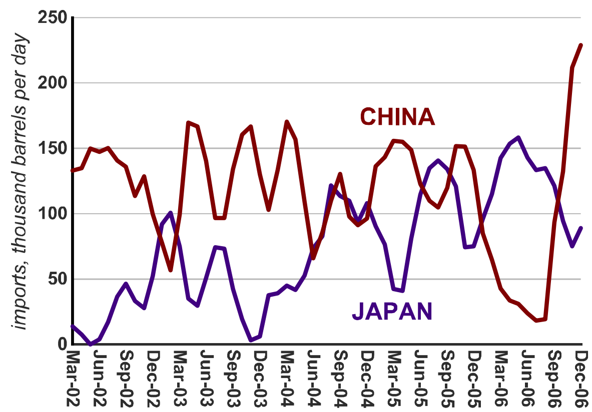
cerns are two assumptions: first that Chinese firms sell the oil they extract overseas only to consumers at home, and second that doing so somehow reduces the amount of oil available to everyone else. Both are wrong.

CNPC, China's largest upstream oil company, produced 2.7 million barrels of oil per day during 2006. Of this only 564,000 barrels per day (21 percent) was produced abroad.[79] Nearly half of this equity output was from Kazakhstan, following CNPC's acquisition of the Canadian company PetroKazakhstan in 2005. Sinopec registered less than 90,000 bpd of international oil production in 2006, mostly in Russia and Latin America and CNOOC less than 35,000 bpd, almost exclusively in Indonesia.[80] All told, overseas equity production by Chinese firms totaled roughly 675,000 bpd in 2006. If all of this oil returned to China, it would have only satisfied 19 percent of total imports last year.

Yet according to our calculations based on customs data, industry intelligence, and news reports, these companies did not ship most of their overseas-pumped oil home, but instead sold it on the open market to the highest bidder. The newly constructed oil pipeline from Kazakhstan to China brought in only 50,000 bpd of the 260,000 CNPC produced. None of the production in Canada, Syria, Venezuela,[81] and Azerbaijan showed up on China's shores, and only a fraction of the production from Ecuador, Algeria, and Colombia did. The percentage of oil CNPC produced in Sudan in 2006 that was sent back to China declined, as did the total amount in volume terms. As shown in figure 31, CNPC chose to sell more of it to Japan, probably because the offered price was higher. And despite CNOOC's strong presence there, Chinese imports from Indonesia fell by 48 percent.

This is a critical point. No one is concerned that when Shell signs an equity agreement somewhere in the world that the Netherlands is taking oil off the market and making everyone else less energy secure. That's because we assume that Shell will sell its production to whoever is willing to pay the highest price. To date, Chinese oil companies appear to be doing the same and thus prioritizing profits over political considerations. And even if every barrel were shipped back home, that would mean less China needed to buy from Saudi Aramco or Kuwait Oil, and thus more available for the United States to purchase. Back in Beijing, some people are beginning to realize this and doubt whether equity production by China's NOCs, as small as it is, does anything to increase the country's energy security. If not, why endure the damage to China's image created by investment in Sudan if all it does is line the coffers of the oil companies and raise the average price of oil? (Downs 2006).

Figure 31: Sudan's Oil Exports by Destination



Source: China General Customs Administration and MITI.

THE ENVIRONMENT

The inability of China's energy policy to address the environmental affects of its energy markets has caused a dramatic deterioration in the quality of the country's air and water. Some of this pollution stays inside China's borders and some doesn't. The impact of the share that doesn't is growing rapidly, and addressing it has become a critical component of any regional and global environmental initiatives. Consensus has gelled that energy policy cannot leave aside these environmental impacts to the extent it did so in the past.

Regional

For China's neighbors, the problem is visible, whether blowing in the wind or floating down the river. China is easily the region's and the world's largest source of SO_2 emissions, primarily from burning coal for power generation. This sulfur, along with particulate matter emitted from the same plants, blows across China's borders to other East Asian countries where it causes many of the same problems as inside China: acid rain, reduced visibil-

[79] Winnie Lee, "CNPC Earned $23.85 Billion Profit in 2006, up 5.7%."

[80] Lin Mo, "2006 Is a Reform Year for Sinopec," *Xinhua China Oil, Gas & Petrochemicals*, 25 January 2007. Lin Mo, "CNOOC: 2006's Ordinary Performance, but with Eye-Catching Prospects " *Xinhua China Oil, Gas & Petrochemicals*, 19 March 2007. Also derived from conversations with WoodMackinzie and PFC Energy.

[81] Though customs statistics show crude imports from Venezuela of 84,000 bpd in 2006, industry sources confirm that due to a total lack of appropriate refining capacity, all of this oil was traded out in favor of more suitable crudes.

ity, and respiratory problems. It's a growing source of political tension with Korea and Japan, which endured their own environmental crises and are not eager to relive them. In Hong Kong, which claims 80 percent of the SO_2 in its air comes from neighboring Guangdong province, officials worry about loosing financial center competitiveness as service firms and the expatriates they employ seek greener pastures.

Sulfur from Chinese power plants travels as far as the West Coast of the United States and Canada. In California, Oregon, and Washington, Chinese sulfur has reached between 10 and 15 percent of EPA's allowable levels in the mountains, enough to be concerned about but not enough to cause acid rain yet.[82] And those same power plants are the world's leading source of androgenic emissions of mercury, which shows up in the fish sold at US restaurants and grocery stores.

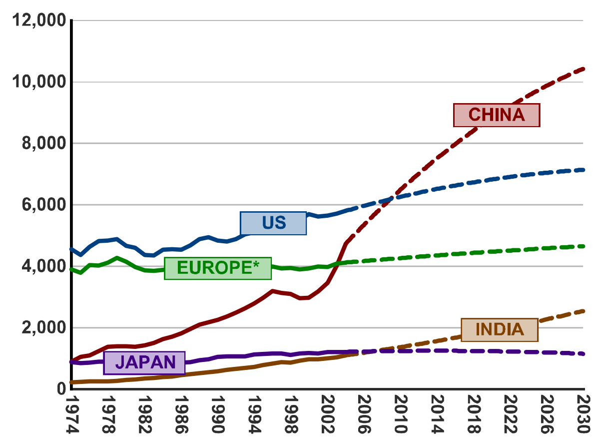
China's potential impact on transnational waterways, as well as air quality, was brought home when a CNPC petrochemical plant exploded in the north of the country in November 2005, sending a 100-ton benzene slick down the Songhua river through populated areas of China and into Russia. Neither CNPC nor the government acknowledged the accident until 10 days after the spill had occurred, giving the Russians little time to prepare for its impact. And in the south, ambitious hydropower development plans, which have already resulted in the dislocation of 23 million people inside China, threaten to change the lives of millions more who live downstream on the Nu (Salween) and Lancong (Mekong) rivers in Vietnam, Laos, Thailand, Cambodia, and Burma, not to mention further impact on the Yangtze in China.[83]

Global

The most global environmental impact of China's energy use, and possibly the most significant in absolute terms, comes from carbon dioxide (CO_2). Currently number two, China will surpass the United States as the world's largest CO_2 emitter (figure 32) by the end of 2007.[84] But in China, as opposed to the United States, the problem comes almost entirely from industry. Only 6 percent of carbon emissions come from automobiles, compared with over 30 percent in the United States. Eighty-two percent of the carbon emitted comes from coal (compared with 37 percent in the United States), half of which is burned in power plants and half of which is burned by in cement kilns, steel mills, and other industrial applications.

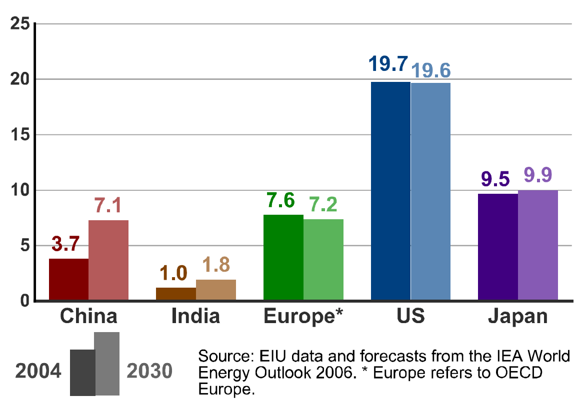
Between now and 2030, the IEA predicts that China will account for 40 percent of the growth in global annual CO_2 emissions, and yet in 2030 China's per capita emissions will still be less than Europe's and Japan's and only a third as much as those of the United States (figure 33). As such, convincing China to agree to the same type of mandatory limits that the rich countries are bound to under the Kyoto Protocol will be extremely challenging.

Figure 32: Projected Annual CO_2 Emissions (million metric tons)



Source: IEA data and forecasts from the IEA World Energy Outlook 2006.
* Europe refers to OECD Europe.

Figure 33: Current and Projected Per Capita CO_2 Emissions (metric tons)



Source: EIU data and forecasts from the IEA World Energy Outlook 2006. * Europe refers to OECD Europe.

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[82] Keith Bradsher and David Barboza, "Pollution from Chinese Coal Cast a Global Shadow," *New York Times*, June 11, 2006.

[83] "Full Text: Report on the Work of the Government," *Xinhua's China Economic Information Service*, 17 March 2007. See also Andrew C. Mertha, "Water Warriors: Political Pluralization in China's Hydropower Policy," (Washington University in St. Louis, 2007). and Milton Osborne, *River at Risk: The Mekong and the Water Politics of China and Southeast Asia* (Lowy Institute for International Policy, 2004).

[84] US Carbon Dioxide Information Analysis Center, 2007.

GOODS TRADE AND INDUSTRIAL COMPETITIVENESS

Energy is a cost of production. The amount of energy that goes into manufacturing and delivering a good to market varies greatly from a little (most light manufacturing, such as apparel) to a lot (aluminum). Transportation can represent a significant share of this cost, as inputs now move halfway across the world to be transformed and then are shipped all the way back for final consumption. The abnormalities in costs and capital flows that have promoted energy intensive industry in China have altered the global distribution of production in these sectors. In some cases this means that foreign producers or even foreign plants have migrated to China.[85] In most cases, it means import substitution that ramps up so quickly and with so little mind for new capacity in the province next door that it spills over into the export market. In either case, it means displacement for production elsewhere even when the non-Chinese operation is far more energy efficient.

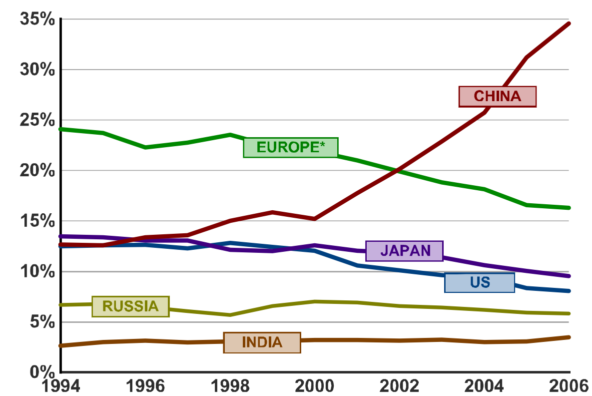
Current Migration

China's share of global output in energy intensive manufacturing has soared in recent years. In 1996, the United States and China each accounted for 13 percent of global crude steel production. Ten years later China's share has grown to 35 percent while the US share has shrunk to 8 percent (figure 34). In absolute terms, Chinese production has grown four-fold while US production has stayed flat. Similar trends have occurred in aluminum (figure 35), glass, and chemicals. The bulk of this new output is to service domestic demand, but a significant and growing share spills into export markets, affecting producers abroad (figure 36).

In 1994, China imported 21 percent of the steel products it consumed. In 2006, China not only met its own steel needs, but ran a trade surplus of 24 million tons. In aluminum the turnaround has been even more dramatic. Relying on foreign providers for more than 25 percent of aluminum demand as recently as 2000, China now exports more than twice as much as it imports. In dollar terms, the metals trade deficit had averaged $7 billion per year between 2000 and 2003; in 2004–06 it amounted to $1 billion, $8 billion, and $34 billion of surplus respectively—accounting for 30 percent of the change in China's goods trade balance those years.[86]

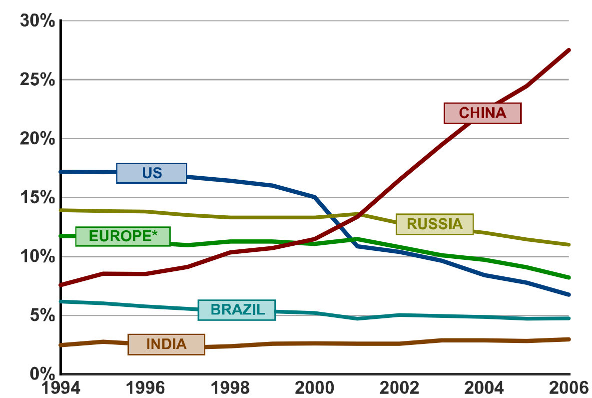
The other energy intensive sector that "migrated" production to China in this way is chemicals. On the whole, China still runs a trade deficit in chemicals, but rapid import substitution is closing the gap. Between 2002 and 2006, exports grew by 48 percent per year while imports grew by 31 percent. And in certain chemicals, such as ethylene and many of its downstreams, China now runs a trade surplus. Most of the new chemicals capacity currently planned will either be built in China or the Middle East (KPMG 2006).

Figure 34: Share of Global Crude Steel Production



Source: USGS and IISI. *Europe refers to the EU25.

Figure 35: Share of Global Primary Aluminum Production

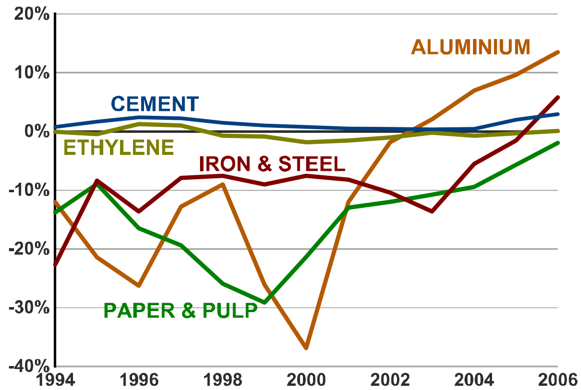


Source: USGS and IISI. *Europe refers to the EU25.

[85] See the steel plant anecdote in James Kynge's excellent *China Shakes the World*, chronicling the movement of an entire Ruhr Valley steel plant to Shanghai.

[86] CEIC data from *China Customs Statistics*, General Customs Administration.

Figure 36: Net Exports as a Share of Total Chinese Production



Source: CEIC, Comtrade and author's estimates.

Future Shock

We are concerned that the migration of global capacity to China could swing back the other way, bringing the same volatility characteristic of China's energy sector to global energy-intensive product markets. Because China's financial and energy systems have encouraged such a build-out of heavy industry, we now depend on the continued stable functioning of that market to maintain supply through myriad global value chains. China's political risk is not negligible, and will get more pronounced as the energy system is strained further. Even without outright system failure, systemic volatility is raising the transactions costs for industrial goods.

Another scenario for supply shock occurs if abnormal costs are successfully addressed by Beijing, changing basic factor costs contributing to industrial investment as described at the beginning of this report. In fact, reform in the cost and distribution of land rights is already afoot, the inefficient allocation of capital is a topic of intense discussion, and industry may be required to foot the bill for its environmental impact sooner than expected to avert a catastrophe already brewing in poisoned rivers, lakes, air, and soil. Rising costs for these factors cannot be offset by cost-cutting on raw materials (terms of trade for which will likely go up, not down), labor (already rising on a steep slope), technology (which has been unnaturally "cheap" in the sense that intellectual property rights of others were not enforced, creating an effective subsidy that is coming to an end), or energy itself.[87]

Such a radical structural shock to China's economy is not happening today, and is not looming in the next year. It is likely however, and liable to commence in the medium term rather than the long term. And with China accounting for between one-quarter and one-half of global production in so many energy-intensive goods, even a change at the margin will have a significant impact on global markets for these products.

It is clear to us that the international impacts of China's energy policy choices are considerable that they demand a rigorous multilateral policy response cooperative to the maximum extent possible, but the template for such cooperation is not evident. In the next section we turn to the policy recommendations.

[87] There are too many dynamic variables to map out seriously in this policy analysis, such as the inflationary results of this scenario; this discussion is notional.

4 Conclusion and Policy Recommendations

We draw four principal conclusions from our study of China's energy situation.

1. The main energy challenge for China today is the shifting industrial structure of its economy, not factory inefficiency, new air-conditioners or more automobiles. These issues are systemic in nature and thus only China can effectively correct them.
2. Given conflicting pressures on the country's leaders, we do not expect China to adequately fix the root causes of its structural over-allocation into energy-intensive industry in the next decade, unless something changes. By coordinating the energy and environment imperative with existing calls to rebalance external and macroeconomic distortions, it may be possible to break through these conflicts sooner than would otherwise occur.
3. Structural adjustment is necessary but not sufficient to address China's energy issues. The international community can and should take steps with Beijing today to mitigate important negative impacts of China's energy footprint on global energy security and climate change.
4. Regardless of how successful Beijing or others are in altering the country's energy trajectory, in 20 years China will likely be the world's largest energy consumer and polluter. Energy regimes built when the OECD was the only game in town must be expanded to reflect the fact that non-OECD economies will consume most of the world's energy in the decades ahead. If the global institutions charged with brokering international energy and environmental solutions are to be effective, or even relevant, they will need to adjust to this reality.

A point of context should be kept in mind when contemplating these recommendations: China is an 800-pound gorilla on the world energy stage that cannot be ignored; but there is a 1,600-pound gorilla in this room too—the United States. Instead of treating that fact defensively, US policymakers might see it as an opportunity. The changes needed on China's behalf seem impossibly ambitious as unilateral adjustments, especially since China feels entitled to follow an industrial path that many OECD nations have trod. Even if progressive Chinese leaders recognize a self-enlightened interest in unilateral reform, there exists a natural tendency to focus more on a rival getting off easier than they should than one's own best interest. The necessity for the United States to improve the sustainability of its own energy profile may be by far the most powerful lever it has for impelling change elsewhere: The opportunity for a grand bargain in energy and environment exists to give policymakers in both China and the United States political cover for painful choices.

ASSESSING THE DOMESTIC RESPONSE

China's energy challenges are not lost on the country's leaders, who are acutely aware of the welfare loss they create (see box 1). In fact, Beijing has lofty ambitions to reduce the energy intensity of growth in the years ahead. As part of the current 11th Five-Year Plan (FYP) the government has set a target of reducing energy intensity by 20 percent and air pollution by 10 percent by 2010.

Each province has been asked to do its part to help the country meet this goal, and Beijing has warned that failure to do so will affect the career prospects of provincial officials, regardless of how they score on other metrics (like GDP growth and foreign investment).[88] To improve the odds of success, NDRC, understanding that industrial energy use is at the core of the problem, compiled a list of the 1,008 top energy-consuming firms collectively accounting for one-third of total energy demand and instructed them to develop efficiency plans in cooperation with local officials.[89]

Many foreign governments and nongovernmental organizations (NGOs) are helping China improve industrial energy efficiency. The US Department of Energy co-

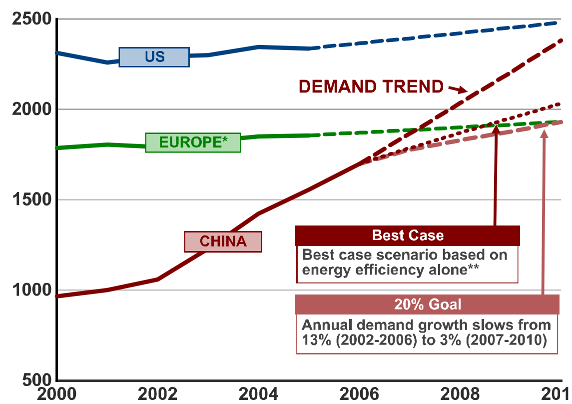
[88] Mure Dickie and Richard McGregor, "Jiangsu Sets the Pace on How to Assess Officials," *The Financial Times*, 15 March 2007.

[89] "China Enterprise Energy Conservation & Efficiency Forum 2006," *Xinhua China Oil, Gas & Petrochemicals*, 13 October 2006. and conversations with EF China. Local governments have signed or are developing similar plans with an additional 100,000 smaller firms.

chairs an Energy Efficiency Steering Committee with NDRC that focuses on reducing the amount of power used in electric motor systems (which account for half of all electricity demand).[90] The government-funded Lawrence Berkeley National Laboratory (LBL) has worked with Chinese partners for over a decade to promote energy efficiency.[91] NGOs including the California-based Energy Foundation and the New York–based Natural Resources Defense Council (NRDC) have successful industrial energy efficiency programs ongoing in China as well.[92] European and Japanese organizations have also done extensive work.

Heavy industry in China is still, on average, 20 to 40 percent more energy intensive than it is in the OECD, which means that the potential for significant gains exists (Wan 2006). And in fact, the efficiency of the country's heavy industry has steadily improved over the past five years and is likely to continue on this path for the next five. This is an important achievement, as the industrial stock getting built now will exist for decades to come. But even in the best scenario, improving the efficiency with which heavy industry consumes energy will not be enough for Beijing to reach its 20 percent target, as shown in figure 37.

Figure 37: China's Ability to Change Course (energy demand in mtoe)



Source: BP Statistical Yearbook 2006, IEA WEO 2006 for US and Europe. Excludes biomass and waste. China economic growth projections are from EIU. *Europe refers to OECD Europe. ** Best case scenario based on LBL estimates of potential demand elasticity improvements using aggressive industrial efficiency measures.

Box 1: Who Pays the Tab? Welfare Loss in China*

Land: Land is regularly taken from farmers at low compensation to make way for industry, hydropower and other projects.

Public Health: Seventy percent of energy demand comes from industry and two thirds of that demand is met with coal. Coal burning emissions from boilers and power generation cause acid rain, respiratory problems, premature mortality and decreased visibility.

Employment: Light industry was China's employment engine during most of the reform period. A shift toward heavy industry means fewer new jobs. In 2007 Chinese officials expect there to be 24 million job seekers but predict the economy will only add 9 million new positions.**

Saving Rates: About $370 billion a year in short term loans goes to the industrial sector (probably an equivalent or greater amount of medium and long-term lending, though "industrial sector" is not broken out in those figures). This bank lending, despite obvious overcapacity, is only possible because China's households save $2 trillion at banks at interest rates barely if at all greater than inflation. The foregone capital gain, and risk borne by households, is enormous.

Energy Security: Volatile energy demand causes blackouts that affect households as well as businesses, and diesel and gasoline shortages for both farmers and car owners.

* A rigorous econometric measure of welfare as a function of the industrial system is obviously beyond the scope of this brief; this discussion is notional only.

** Tom Miller, "Booming Economy Creates 12m Urban Jobs." *South 'China Morning Post*, March 13, 2007.

In his annual address to the National People's Congress in March 2007, Premier Wen Jiabao acknowledged that China had failed to meet its energy intensity goals for the first year of the 11th FYP.[93] For it to still make the target, Chinese energy demand growth would have to slow from the 13 percent per year average between 2002 and 2006 to 3 percent per year between 2007 and 2010. Based on calculations done by LBL in the summer of 2006, even the most herculean energy efficiency measure, absent some structural change, will only get the country 85 percent of the way there.

Even if China is somehow able to reach its 20 percent target, it would still surpass Europe in overall energy consumption by 2010, and many of the challenges associated with the country's energy footprint would persist. After all, energy intensity is just a ratio of the amount of energy used per unit of economic output in dollar (or

[90] US Department of Energy, *Fact Sheet: U.S. Department of Energy Cooperation with the People's Republic of China.* www.pi.energy.gov (accessed March 13, 2007).
[91] More on LBL's work in China can be found at http://china.lbl.gov.
[92] More on the Energy Foundation and NRDC's China work can be found at www.efchina.org and www.nrdc.org/air/energy/china, respectively.

[93] "Full Text: Report on the Work of the Government."

renminbi) terms. Given a constant structural mix, energy intensity declines naturally with economic growth even while absolute energy consumption continues to increase (see box 2). Between 2001 and 2005 energy intensity declined by 9 percent in India (and 8 percent in the United States) without a specific government mandate, while it increased by 7 percent in China despite a government mandate.[94]

Beyond Energy Efficiency

Addressing the demand volatility, supply shortages, investment practices, and environmental deterioration of recent years means correcting some of the distortions that foster heavy industry in the first place. This means moving away from the administrative approvals and price controls that stand in for energy policy in favor of a better regulatory toolkit and market signals (discussed in greater depth earlier in this report). In short

a) improving the efficiency of *capital allocation* in a way that reflects full costs and removes the ingrained bias toward heavy industry lending;
b) continuing reform of *energy prices* in conjunction with improved data collection and price transparency; and
c) incorporating *environmental costs* in a way that incentivizes cleaner behavior, rather than relying on administrative controls alone.

Efforts to improve the capital system, energy pricing and environmental enforcement have certainly been made in recent years, but with mixed results. Beijing is beginning to raise electricity prices for more energy-intensive industries and is tuning the tariff and tax codes to reduce incentives to export energy-intensive products. And SEPA, China's environmental watchdog, is gradually exerting more influence on the policymaking process. Most encouraging is the progress made in using economic incentives to reduce SO_2 emissions (as discussed in a previous section). While absolute SO_2 emissions increased in 2006, the majority of new power plants built had sulfur scrubbers installed. Environmental Defense's Beijing office has done impressive work in this area and is engaging with provincial officials for experiments in sulfur trading.

But on the whole, progress is slow. The same vested interests responsible for the current economic trajectory frustrate efforts to change course. State-owned heavy industry and its provincial allies oppose policies that reduce their competitiveness vis-à-vis neighboring provinces or countries, even when those policies would create welfare gains for China as a whole.[95] This means that SOE governance reforms and reform of government and party promotion criteria may have to come first before and significant change is seen.

Box 2: Energy Intensity Demystified

Energy intensity is simply the measure of how much energy is consumed in a country (or industry) for each dollar of economic output. As such, it can either be reduced by cutting the amount of energy consumed or raising the value of the output. The easiest way to achieve the former is by raising the cost of energy (or the associated environmental externalities), and thus provide firms with an incentive to consume less. Yet as doing so would reduce the competitiveness of existing state-owned heavy industry firms, efforts by Beijing on this front are often frustrated by provincial opposition.

A more politically expedient way to improve energy intensity, and the one Beijing has chosen to embrace, is to raise the value (and thus the price tag) of the industrial goods that energy is being used to create. By assigning energy intensity targets to each province (who in turn delegate them to local energy-hungry enterprises) without addressing the cost of power, land, capital or environmental compliance, the cheapest way for industry to reach their goals is to extend their cost advantage into higher value steel, aluminum, glass or chemical products, thus raising total revenue faster than energy consumption.

Beijing often resorts to second-best solutions that may exacerbate energy problems. When successful, central attempts to constrain industrial capacity through approvals can provide rents to the firms already in place. Caps on new lending to energy-intensive industries risk blocking investment that would improve the energy efficiency of the existing stock. Even the energy intensity programs within the 11th FYP may incentivize an expansion of steel, aluminum and cement production in the years ahead (box 2). So, should Beijing be blocking new capacity or not? The answer is that if it hopes to significantly alter the country's energy future Beijing must deal with the sources of boom and bust driving so much of the present misallocation and scarcity rents (nontransparent macro and accounting data, nonmarket set capital costs, state-guided lending, and the like) and stop trying to steer an airplane by adding a little weight to one wing or the other once it is already in the air.

[94] Calculated from the BP (2006) and Economist Intelligence Unit (EIU) GDP figures.

[95] NDRC's efforts to raise electricity prices for energy-intensive users face serious compliance problems. See "China Tells Provinces to up Guzzlers' Power Tariffs," *Reuters News*, 16 April 2007.

As the income and influence of Chinese households grows, the pressure on local officials to deal with pollution, low portfolio savings returns to households, and higher-income job creation will grow as well. But progress on these fronts is likely to be measured in decades, and pressure in foreign capitals to address issues of energy security, climate change and the China's global trade surplus is growing by the day. Fortunately, some of the steps the international community can take in response to China's emergence may help Beijing alter the country's energy trajectory.

PRIORITIZING THE INTERNATIONAL POLICY RESPONSE

In the United States and around the world unease over energy security and the environment add to existing anxiety about China's rise (see box 3). In Washington, concern over these issues has reached a high point with the stymied Chinese bid for Unocal, Chinese oil investment in Sudan, Iran, and Venezuela, and China's contribution to climate change all making headlines and spawning congressional hearings. Opinions are being shaped and legislation crafted regarding how the United States should respond to China's energy footprint and what the future looks like for the world's two largest energy consumers and environmental polluters. Our hope with this policy analysis is to clarify the issues on the table and help avert policy responses that are either unhelpfully combative or substantively ineffective.

Box 3: Beggaring the Neighbors, Welfare Loss Abroad

Energy Markets: The shortages created by investment cycles and price controls within China pass through to international markets in the form of price volatility.

Overseas Investment: The close relationship between the government and the energy companies that shapes policy inside the country raise issues of unfair and potentially destabilizing investment competition when these firms venture abroad.

Environment: Surging energy consumption in a system that does not price in externalities creates environmental challenges outside China's borders: emissions of sulfur dioxide and particulate matter regionally and carbon dioxide globally; as well as pressure to "race to the bottom" in terms of process and production methods (PPMs).

Product Markets: China's economic conditions shocked global markets by rapidly attracting heavy and light industry. Righting the distortions in this economy could cause an equally large shock if industry must once again relocate in the face of urgent Chinese reforms.

We divide our discussion into three of the topics foremost on policymakers' minds and in which China plays a large role: energy security, industrial competitiveness, and climate change. As we said at the outset, this is a report about China for the United States, and thus our recommendations will largely concern what the United States should (and should not) do regarding a growing, more energy-hungry China. Yet US success or failure in dealing with the implications of China's energy use hinges on US ability to deal with its own. The issues facing the two countries are far too large to be addressed in isolation. And China's inability to significantly alter its medium-term energy footprint should not be used as an excuse for inaction in addressing the world's long-term energy future.

ENERGY SECURITY

Definitions of energy security vary widely. For the purposes of our discussion, we will define it simply as the ability to secure adequate and consistent supplies of energy to fuel an economy at a price that doesn't bring it to its knees. We cover here both the ways in which China does and does not affect global energy security (box 4).

Overseas Investment

As stated in the previous section, concerns about the overseas activities of China's energy firms fall into three categories: Such firms harm the energy security of others by taking oil off markets; they harm the economic interests of IOCs by competing unfairly; and they hurt strategic interests by disrupting existing political and economic dynamics.

The first contention we reject out of hand. Despite all the rhetoric about Chinese oil companies locking up resources through equity agreements, total international production by Chinese firms accounts for less than 2 percent of the global oil trade.[96] It will be nearly impossible for these companies to satisfy China's import needs, let alone gain a big enough position in the market to threaten US oil security. As China is now the world's second-largest oil consumer, we should expect the profile of Chinese oil companies on the international stage to increase. And we should welcome and encourage the emergence of Chinese firms that abide by international norms for competition and investment.

[96] BP plc., *Statistical Review of World Energy 2006*. and authors' estimates.

The second point warrants more concern, that Chinese oil companies operate in a way OECD countries have spent decades working to prohibit. This is less an energy security concern per se than an industry competitiveness concern, but we address it here. State-related bank lending subsidies and government transfers at home lower the commercial criteria that China's NOCs must apply in operating overseas. Preferential market structure conditions (monopoly, oligopoly, or oligopsony) benefit national energy firms. Forgiveness of financial liabilities to government, such as taxes, fees, royalties, or dividends (in the case of state ownership of shareholding enterprises—a major consideration for the NOCs) apply in the energy sector, as in others.

While many of these circumstances certainly exist and accrue to the financial benefit of firms in the energy sector in China, none are unique to the energy sector, or unique to China. Others are suspected to take place but have proven difficult to demonstrate to the standard likely to prove actionable under the limited international agreements governing subsidies. The WTO Agreement on Subsidies and Countervailing Measures (ASCM) is the principle discipline on subsidies in general, and applies to China's energy companies (state owned and otherwise). Flatly prohibited subsidies are limited to those with certain trade effects: export subsidies and import substitution subsidies. These do not appear relevant to support China's energy companies, as generally they are not exporting.[97] Actionable domestic subsidies are those that, while not aimed at trade results directly, could distort trade by indirectly altering the economic viability of firms that then engage in trade. Nonactionable domestic subsidies are also noted as a classification in the ASCM. Moreover, even if a WTO party felt ready to bring a domestic subsidies case, the regime cannot be used to confront the overseas investment behavior of China's NOCs, which is where their behavior is most challenging to IOCs.

The instances of subsidized lending and alleged tied aid that have helped Chinese firms invest abroad are not covered by the WTO. A specialized agreement overseen by the OECD known as the Export Credit Arrangement disciplines the subsidization of overseas credits to spur exports, including the tying of aid to export goals. But if China subsidizes an NOC's purchase of an oil block in a developing country, it is not exporting so much as fueling its imports. Further, China is not a member of the OECD and has not expressed an interest in joining this agreement that we are aware of. In sum, there really is no regime to discipline aggressive deal-making in energy, let alone a regime that China has made commitments to join or comply with. Though not very satisfying in the short term, the best option appears to be the one that the United States is already taking: to educate Beijing on the long-term merits of closing ranks to discipline overseas investment supports, and get them to join expanded arrangements voluntarily, for their own good. The invitation has been made, but high-level efforts have been concentrated on Beijing's currency policies rather than getting China to join the OECD investment commitments; these priorities may need to be reconsidered.

While the implications of China's overseas energy investment on security and human rights concerns are largely outside the scope of this paper, we would offer the following to the discussion. First, there are indications that some in Beijing are critical of a blank check for China's resource-extracting firms overseas, particularly if they are unlikely to provide real energy security. Their case is strengthened as China's "soft power" continues to be diminished by lending political support and Security Council cover to the business activities of CNPC and Sinopec's business activities in Sudan.[98] This view is

Box 4: Energy Security

Overseas Investment

- encourage China to join the OECD's Export Credit Arrangement
- welcome Chinese oil companies that behave in accordance with those agreements into international markets
- stress to Chinese officials the cost in "soft-power" of investments in places like Sudan.

Global Energy Markets

- encourage Chinese companies to release inventory data
- cooperate with China on respective SPR fill schedules

Technical Cooperation

- "green buildings" and energy conscious urban planning
- expand R&D in hydrogen vehicles and begin it in cellulosic ethanol
- power-sector reform in urban markets

International Institutions

- either expand the IEA to include China (and other large developing countries) or create something else in its place.

[97] We say generally because there is a limited export of thermal and coking coal, and limited export by wire of (mostly hydro) electricity in the southwest.

[98] Recent kidnappings of Chinese nationals working on projects in Africa also bring this point home. See, for example, "Foreign Ministry Spokesman Liu Jianchao's Regular Press Conference on March 20, 2007 " Ministry of Foreign Affairs of the People's Republic of China http://www.fmprc.gov.cn/eng/xwfw/s2510/t305261.htm..

aligned with calls for China to be a "responsible stakeholder" and should be encouraged.

Second, China's firms invest in places where IOCs fear to tread, not only because of the lack of competition, but also due to the absence of alternatives. The acreage available to IOCs in safe, developed areas is shrinking. To grow an upstream business there are only two options: explore somewhere more risky or expand through mergers and acquisitions. Following CNOOC's aborted bid to acquire Unocal, China's firms see heavier risk in bidding for US and European energy firms than in drilling for oil in Sudan or Iran. In order to coordinate efforts to impose regime pressure on states of concern, the United States and the European Union will need to temper their eagerness to intervene politically to block foreign investments at home. Reform of the US Committee on Foreign Investment in the United States (CFIUS) process now before Congress does not appear designed to achieve that.

Global Energy Markets

While China's overseas investments do not pose a risk to global energy security, the nature of China's demand creates a great deal of uncertainty in energy markets, particularly for oil. In the near term there is little the United States or the international community can do to reduce China's demand volatility: It is caused by the country's cyclical investment torrent. There are, however, steps China could take right now that would greatly reduce the extent to which this volatility affects international prices.

The first would be requiring CNPC, Sinopec, and CNOOC to publish their corporate inventory data, which is common practice in IEA member-countries. Being able to track inventory changes month-to-month would help international markets forecast how much oil China will need in the future, thus avoiding spikes in crude prices associated with upside surprises in Chinese demand. China is already cooperating with the IEA and providing some data to the Joint Oil Data Initiative, though not about corporate inventory levels.[99]

The second would be to make public the schedule for filling China's strategic petroleum reserve (SPR), currently under construction. Fill rates so far have been extremely modest and should have no impact on prices.[100] Yet the opacity surrounding the SPR fuels market speculation and creates price fluctuations based on rumor alone. While it is not common practice to publish SPR fill schedules (even among the OECD) doing so would benefit China as it would reduce price volatility in the crudes on which China relies. Washington should join Beijing in this effort, as a confidence-building measure, regarding the expansion of the US SPR proposed by President Bush in his 2007 State of the Union address. Such cooperation could be facilitated by the IEA, which is currently working with China on the construction of its SPR tanks.

Finally, China relies on the spot market for the vast majority of the crude oil it imports, and stands to gain by improving transparency in its oil purchasing and removing some uncertainty from the markets. This is also important for the United States and should be stressed as such in bilateral meetings with China.

Technical Cooperation

Outside of near-term oil market cooperation, there is a significant amount of bilateral technical cooperation that would help both China and the United States improve their long-term energy outlooks. Several successful programs already exist in industrial energy efficiency. And while industrial demand is certainty China's present energy challenge, looking forward the international community will likely get more bang for its buck by focusing on the consumption-led future. Foreign cooperation will have little impact on the systemic causes of China's structural shift between industries; within industries incentives to improve energy efficiency already exist and the technology is largely available on a commercial basis.

Yet the steel mills, cement kilns, and glass factories that are driving current demand are feeding an infrastructure boom that is quickly locking in China's energy and environmental future. Steps taken to improve the energy impact of what's being built now will pay off in spades down the road. International cooperation can play an important role in this area, particularly in the following:

a) **Buildings:** While the concept of "green buildings" is starting to take off in China, there is a great deal of work to do in improving building code and bringing energy consciousness into urban planning.

b) **Transportation:** Though the United States has little influence over the way China builds its transportation system, the two countries share an interest in reducing the energy profile of their vehicle fleets. Cooperation currently exists between the two countries in hydrogen R&D and should be extended to cellulosic ethanol (Huang et al. 2007). Both the United

[99] For more information, see www.jodidata.org.

[100] In 2006, we estimate that between 50,000 and 60,000 bpd was added to China's SPR, less than 1 percent of China's total oil demand that year.

States and China have aggressively pursued ethanol as a petroleum substitute and both now face rising food prices as a result.

c) **Urban Power Markets:** Electricity reform is a critical issue for China's energy future. While at its core it is a political process that the outside world will have little ability to shape, there exist opportunities for international cooperation in urban power markets, where a desire for cleaner and more reliable energy is driving experiments with time-of-use pricing and green dispatch.

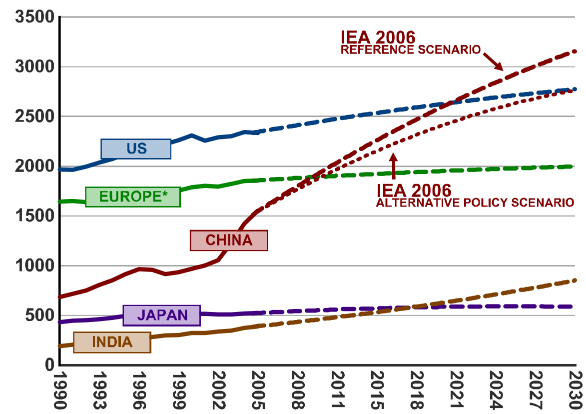
All of these areas of technical cooperation may well be most successful if undertaken on a city-to-city or state-to-province basis. Several examples of this already exist.[101] The energy priorities of the more affluent coastal provinces, where much of this consumption-led demand is taking place, are not necessarily the same as the country as a whole.[102] And at the end of the day it is the city or province that is going to have a greater role in determining the success or failure of any program.

International Institutions

Regardless of how successful the collaborative efforts are in improving the country's energy outlook, China will be a major player in the world's energy future. Under its current reference scenario based on conservative growth projections the IEA sees China as the world's largest energy consumer in 2030, accounting for 20 percent of global demand (figure 38). Even if China takes fairly aggressive steps to conserve energy, it will likely still consume more energy than Europe and Japan combined. A growing share of this energy will come in the form of oil, and China is likely to account for more than one-quarter of the additional global oil demand over the next 25 years. And as domestic production is flattening out, each marginal barrel will have to come from overseas.

Yet at existing multilateral institutions set up to address energy, China is missing from the table. The IEA only counts OECD countries as members, though some non-OECD countries, including China, hold observer status. This collective of energy-consuming countries was established as a counterweight to the energy-producing Organization of Petroleum-Exporting Countries (OPEC). But while OPEC's share of global oil production is set to grow, the OECD's share of oil consumption is quickly declining, from 60 percent today to 47 percent by 2030. To stay relevant the IEA must either adapt to the growing weight of the developing world, China in particular, or give way to a new institution that does not determine membership by income level.

Figure 38: Energy Demand Forecasts (mtoe)



Source: BP Statistical Yearbook 2006, IEA WEO 2006. Excludes biomass and waste.
*Europe refers to OECD Europe.

INDUSTRIAL COMPETITIVENESS

The discussion of subsidies above applied to their relationship to energy company investments and behavior overseas, and found little basis to challenge Chinese behavior multilaterally (WTO) or plurilaterally (the arrangements in the OECD). However subsidies that spur China's exports of goods could be a different story. One of the demonstrable abnormalities of China's current economic model is that it has become a large net exporter of energy intensive goods—notably steel—which, given the energy risk premiums pervasive in China, naturally raises the question of whether there exist energy subsidies per se to heavy industry manufacturers in China, and if so what should be done about them (box 5).

In early 2007 the United States requested consultations with China over prohibited export subsidies. Several other major parties joined the consultations. China is already in the process of changing many of the policies identified by the United States, and so it will be relatively easy for the United States to declare victory. A case alleging actionable domestic subsidies has not been pursued yet, though a number of US industries, steel foremost, are

[101] See specifically Environmental Defense's SO_2 programs and NRDC's energy efficiency work in Jiangsu Province at www.nrdc.org/air/energy/china.

[102] For an excellent discussion on energy and environmental governance as an income function, see Eric Gregory Zusman, "The Limits to Access: An Institutional Explanation for Why Air Pollution Regulations Vary in East Asia's Rapidly Industrializing States" (University of California 2007).

keen to see such a case brought.[103] In the evidence publicly available to date, little or no evidence of improper energy subsidies per se has been provided. In our primary research for this study, we found little clear evidence of direct energy cost subsidies either.

Specific cases of favorable energy-cost terms for exporting companies in China will likely be identified in the near term. However, the pervasive revealed comparative advantage of heavy industry manufactured goods from China is generally rooted in distortions other than energy inputs, and a challenge to China's exports of these goods will likely attack subsidization through the domestic financing system more generally rather than subsidized physical inputs, including energy more discretely. That will be a challenging case to win.

To be more visionary still, the energy intensity of the process and production methods employed in an economy may in the future require expansion of existing regimes, or new regimes. The concept of a carbon tax imposed by nations disciplining carbon emissions on imports from countries free-riding on those efforts, which was anathema to free trade thinkers a decade ago, is no longer seen as radical. While auditing the carbon content of a DVD player on the shelf at Wal-Mart all the way back through the production value chain is a daunting notion, such an approach, if addressed in a multilateral context, would have the benefit of harnessing market incentives, rather than elusive political will, to reduce energy consumption and CO_2 emissions.

Box 5: Industrial Competitiveness

Energy and Capital Subsidies

- China is already in the process of changing explicit export incentives.
- The pervasive nature of China's heavy industry prowess and the difficulty in identifying systematic energy or capital subsidies mean trade cases on these fronts will be difficult.

Environmental Subsidies

- Attempts to unilaterally levy tariffs on Chinese imports on environmental grounds would also face a questionable future at the WTO.
- Establishing a multilateral framework (with China as a participant) to address the carbon content of internationally traded goods would stand a better chance of success.

[103] As we go to press, a unilateral countervailing duty (CVD) case is being pressed on China by the United States, aimed at coated paper. It computes—tenuously, in our opinion—financial subsidies, by comparing the cost of capital in China to 37 other countries. This may mark the turning point in willingness to address financial subsidies.

CLIMATE CHANGE

Regardless of whether China passes the United States as the world's largest emitter of CO_2 in 2007 or 2010, it is clear that there can be no solution to climate change that does not include China. Both aggressive bilateral technical cooperation and serious multilateral regime building needs to begin at once. Building 2GW of coal-fired power per week, China is quickly locking in its carbon future. And with the Kyoto Protocol expiring in 2012, the groundwork must be laid now for what comes next.

Technical Cooperation

The United States and China are both rich in coal and look to it for a majority of their electricity needs. China is building its power generation base for the first time and the United States is preparing to replace a generation of aging stock. In both countries, the CO_2 is vented into the air from all the existing coal-fired plants and will be from all the plants currently on the drawing board.[104] Carbon capture and sequestration (CCS), the only feasible means of large-scale carbon mitigation at these plants, is a viable technology that still needs significant amounts of R&D before it can be widely commercialized. A recent study by MIT (2007) on "The Future of Coal" outlines the need for several integrated projects to demonstrate the feasibility of CCS in a variety of countries and geological settings. We believe this should be a priority area of cooperation between the United States and China (box 6). The two countries are already working together on the FutureGen project in the United States. Below we suggest two potential locations for such work in Asia that would meet other US policy goals in the process:

1) **Shengli Oil Field:** In China's Shandong Province, Shengli is a mature Sinopec oil field that produces around 500,000 barrels per day. Output from many of the wells is declining and Sinopec has been performing some enhanced oil recovery (EOR) using gas and steam. A power plant or refinery in the area (which is rich in both coal and refineries) equipped to capture carbon could sell it to the Shengli field for EOR and thus reduce the overall cost of the demonstration project. Doing so would also help boost

[104] There are a couple small exceptions to the in the United States including the government-funded FutureGen project which plans to capture and sequester its CO_2 stream.

China's domestic oil production, reducing the amount it needs to import from abroad.

2) **Mongolia**: China's neighbor to the north is rich in coal and looking for ways to develop its mineral resources that keep as much of the economic value-chain inside the country as possible. Sandwiched between Russia and China with no seaport, Mongolia is weary of becoming a resource-supplying appendage of either and looks to the United States as an important "third neighbor." Demonstrating a clean coal power plant with carbon capture and sequestration in Mongolia with US and Chinese involvement would give Mongolians an opportunity to sell electricity to China instead of just raw coal (and hence create more jobs and economic activity inside the country) and provide the United States and China with an avenue for cooperation outside their borders (and hence removed from some of the political considerations).

Projects such as these could be undertaken independently or as part of the Asia-Pacific Partnership. Moving quickly to demonstrate the viability of CCS will help to ensure it is an available mitigation option under a future international climate regime.

In addition to coal-fired power generation and CCS, nuclear energy is another area ripe for collaboration. China plans to build more than 30GW of nuclear power over the next 15 years and the United States will have to make decisions about whether to extend or replace its aging reactor stock. Fortunately, one of the longest-standing and most successful areas of US-China energy cooperation is in nuclear technology and safety. This ongoing work is well worth expanding.

International Regimes

While technical cooperation is important, particularly in the near term, it is no substitute for a multilateral framework to address climate change in which both the United States and China take part. While the vast majority of the CO_2 added to the atmosphere over the last century came from the West (and the United States in particular) the lion's share of the CO_2 emitted over the next century will come from the East (China in particular) (figure 39). In the current IEA reference case, growth in annual CO_2 emissions in China alone between now and 2030 will more than double that in the OECD. Total emissions from the developing world that year will equal global annual emissions today, meaning that even if the rich world went entirely carbon-free over the next two decades, it wouldn't be enough to get back to 1990 levels.

Box 6: Climate Change

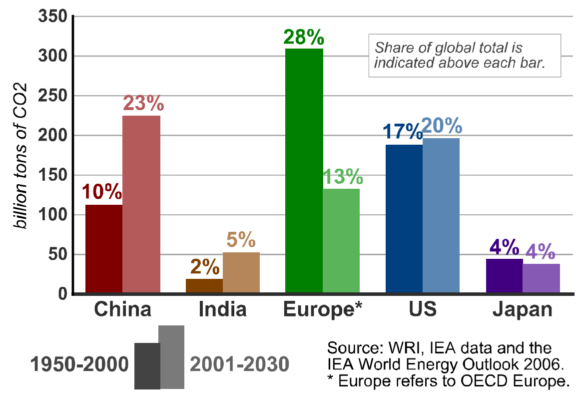
Technical Cooperation

- CCS demonstration projects in China or Mongolia.
- expanded cooperation on nuclear energy.

International Regimes

- existing approach to multilateral framework must be revised to reflect the reality of the developing world.
- a combination of comprehensive emissions caps for the developed world and sector-level agreements for the developing world holds the promise of getting China and India on board and alleviating competitiveness concerns in the US and Europe.

Figure 39: CO_2 Concentrations by Country, 1950–2000 and 2001–30



Source: WRI, IEA data and the IEA World Energy Outlook 2006.
* Europe refers to OECD Europe.

As stated in the beginning of this section, the environmental challenge raised by the developing countries *should not* be used as an excuse for inaction by the developed countries responsible for the bulk of the carbon in the atmosphere already. Our purpose here is rather to demonstrate that while reducing emissions in the OECD is critical, it is far from sufficient.

Under the Kyoto Protocol, rich countries were given the opportunity to offset some of their own emissions by investing in emissions-reducing projects in the developing world (known as the Clean Development Mechanism, or CDM). This was never intended as a long-term solution to emissions from the developing world but served as an intermediate step until developing countries were able to accept binding targets. The protocol expires in 2012, and in shaping what comes next we need to look beyond the CDM approach to the developing world.

Ultimately, to have any hope of stabilizing global CO_2 levels, the world will need to deal with both US consumers and Chinese industry. While political will is emerging in both countries to address their impact on the world's climate, the ability to implement policy varies greatly between the two. The current politics of energy in China makes it highly unlikely that Beijing will be able to significantly alter its carbon future alone, and Beijing will see absolutely no reason to take this challenge on if America hasn't done so first. Therefore US leadership is required, both to address its own environmental footprint, and to help change the economics of doing so elsewhere in the world.

Yet many in the United States are concerned about the impact on global industry allocation if they agree to targets from which the developing world is exempt; they argue that it won't do much good to cap emissions on US industry if that industry then picks up and moves to China. These are the same objections that were voiced about the Kyoto Protocol except that China is now much larger and US anxiety over global competitiveness is more pronounced.

There are ways to get beyond these roadblocks that address both the political challenges in the United States and the capacity challenges in China. In the United States the main culprit is consumer energy demand, in the form of either gasoline in cars or electricity for homes and offices. In China, however, as we have shown throughout this policy analysis, 70 percent of energy demand comes from the industrial sector, much of which makes the goods consumed by households in the United States.

Given this, we see no reason why global climate talks need to come to a stalemate because the United States and China aren't willing to agree to the same types of targets during the same time frame. There has been a great amount of focus recently on the concept of sectoral emission reductions agreements in the most energy-intensive industries, like steel, aluminum, chemicals, and automobiles.[105] While China (or India) might not be willing or able to agree to comprehensive emissions reduction targets, sectoral agreements may be an easier sell. And as industry is the leading source of greenhouse gases in large developing countries, such an approach would address a significant portion of their emissions. It would also give Beijing the cover and the leverage to discipline and consolidate these industries, which they have been attempting to do for several years.

With the prospect of steel mills and aluminum smelters in China and India being held to the same standard as those in Pennsylvania and Ohio, sectoral agreements could mitigate enough of the competitiveness concerns in Washington to get the United States to agree to the kind of economy-wide reduction targets that are needed to move global talks forward. The developing world would also be included in the emerging global regime in a manner that would pave the way for the adoption of comprehensive targets as the commercial and transportation sectors play a larger role in shaping the energy profile in these countries.

There are certainly drawbacks to sectoral agreements, many of which are detailed in a forthcoming study on the topic by the World Resources Institute (Baumert and Bradley 2007). Regardless of which approach, or combination of approaches, makes the most sense in multilateral negotiations, China will not make real moves on climate change in the absence of US leadership.

[105] As Michael Laske of AVL China points out, most domestic Chinese auto companies are looking to export in the years ahead. As such, sectoral agreements governing the automotive industry would likely have an impact on the behavior of these firms if access to foreign markets was on the line.

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