
Energy Implications of China's Growth

It remains to be seen how flexibly the PRC will interpret self-reliance in this age of interdependence. The degree of flexibility may ultimately reflect, internally, the pace at which the PRC chooses to modernize its agriculture and industry and, externally, the direction in which PRC relations with the United States . . . develop.

— Choon-ho Park and Jerome Alan Cohen¹

On one side of China's balance sheet stand shining economic achievements; on the other—inseparable from the nature of its industrialization—lie disquieting energy and environmental liabilities. Between 1978 and 2000, the Chinese economy grew at 9 percent while energy demand grew at 4 percent. At the turn of the century, China accounted for 10 percent of global energy demand but met 96 percent of this demand with domestic energy supplies. After 2001, economic growth continued apace, but changes in the structure of the economy pushed energy demand up by 11 percent a year. Today China's share of global energy use has swelled to over 16 percent, forcing the country to rely on international markets for more of the oil, gas, and coal it consumes.² This fundamental shift in China's energy profile has created shortages at home and market volatility abroad and raised questions about whether China's growth trajectory is sustainable. China is now the world's second largest energy consumer and has likely become the leading source of greenhouse gas emissions.³

Understanding the changing relationship between macroeconomic trends and energy outcomes is critical in addressing energy security and environmental protection, both inside China and abroad. Conversely, how these issues are addressed will shape the macroeconomic trajectory and sustainability of China's development model. This chapter explores how China's energy footprint has evolved as a function of costs, the implications at home and abroad of China's energy use, and the policy agenda for dealing with those implications.⁴

Evolution of Energy Demand in China

Decades of state planning and ideological aspiration prior to reform in the late 1970s had distorted China's energy demand profile. Rather than embracing a development strategy compatible with its natural endowments (China is rich in labor, poor in capital, arable land, and technology) as Japan, Hong Kong, Taiwan, and others had done, leaders ignored comparative advantage and dragged China—kicking, screaming, and sometimes starving—toward Soviet-style industrialization. In fits and starts over 30 years, resources were shifted 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 output tripled (figure 7.1).⁵ This command-and-control fiasco resulted in severe inefficiency, which, ironically, created the potential for impressive catch-up growth later—what we think of as a Chinese miracle today.

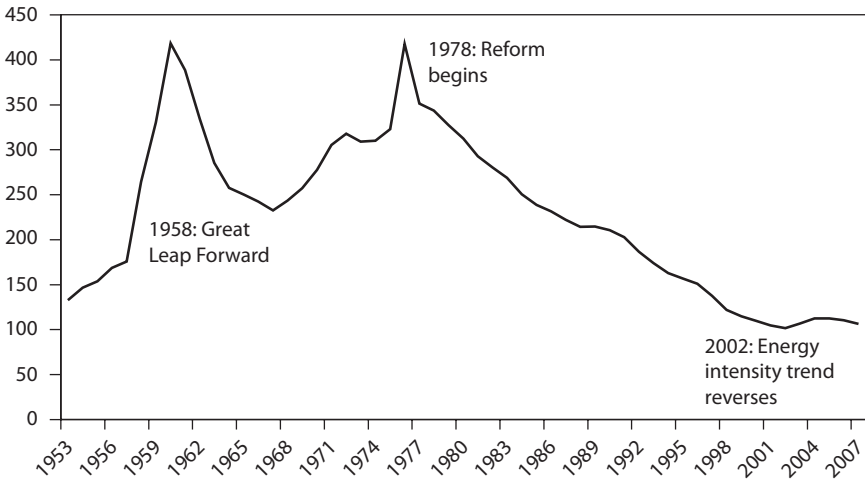
In 1978 leaders began to unleash China's potential. Faced with continued worry about famine, Beijing let farmers “catch their breath” by reforming agricultural production targets and raising prices, with dramatic results. Farm output increased, and the early 1980s saw rural residents with more time on their hands, cash in their pockets, and freedom to use it as they chose. Much of this new wealth was invested into township and village enterprises (TVEs) set up to exploit what China was best suited for: labor-intensive light manufacturing. These TVEs became an engine of economic growth and the first step away from energy-intensive industry, a shift that would shape China's energy footprint for the next 20 years.⁶

Reform also brought changes within heavy industry, which reduced the energy intensity of Chinese growth. Economic incentives—the right to aspire to and keep profits—were introduced where only planned mandates existed. Awareness among enterprises of bottom-line profits made them focus more on top-line expenses, including on energy. And as enterprises were becoming more aware of the impact of energy costs on profitability, their energy bills were growing as a 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 also from a growing private sector, made energy cost management all the more important. Domestic competition was accompanied by gradual integration with world markets; lower trade barriers not only brought pressure on SOEs from energy-efficient foreign companies but also allowed them to acquire the more energy-efficient technology their competitors enjoyed. China's small existing base of modern plants and equipment enabled it to absorb new technology quickly, significantly improving the efficiency of the country's capital stock.⁷

By 2000, Chinese economic activity required two-thirds less energy per unit of output than in 1978 (figure 7.1). Energy intensity improvement on

Figure 7.1 Energy intensity of the Chinese economy, 1953–2007

tons of coal equivalent
per million real renminbi



Source: CEIC data from National Bureau of Statistics of China, *China Statistical Yearbook*, various years.

this scale was unprecedented for a large developing country and meant that in 2001, China accounted for 10 percent of global energy demand rather than the 25 percent based on 1978 energy performance.

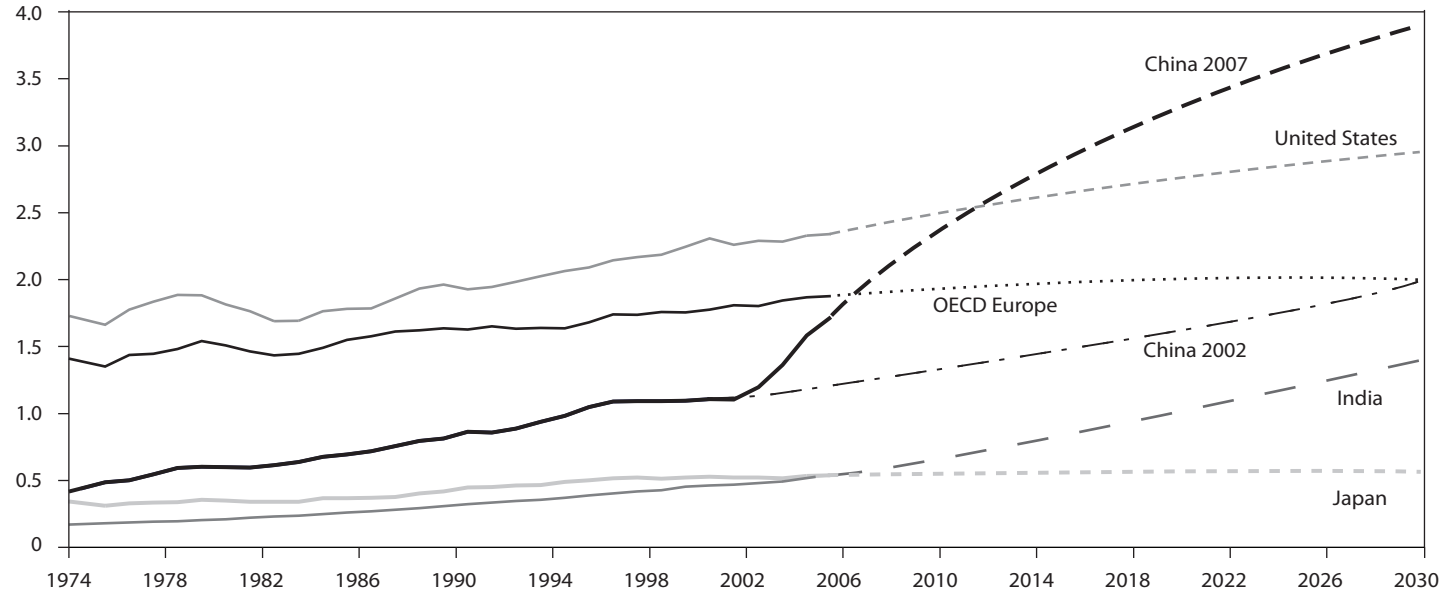
Investment-Led Energy Surprise

At the start of the new millennium in 2001, China's leaders expected the energy intensity improvements that had been taking place since 1978 to continue. Economic reform was an accepted reality and was assumed to presage further energy efficiency. China had decided to join the World Trade Organization (WTO), locking in greater market competition at home and recognizing the importance of comparative advantage.⁸ Most energy forecasters at home and abroad assumed that the structural shift away from energy-intensive heavy industry would persist; at least, no one expected the evolution to reverse quickly. Further, GDP growth was expected to expand by 7 to 8 percent for the coming decade, fast but not furious.⁹ In 2001 both the Chinese government and the International Energy Agency (IEA) predicted 3 to 4 percent energy demand growth between 2000 and 2010 (figure 7.2).

Both wildly missed the mark. The economy grew much quicker than anticipated in 2001–06, but the real surprise was a change in the energy intensity of economic growth. Energy demand elasticity (ratio of energy demand

Figure 7.2 Energy demand, historic and recent forecasts, 1974–2030

billion tons of oil equivalent



OECD = Organization for Economic Cooperation and Development

Note: The International Energy Agency, in its *2002 World Energy Outlook*, predicted Chinese energy demand would reach 2.1 billion tons of oil equivalent by 2030. Just five years later, in its *2007 World Energy Outlook* it raised its 2030 forecast for China's energy demand by 1.7 billion tons of oil equivalent (a 79 percent upward revision) to 3.8 billion tons of oil equivalent.

Sources: Historic data from International Energy Agency, *World Energy Statistics and Balances 2007*; projections from International Energy Agency, *2007 World Energy Outlook*.

growth to GDP growth) increased from 0.4 between 1978 and 2001 to 1.1 between 2001 and 2006.¹⁰ Energy consumption grew four times faster than predicted to 16 percent of global demand in 2006. And yet on a per capita basis, China's energy demand remains one-sixth that of the United States, triggering anxiety about how much more growth is to come.¹¹

This upside surprise not only shocked domestic and international energy markets but also prompted a fundamental reassessment of China's energy future—and hence the world's. In its *2007 World Energy Outlook*, the IEA raised its 2030 forecast for China's energy demand by 1.7 billion tons of oil equivalent (a 79 percent upward revision) to 3.8 billion tons of oil equivalent from the 2.1 billion tons of oil equivalent it had predicted in its 2002 outlook. The new forecast is more than India's total projected demand for that year.¹² Under this scenario, China will account for 22 percent of global energy demand, more than Europe, Russia, and Japan combined, easily surpassing the United States as the world's largest energy consumer.

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 transportation—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 one; 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 predecessor—uses substantially more energy than a garment factory. Industry today accounts for two-thirds of final energy consumption in China, while the residential, commercial, and transportation sectors account for 12, 5, and 13 percent, respectively.¹³ This is high by either developed- or developing-country standards (table 7.1).

When pundits express shock at how much more energy intensive China is than, say, Japan, they usually ignore the important factor of what the country makes. High energy intensity partly reflects the role of industry in the Chinese development model, as opposed to India, which has taken a more services-heavy approach, or Japan, which has lowered its energy intensity in part by migrating its energy-intensive sectors to China. As shown in table 7.2, industry accounts for 48 percent of all economic activity in China compared with India at 29 percent and Japan at 26 percent. So the fact that one unit of economic output requires five times as much energy in China as in Japan says more about the type of economic activity taking place in China than the efficiency with which it occurs (though energy efficiency in most industries in China lags OECD averages, discussed later). And economic activity in China is increasingly skewed toward investment.

Table 7.1 Energy demand by sector, 2005 (percent)

Sector	China	India	Russia	Brazil	Japan	EU-27	United States	World
Agriculture	4.6	7.2	2.3	4.9	0.9	2.2	1.1	2.4
Industry	63.8	52.1	38.4	41.1	38.3	32.4	26.8	37.8
Commercial	4.7	3.0	8.1	6.8	17.7	10.5	13.0	9.0
Residential	12.3	16.7	26.2	10.3	15.7	22.0	16.8	17.1
Transportation	12.8	18.5	22.7	36.9	26.9	29.8	41.4	31.5
Other	1.9	2.5	2.1	0.0	0.0	3.0	0.9	2.0
Total (million tons of oil equivalent)	890	199	417	128	348	1,249	1,546	6,893

Note: This table excludes biomass but includes nonenergy use of energy commodities.

Source: International Energy Agency, *World Energy Statistics and Balances 2007*.

Table 7.2 GDP by sector, 2005 (percent)

Sector	China	India	Russia	Brazil	Japan	OECD Europe	United States	World
Agriculture	12.5	18.8	5.5	5.7	1.5	2.3	1.0	n.a.
Industry ^a	47.5	28.8	39.5	29.3	26.2	27.3	20.7	28.2
Services	39.9	52.4	55.0	65.0	72.3	70.5	78.3	n.a.
Total (billions of US dollars)	2,303	809	765	882	4,554	13,671	12,434	44,730

n.a. = not available

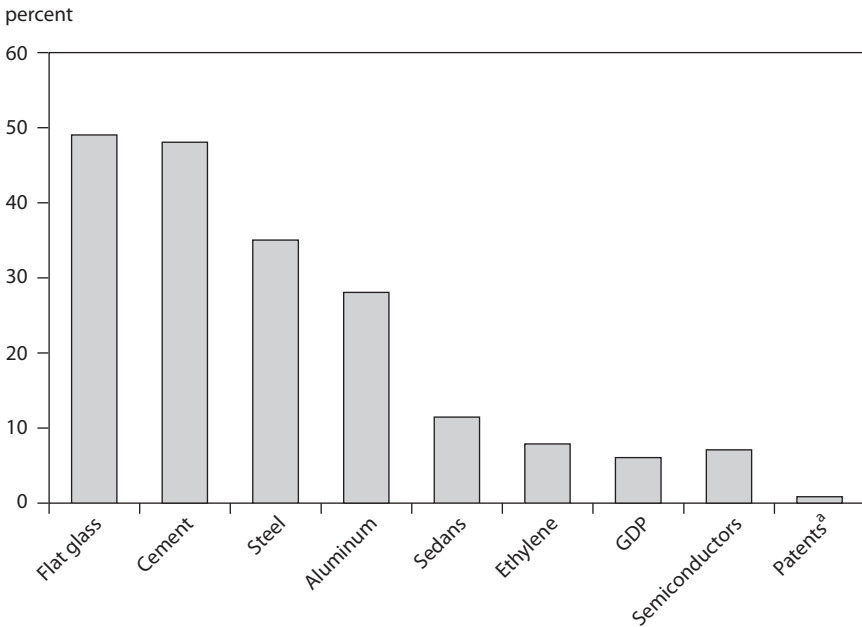
OECD = Organization for Economic Cooperation and Development

a. Industry includes manufacturing and construction.

Source: Economist Intelligence Unit Country Data based on national sources.

Is it the case then that energy intensity booms whenever there is an investment boom in China? Investment as a share of China's GDP approached its current high of 43 percent two other times, in the late 1970s and the early 1990s, when it also created a surge in industrial activity.¹⁴ From an energy standpoint, the current investment cycle is different. Based on a review of the literature, data analysis, and primary research, we postulate a number of things.

First, China is now producing domestically, rather than importing, 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 49 percent of global flat glass production, 48 percent of global cement production, 35 percent of global steel production, and 28 percent

Figure 7.3 China's share of global production, 2006

a. Refers to share of US patents awarded to foreign countries.

Sources: CEIC data from ISI Emerging Markets; US Patent and Trademark Office; International Energy Agency; Pilkington, "Flat Glass Industry—Summary," www.pilkington.com; International Iron and Steel Institute, www.worldsteel.org; US Geological Survey; Comtex, www.comtex.com; and authors' estimates.

of global aluminum production (figure 7.3).¹⁵ Some of this production reflects migration of industry from other parts of the world not only to serve Chinese demand but also for export. Where China used to be a net importer of many energy-intensive goods, it has now become a major global exporter of steel, aluminum, and cement.

Second, the energy impact of China's investment cycles is worsening: With each boom more finance is pumped in to build domestic energy-intensive industrial capacity. The implication is that energy policy alone cannot fix the energy problem, and it must be incorporated into the larger agenda for rebalancing China's growth; this agenda must include adjustments to the financial system, environmental protection regimes, trade policy incentives, and other variables discussed in this book.

Third, the changing composition of China's industrial structure is less the result of ideological aspiration (as it was for Mao Zedong) than competition among provinces and localities to grow GDP, tax revenue, and corporate profits.¹⁶ Not just Beijing but also local interests, including industrial enterprises, set the rules of competition. And regardless of who

sets the rules, implementation is a local matter. Within this context of competition, short-term economic incentives—low operating costs and profits—explain much of the increase in heavy industrial activity.

On the profit side, after-tax earnings in energy-hungry industries have been good, thanks to depreciation, dividend waivers for SOEs, transfer payments, and other factors. Heavy-industry profits have risen from near-zero in the late 1990s to a level comparable to that of their light-industry counterparts—ranging from 4 to 7 percent in steel, glass, chemicals, and cement in recent years.¹⁷ 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 after 2001. But with overcapacity arising almost as soon as the first profits come in, the ability of firms to sell surplus production in international markets has been critical to remaining profitable.

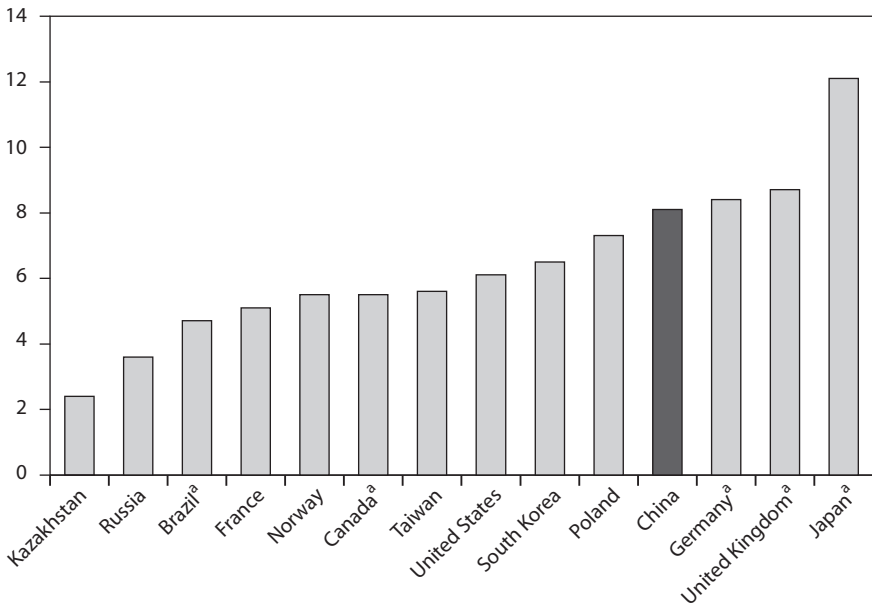
China's energy-intensive industry enjoys low operating costs, which has allowed for rising profit margins and a dramatic growth in capacity that is at the center of China's overinvestment in heavy industry. Local governments often provide deeply discounted land, and they often do not enforce regulations to protect air and water. Construction time is short, and labor costs are low. These benefits apply to all industries; however, they are particularly valuable in the energy-intensive sector, where capital costs are large. The financial system also favors heavy industry: SOEs worry little about the threat of default, and borrowing rates are not even high enough to afford depositors a positive real rate of return. Not only are profit margins high (for borrowers, not depositors) but also SOEs do not have to distribute the profits to their shareholder (the state), leaving them with plenty to reinvest. The following subsections lay out these various operating cost advantages in detail.

Energy Prices and Environmental Costs

Energy prices in China, once highly subsidized, have gradually converged with world prices over the past 30 years. Yet, given local idiosyncrasies in pricing, dual supply channels for many legacy SOEs, arrears, and other factors, it can be difficult to accurately assess the price a specific firm pays for coal, gas, oil or electricity. Chinese prices for raw energy commodities including coal and natural gas, particularly in interior provinces close to resource deposits, can be significantly cheaper than those in the OECD. For coal, low prices result not from subsidization but rather from low extraction costs in areas isolated from international markets. As transportation bottlenecks ease, coal prices will continue to rise toward world prices. Coke, a coal-derived fuel used in steelmaking, was once significantly cheaper inside China than on international markets due to limitations on Chinese coke exports. In recent years, however, the gap between Chinese

Figure 7.4 Industrial electricity prices, 2006

US dollars per kilowatt hour



a. 2005 data.

Sources: US Department of Energy, Energy Information Administration; International Energy Agency; CEIC data from National Development and Reform Commission Price Monitoring Center.

and global coke prices has significantly narrowed. Beijing directly controls natural gas prices, attempting to keep them competitive in the face of competition from the Middle East in gas-intensive industries like petrochemicals. But this approach has failed to encourage development and delivery of sufficient quantities of natural gas to meet demand, and authorities are allowing domestic prices to increase.

Reported prices of electricity—the form in which China's industry increasingly receives its energy—are high compared with those in developing and some developed countries (figure 7.4). However, based on our conversations with Chinese business leaders and industry analysts, 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, which answer to local officials. While the NDRC would like to see energy pricing rationalized to reduce overall energy consumption, it is sensitive to local social and economic development concerns. Energy-intensive firms in China typically consume more energy per unit of output than their peers

in the OECD (on average, 20 to 40 percent more, according to some estimates¹⁸) and are thus sensitive to electricity price increases (as well as gas and coke prices, which may be low).

The recent surge in global commodity prices and inflation has challenged Beijing's commitment to price reform. Gasoline and diesel prices, which are also directly controlled by the state, were increased by 10 and 7 percent, respectively, during 2007. In the six months following a price increase in October 2007, crude oil costs rose 33 percent, leaving Chinese gasoline and diesel prices 20 and 40 percent below US levels on average at the end April 2008.¹⁹ Coal prices also increased significantly in 2007 and during the first quarter of 2008, yet Beijing has been reluctant to increase electricity prices. As with natural gas, price controls restrict supply rather than boost demand. Loss-making oil refineries cut back production, causing filling stations to ration. In the first two months of 2008, some power generators were unwilling to buy coal at higher prices, leading to a draw-down in inventories, which contributed to the blackouts during the Chinese Spring Festival. By mid-June, these shortages had grown severe enough that the government had little choice but to raise prices, 18 percent for gasoline and diesel and 5 percent for electricity, improving the operating economics of the country's refiners and power plants.²⁰

Energy prices in China have not historically reflected environmental costs. Over 80 percent of the country's electricity is generated from coal. At the end of 2006, less than 15 percent of coal power plants had flue gas desulfurization (FGD) systems (used to remove SO₂ from emissions streams) installed and even fewer had them running.²¹ Operating an FGD system reduces production efficiency by 4 to 8 percent and therefore contributes to higher electricity prices. If all the power plants in China installed and operated FGD systems, average electricity tariffs could rise by 10 to 20 percent.²² 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. 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 strong environmental regulator, like the US Environmental Protection Agency, that balance is skewed toward near-term economic growth, as industry threatens to cut jobs and tax revenue if enforcement of environmental regulations 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 (generally 50-year) leases do 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 cities, however, the government largely handles land transfers. Local officials can take farmland to create industrial parks, compensating farmers only the agricultural value, not the industrial-use value. In other words, local officials can price land well below what a firm would pay elsewhere in the world, and since industrial users will pay taxes while farmers will not, there is a powerful incentive to put land to industrial use. While land use prices are rising in coastal areas, new swaths of heavily discounted farmland are being offered for industrial use in China's interior to lure investment.

In interviews with the authors, directors of energy-intensive firms in China emphasized the land cost advantage. The cost of transforming the land is low, and construction time short. Local governments often contribute generously to groundwork—grading, infrastructure buildout, 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. Construction labor costs are dramatically lower in China than in the OECD countries. An aluminum smelter that would take three or more years to build in the United States at high labor and ground preparation costs can be constructed in China in under a year and at much lower daily cost.²³ (For political and social factors bringing about low land and construction costs in China, see chapters 4 and 5.)

Capital and Consolidation

Beijing does not intend for China's financial system to relentlessly favor heavy industry; nonetheless, the outcome has been just that: too much capital to build energy-guzzling industrial capacity. This outcome is rational from a short-term financial perspective because industrial operating costs are low, excess capacity can be exported without inducing normal exchange rate effects (thanks to the heavily managed exchange rate), and borrowers are mostly state-owned firms to which loan officers bear little career risk lending. Further, foreign firms are willing to join in many projects, contributing technology and creating backward linkages to developed-country markets.

While central authorities lean against approving investments in sectors where they see (national) overcapacity, local authorities encourage additional investments. Beijing has tried to curb lending to steel, aluminum, cement, and other industries in recent years. It has tried to prevent lending to new firms in the automobile sector; force consolidation in steel,

Table 7.3 Industrial profit margins, on an earnings-before-tax basis (percent)

Industry	1998	2002	2006
Heavy industry			
Iron and steel	0.80	4.60	5.20
Nonferrous metals	-0.80	3.20	6.80
Cement and glass	-0.40	3.70	5.30
Paper and pulp	1.80	5.00	5.20
Basic chemicals	1.00	4.00	5.60
Light industry			
Textiles and apparel	0.20	3.10	3.90
Furniture manufacturing	3.70	4.00	4.40
Computers and telecom	4.30	4.80	3.30
Electronic machinery	2.60	5.00	4.70

Note: Calculated as earnings before tax divided by total sales revenue.

Source: CEIC data from ISI Emerging Markets.

coal, and other sectors; and raise borrowing costs for energy-intensive industries in general. But in most cases, especially at the local level, financing of additional capacity continues, and little unauthorized capacity is ever shut down.

Since 1998, profit margins on an earnings-before-tax (EBT) basis²⁴ have recovered from less than 1 percent to between 4 and 7 percent for China's most energy-hungry industries (table 7.3). In 2007 profit 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 calculating return on investment in 12,400 firms across the country supports sectorwide profit data trends.²⁵ Since 2002, iron and steel profits have surpassed those in most light industries.²⁶

Some debate whether China's firms are truly profitable. Shan Weijian of TPG, an investment firm, argues that the value of debt-to-equity swaps and bank recapitalization has exceeded the entire pretax profits of the industrial sector since 1999—suggesting zero profitability but for lax bank financing on a gargantuan scale. This theory suggests that the direction China is headed is wrong but that from the borrowers' short-term perspective, does not contradict their instinct to pile into energy-intensive industries. Additionally, if banks are told not to lend or to charge higher rates, many SOEs can self-finance with retained earnings: Enterprise bank deposits—like household deposits—earn minimal interest, so there is little reason not to reinvest. If SOE shareholders—the government—were paid a reasonable share of profits as dividends, these firms' investment criteria

Table 7.4 Global steel industry: Production, market share, and industry concentration, 2006

Country/region	Production (million tons of crude)	Share (percent of global production)	Share of top three firms (percent of domestic production) ^a
China	422	34.60	14.10
EU-25	198	16.30	44.70
Japan	116	9.50	69.30
United States	99	8.10	59.70
Russia	71	5.80	55.10
South Korea	48	4.00	85.80
World	1,219	100	—

a. Share of domestic production from the three largest companies in 2005.

Sources: CEIC data from ISI Emerging Markets; International Iron and Steel Institute, www.worldsteel.org; company annual reports.

might be different, but the dividend policy reforms announced for 2008 are trivial in this regard.²⁷

High profits impede rational resource allocation. The NDRC has promoted steel industry consolidation for years, not only to reduce energy consumption but also to nurture Chinese steel companies with scale to compete worldwide. Yet the number of steel enterprises doubled between 2002 and 2006, as firms saw profit opportunities and joined in. The three largest of China's 7,000 steel companies are now world class but accounted for only 14 percent of Chinese production in 2006. Compare this with Japan, South Korea, and the United States, where the top three companies each control well over half the market (table 7.4). China's steel industry is balkanized, with many provinces promoting their own champions. Local officials often resist attempts to consolidate firms. Conditions are similar 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. Despite government attempts at consolidation, these industries have further fragmented, as rising profits and local encouragement attract more companies (table 7.5).

Were it not for the export safety valve, this pile-on would have created profit-eroding overcapacity. China's metals companies, in particular, have been able to utilize capacity and remain profitable by selling overseas, accounting for much of the growth in China's trade surplus since 2004. 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. China's iron and steel industry was responsible for 18 percent of national energy consumption

Table 7.5 Industry concentration in China (number of firms)

Industry	2002 ^a	2004	2006
Iron and steel	3,551	4,947	6,959
Nonferrous metals	1,332	1,766	2,798
Cement production	4,656	5,042	5,210
Glass and glass products	1,739	2,205	2,982
Paper and pulp	2,606	3,009	3,388
Chemical materials	12,481	15,172	20,083

a. 2002 figures are from a February 2003 survey.

Source: Beijing Kang Kai Information & Consulting data from ISI Emerging Markets.

that year, compared with only 10 percent for all the households in the country combined. Aluminum production, in which China now also runs a trade surplus, consumes nearly as much energy as the commercial sector, and production of chemicals, in which China still runs a trade deficit but a shrinking one, consumes as much as the transportation sector. Taken together, China's heavy industry is responsible today for 54 percent of the country's energy demand, up from 39 percent only five years ago.

The bottom line: Capital allocation is the palliative keeping China's energy-intensive market structure going when it should adjust. The consequences of making ill-considered investments in energy-intensive sectors must be permitted to bite at the firm level.

Local and Global Implications

The consequences of China's investment-led growth are significant both at home and abroad. In addition to the energy security and environmental challenges, the current investment-led, heavy industrial model of development leads to less-than-optimal economic growth and employment both for China and the rest of the world.

Energy Security

The impact of China's investment-led surge in heavy industry is felt first and foremost inside China. Between 2001 and 2006, electricity consumption doubled as new steel mills, aluminum smelters, and chemical industry parks were added to the grid. The power generation industry, still in transition from a government ministry to multiple state-owned enterprises, struggled to keep up with double-digit demand growth. During the late 1990s, Beijing restructured much of the state sector in advance of WTO accession, shutting down old inefficient industrial capacity. As a

result, China found itself with an electricity surplus, and in 1999 policy-makers issued a three-year moratorium on the construction of new power plants.²⁸ When demand started taking off in 2001, provincial officials struggled to win approval to build the generation capacity they would need to supply the new industrial activity taking place in their backyard. And when Beijing turned them down, many provinces went ahead and built the plants anyway, concerned that failure to do so would result in the loss of investment to competing provinces. In total, about 140 gigawatts of unauthorized capacity was built over a three-year period. Yet, this was not enough: Blackouts roiled the country during 2004 and 2005, raising energy security to the top of the political agenda.

China had long considered that its large reserves of coal—currently meeting 69 percent of the country's energy needs—would safeguard its energy security. Yet during 2002–05, China's coal-dominated energy supply system failed to deliver. Fatalities spiked at coal mines working overtime to meet surging demand. Clogged railways were unable to get enough coal to market to supply the newly constructed power plants, and a fragmented electrical grid was unable to get power where and when it was needed. And the surge in heavy industrial activity straining domestic coal and power supplies was forcing China to import more oil.

Between 1980 and 2002, China's oil demand grew by less than 6 percent per year on average. In 2003 and 2004, demand spiked to 9 and 17 percent, respectively.²⁹ While the growing number of passenger cars was responsible for some of this growth, expansion of heavy industry was the principal culprit: Newly constructed chemical industry parks required large amounts of naphtha, a petroleum-derived feedstock; firms increasingly turned to trucking to move products as the country's rail system was bogged down with coal shipments; and when the coal-fired power plants fell short in terms of electricity supply, industry scrambled to buy diesel and fuel oil to run back-up generators. As a result, China's dependence on imported oil grew from 30 percent in 2002 to just under 50 percent by 2006. China accounted for 36 percent of the growth in global oil demand during that period, compared with the United States at 14 percent.³⁰ This took oil markets by surprise and, along with political instability in the Middle East and hurricanes along the Gulf Coast of the United States, helped push oil prices toward historic highs. Most analysts had, in fact, anticipated a decline in Chinese oil demand growth from the rates seen in the 1980s and 1990s.³¹ So when China's call on global oil markets doubled between 2002 and 2006, producers struggled to keep up.

Since the peak of the blackouts in 2004, China has increased its power generation capacity by 70 percent.³² In 2006 and 2007, 200 gigawatts of new capacity was added to the grid, more than the entire installed base of Germany and Italy combined. While this rapid buildout temporarily alleviated electricity shortages and helped bring oil demand growth back in line, China's energy security problems are far from solved. To reduce coal

mine fatalities and improve the efficiency of the coal sector, Beijing now factors coal mine fatalities into the criteria used to assess job performance of local government officials. In advance of the Communist Party Congress in October 2007, where Party members came up for job review, and the National People's Congress in March 2008, several small coal mines were closed, as local officials sought to prevent high-profile mine collapses in their jurisdictions during China's political season. This policy, which was successful from an environmental and workplace safety standpoint, meant that overall coal production growth slowed significantly in 2007. Coming into 2008, large coal companies, aware of reduced domestic supply and a tight international market, pushed for a 15 percent increase in annual contract coal prices. The power generators pushed back, concerned that with inflation headed toward 8 percent, the government would not allow them to pass higher coal costs through to electricity prices. Though the two sides ultimately settled on an 8 percent increase, neither party was eager to start fulfilling the new contracts.³³ Power companies started drawing down coal inventories rather than buying from miners at these prices, hoping that spot prices would fall. Then when severe snowstorms cut off coal delivery routes, inventories ran dry and blackouts ensued.

As long as coal and crude oil prices remain liberalized, and gasoline, diesel, and power prices remain controlled, China will have difficulty ensuring reliable energy supply to its citizens. This difficulty is compounded by the fact that demand growth continues to be industry-led, and thus volatile, oscillating with the boom and bust of investment cycles. In addition to making it difficult to plan domestic supply, volatile growth and controlled prices increase China's impact on international energy markets.³⁴

Environmental Protection

Given limited supplies of natural gas and challenges in ramping up nuclear or renewable sources of energy, 80 percent of electricity in China comes from coal-fired power plants.³⁵ These power plants are the country's leading source of air pollutants including sulfur dioxide (SO₂) and particulate matter (PM). Annual SO₂ emissions have increased 30 percent since 2002 and are now nearly twice that of the United States.³⁶ While a steady increase in the average height of smokestacks at power plants and industrial facilities has reduced ambient air pollution levels from their historic highs in the 1980s, those improvements have slowed, and in many cases reversed, since 2003. China's State Environmental Protection Agency (SEPA) estimates that SO₂ pollution now costs the country \$60 billion per year in economic impacts on public health and agricultural production.³⁷ Concentrations of particulate matter (PM₁₀), which is tied to respiratory illness, are some of the highest in the world.³⁸ Only 1 percent of China's urban population lives in cities meeting SEPA's preferred PM₁₀ stan-

ard.³⁹ In Beijing, PM10 levels are four times higher than in Los Angeles and six times higher than in New York. The World Bank estimates that all outdoor air pollutants combined account for between 350,000 and 400,000 premature deaths each year in China.⁴⁰

China's investment-led industrial growth has also taken its toll on the country's water resources. Around urban areas, 90 percent of riverways are polluted, depriving millions of fresh, safe drinking water. Heavy metals and toxic organic chemicals from industrial wastewater are of greatest concern, increasing the risk of cancer, bone deformity, neurological disease, and complications during pregnancy. The World Bank estimates that air and water pollution, taken together, reduce overall Chinese economic output by 6 percent.

The environmental implications of China's booming heavy industry transcend borders. China's potential impact on international waterways was brought home when a CNPC petrochemical plant exploded in November 2005, sending a 100-ton benzene slick down the Songhua River through populated areas of China and into Russia. 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.⁴¹ And SO₂ emissions blowing eastward from China are a growing source of political tension with Korea and Japan.

The most global impact of China's energy use, and possibly the most significant in absolute terms, comes from carbon dioxide (CO₂). In 2007 China surpassed the United States to become the world's largest emitter of CO₂ on an annual basis (though still lagging considerably if measured in cumulative or per capita terms).⁴² Industry in China is responsible for 68 percent of all emissions, compared with the United States, where energy used by consumers accounts for the majority of emissions.⁴³ If the current investment-led, heavy industrial model of economic development continues, the IEA estimates that China will account for 42 percent of the growth in CO₂ emissions worldwide between now and 2030.⁴⁴

Employment, Income, and Growth

Overinvestment in heavy industry—which is generally capital not labor intensive—instead of light industry and services reduces job creation and the flow of salary income to consumers. Investment-led growth has also depressed the flow of interest income to households that would otherwise have increased their disposable income and thus promoted consumption (see chapter 6). As discussed earlier, low costs—one of which has been low-interest income to lenders relative to the profits enjoyed by borrowers—

have abetted the investment boom in heavy industry. Investment-led growth is also responsible for the environmental and pollution-related health costs of reckless industrial processes. The Chinese people increasingly have to bear these health costs on their own as medical care is underfunded in China. These costs are threatening household savings throughout the country, necessitating precautionary saving and hence depressing consumption.

The World Bank, working with Chinese government economists, has modeled the employment and household wealth effects associated with mollycoddling heavy industry. Balanced growth among sectors would increase employment growth by five times through 2025, increase incomes for those jobs thanks to 20 to 30 percent growth in productivity, aid more rapid urbanization and hence reduce rural-urban income inequality, and dramatically reduce negative environmental and health externalities due to reduced weight for dirty industries in the economy relative to less noxious services.⁴⁵

Most importantly, these employment and rebalancing gains are *not* a trade-off between environmental protection and economic growth: Overall GDP growth is comparable in the business-as-usual and improved scenarios. The economic activity entailed in shifting from heavy industry to a less energy-intensive future makes just as great, if not greater, a contribution to GDP growth. A more benign energy future is not a luxury or otherwise incompatible with official pronouncements that China must deal with achieving “moderate prosperity” first before turning to sustainable development: More sustainable development is in fact the quicker route to moderate prosperity.

International Commercial Impacts

Just as China’s post-2001 investment-led growth has had welfare consequences for households and other economic sectors at home, it has had commercial consequences abroad. If the 2002 pattern of industrial self-reliance versus reliance on heavy industrial imports had remained constant, by 2007 China’s net imports would have grown by an additional 92 million tons of steel—the entire present steel output of the United States, employing 250,000 and creating \$37 billion in economic activity.⁴⁶ Using this constant market share approach, China, on net, would have imported 2.2 million tons more of aluminum, 43 million tons more cement, and 8.7 million tons more paper. Taken together, domestic production substituted about \$110 billion worth of heavy industrial imports (the four above plus some energy-intensive chemicals) in 2007.⁴⁷ The value added in this trade is, of course, a fraction of that total, and the corresponding export shares would be dispersed among many nations. If China had eschewed investment in these heavy industries, then it quite possibly would have in-

vested in and amassed additional surplus in other light industries or even services. So it would be misleading to score 100 percent of forestalled trade as a welfare loss for the rest of the world. There may even be positive externalities for OECD nations where heavy-industry opportunities were impaired: Steel-consuming, higher value-added industries in these countries got cheaper intermediate inputs for their finished goods, while energy intensity was likely lowered and pollution reduced.

While it is a daunting and subjective challenge to compute the external impacts of China's penchant for heavy industry, it is important to recognize that they exist: China does not necessarily do the world a favor by overproducing. Moreover, there are other, dynamic welfare effects to be considered. A rebalanced China, better aligned with its natural endowment of labor, would be a bigger economy, grow faster, and be less prone to collapse and hence be a *better* engine of world growth. Also, heavy industry in China is less likely to attract innovation and hence technological change due to weaknesses in intellectual property protection and the difficulty of recovering R&D investments.⁴⁸ Similarly, institutional weaknesses in regulation and enforcement of pollution controls undermine the process of finding innovative ways to remedy environmental damage.

The Domestic Response

China's top leadership is becoming increasingly aware of the consequences of the current investment-led, heavy industry-dominated pattern of growth and expressing a desire to change course. In his address to the 17th Communist Party Congress in October 2007, President Hu Jintao pointed to the shortcomings of China's development model that "economic growth is realized at an excessively high cost of resources and the environment" and encouraged the formation of an "energy and resource-efficient and environment-friendly structure of industries."⁴⁹ Beijing has ambitions to reduce the energy intensity of growth in the years ahead. As part of the current 11th Five-Year Program 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).⁵⁰ To improve the odds of success, the 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.⁵¹ Local governments have signed or are developing similar plans with an additional 100,000 smaller energy-intensive firms.⁵² The NDRC

also raised electricity prices for energy-intensive industry and stepped up efforts to ensure provincial enforcement.⁵³

Power generation efficiency is also improving, thanks in part to a concerted effort by the NDRC to close small power plants. In 2007, 553 small inefficient plants, accounting for 14.4 gigawatts of capacity, were closed. Replacing this capacity with more efficient plants helped reduce the average amount of coal required for each kilowatt hour nationwide by 3 percent. This shaved overall coal consumption by 30 million tons and resulted in overall annual energy demand growth of 7.8 percent in 2007 rather than 8.6 percent.⁵⁴ Closing the remaining 100 gigawatts of small-scale power generation at this rate would reduce the energy intensity of economic growth by 0.75 percent each year through 2012.

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 SO₂ emissions from power plants. The SO₂ pollution levy enacted in the late 1970s was too cheap, too narrow, and too weakly enforced to discourage power plants from polluting.⁵⁵ Recently, the sulfur levy was increased and, importantly, coupled with a market-based incentive: If plants install FGD systems, they can add the cost of installation and operation to the price they charge the grid companies for power. While absolute SO₂ emissions increased in 2006, the majority of new power plants had sulfur scrubbers installed.⁵⁶ As those sulfur scrubbers came online, SO₂ emissions declined by 4.7 percent in 2007.⁵⁷ In addition, SEPA is increasingly cracking down on polluting industries by denying permits: In 2006 110 projects were rejected on environmental grounds compared with only two during the entire preceding decade.⁵⁸

These measures are yielding some positive results. Energy intensity declined by 1.8 percent in 2006 and 3.8 percent in 2007.⁵⁹ While this falls just short of the 4 percent per year needed to meet the 20 percent goal, policies put in place fairly recently are likely to show more progress in the years ahead. That said, improved energy efficiency and enforcement of environmental regulations alone will be insufficient to fundamentally change China's energy future. Even if Beijing is successful in meeting its 20 percent goal by 2010, overall energy demand will have increased by more than 40 percent since 2005, if economic growth continues at current rates. And much of the low-hanging fruit, in terms of efficiency improvements, has already been picked. To move China off its current trajectory, smarter energy and environmental policy will need to be coupled with a rebalancing of the economy as a whole.

Relationship to Overall Macro Rebalancing

In chapter 6 Nicholas Lardy centers the rebalancing imperative on raising consumption relative to investment and exports in national expenditures.

He highlights fiscal policies, financial system reforms, exchange rate system reforms, and increased energy prices as the four levers with which to propel consumption-led growth. For Jianwu He and Louis Kuijs, rebalancing also means raising consumption relative to investment and net exports.⁶⁰ They offer a longer laundry list of prescriptions for rebalancing, including the three components of Lardy's analysis plus more policy incentives (prices and taxes), labor and factor mobility reforms, center-local reforms, and more aggressive sector-specific industrial policies. Central authorities in China would disagree little with most of this; they do, as US Treasury Secretary Henry Paulson, Jr. often notes, have a difference of opinion on timing.

Unfortunately, there is little indication that Beijing has taken the steps necessary at the macro level to rebalance development. Money supply (M2) and bank lending have accelerated since 2005, despite administrative tightening on lending in late 2007 and a gradual rise in nominal interest rates since 2005. Dividend payment requirements for central SOEs were announced in 2007 for implementation in 2008 (on a trial basis in 2007) but at a very low rate. Fiscal reforms have not offset household anxieties that reduce consumption, and financial reforms are far from correcting the unfair division of investment income between borrowers and lenders. Appreciation of the renminbi against the US dollar remains modest in real terms, while the currency has moved even less against the real basket of currencies against which it trades. The simple bottom-line: As of end-2007, investment remains above 42 percent of GDP and growth in heavy industry continues to outpace that in light industry and services.

Attempts to change the economics of key energy-intensive industries may be having more success in reining in output growth. Policymakers have tried to restrict lending to the most energy-intensive sectors⁶¹ and reduce incentives for these firms to export by cutting the value added tax rebate for many types of steel, aluminum, cement, and chemicals, effectively raising their price on international markets by 2 to 12 percent.⁶² Energy and environmental compliance costs continue to rise for Chinese producers, and land use policies have made it more difficult for local officials to lure industry with land giveaways. In addition, changes in global steel, aluminum, and chemicals industries are putting competitive pressure on Chinese firms. In steel and aluminum, rising shipping costs have put China at a disadvantage vis-à-vis producers closer to ore reserves and Western markets. And with high crude prices and limited availability of natural gas, new capacity in the Middle East is challenging China's chemicals industry. In 2007, output from these industries continued to grow, but for steel, cement, and basic chemicals, the rate of growth declined from 2006, helping move China closer to its goal of reducing energy intensity by 20 percent by 2010.⁶³

Rising resource costs, lending controls, and border adjustments alone, however, are unlikely to correct China's systemic bias toward heavy in-

dustry unless coupled with structural and institutional reforms. While physical output growth in energy-intensive industries slowed in 2007, higher prices and movement up the value chain meant their share of overall economic activity expanded. And while rising costs and stiff international competition are starting to put pressure on profit margins, investment in these industries has yet to slow relative to the economy as a whole. Improved efficiency and movement up the value chain have reduced the energy intensity of China's economic growth from its 2004–05 high, but for Beijing to quadruple economic growth by 2020 while only doubling energy demand, that growth will need to be rebalanced.

The Energy Footprint of a Rebalanced Chinese Economy

If Beijing pursued an inclusive rebalancing policy package, would the energy outcomes be positive? Yes, they would. A shift toward light manufacturing and services could unfold as quickly as the shift toward heavy industry eventuated in 2001–02. This is a critical point. As industry overwhelmingly drives China's energy demand, it is tied to investment cycles, which are volatile. In 2007, responding to the current investment-led heavy industry surge, the IEA raised its forecast for Chinese energy demand in 2030 by 79 percent from what it had forecast in 2002. Projections of China's energy future based on the current economic structure face similar risks, but in the other direction (i.e., less energy demand than expected).

One dollar of economic output from the apparel or electronics industry, as well as most service-sector activities, requires less than one-tenth the energy required to produce output of the same value from the steel or cement industries.⁶⁴ If services and light manufacturing were to significantly outgrow heavy industry in the years ahead, China's energy future would look much different than the alarming picture painted by today's forecasts. In the World Bank's rebalancing scenario mentioned earlier, not only does economic growth stay the same but also energy demand in 2030 declines by 25 percent from the business-as-usual projection, roughly equivalent to what the IEA sees China reaching in 2015—all this while increasing employment and returns to household savings.

That said, a Chinese economy rebalanced away from investment and net exports toward consumption will bring energy challenges of its own. Many Chinese households are today earning enough to afford energy-intensive consumer goods like air conditioners and automobiles. An emerging consumption-oriented middle class is more likely to work in an office than in a factory and can easily satisfy its food and shelter needs and have money left over to spend on consumer goods and services. If making the steel and glass to build office buildings and shopping malls drives China's energy demand today, lighting, heating, and cooling those malls and offices will drive China's energy demand in a consumption-led

future. Likewise, the energy needed to make the cement and asphalt used to construct highways will be replaced by the energy needed to fuel the cars that will ply those highways.⁶⁵

Dealing with the consequences of the energy demand of a rising middle class is, in many ways, easier than managing the consequences of today's investment-led energy demand. Consumption-led energy demand grows in a relatively steady, predictable manner compared with the volatile nature of investment-led demand. That means more reliable energy delivery inside China and less uncertainty in international energy markets. Also, as income (and thus purchasing power) grows, consumers are generally more willing and able to pay for cleaner energy supplies. While energy-intensive industry, in China as in most countries, fights environmental regulation out of fear of profit loss and decreased competitiveness, energy-intensive consumers also tend to be the same middle-class citizens pressuring government to clean up the air they breathe and the water they drink. Thus a consumption-led energy trajectory is more likely to unfold sustainable growth, from both energy security and environmental standpoints. Importantly, however, as we touch upon briefly in the following section, shrinking China's domestic energy footprint does not necessarily reduce the net global energy tab, since some other country will be making for export to China the same investment-heavy products that China rebalanced away from making for itself.

Conclusions and Policy Agenda

China's leaders are now aware that broad rebalancing must be part of dealing with energy and environmental challenges, but policies to do so have been slow to materialize. In addition, the macro rebalancing package, while necessary to address China's energy challenges at home, will not be sufficient when it comes to international energy security and global climate change. Outside China, unease over these issues is adding to already considerable anxiety about China's rise. In Washington, concern over these issues has centered on China's failed bid for Unocal; Chinese oil investment in Sudan, Iran, and Venezuela; and its contribution to climate change. Opinions and legislation on the US response to China's energy footprint are evolving rapidly.

The context should be kept in mind while contemplating ways to address this issue: China is an 800-pound gorilla on the world energy stage and cannot be ignored; but there is a 1,600-pound gorilla here too—the United States. Instead of defending that fact, US policymakers might see it as an opportunity. The scope of action needed from China seems impossibly ambitious as a unilateral matter, especially since China feels entitled to follow an industrial path that many OECD nations have taken. Acknowledging the need for it to improve the sustainability of its own en-

ergy profile may be by far the most powerful lever the United States has for impelling change elsewhere: There is an opportunity for a bargain in energy and the environment that gives policymakers in both China and the United States political cover for painful choices. And the world's two largest energy consumers and polluters will need to make numerous painful choices together in the decades ahead. Recognizing this, the two countries in June of 2008 launched a 10-year framework agreement for cooperation on energy and environmental issues.

Energy Security and the Role of Volatility

The energy security problem with China's investment-led energy demand is not so much the sheer volume of fuel the country needs—the world can deliver that supply if it has the time and confidence about demand—but the uncertainty and volatility it creates in international energy markets. Annual oil demand growth that jumps from 2 to 17 percent, accounting for anywhere between one-fifth and one-half of growth in global oil consumption in a given year, has contributed to the crude price premium as producers struggle to forecast future demand. China has also recently become a net importer of both coal and natural gas. Greater transparency and cooperation between China and other large energy-consuming countries on stockpile and inventory levels, ensuring sea lane safety, demand management, and development of alternative sources of energy would go a long way toward reducing price volatility and supply uncertainty, both for China and the rest of the world.

Yet as existing multilateral institutions work to facilitate such cooperation, China is missing from the table. The IEA counts only 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 collective, the Organization of Petroleum Exporting Countries (OPEC). 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. The United States has recently indicated it is interested in including China in the IEA, but it is unclear in what capacity and under what terms this participation would take place.⁶⁶

Both the IEA and OPEC should also pay careful attention to the energy implications of China's macro rebalancing, if it were to occur. While moving from investment- and export-led growth to consumption-led growth would reduce China's domestic energy demand, it would likely increase energy demand elsewhere, as non-Chinese producers gain market share in industries like steel, cement, aluminum, and chemicals. To the extent

that this readjustment rationalizes the energy footprint of global supply chains (i.e., moving energy-intensive industry closer to resource bases and to countries with more efficient production processes), global energy demand trend growth may be reduced. But the adjustment itself will likely create market volatility, and in some models a rebalanced China urbanizes faster, which raises questions about the net demand for energy-intensive goods in the medium term and beyond. Increased awareness and understanding of the linkage between macroeconomic trends and energy outcomes will help reduce market uncertainty.

Climate Change

The United States and China are both rich in coal and look to it to satisfy the majority of their electricity needs. China is building its power generation base from scratch and the United States is preparing to replace a generation of aging stock. In both countries, CO₂ is vented into the air from all the existing coal-fired plants and will be vented from all the plants currently on the drawing board.⁶⁷ Carbon capture and sequestration (CCS), which would mitigate CO₂ emissions from these plants, is a viable technology that still needs significant R&D before it can be widely commercialized. A recent MIT study on the future of coal pitches for several integrated projects to demonstrate the feasibility of CCS in a variety of countries and geological settings.⁶⁸ We believe this should be a priority area of cooperation between the United States and China. Industrial energy efficiency, biofuels, green buildings, and nuclear power are also important areas for collaboration.

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. The existing approach, as embodied in the Kyoto Protocol, is inadequate to address energy use in China and the rest of the developing world. While the vast majority of the CO₂ added to the atmosphere over the last century came from the West (and the United States in particular), most of the CO₂ emitted over the next century will come from the East (China in particular). Yet even in 2030, China will still be a relatively poor country, with per capita CO₂ emissions less than half those from the United States. As such China refuses to accept absolute limits on emissions, afraid that it will impede economic growth. That said, Beijing says it is willing to go beyond what was required under the Kyoto Protocol and commit to “nationally appropriate mitigation actions” under a post-Kyoto framework.⁶⁹ This willingness bodes well for global climate negotiations, not least because it removes the key obstacle to active US involvement. Washington has argued for over a decade that action by the developed world will be ineffective from a climate standpoint unless large developing countries like India and

China follow suit and harmful from an economic standpoint as energy-intensive industry in the developed world migrates to countries without similar costs on carbon emissions.

The nature of China's energy challenges informs the prognosis for a multilateral climate framework in which both China and the United States take part in three ways.

First, there is considerable scope for China to commit to emissions reductions, which would be positive for the country's economic growth. As 68 percent of the Chinese CO₂ comes from industry, rebalancing the economy away from heavy industry toward light manufacturing and services would maintain headline GDP growth at current levels while significantly reducing emissions.

Second, such rebalancing would allay industrial competitiveness concerns in the United States and other developed nations and increase the likelihood that they take action appropriate for their income level and historic emissions. While US climate leadership should not be conditioned on Chinese action, concerns that US national climate policy would result in an industrial exodus to China could translate into protectionist provisions or derail policy progress in Washington altogether. An agreement between the United States and China that both countries impose similar carbon costs on industry would enable bolder US domestic legislation and international negotiating positions.⁷⁰

Finally, in considering the type of climate commitments China should be asked to make, it is important to remember that China's carbon future remains highly uncertain. A shift in the growth structure of the Chinese economy between 2002 and 2007 resulted in an upward revision of 70 percent in the IEA's 2030 forecast for China's CO₂ emissions, a change larger than *total* projected European emissions for that year. Successful rebalancing of economic growth, perhaps aided by new climate policy, could result in a similar large downward revision in expectations for future Chinese emissions. The difficulty in establishing a credible emissions baseline means that negotiating absolute caps on Chinese emissions, while politically challenging, is not advisable. It also means that any agreement on climate change needs to ensure that if China rebalances growth and its heavy industry migrates abroad, that shift in production reduces that industry's carbon footprint globally. Otherwise, from a climate standpoint, rebalancing the Chinese economy will just move China's emissions to other countries.

Notes

1. "The Politics of China's Oil Weapon," *Foreign Policy*, no. 20 (Autumn, 1975).
2. BP plc., *Statistical Review of World Energy 2007*; National Bureau of Statistics of China, *China Statistical Yearbook*; General Customs Administration, *China Customs Statistics*. The latter two, as well as all other Chinese statistics used in this chapter

(unless otherwise indicated) have been collected via CEIC, a commercial statistical database provided by ISI Emerging Markets. Henceforth, all figures accessed in this manner will be referenced as “CEIC” followed by the source publication or government agency.

3. International Energy Agency (IEA), *World Energy Outlook 2007* (Paris: Organization for Economic Cooperation and Development). This refers to annual emissions rather than cumulative emissions, in which the United States still leads.

4. This chapter draws heavily from Daniel Rosen and Trevor Houser, *China's Energy Evolution: The Consequences of Powering Growth at Home and Abroad* (Washington: Peterson Institute for International Economics, forthcoming).

5. CEIC data from National Bureau of Statistics of China, *China Statistical Yearbook*.

6. 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, NJ: 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: Cambridge University Press, 1995); Susan L. Shirk, *The Political Logic of Economic Reform in China*, California Series on Social Choice and Political Economy, no. 24 (Berkeley: University of California Press, 1993); Barry Naughton, *The Chinese Economy: Transitions and Growth* (Cambridge, MA: 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: Brookings Institution Press, 2002); Nicholas R. Lardy, *China's Unfinished Economic Revolution* (Washington: Brookings Institution, 1998); Kenneth Lieberthal, *Governing China: From Revolution through Reform*, 2d ed. (New York: W. W. Norton, 2004).

7. 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). See in particular the forthcoming study by Lin Jiang of the Lawrence Berkeley National Laboratory on energy intensity in China, 1996–2003.

8. Daniel Rosen, “China and the World Trade Organization: An Economic Balance Sheet,” Policy Briefs in International Economics 99-6 (Washington: Institute for International Economics, June 1999), www.petersoninstitute.org (accessed June 10, 2008).

9. Zhou Dadi and Mark D. Levine, “China's Sustainable Energy Future: Scenarios of Energy and Carbon Emissions” (Energy Research Institute and Lawrence Berkeley National Laboratory, 2003).

10. CEIC data from *China Statistical Yearbook*.

11. Between 1997 and 1998, energy demand in China fell in absolute terms while GDP grew at 7.8 percent, resulting in a particularly sharp decline in energy intensity. Thomas Rawski and others have argued that this is evidence that China over-reported economic growth during those years; Thomas G. Rawski, "What is Happening to China's GDP Statistics?" *China Economic Review*, no. 12 (2001). Jonathan E. Sinton and David G. Fridley examine the sources of the decline in energy demand and isolate it to a fall in direct coal use in a handful of energy-intensive sectors, resulting from industry consolidation, increased efficiency, and a dramatic improvement in the quality of coal (Jonathan E. Sinton and David G. Fridley, "What Goes Up: Recent Trends in China's Energy Consumption," *Energy Policy*, March 2000). Even if the years 1997–2000 were an anomaly (either on the GDP or energy demand side of the equation), the underlying story remains the same. Energy demand grew at an average annual rate of 5 percent between 1978 and 1996 and 11 percent between 2001 and 2007 (a change in energy demand elasticity from 0.51 to 1.03).

12. IEA, *World Energy Outlook 2007* and *World Energy Outlook 2002* (Paris: Organization for Economic Cooperation and Development).

13. CEIC from *China Energy Statistical Yearbook*. This figure on residential use, as those used throughout this chapter, 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.

14. Nicholas R. Lardy, "China: Towards a Consumption Driven Growth Path," Policy Briefs in International Economics 06-6 (Washington: Peterson Institute for International Economics, 2006).

15. Michael Taylor, "Energy Efficiency and CO₂ Reduction Opportunities in the Global Cement Industry" (paper presented at the IEA-WBCSD Cement Industry Workshop, Paris, September 4, 2006); Pilkington, "Flat Glass Industry—Summary," www.pilkington.com; International Iron and Steel Institute (IISI), www.worldsteel.org; Abare Economics, www.abareconomics.com; CEIC from *China Statistical Yearbook*.

16. In his recent textbook, *The Chinese Economy*, Barry Naughton argues (p. 347): "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." Andrew 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 (Andrew Wedeman, *From Mao to Market: Rent Seeking, Local Protectionism, and Marketization in China*, Cambridge, UK: Cambridge University Press, 2003). 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, MA: Harvard University Press, 2005).

17. CEIC from *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?" World Bank Policy Note (Washington: World Bank, 2005); Weijian Shan, "The World Bank's China Delusions," *Far East Economic Review* 166, no. 29 (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); David Dollar and Shang-Jin Wei, "Das (Wasted) Kapital: Firm Ownership and Investment Efficiency in China," IMF Working Paper 07/9 (Washington: International Monetary Fund, 2007).

18. Jiankun He, "Achieving the 2010 20-Percent Energy Intensity Target through Industrial Technology Advancement" (paper presented at the Senior Policy Advisory Council Meeting & Forum on Implementing China's 2010 20-Percent Energy Intensity Reduction Target, Hainan, China, November 2006); Yanjia Wan, "China's Energy Efficiency Policy in Industry" (paper presented at the "Working Together to Respond to Climate Change" Annex I Expert Group Seminar in Conjunction with the OECD Global Forum on Sustainable Development, Paris, March 27–28, 2006).

19. CEIC from NDRC Price Monitoring Center and US Department of Energy, Energy Information Administration.

20. Xinhua News Agency, "China to Raise Prices of Refined Oil, Electricity," June 19, 2008, <http://news.xinhuanet.com>.

21. Estimates for the amount of power generation capacity with FGD installed range from 60 to 90 gigawatts out of a total base of 622 gigawatts.

22. 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.

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

24. Calculated as earnings before tax divided by total sales revenue.

25. Dollar and Wei, "Das (Wasted) Kapital."

26. Ibid.

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