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Hot Air and Cold Water
The Unexpected Fall in China's Energy Use[1]

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Between 1996 and 1999, China's energy output dropped by 17 percent, while primary energy use declined by 12 percent, mainly due to falling coal use. Since China is the world's second-largest emitter of greenhouse gases, it is important to understand the sources of this apparent transformation, including intentional and unintentional policy impacts, and whether it portends a permanent change in patterns of energy use. This remarkable reversal of the long-term expansion of energy use has occurred even as the economy has continued to grow, albeit more slowly than in the early 1990s. Policies instituted under the umbrella of economic system reform, along with energy-supply, energy-efficiency, and environmental-protection policies, have apparently led to at least a temporary decline in, and perhaps a long-term reduction in the growth of energy use, and therefore greenhouse gas emissions. The rate of growth in energy use in the coming decades will depend crucially on what steps China takes over the next few years to formulate policy and build institutions in the areas of energy supply and energy efficiency.

POSSIBLE EXPLANATIONS FOR THE DROP IN ENERGY CONSUMPTION

Until recently, even the most optimistic of China's experts and planners anticipated that the country would experience uninterrupted growth in energy use. Contrary to all earlier expectations, however, China's output and consumption of energy went into decline in 1997, driven by a fall in China's most important fuel, coal. Total primary energy use in 1999 was about 36 EJ, 12 percent below the 1996 peak, while coal use was 21 percent below the peak.[2] Meanwhile, consumption of electricity, oil, and especially gas has continued to grow. The decline in primary energy use has occurred despite robust, though slowing, GDP growth of nearly 8 percent between 1996 and 1999.

These sharply divergent trends in energy and economic growth are puzzling, and a number of explanations could be made. For example, one class of explanations deals with intentional efforts to curb energy use, e.g., programs to promote energy efficiency and to prevent pollution. Another class gives prominence to side effects of intentional policies adopted for reasons unrelated to energy, such as economic system reforms. Yet another class views the decline as related to uncontrollable or unanticipated factors, such as the Asian economic crisis in the late 1990s. Below are some potential explanations sorted according to this scheme.

Intentional Policy Impacts

1. The ongoing and evolving program of energy-efficiency policies and state-supported energy-efficiency investments have reduced energy intensity in all sectors.
2. Reforms in the coal sector that have led to the shutdown of many small mines have reduced "oversupply".
3. Policies in the power sector to eliminate small generators have reduced net growth in electricity generation and slowed growth in coal use even more by getting rid of inefficient units.
4. Residential use of coal is falling as urban dwellers are encouraged to switch to gas and electricity for cooking and water heating, and as more people move into apartments with central heating.

Unintentional Policy Impacts

5. Bankruptcies and mergers resulting from the on-going program of economic system reforms have shut down many state-owned factories that were large, inefficient consumers of energy, favoring development of more energy-efficient enterprises.
6. Economic system reforms that fostered the development of the non-state sector have created a new class of enterprises that have become more energy-efficient in response to strong competitive pressures.
7. The recent buyers market for coal has allowed consumers to switch to higher quality coal, leading to greater end-use efficiency and lower total demand.
8. Changes in the structure of China's economy, away from energy-intensive heavy industries and towards less energy-intensive, high-technology industries and services, are reducing energy demand.
9. Stricter implementation of environmental regulations forced highly polluting and generally more inefficient plants to shut down or, in the course of cleaning up, to become more energy-efficient.

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[2] Note that, since coal dominates China's commercial energy mix, Chinese energy statistics are typically reported in terms of metric tons of standard coal equivalent (tce). One tce equals 29.31 GJ. One EJ equals 0.9478 Quads (quadrillion Btu).

10. Relatively higher prices for electricity have stimulated energy conservation, leading to substantially lower demand.

Uncontrolled Factors

11. A slowdown in heavy industry in response to slowing economic growth—due to the impact of economic system reforms and the Asian economic crisis—has caused demand from the largest users to drop.
12. Slower economic growth has reduced electricity demand, cutting growth in demand for coal from the utility sector, which is now the largest consumer of coal.
13. Normal turnover of capital equipment has improved the average energy efficiency of industrial processes, reducing demand for fuels.
14. Reductions in energy use are overstated; energy consumption is significantly greater than production as China's enormous stockpiles of coal are used, and recent energy and economic statistics are inaccurate.

As we explain in this paper, we feel that the most important contributors to the dropping energy consumption and production have been 1) economic system reforms, which, for instance, have allowed many unproductive facilities to close down and thus let some of the "hot air" out of the system, and 2) the slowdown in economic growth, which has thrown cold water on the overheated expansion of energy-intensive sectors. We believe that some of the other factors mentioned above have been significant as well, and, perhaps more importantly, have prepared the way for China to continue growing in a less energy-intensive manner.

Understanding the forces behind the decline in energy production and consumption has immediate and apparent implications for forecasting China's energy demand, setting policy priorities, and assessing China's role in a possible future international regime of greenhouse gas reduction activities. Questions about the environmental sustainability of China's continued economic growth are inextricably linked to the country's coal-based energy system (McElroy, *et al*., 1998). Above, we have already summarized some potential explanations for the drop in China's energy use. In the next sections we lay out in more detail the phenomena requiring explanation, i.e., trends in energy supply and demand in China over the past several years. After analyzing the influence of economic, energy, and environmental policy, we evaluate the relative importance of the potential explanations presented above, and then conclude with some remarks on the outlook for China's energy system and policy recommendations.

ENERGY TRENDS

In this section we detail the changing patterns of energy supply and use in China, and briefly discuss possible developments in the near future. China's overall energy output and use have fallen drastically in the past several years. Energy *production* in 1999 was more than 17 percent below the 1996 peak (Figure 1). Natural gas and hydropower output have grown and oil production has been constant, while coal production and nuclear power generation have both dropped. Estimated energy production in 2000 is slightly below 1999 levels. Primary energy *consumption* basically mirrors that of energy production. Consumption peaked in 1996 and fell 12 percent by 1999. Preliminary indications are that energy use in 2000 will be close to that in 1999; while coal use continued to fall, electricity use grew by over 10 percent, and gas and oil use rose by about 7 percent. Consumption has been higher than production in recent years due to rising imports of oil and changes in coal stockpiles.[3] Supply and consumption of the various energy forms are treated in turn below.

Coal

The heart of this story is the country's single largest fuel source—coal. From a peak of nearly 1,400 million metric tons (Mt) in 1996, China's coal production slid to 1,045 Mt in 1999, and fell further in 2000 to about 870 Mt, if official plans to suppress production were fulfilled (NBS, 2000; Nengyuan, 2000).[4] This would be the country's lowest coal output since 1986. Coal's share of total primary energy output would fall to about 63 percent, the lowest level since the founding of the People's Republic of China.

On the supply side, the reasons for this phenomenon are straightforward. A strong, centrally mandated campaign to improve the profitability of big state-owned mines and to close small mines has helped to push down output. In the mid-1990s, the central government began to require that large state-owned mines limit output. In 1998,

[3] Inadequacies in statistics on energy supply and consumption may also play a part. For instance, oil supply and consumption figures may be understated, since oil products (mainly diesel) that are smuggled into the country are not reflected in import statistics. Similarly, some of the thousands of coal mines that have been closed since 1998 have quietly reopened. While their output remains unreported, consumption of some of their product may be counted.

[4] Actual output may have been somewhat higher, about 950 Mt (People's Daily, 2000).

the government began the current campaign to shut down coal mines, and by May 2000, over 33,000 mines with combined annual production capacity of 300 Mt had been closed, with another 18,900 slated for closure by the end of 2000 (China Online, 2000a). The government also aimed to reduce coal stockpiles to under 100 Mt by the same deadline, down from 198 Mt at the end of 1998 (China Online, 2000b, Wang, 1999a). China has been exporting substantial amounts of coal and coke, though still less than 5% of total output; in 1999, exports totaled 37 Mt of coal and 10 Mt of coke (Figure 2).

On the demand side, the picture is more complicated. Most evidence points to continued rise in demand for transformation, i.e, to electricity, heat, gas, and coke. Virtually all of the decline has thus been in direct uses of coal, such as boilers for industry and buildings, kilns, and stoves. Apparent direct use of coal dropped from 685 Mt in 1996 to about 420 Mt in 1999, 39 percent below the 1996 level (Sinton and Fridley, 2000). Since industry is by far the largest direct user of coal, the drop in coal use implies a sharp slowdown in industrial output. Physical and economic output figures for industry provide mixed support for this interpretation, since output of many energy-intensive products, like steel and cement, has continued to rise even while that of other products, such as paper, has fallen (Figure 3). On the other hand, press reports indicate widespread shutdowns of old factories.

Another major reason for the decline in coal use is a substantial rise in coal quality (better coal is used more efficiently) due to reduced poorer-quality output from small mines. Quality improvements were driven in part by the transformation of coal markets from a supply-limited system to relatively free buyers' markets. We estimate that the increase in average heat content between 1996 and 1998 lowered coal consumption in the power sector alone by 30 Mt, and by another 30 Mt in other sectors (Sinton and Fridley, 2000).

It seems likely that the fall in coal use has run its course. While gains in end-use efficiency, fuel switching, and changes in economic structure will limit the pace of growth, coal use may begin growing again in the next year or two, as industrial output keeps growing, and as rising power generation continues to rely mainly on coal.

Oil

Throughout the 1990s, oil production stagnated in China as rising output from offshore fields has offset declines in the large eastern oil fields. Demand, however, continues to grow, particularly for transport fuels, leading to rising imports of both crude oil and petroleum products. By 1999, China's gross external dependency for oil had risen to 29 percent (Figure 2; NBS, 2000). The domestic market has become increasingly affected by changes in the international market, leading to severe disruptions in early 1998, when international oil prices collapsed.

Faced with fixed ex-refinery and retail prices up to twice the level of import prices, oil consumers sought alternatives to the high-priced oil. By late spring 1998, smuggling had become so rampant that domestic refineries were forced to cut back on production as their inventories of high-priced oil swelled. The government was forced to move decisively in June 1998, when a new import and pricing regime—linking Chinese domestic prices for the first time to the Singapore market—was announced along with a crackdown on smuggling. Soon after, imports of crude oil, diesel fuel and gasoline were banned or curtailed to provide protection to domestic refiners and to allow draw-down of refinery stocks (SCMP, 1999). Consequently, oil imports dropped in 1998, and apparent oil consumption fell 2.9 percent. Reports suggest, however, that smuggling brought from 8 to 12 Mt—and possibly more—of additional product to market, sustaining an apparent demand growth of 1.3 to 3.3 percent (New York Times, 1999; Reuters, 1999a). Another element of the government's response to the poor performance of the domestic industry was a reduction in crude oil exports and import preference for crude oil in order to raise the utilization rate of domestic refineries. This shift resulted in a sharp increase in domestic product output, obviating the need for most product imports.

The fastest growth in domestic oil demand has been for two products not under strict import controls. Fuel oil demand has risen rapidly in the last few years, particularly from industry and power generators in southern China, and imports now account for about one-quarter of total consumption. LPG demand has been spurred by rising demand in households as they continue to shift away from coal. In 1998, LPG imports jumped 33 percent, and now account for nearly half of domestic consumption (Bloomberg 1999a).

Recently, high international crude prices have led to calls in China to reorient the country's development strategy to emphasize coal. However, while high prices may suppress oil demand to some degree, the prospects for continued strong economic growth in China, particularly in growing oil-hungry sectors like transport and petrochemicals, suggest that net imports will continue to grow. Very little of this growth will come about due to fuel switching away from coal, since new oil demand will come from end uses that require oil and cannot use coal. This highlights the origin of the decline in overall energy use in falling coal demand.

Natural Gas

China's natural gas production has been gradually rising since the mid-1990s, as new fields, particularly offshore, come on line and new pipelines are built. Natural gas still accounts for only about 3 percent of the nation's energy use, however, the same as in 1980, and significant growth requires long-term investments in new resources and infrastructure for imports. Current output is about 25 x 10^9 m^3 (bcm) per year, but China has targeted expansion of combined onshore and offshore output to 30 bcm in 2005 and 50 bcm in 2010 (Fridley, 1999). Output in 2010 is to be supplemented by annual imports of 50 bcm, but this assumes optimistically that an approved 3 Mt (4.2 bcm) LNG terminal in Guangdong and several mooted international pipeline projects go forward. The much-touted $15 billion West-East gas pipeline promises to deliver at least 15 bcm of natural gas to eastern China, but the challenges of planning, designing, financing, operating, and maintaining a pipeline of this scale may exceed China's current capabilities. China has opened the project to foreign investors, but the lack of comprehensive regulations and laws regarding foreign participation in the natural gas sector gives many potential partners pause. The government has made investment in natural gas more attractive by adjusting domestic prices closer to internationally comparable levels. However, gas pricing varies widely from city to city, and in the absence of a national pipeline network, a true market for natural gas does not yet exist.

Potential demand for natural gas in China is likely to be as large as potential supplies, at least in the short term. There is currently very little natural gas-fired power generation in China, but the country could benefit enormously by replacing coal-fired power plants (particularly small ones) with gas turbines. Even greater benefits, in terms of improving human health, are to be had by replacing household coal use with natural gas, a transition that is underway on a major scale in a number of cities, including Xi'an and Beijing. Growth in natural gas use in the next few years will likely be more affected by supply constraints than the level of general economic activity, even if overall energy consumption continues to decline.

Electricity

Power generation has risen faster than any other form of energy, growing at an average of 7.8 percent per year since 1980 to reach 1,230 TWh in 1999 (NBS, 2000). In 1997, coal-fired power plants accounted for 92 percent of power from fossil units, with small oil- and gas-fired units making up the remainder (Zhou, et al., 2000). Generating capacity has risen even faster than generation, reaching 277 GW at the end of 1998, and a projected 320 GW at the end of 2000 (People's Daily, 1999; China Online, 2000c). New power plant projects have slowed, however, and preferential treatment for foreign power developers has been scaled back (SCMP, 1998).

This slowdown comes as capacity has surpassed demand in many areas of China, although this condition has been short-lived in some places. Recent investment has been focused on transmission, in support of building a true national grid and balancing regional supply and demand. Another factor contributing to slower growth in power generation is the closing of small power plants. For years, the central government has prohibited new and closed existing small, inefficient power plants. With growth in demand slowing, and sensitivity to pollution gaining strength, the government has renewed its commitment to shutting small plants down. Improvements in average power generation efficiency from shutting down these plants probably accounts for a small portion of the recent declines in coal demand. On the other hand, much of this potential source of efficiency remains untapped.

In 2000, power demand and output have grew more rapidly than in 1998 and 1999, by 10 percent or more (China Online, 2000c). Along with economic growth, there is a long-term trend in China—as in other developing economies—towards electrification in industry and households, as new end-use applications become widespread (e.g., computers, office equipment, and environmental control equipment) and as electricity substitutes for fuels in cooking and other end-uses. There is also tremendous latent consumer demand for power in China. How China will meet this demand, and what the implications are for fuel consumption, will depend very much on how the country proceeds with restructuring of the utility sector—an area that remains very unclear. If, for instance, China decides to rely on coal to remain self-sufficient in energy, the increase in pollutant emissions will depend on how quickly clean-coal and emissions control technologies are deployed.

Biomass and Other Renewable Energy

Biomass energy remains a significant source of energy for much of China's rural population. Most biomass fuels are used for home cooking and heating and for agriculture, and are not tied to major portions of economic activity. In energy terms, the amount used is approximately equivalent to oil consumption. Unlike oil, however, biomass use has been dropping since the 1980s, as greater supplies of coal and electricity have become available to rural residents, who make up the largest portion of China's population. Between 1991 and 1996 alone, biomass energy use in China's rural areas fell by nearly one fourth, while the ratio of biomass energy use to commercial energy use fell from 0.26 to 0.15. Biogas use has been rising, but it still accounts for less than 1 percent of biomass energy.

Most areas of China have at least one large renewable energy resource. More than most developing countries, China has made significant—and relatively successful—efforts to promote renewable energy use, particularly as an adjunct to the overall programs for rural development and electrification. China expects to have around 20 GW of renewable power generation capacity in 2000 (mainly small hydro; the figure excludes large hydro), or over 7 percent of total installed capacity, compared to just over 15 GW in 1993 (The World Bank, 1996). Adding in electricity from large hydropower projects, direct use of biomass fuels and solar heating of water and buildings, one quarter of China's energy is already supplied by renewable sources (RTCCCCS, 1999).

If recent trends continue, non-biomass renewables will continue to make up a small but significant portion of China's energy mix in the near term. Over the next 20 years, although renewables are unlikely to substitute for coal and other fossil fuels on a large scale, there is hope that they will break out of niche markets and represent a growing share of total energy, so long as there is continued support for the development of renewable energy markets and industries.

Future Directions in Energy Use

The current energy mix and trends will be greatly altered if the Chinese government continues its planned reductions in coal dependence. The Energy Research Institute (ERI), a Chinese think tank, considers a reasonable goal to be a reduction in the country's dependence on coal by 15 to 20 percentage points over the next two decades (Bloomberg, 1999b). By 2020, under this assumption, coal would account for 55 to 60 percent of commercial energy use, compared to 75 percent in the mid-1990s. If total energy use grew at an average of 3 percent per year, China would use 72 EJ of primary energy in 2020, 80 percent more than consumed now. To maintain a 55 to 60 percent share of that total, coal use would need to rise 40 percent to 50 percent over current levels, while consumption of energy sources other than coal would have to triple. If oil is assumed to retain its current share of total energy (about 20 percent), then China would need 360 Mt of oil in 2020, twice the current rate of domestic production. The excess demand could be easily imported, probably without major impacts on global markets or foreign exchange reserves. To make up the balance of total energy use in 2020, consumption of natural gas, hydroelectricity, nuclear electricity, and other energy sources combined would have to grow five-fold over current levels, requiring very large new investments. Overall, ERI's recommended goal seems achievable and practical, though some of its implications (like high oil imports) are controversial in China.

In fact, even the goal of reducing energy use has its detractors. Within China's leadership and among energy experts there is agreement on the need for greater end-use efficiency, but opinion is divided on how to develop China's energy supplies. The debate essentially is about whether to continue relying on coal, consuming more of it using clean-coal technologies, or to diversify energy sources and rely more on imported oil and gas and on renewable energy. Key aspects of the discussion are security, issues associated with state-sector reform, and environmental protection. Some believe that continuing to use coal to meet most energy needs would fulfill the goal of energy security through self-reliance. Others feel that China's interests are best served by participating fully in international trade in energy products, particularly "cleaner" sources such as oil and natural gas, and by developing nuclear power and renewables, especially hydropower. For many, however, the debate is driven mainly by economic issues. The coal industry, with seven million workers, is one of the country's largest employers, and efforts to reform the industry are already quite painful (Chang and Zhao, 1999).

There is broad agreement that energy-related environmental problems need solutions, but some feel that problems can be addressed even with coal as the backbone of the energy system, while others see diversification away from coal as an essential step. Still, environmental regulations increasingly have teeth, and shifts in local and regional fuel structures, generally away from coal, can be attributed in part to environmental statutes. In any case, the ongoing debate over energy development may not result in any radical shifts in fuel mix, since trends are increasingly dominated by the logic of markets, including international markets for energy commodities.

POLICY IMPACT ON ENERGY SUPPLY AND USE

National policy can affect energy use, intentionally or otherwise. Above, we touched on policy and on uncontrollable factors as they affected various energy types. In this section, we consider more systematically how economic, energy, and environmental policy may have contributed to the fall in energy use in China in the late 1990s.

Economic Policy

Since energy use is so closely tied to the overall level of economic activity, the slowdown in the growth of China's economy—whether due to internal factors such as implementation of economic system reforms or external factors like the Asian economic crisis—surely brought down the rate of growth in energy use. Despite deceleration in the past several years, however, China's economy continues to grow rapidly. While GDP growth fell to 7.1 percent in 1999, the rate appears to be rising again, with growth expected to be over 8 percent in 2000. The official statistics have their detractors, however, and there are reasons to believe that growth has been overstated, possibly by as much as two percentage points per year over the past 20 years (Sinton and Fridley, 2000). Even if the lower GDP estimates are used, however, the energy intensity of China's economy (i.e., the amount of energy required to produce a unit of real economic output) has been declining as fast as in developed countries like the U.S. and newly industrialized areas like Taiwan—a remarkable and unique achievement for a large developing country. Changes in the product mix, in industrial structure, and in the efficiency of energy end uses, as well as turnover of equipment and enterprises, have all contributed to the improvements in energy intensity years (Sinton and Fridley, 2000). All of these changes have been influenced by economic policy.

Recent economic policy in China can be thought of as comprising elements of the broad program of economic system reforms that was initiated at the end of the 1970s. These reforms may have raised the overall energy-efficiency of the economy, and thus reduced energy demand or growth in energy demand, by catalyzing changes in energy-use behavior, shifts in the population of energy users, changes in the sectoral structure of the economy, and changes in the product mix within sectors. All of these factors, aside from changes in sectoral structure, seem to have been major contributors.

Let us first consider the effect of economic system reform on the tendency of energy end-users, such as factories, to improve energy efficiency. The overall thrust of the past 20 years of economic system reforms have been to move from a planned economy to a market economy. Under the planning system, decisions about how much energy to use were driven by production targets and the type of technology available for meeting those targets. Under such a system, incentives to improve energy-efficiency (and to use less energy) were created through a set of rules and additional targets imposed from above, and these incentives did work in many cases. Because the economic system was planned, with characteristic features such as price controls and centralized capital allocation, market logic could not work well to promote greater energy efficiency. For instance, it would have been unreasonable to expect that removal of energy price subsidies would effectively stimulate energy conservation.

Years of economic system reforms have changed that. Among the key areas of reform have been: deregulation of prices of many energy products (and most other products) and removal of most subsidies; lifting of the allocation system governing flows of intermediate and finished products; ownership and management reforms in state-owned enterprises that have given them more authority and responsibility for their operations and investments; allowance of non-state sectors (collective, private, and foreign-invested enterprises) to expand; and restructuring of the banking and finance systems. While far from complete, these reforms have created an environment that now allows the operation of disaggregated, market-driven decision-making to improve energy efficiency. However, while that logic may be recognized by many of the relevant decision-makers, from enterprise managers to ordinary workers, and from procurement department heads to individual consumers, market-based reasoning is not the only type of logic that is relevant or reasonable. In many decision-making situations that affect what kind and how much energy is used, the reasonable choice is not always the one that leads to the lowest cost, the greatest energy-efficiency, or the least environmental impact. This is true not just in China, but in all countries with market-based economies. Overall, the impact of the economic system reforms on energy-using behavior is ambiguous, although it seems likely that there has been a small net positive effect on efficiency (Sinton, 1996).

Economic system reforms have undoubtedly changed the population structure of energy-using enterprises—an important effect since different classes of end-users tend to have different efficiency characteristics. Consider the case of industrial users. Reforms that allowed rural, non-state enterprises (township and village enterprises, *xiangzhen qiye*) to go into business created a growing number of smaller factories that started up and operated as cheaply as possible, often using poorly maintained second-hand equipment and low-quality inputs. Although there are significant exceptions, in most energy-intensive sectors these enterprises tended to be less energy-efficient than larger enterprises. As long as the proportion of such enterprises grows, then, energy demand is likely to rise significantly. These enterprises can fold as quickly as they appear, however, unlike most state-owned enterprises, and a sudden closure of a large number of them would have a big effect on aggregate energy demand. This, in fact, may have happened in the late 1990s and 2000, as the government undertook an extensive campaign to shut down small manufacturers of metals, building materials, fertilizers, and paper, as well as refineries and mines, in the name of economic rationalization, environmental protection, and resources conservation. This is reflected in sectoral employment figures; between the end of 1997 and 1999, employment in industrial collectives, a category dominated by rural enterprises, fell by nearly half (NBS, 2000). Over the same period, employment in mining industries (including all types of enterprises) fell by 24 percent, in building materials manufacturing by 32 percent, in iron and steel by 25 percent, and in chemicals by 28 percent.

Another way the population of enterprises has changes is through attrition in the ranks of state-owned enterprises. While some state-owned enterprises use large, modern, and relatively energy-efficient equipment, many of them are saddled with outdated and wasteful process equipment. Often, these latter plants are among those that are poor economic performers, chronic money-losers that manufacture substandard product. Economic reforms and a greater willingness to let state-owned enterprises go bankrupt have made it easier for these plants to merge with other, better-performing enterprises, or close altogether. From 1997 to 1999, the number of state-owned and state-controlled enterprises dropped by more than 40 percent, as did employment in the same category (NBS, 2000). Over the same period, output of most industrial products continued to climb. If the enterprises that remained in business were more energy-efficient, as seems likely, then the net effect would be for energy demand to stagnate or fall.

As we have already discussed above, the gross sectoral structure of China's economy has not changed in ways that would be expected to reduce energy use; industry still accounts for about half of economic output, and heavy industry for a share similar to that a decade ago. The array of products available, however, has changed. Despite the continued existence of significant barriers to trade, economic system reforms have created much freer markets for most types of products, creating competition between suppliers of goods and services to meet growing demand for higher-quality products. Steel mills, for instance, need to provide better grades of steel and a wider variety of finished products than before. In the course of modifying or replacing production technologies to provide a better product, enterprises often (though not always) upgrade in ways that also improve energy efficiency. This would tend to cause energy demand to grow more slowly than economic output. This is not always the case, of course; in the transport sector, providing larger, more comfortable vehicles for passengers would tend to raise fuel consumption. On balance, however, changes in product mix, driven—or permitted—by economic system reforms appear to have contributed to slower energy growth, and perhaps to the recent drop in energy use.

The prospect of accession to the World Trade Organization is already bringing changes to China's energy markets. The tariff on imported coal has hindered import growth, even in Guangdong, where delivered prices of domestic coal are virtually at import parity. Imports could grow to nearly 60 Mt per year by 2010 with the reduction or abolition of import tariffs under the WTO and further removal of subsidies to state mines (Bloomberg 1999c). Restructuring of the national oil companies China National Petroleum Corporation (CNPC) and Sinopec increased pressure for protection in the short term to assist the companies while they cut costs and increased efficiency leading up to their international stock market offerings and expected increased competition after formal WTO entry. Even with WTO entry, restrictions will remain in the near-term on foreign company involvement on crude and product imports and domestic retailing (Reuters, 1999b).

To the extent that current and future economic policy reinforces the mechanisms discussed above, it is likely to promote growth in future energy demand at a rate lower than economic expansion. Greater wealth, however, leads to greater consumption, as latent consumer demand is fulfilled, and it seems unlikely that China will experience a similarly large and extended contraction in energy demand in the near future. The decline in energy demand from 1996 to the present seems to be closely related to a one-time extended shakeout of industry, in which many relatively energy-intensive enterprises shut down. This was, perhaps, in hindsight a logical outcome of a series of economic system reforms. Once that source of energy demand has been eliminated, however, it will be difficult to find another similarly large source to let the hot air out of.

Energy Supply Policy

In this paper, we are mainly concerned with changes in energy demand. However, energy supply policy can affect overall demand by limiting the amount of energy available for consumption, and by influencing the availability of energy forms, like electricity and natural gas, that can be used more efficiently than others. In addition, utility sector policy can affect the efficiency of both conversion of primary fuels into electricity and transmission to end users.

In the first decades of the People's Republic of China (from 1949 to about 1980), the dominant model for energy development was a "Soviet Style" that focused solely on expanding output as rapidly as possible, in support of an industrial policy that emphasized heavy industry, both in urban areas and in industrial centers that were geographically dispersed in the name of a national defense strategy.[5] Energy products were allocated according to a centrally developed plan, prices were heavily subsidized, and environmental concerns were non-existent. A policy of self-reliance gave primacy to exploitation of abundant domestic coal resources. Successes in onshore oil exploration in the 1960s gave rise to expectations that vast oil reserves would be found. Natural gas was virtually ignored. Increasingly large hydropower projects were built, along with tens of thousands of small hydropower dams to provide electricity to remote communities, and a nuclear power program was begun. The result was an inefficient and fast-growing energy system.

In the late 1970s and early 1980s, significant changes came about in energy policy. The government realized that plans for economic growth could not be supported by existing patterns of energy development, and so major reforms were instituted in all energy supply sectors. Just as importantly, new initiatives in energy efficiency were launched (see next section). Small, rural coal mines sprouted up, reducing the government's burden of investment and expanding local coal supplies so that chronic energy shortages essentially disappeared by the early 1990s. Progressive reforms in energy pricing and allocation allowed ever-greater amounts of energy products to be sold freely on open markets, and a more diverse array of energy producers and distributors to arise. The government began to withdraw from direct management of activities in the energy sector, allowing newly formed corporations to make more decisions about operations and investments.

More rapid movement towards a market-based system has come about since the early 1990s. Today, most energy prices in China are near international market levels, even for products (like oil) that remain heavily regulated. Prices rose particularly rapidly in the early 1990s, especially electricity, sparking greater interest in efficiency measures. Electric utilities, oil companies, coal companies, and the governmental apparatus regulating them are all undergoing restructuring. There have been continuing efforts to separate the government's regulatory functions from energy corporations' operational functions, although there remain many instances of strong state control. There have been large-scale layoffs, particularly in the coal industry, where overstaffing contributed to unprofitability, and a focus on financial performance.

In this transitional phase, the roles of governments and energy corporations and utilities are constantly being redefined, administrative structures remain unclear, and state-owned corporations wield tremendous political power. The role of the government remains powerful, as evidenced by the vigorous campaign to close the same small mines that, a decade earlier, were eagerly promoted. Moves to restructure the major oil companies and to carefully control their share offerings also show the strong hand of government. This environment provides mixed signals to energy consumers, and creates difficulties for those who would redesign the system of incentives for efficient use of energy and development of renewable energy resources.

It seems unlikely that policy in the coal industry has contributed much to falling energy use, even with the drastic shrinking of coal supply resulting from the recent campaign of closures. Unlike the situation that prevailed in the 1980s, economic growth in China is not constrained by coal supply (although availability of electric capacity sufficient to meet demand may, in some areas, limit growth). Coal pricing policy has for at least seven years subjected all but a very few protected end-users to fluctuating market prices. Coal prices rose very quickly while coal use was rising much more slowly, in part due to the artificially low price of coal prior to 1993, and in part to general inflation in the economy (Figure 4). In the past several years, as might be expected, prices fell when coal use fell, indicating that the decline was demand-led, implying that economic policies affecting demand were the most influential factors.

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[5] For overviews of energy policy in China see, for instance, Yang *et al*., 1995, Sinton *et al*., 1996b, and Andrews-Speed, *et al*., 1999, which were used to inform this section.

The relationships between indexes for prices and consumption of oil and electricity are also instructive (Figure 4). In the mid-1990s, the trajectories for both consumption and price for oil and electricity followed the same path as for coal. In the late 1990s, however, oil use leveled off, and electricity use continued to climb. In the case of oil, a sharp reduction in price, followed by an equally sharp price hike, was not accompanied by any large change in consumption. This suggests that (as in most countries) oil demand is fairly inelastic, at least in the short term. In fact, China has a great deal of latent demand for oil. More than for other energy products (except perhaps natural gas), consumption of oil is still supply-limited. For this reason, supply-side policies have more impact on demand than for coal. Restrictions and high tariffs on imported oil, for instance, have tended to keep oil demand down, through both direct and indirect control of markets. When China loses its ability to impose such restrictions and high tariffs under the rules of the WTO, i.e., when it is forced to change oil supply policy, then it is possible that oil use will jump, as pent-up demand is fulfilled.

Energy Efficiency Policy

Since the early 1980s, China has adopted a far-reaching series of policies and programs to promote greater efficiency in energy end uses in all sectors. Besides direct support for energy efficiency projects—accounting in some years for 10 percent or more of all investment in energy in the early 1980s (see Figure 5)—administrative and regulatory structures were developed to manage energy use, standards for process and equipment efficiency were developed, building energy codes were formulated, financial incentives were created, and a nationwide network of technical service centers was established for consulting, training, and public education (Sinton *et al*., 1998). In 1998, the national Energy Conservation Law came into force, codifying the country's approach to promoting energy efficiency under a more market-oriented economic system, although implementing provisions are still being formulated. Numerous international assistance projects have aimed to help China raise energy efficiency, from earlier direct assistance for demonstration projects and technology transfer, to more recent projects aimed at comprehensive transformation of markets, e.g., for lighting products and home appliances.

In the 1980s, when the government directly controlled a much larger portion of the national economy, it was simpler to gauge the impact of these programs. In the 1980s, when the energy intensity of the economy fell by a third, from one third to one half of the change was attributable to improvements in energy efficiency, largely due to government-led investment programs and regulatory activity, both through retrofits of existing equipment and construction of new capacity (Sinton *et al*., 1998). Since the deepening of ownership, management, and financial reforms in the early 1990s, and the consequent spinning off of investment and operational decision making to managers and local officials, it has become much more difficult to promote energy efficiency in the same way as in the past. Still, government-supported research and development, technical support, and information exchange remains crucial to ensuring that more energy-efficient products and equipment are available to factories and other businesses that are retrofitting and building new facilities. How well the government is able to play its role as facilitator of choices regarding energy-using equipment made by businesses and consumers will, in part, determine how quickly China's energy use will grow.

Environmental Regulation

All across China, and particularly in the wealthy coastal provinces, cities and towns are gradually becoming stricter in enforcing limits to pollutant emissions. When local administrations are supportive, environmental protection bureaus can levy significant emissions fees and fines, mandate process changes, and apply more drastic measures. In some cases this results in installation (and often operation) of pollution control equipment, or replacement of old production equipment. In other cases, urban factories move to rural locations, or shut down altogether.

Forceful application of environmental regulations has the potential to change industrial energy demand significantly. The regulation of sulfur dioxide emissions in China's legislatively defined "acid rain control zones" may, for instance, result in greater use of washed coal and installation of flue-gas desulfurization (FGD) equipment at power plants. Coal washing would provide a higher heat-content product that would burn more efficiently, reducing demand for coal, all else being equal. FGD, on the other hand, requires a great deal of a power plant's output, raising demand for coal inputs to power generation. In general, although the effect is hard to quantify, emissions controls and workplace health regulations have contributed to the rise in industrial demand for electricity.

Requiring urban factories to move or to replace equipment often results in the use of newer, generally larger, cleaner, and more efficient equipment. While there have been large markets in China for used production equipment, introduction of newer equipment still tends to increase average energy efficiency. Closing down heavily polluting factories contributed to concentration in industries, which tends to favor cleaner production, and, again, greater energy efficiency. Whatever net effect environmental regulations have on industrial energy demand, e.g., a rise in electricity use and a fall in direct use of coal, it is likely to be drowned out by the effect of the economic forces discussed above.

CONCLUSIONS

It is clear that the decline in energy consumption is, in essence, a decline in coal consumption. Moreover, the fall in coal consumption appears to be concentrated in direct uses; even if available data are not entirely accurate, the balance of evidence shows that coal consumption for conversion (power generation, heating, coking, and coal washing) has remained stable.

The decline in direct coal use reflects the convergence of a number of trends, both short- and long-term. Among the short-term trends, the economic downturn beginning in 1998 appears to have had a significant impact on coal use, reflected both in the slowdown in growth of electricity generation and in the decline in demand from industrial subsectors such as building materials and chemicals. This decline was shaped by a second near-term trend as well—the government's promotion of industrial restructuring though consolidation, increases in scale of facilities, and closures. Reducing production from or closure of small ammonia producers, for example, resulted in both lower energy consumption and higher average energy efficiency of the remaining productive capacity. Campaign-style closures of small paper mills, cement and glass plants, power plants, refineries, and mines have had similar effects. The net impact was a one-time acceleration of equipment turnover.

Another short-term trend with longer-term implications is the emergence of a buyer's market in coal. With prices depressed and coal oversupplied, consumers have been able to purchase cleaner coal with higher heat content, resulting in a decline in apparent coal consumption even as the economy grew. We estimate that this factor alone may account for 40 percent of the total decline in apparent energy use since 1996. It is uncertain, however, whether this trend can be sustained once energy demand resumes faster growth and coal output rebounds, but it is likely to remain a factor affecting consumption in the near future, as the government continues to suppress coal output to manage the surplus market.

At the same time that slower economic growth, industrial reform, and higher coal quality have resulted in a substantial reduction in coal consumption, other longer-term trends are also having a continued impact. The shift from state-owned to collective, private and foreign-invested ownership of production is widely seen as a shift to greater efficiency, particularly since the productive assets of the non-state sector are often newer and better operated, even in some rural township enterprises. The product mix is also improving, providing greater quality and value of output per unit of energy input. Although industry remains the leading sector of the economy, within the industrial sector certain energy-intensive subsectors have declined while others of lower energy intensity have gained in importance. These are all natural processes of economic growth and modernization, and not easily attributable (or susceptible) to the influence of particular government policies. These changes will be further spurred as China gains formal WTO entry and broad sectors of domestic industry are subjected to greater international competition, and are likely to remain factors in reducing energy demand growth.

Sustained support for environmental and energy-efficiency policies is a factor in the continuing decline of coal use by households. Residential coal use is being aggressively replaced by cleaner forms of energy such as LPG, natural gas, town gas, and electricity. Planned expansion of natural gas use from 20 bcm today to 100 bcm in 2010 will benefit millions of residential users and further displace coal. Long-term implementation of policies to promote energy conservation has helped to accelerate improvements in end-use efficiency in most sectors, and will continue to be key as China's market orientation deepens.

Our provisional conclusions about the significance of the factors we set out at the beginning of this paper are summarized in Table 1. Overall, a combination of slowing economic growth, industrial restructuring, broader economic system reforms, and environmental and energy-efficiency policies has led to at least a temporary decline in, and perhaps a long-term reduction in the growth of energy use, and therefore greenhouse gas emissions. While the available data on current energy consumption in China do not allow us to precisely assess the contribution of each factor to the total decline in consumption since 1996, it seems likely that improvements in coal quality, the economic slowdown, and disruption of the state-owned industrial sector were the largest sources of the decline. Energy-supply, energy-conservation, and environmental policies did not, on their own, have large impacts, but they have been essential catalysts for change. While intentional efforts to reduce energy use were important, the greatest influences on trends in energy use were incidental effects of economic policies and uncontrollable factors in the economic environment.

Table 1. Impacts of Proposed Explanations

Factor	*Magnitude of Effect*
Intentional Policy Impacts	
1. Energy-efficiency policies and investments have reduced energy intensity in all sectors.	moderate
2. Reforms in the coal sector that have led to the shutdown of many small mines have reduced "oversupply".	small
3. Elimination of small power generators has reduced growth in coal demand from electricity generation.	small
4. Urban dwellers are switching to gas and electricity for cooking and water heating, and from stoves to central heating.	small
Unintentional Policy Impacts	
5. Economic system reforms have shut down many inefficient factories, favoring development of more efficient enterprises.	large
6. New non-state sector enterprises have become more energy-efficient in response to strong competitive pressures.	small to moderate
7. Consumers have switched to higher quality coal, leading to greater end-use efficiency and lower total demand.	large
8. Changes in the gross structure of China's economy reduced energy demand.	small
9. Implementation of environmental regulations forced inefficient plants to shut down or to become more efficient.	small
10. Relatively higher prices for electricity have stimulated energy conservation, leading to substantially lower demand.	moderate
Uncontrolled Factors	
11. A slowdown in heavy industry in response to slowing economic growth has caused demand from the largest users to drop.	moderate
12. Slower economic growth has reduced electricity demand, cutting growth in demand for coal from the utility sector.	moderate
13. Normal turnover of capital equipment has improved the average energy efficiency of industrial processes.	possibly large
14. Reductions in energy use are overstated; energy consumption is significantly greater than production, and recent energy and economic statistics are inaccurate.	small; unlikely to change conclusions

OUTLOOK AND POLICY RECOMMENDATIONS

Events of the past several years have already reduced China's energy use—and greenhouse gas emissions—far below what was expected. Figure 6 compares the view of a widely circulated report (the China Country Study) of how carbon dioxide emissions were expected to grow, and what actually happened. In the mid 1990s, it might have seemed plausible that emissions estimates for China were conservative; carbon dioxide emissions were slightly higher in 1996 than the baseline projection in the Country Study. By 1999, however, actual emissions were 15 percent lower than even the lowest policy scenario.

Straight-line projections of current trends are typically not the most useful guide to future conditions, of course. Based on information available now, it seems likely that consumption of energy in China may have already stopped falling, and will resume growth in the near future; the available data for 1999 and 2000 confirm a continuing slowdown in coal output and consumption, though electricity use is already growing very quickly again. How fast, then, will it grow? Even if energy use rises at the same rate that prevailed in the early 1990s, i.e., at half the speed of economic expansion, carbon dioxide emissions will not reach 1996 levels until after 2005 (Figure 6). Clearly, current projections of China's greenhouse gas emissions will have to be revised downwards significantly, but China should not be content with its unexpected success in reducing emissions. China can do a great deal to reduce the global environmental price of its future economic development, and the rest of the world can do much to help.

In the arena of economic policy, it will be crucial for China to continue its progress in structuring markets, putting in place institutions of governance of corporate behavior, revamping the banking and finance sector, and finding other means to fulfill the social-welfare functions that formerly were provided by enterprises. These are broad tasks with multiple goals, but they will affect energy supply and use at least as much as policies aimed directly at energy. How they are dealt with will shape the environment in which energy choices are made.

Challenges for energy-supply policy abound. In the long term, commitment to developing and deploying renewable energy will have a tremendous impact on fuel structure, but for now conventional energy supply will be central. For the coal sector, ensuring that large mines become financially viable remains a key task. How China finds ways to improve coal supply to meet environmental goals, such as reducing acid precipitation from sulfur dioxide emissions, will affect how coal is used. The debate, driven by financial and security concerns, over whether China should rely more heavily on domestic coal resources instead of imported oil, also bears watching, though the potential for greater coal use will hinge again on coal quality, which in turn will depend on water availability in the water-poor coal-mining regions. Greater reliance on coal will signal higher growth in energy use and carbon emissions, since coal is used less efficiently than other fossil fuels, and emits more carbon dioxide per unit of useful energy.

Since accession to the WTO will leave China with fewer tools to restrict oil imports, policies that affect demand will be the ones to watch for. Transport policies that affect mode choices (e.g., road vs. rail, private vehicle vs. public transportation), fuel efficiency standards for vehicles, and policies affecting demand for petrochemicals will have a large bearing on how much oil China will have to import.

Natural gas is such a desirable fuel for so many reasons that consumption will likely be limited by supply and availability of end-use equipment. Policies affecting international trade in natural gas, support for construction of pipelines and distribution networks, pricing policies, and regulatory development all become relevant, then.

For electricity, the main question is how regulatory reform of utilities will proceed. Issues include how government will reduce its role in the management and operations of utilities, how generation will be separated from transmission and distribution, and how markets for electricity will be transformed and regulated. How China treats the activities of foreign investors, lenders, and developers in the sector will also be important, as well as national policy towards development of nuclear power and non-hydro renewables. Developments in these areas will affect what types and scale of new generating units are built, system efficiency, environmental performance, and what kinds of demand-side electricity-efficiency programs can be feasibly deployed in China.

As suggested above, energy-efficiency policies are unlikely to bring about great change on their own, but they will help to create attractive opportunities for energy suppliers and users to raise efficiency—and slow growth in energy use—when the economic and institutional environments permit. China is now implementing its Energy Conservation Law, providing opportunities now to shape future developments. Some of the challenges to implementing this law are:

- creation of new fiscal and other incentives;
- reassessment of existing energy price regulations;
- establishment and enforcement of mandatory efficiency standards for common energy-using equipment and buildings;
- integration of energy efficiency with environmental protection efforts;
- penetration of the rapidly growing non-state (rural) sector;
- retaining and transforming the former system of efficiency centers; and,
- institutional coordination in implementation, management and supervision of energy conservation law.

Within the above areas, there are substantial opportunities for international assistance and cooperation. On the supply side, for instance, efforts to help ease China's participation in international energy markets will be important to ensuring that China has access to adequate supplies of oil and natural gas so that it can run its economy more efficiently and with lower emissions of greenhouse gases and other pollutants. China is now at the initial stages of establishing a national network for natural gas, and U.S. experience here could be a key reference point for China. For the United States, one key challenge will be to find ways to accommodate China's needs for access to energy from the Middle East, Central Asia, while continuing to serve US energy and security needs.

While China still has some claim to status as a developing nation, it is increasingly a heterogeneous country, with aspects that are highly developed and others that are much less developed. Consequently, the kind of multi- and bilateral assistance that would be most valuable is different from that traditionally provided to developing countries. As the country's financial system evolves, for instance, direct grants and loans for projects to promote energy efficiency or alternatives to fossil fuels become less important than efforts to develop strong domestic financial institutions and training to develop commercial link to international capital markets. Promoting efficient technology development and transfer could be particularly valuable, including joint pre- commercial research and development, as well as foreign industry involvement in commercial activity in China. Even though most exchanges affecting how particular actors obtain and use energy will occur in the commercial realm, cooperation at the policy level remains important. The United States has considerable experience, both positive and negative, in regulating energy supply and use in a market economy, and this experience is valuable for China. If the guiding philosophy behind assistance is one of helping a partner build capabilities that will serve mutual interests, rather than one of providing a handout to a poor neighbor, then the chances will be much greater that a strong, peaceful, trusting collaborative relationships will develop, relationships that will allow the participating countries to work together to solve global challenges.

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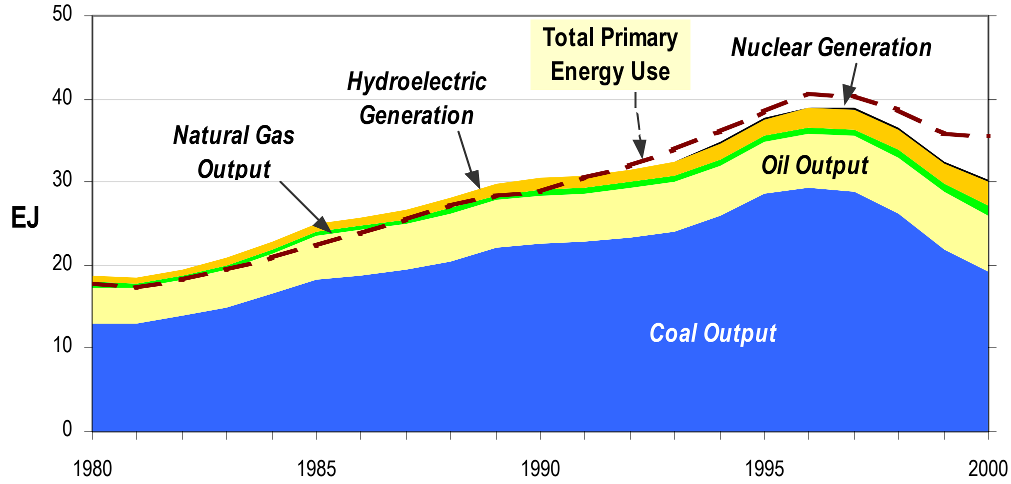
Figures

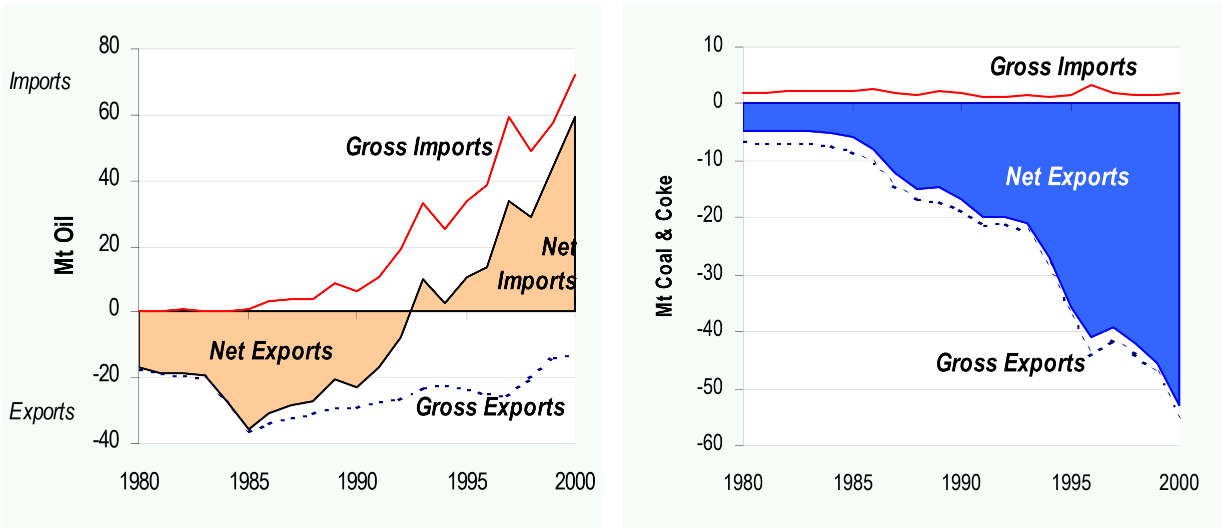
Figure 1. Primary Commercial Energy Production and Total Primary Energy Use, 1980-2000



N.B. 2000 figures are estimates based on data for first eight months.

Source: SSB, 1992; NBS, 2000; CSIN, 2000.

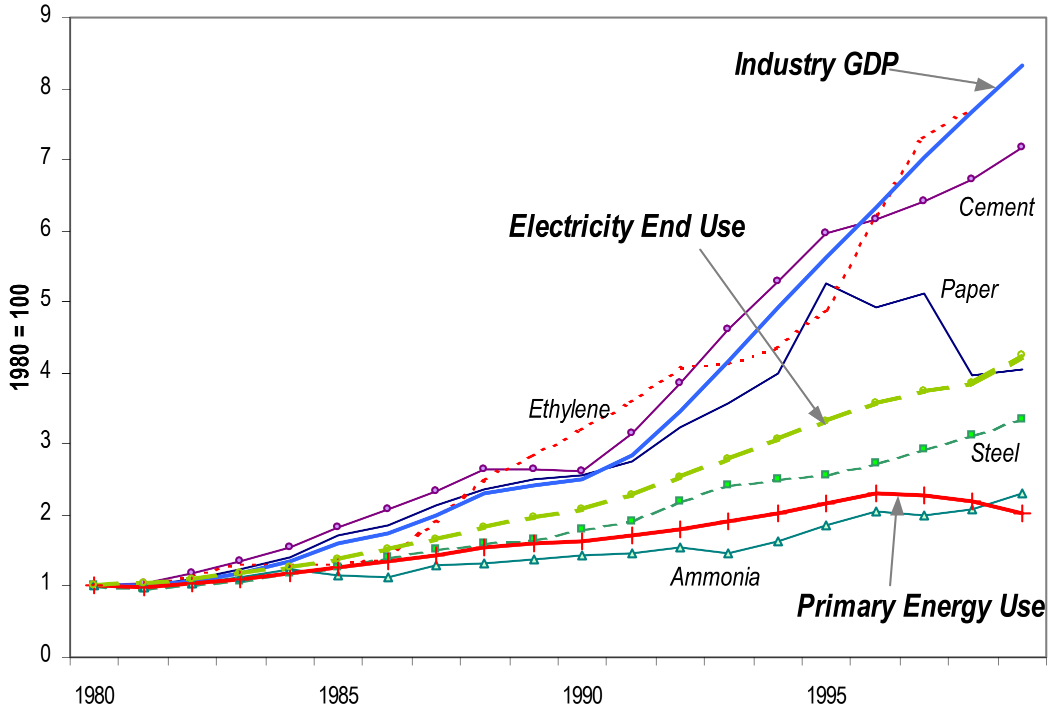
Figure 2. International Trade in Oil and Coal, 1980-2000



N.B. These are based on official customs figures, and do not include estimates of any smuggled products. 2000 figures are estimates.

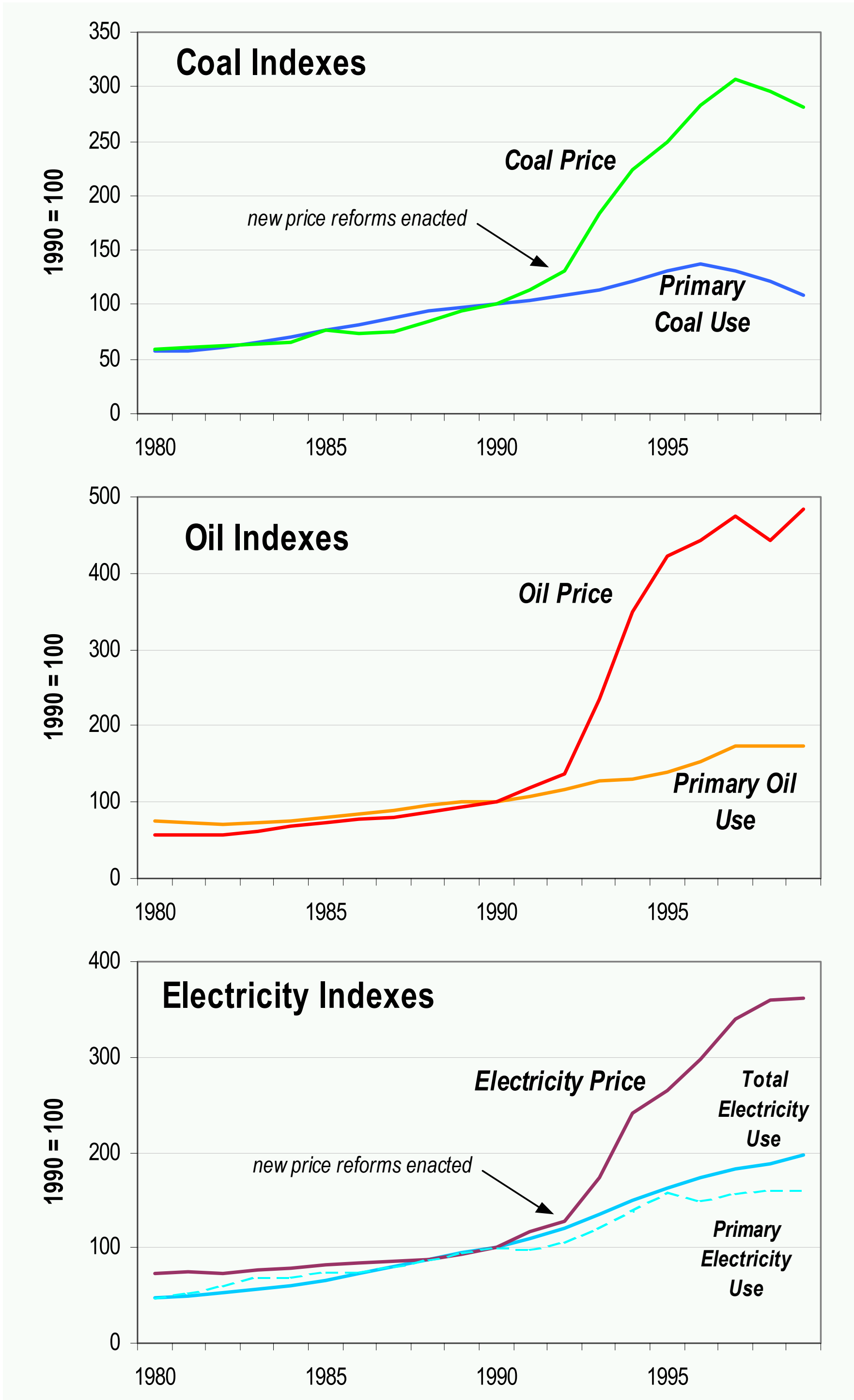
Source: SSB, 1998a; NBS, 2000.

Figure 3. Industrial GDP and Total Energy Use, 1980-1999



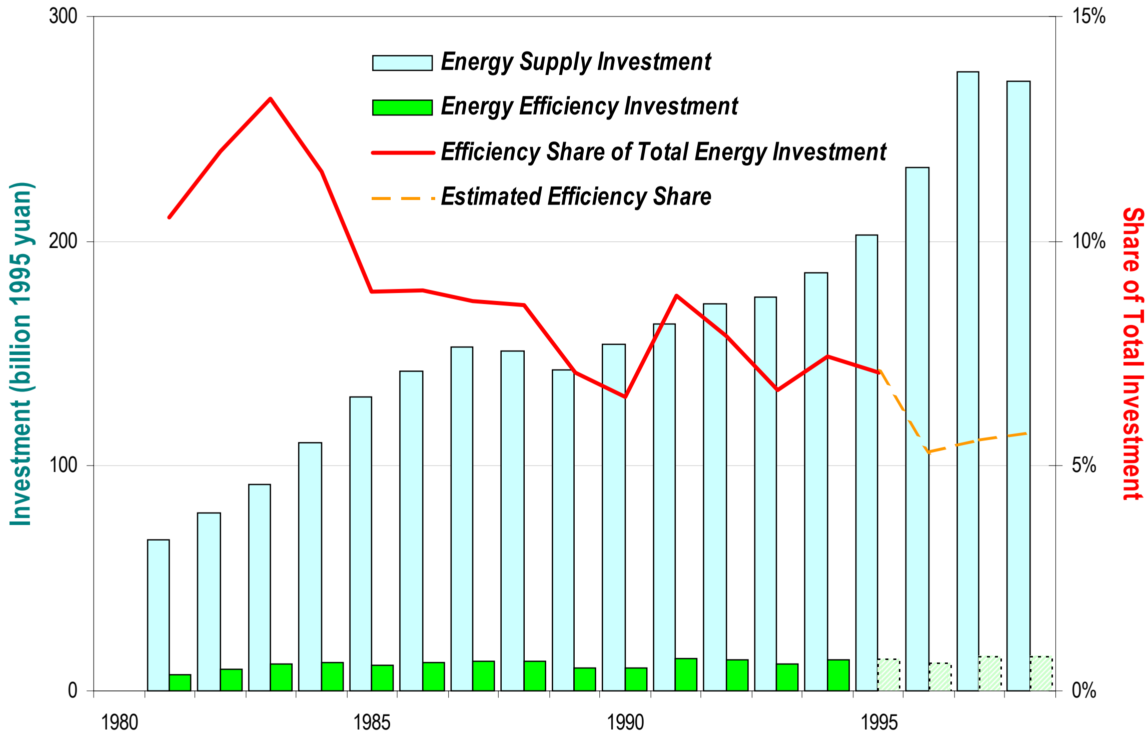
Source: NBS, 2000.

Figure 4. Energy Consumption and Price Indexes, 1980-1999



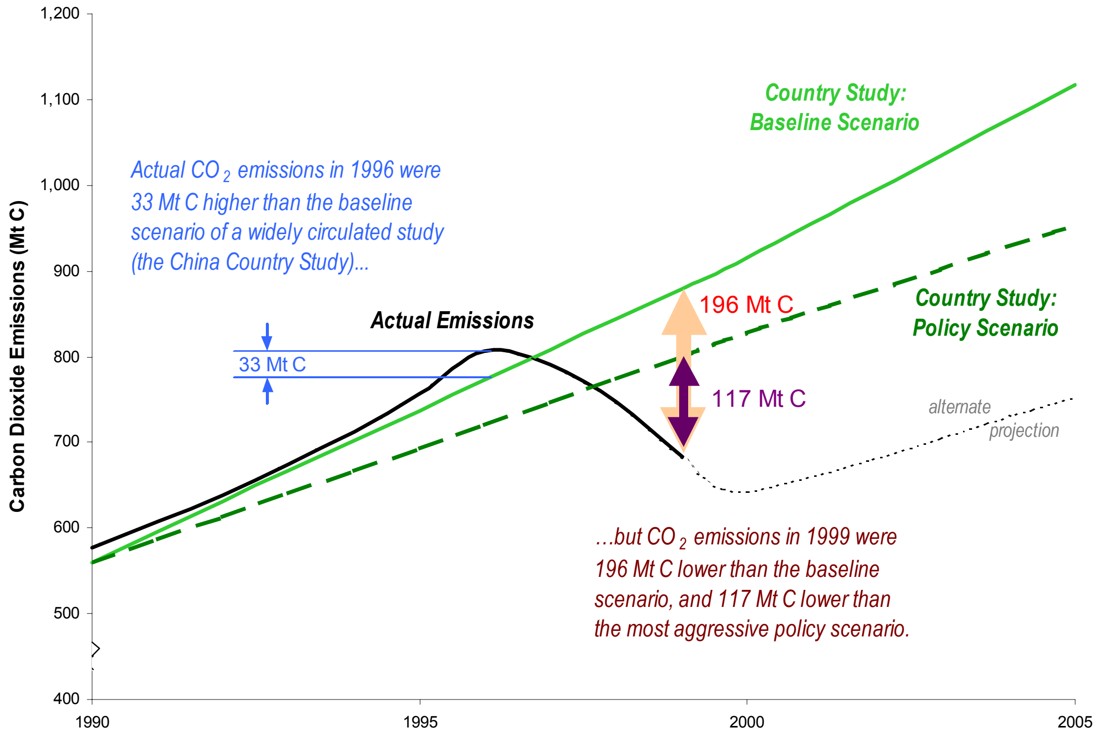
Source: NBS, 2000.

Figure 5. Energy Supply and Energy Efficiency Investment, 1981-1999



N.B. Only partial data on energy efficiency investments after 1995 are available. These partial data informed the estimates presented here of efficiency's shares of total energy sector investment for 1996-1999. All investment data are for state-owned units only.
Source: Sinton *et al*., 1996a; SSB, 1999; NBS, 2000.

Figure 6. China's Carbon Dioxide Emissions, Actual and Projected



Source: RTCCCCS, 1999; authors' calculations.