An Update on Recent Energy and Carbon Dioxide Trends in China

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Economic reforms have had a significant impact on China's energy sector over the past five years, most notably in the coal sector. The reported output and consumption of coal has fallen by roughly 20 percent since 1996 despite relatively strong economic growth and demand for other sources of energy. While unreported coal production and use may account for half of this reported decline, carbon dioxide emissions are still far lower than earlier forecasts had predicted.

Economic Reform and Energy

China's economy began a period of deeper change in 1996. Painful domestic reforms combined with the impacts of the Asian financial crisis caused a sudden slowdown in demand for Chinese commodities and manufactured products. Efforts to cut financial losses at state-owned enterprises have resulted in mergers, bankruptcy, and elimination of millions of jobs. These reforms helped phase out the "iron-rice bowl" benefits of near-free housing, education, and health care enjoyed by many urban Chinese, causing them to dramatically reduce spending on other items. As a result, many sectors of China's economy became seriously oversupplied beginning in 1997. The impact on China's energy sector, although still poorly understood, has been profound, most notably in the coal sector.

Reported use of coal in China dropped by over one-fifth between 1996 and 1999, while GDP grew by one-quarter. (See Figure 1.) Reasons for the dramatic divergence are not fully understood due to limited information, but preliminary data for 2001 suggest that demand has picked up speed. Use of other forms of energy has continued to grow and does not appear to have played a significant role in the decline of coal consumption. Understanding how such a rapid decoupling of coal use and economic growth occurred might shed additional light on future domestic trends and international efforts to mitigate greenhouse gas emissions.

Coal Sector: Rock Bottom?

Activity in China's coal markets has swung wildly in the past five years. Through the mid-1990s, Chinese energy planners questioned whether coal supply and transport capacity would be able to satisfy the market's rapidly growing demand appetite. But after the apparent free fall in coal production and consumption during 1998 and 1999, these concerns draw much less attention today. Dealing with underemployed rural workers—some of them miners who used to work in the small coalmines that have since closed—is a much greater security issue now.

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Reported coal production peaked in 1996 at 997 million tons of coal equivalent (MTCE).[2] By the end of 1999, output had declined by one-quarter to 750 MTCE. (See Table 1.) The trend in reported coal consumption over this period is similar, although slightly less dramatic, falling from 1038 MTCE to 819 MTCE. Over these three years, coal use as a percentage of total primary energy consumption fell from 74.7 percent to 67.1 percent. Not even the most progressive of Chinese energy watchers could have predicted such a rapid decline. Preliminary data for 2001 indicate that coal production grew sharply during the first two months of the year.

Determining how and where coal use may have declined is critical if analysts hope to learn useful lessons from the phenomenon. Data cited by Sinton and Fridley suggest that improvements in coal quality could account for roughly 75 MTCE of the decline, while improved efficiency resulting from closure of small, inefficient factories could explain another 75-125 MTCE.[3] Together, these changes account for up to 85 percent of the decline from 1996, but only about 50 percent of the reduction from what earlier forecasts had predicted for 2000. Additional data are needed to gauge the impact from other variables within the economy such as state-owned enterprise reform, structural change, variation in coal stockpiles, measurement of GDP, and unreported coal use.

It seems likely that at least a portion of the apparent decline is due to unreported coal production and consumption. The central government claims to have closed over 33,000 small coalmines since 1998, primarily to help improve the bottom line of larger, state-owned coal companies. These small mines are typically owned by private firms or local governments and regulated poorly. Keeping these mines closed is difficult because local governments often have economic interests at stake. Unreported coal production and distribution might account for up half of the reported decline in consumption, but additional field research is needed to verify the numbers.

Verifying the accuracy of China's coal statistics is important for at least three reasons. First, flawed statistics will distort policies to grow the economy while minimizing environmental damage. For example, emissions of sulfur dioxide and particulates had reportedly declined by about 10 percent between 1997 and 1999, but these statistics are calculated, at least in part, based on energy consumption and may be giving government planners a false sense of success in improving urban air quality. Second, accurate figures on coal consumption are necessary to forecast future energy needs, greenhouse gas emission trends, and opportunities for carbon mitigation. Despite uncertainty in ratifying the Kyoto Protocol anytime soon, enormous markets for carbon mitigation will eventually develop and accurate accounting standards will be needed. Finally, other countries can draw important lessons from China's experience in addressing its own sustainable development issues.

The future of China's coal sector is influenced by competing trends. Growth in coal demand appears to be returning this year, although the government is still concerned

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[2] One million tons of coal equivalent equals 29.3×10^{15} joules.

[3] Sinton, J. and D. Fridley. 2000. "What Goes Up: Recent Trends in China's Energy Sector." *Energy Policy*, 28(10): 671-687.

about excess regional production. Concern over environmental quality has continued to put pressure on planners to find cleaner sources of energy than coal. Natural gas and, to a lesser extent, renewable energy, will likely offset a share of coal use over the coming decades. But other forces will continue to encourage the use of coal, predominantly from the political need to keep rural workers employed. Additional market reforms are also likely to improve economies of scale within China's coal sector, which could result in lower coal costs that in turn inhibit development of alternative energy supplies.

Oil: Record Imports, Surging Investment

China depends on imported oil now more than at any time in its modern history. Average oil production grew by a scant 1.9 percent annually between 1995 and 2000 while demand rose by over 5.3 percent each year. Imports of crude oil jumped to 70 million tones in 2000, compared to domestic production of about 165 million tones.

Domestic production remains relatively flat although large verified reserves indicate a significant potential to boost output. Most of the currently producing fields are worn out and rely on outdated technology and distorted incentives. As a result, oil extraction is expensive and challenging. Petroleum prices remain largely state-controlled, although recent reforms have kept retail prices pegged to international levels.

To improve energy security, China began in the early 1990s to acquire interests in oil fields abroad. Significant investments occurred in the Middle East, Central Asia, Africa, and South America. Some of these ventures have proven costly, slow to develop, and less than ideal. Others, notably in the Sudan, have attracted negative political attention. These overseas projects will continue to play a role in meeting China's future oil needs, but expectations have declined somewhat. Attention has shifted back to reform of China's state-owned oil firms and closer cooperation with international oil companies and markets.

China reformed the petroleum industry in 1998 to separate regulatory and administrative functions from ownership and operation. The potential impact of major structural reforms on the country's two major state-owned petroleum companies—China National Petroleum Company (CNPC) and China Petrochemical Corporation (SINOPEC)—is hotly debated. Both companies have taken steps to improve efficiency, but continue to operate in distorted, opaque markets and remain overstaffed. Despite these drawbacks, multinational oil companies and international investors have demonstrated an interest in controlling a piece of China's future petroleum market by investing heavily in these enterprises.

China's two major petroleum companies raised over $6 billion in initial public offerings (IPOs) in the New York and Hong Kong stock exchanges earlier in 2000. PetroChina, a subsidiary of CNPC, attracted worldwide attention in April by raising $3 billion from international investors. At least one multinational oil company agreed in advance to purchase a large portion of the shares in exchange for exclusive business opportunities within China. SINOPEC, in its own IPO in October, raised about $3.4 billion, again with strong commitments from international oil companies to buy shares. China's other

petroleum company, China National Offshore Oil and Gas Company (CNOOC), finally conducted its IPO in February of 2001 raising over $1 billion. Multinational oil companies also continue to invest directly in project specific opportunities, mainly in the downstream and retail sectors. International investors will push for changes in the way Chinese petroleum companies operate in exchange for their capital, although the degree and schedule of these changes are largely uncertain.[4]

Electric Power: Rapid Growth Returns Despite Halting Reforms

China's power sector continues to grow rapidly despite significant distortions. Installed capacity surpassed 320 gigawatts in early 2001, although per capita power consumption in China is only one-thirteenth that in the United States. A power glut appeared in many parts of the country beginning in 1997 and 1998, prompting officials to declare a moratorium on construction of new, traditional power plants for three years. The power glut resulted in some local grid operators breaking their power purchasing agreements with power plants and raised concern over enforcement of contract law.

Growth in power demand fell to less than three percent in 1998, but recovered to a more typical value for China of six percent in 1999 and a surging 10 percent during 2000. While some regions are still oversupplied, others like Guangdong are having trouble meeting recent demand growth of approximately 20 percent. The supply and demand mismatches have altered the planned transmission route for power that will be generated at the Three Gorges dam beginning in 2003. The new plan will send more power to hungry Guangdong and less to the saturated north and east.

Over the next few years China will begin to experiment with competition in selected regions. Power generators will compete to sell power to the grid in an effort to improve overall efficiency and lower costs. True competition requires—at a minimum—a robust transmission grid, non-colluding suppliers, independent management of the power pool, and enforceable laws. It will take some time before larger regions in China are ready to introduce competition in electricity generation. The State Power Corporation, which owns the vast majority of power plants in China, continues to influence the pace of reform within the sector despite restructuring in 1998 that attempted to remedy this situation.

Natural Gas: Supply Growing, Demand Uncertain

Natural gas is enjoying a renaissance throughout the world due to its relatively clean combustion and high efficiency. Recent improvements in gas turbines, fuel cells, and energy transformation technologies that use natural gas even more efficiently promise to keep future demand strong. Throughout China's modern history, natural gas has been largely ignored as a meaningful source of energy, but that now appears set to change, at least on paper. Planners hope that gas will account for about 10 percent of all commercial energy by 2020, up from the current three percent. It could account for an even larger slice of the energy pie given the right encouragement. Significant market reform and

[4] PetroChina, for example, agreed to shed 10,000 workers each year through 2002 to entice investors to buy shares in its IPO. Transparency in the relationship between PetroChina and CNPC is poor, however, and investors remain in the dark about potential cross-subsidies.

investment is needed, however, to identify domestic gas resources, build transport and distribution infrastructure, and—perhaps most importantly—create markets for gas utilization.

China has more methane-rich gas than once thought. Major gas discoveries have occurred over the past few years in western China and in offshore regions. These larger fields can now justify the construction of long-distance pipelines. China will begin building a cross-country pipeline from Xinjiang to Shanghai in 2001 capable of transporting 30 billion cubic meters (BCM) of natural gas per year.[5] Other pipelines have recently been completed that transmit gas to Beijing, Xi'an, and Shanghai. Coalbed methane is also receiving greater attention and several international oil companies have signed contracts in China to explore for and develop coalbed methane fields. Coalbed methane is expected to contribute 10 BCM to overall supply by 2010. Foreign investment is flowing to some of these projects, although perceived barriers that increase risk prevent much greater utilization of overseas capital.

China also seems more willing to consider importing large quantities of natural gas. At least one memorandum of understanding has been signed with Russia to build a natural gas pipeline from Siberia to northern China. Thorny regional issues need to be addressed, however, to develop financing for the pipeline. China also recently announced that its first liquefied natural gas import terminal would be built in Guangdong, and announced the winning project development team in early 2001. Other terminals could quickly follow along the coastline from Shenzhen to Shanghai.

Environmental benefits are largely pushing the renewed interest in natural gas. Switching from coal to natural gas slashes emissions of harmful pollutants, including carbon dioxide, and improves operating efficiency. City planners in Beijing hope to continue converting thousands of industrial boilers operating in the downtown area from coal to natural gas in an effort to improve air quality enough so that the city can host the 2008 Olympics. Energy users will need greater incentives to switch to natural gas, however, if sustainable markets are to develop nationwide. Currently, prices and regulations do not reflect the environmental benefits of using natural gas in place of coal.

In a carbon constrained world, international investors may find attractive opportunities in China's natural gas sector. Fuel switching from coal to gas benefits both regional and global environmental quality. For every 30 BCM of gas used in place of coal, sulfur and carbon dioxide emissions would decline by approximately 1 and 20 million tons, respectively.[6]

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[5] Thirty billion cubic meters of natural gas is equivalent to approximately 1.2×10^{18} joules, or about 55 million tons of Chinese coal.

[6] Measured in terms of the molecular weight of sulfur dioxide (SO_2) and the carbon equivalent of CO_2 (C). The calculations assume that half the gas is used to replace coal in power generation and the other half is used evenly in industry and residential applications.

Alternative Energy: High Costs and Distorted Markets Hinder Growth

China has extensive renewable energy resources that could one day play a huge role in meeting the country's energy needs. Biomass energy already helps many rural Chinese meet their heating and cooking needs, although overall use has been falling as other forms of commercial energy gain favor. World-class wind power resources in coastal and western China have the potential to provide electricity without harmful emissions. Much of western China is bathed in solar radiation that could be converted to electricity without damaging environmental consequences. Nuclear power, once a panacea to many energy planners in China, has received less attention recently due to persistent high costs and financing difficulties. Advanced clean coal technologies remain expensive, complex, and limited to restricted markets.

High costs and distorted markets have slowed the development of renewable energy in China. Wind power, for example, can be generated competitively in some regions but backup power supplies are needed when the wind fails to blow, raising overall costs. The environmental benefits of wind power are not accounted for in electricity tariffs, which further impedes development of markets. China still relies on imported wind turbine technology for most commercial applications, and export subsidies from turbine manufacturers hinders the development of China's own domestic production capability. Without market reforms to correct these distortions, and technological breakthroughs to lower costs, renewable energy will continue to play a limited role in China's near-term energy future.

Carbon Dioxide Emissions: Forecasts Slashed

China is currently the second largest emitter of greenhouse gases and produces about half as much as the United States. Approximately 85 percent of China's greenhouse gas emissions is associated with fossil fuel production and use. Carbon dioxide produced from the combustion of coal is the single largest contributor to China's total greenhouse gas emissions. The apparent decline in coal consumption therefore has a significant impact on China's greenhouse gas emissions. If the reduction in coal use described earlier is real, China's emissions are not only far below the level earlier forecasts had predicted, but also down significantly from the peak level in 1996.

International and Chinese experts collaborated on at least 5 major studies during the 1990s on greenhouse gas emission scenarios. (See Table 2.) One main goal in each study was to project baseline future energy use and associated carbon dioxide emissions and then provide at least one alternative policy scenario resulting in lower emissions. The policy scenarios, for example, identified variables such as standards for domestic appliance efficiency or fuel switching that could be changed through regulation or market incentives to mitigate carbon emissions. Each study translated the energy consumption forecasts into carbon dioxide emissions using carbon equivalent coefficients. There was some variation in the coefficients used, but in general they follow guidelines defined by the Intergovernmental Panel on Climate Change.[7]

[7] IPCC guidelines are 25.8 kg of carbon per gigajoule of coal energy, 20 kg of carbon per gigajoule of oil energy, and 15.3 kg of carbon per gigajoule of natural gas energy.

Carbon dioxide emissions in 2000 calculated from reported energy consumption statistics are significantly lower than the average value forecasted from these studies. (See Table 3.) The average forecast of carbon dioxide emissions from fossil fuel use in the baseline scenarios from the five studies was 950 million tons of carbon. Based on energy statistics reported through 1999 (and preliminary statistics for 2000), carbon dioxide emissions in 2000 will be approximately 725 million tons of carbon, 225 million tons less than the average of the forecasts. Revised energy consumption estimates that assume some unreported coal consumption indicate the decline is a more modest 100-175 million tons of carbon. The average value for the policy scenarios was 882 million tons of carbon. So, without adopting specific measures to mitigate carbon emissions, China is already below this level, although future emissions may not continue along the same trend.

China has demonstrated increasing interest in playing a constructive role in international carbon mitigation efforts. It still believes that industrialized countries must act first to address the problem they largely created, but now appears ready to cooperate in the Clean Development Mechanism and other joint carbon mitigation activities that have additional domestic benefits.

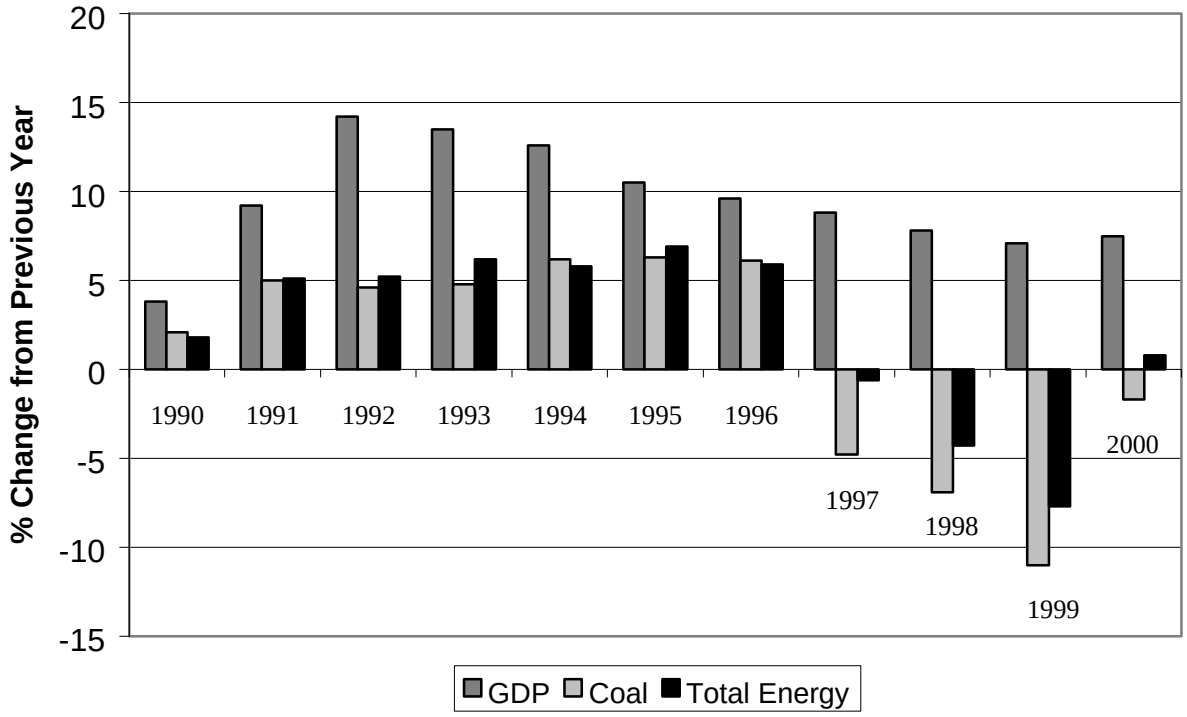
Conclusions

Chinese energy markets rode a roller coaster of uncertainty over the past five years. Coal use fell precipitously, even as the economy continued to expand, but market demand is beginning to recover and future demand will likely grow, albeit slowly. Domestic oil production is stagnant, but robust demand has forced China to import growing quantities of oil. Surging international investment is also helping to accelerate the pace of reform within China's petroleum sector. Electric power supply overshot expected demand from 1997 to 1999, causing a sudden slowdown in foreign investment in the power sector. Strong growth over the past year has begun to correct the mismatch, however, and China's overall power consumption remains relatively low. After decades of being ignored, China's natural gas sector looks set to play a much larger role in helping China meet its energy needs efficiently with minimal environmental damage. Renewable energy will continue to play a limited role until market distortions are removed and costs decline. Government policies focused on energy conservation and energy efficiency within the central planning context succeeded in preventing the need for a substantial amount of new energy supply over the past two decades. Opportunities to improve the overall efficiency of energy use in China remain enormous and the transition to a market economy is creating new opportunities for companies to profitably cut energy use.

Further research is needed to understand recent energy trends in China. In particular, researchers need to survey some of the coal mining areas that were reportedly closed to estimate how much illegal production might be occurring. Some aspects of China's participation in the Clean Development Mechanism related to the United Nations Framework Convention on Climate Change could be affected if the measurement of key statistics remains in doubt. Better understanding the linkage between economic reform and energy consumption would help predict future trends and focus limited resources on the most promising pollution mitigation options.

Domestic reforms continue to tighten the links between the Chinese economy and the global marketplace. This integration will help overcome the distortions in energy markets created during decades of central planning. It will also have an overall positive impact on the environment. The pace of implementing these reforms, however, is likely to continue in fits and starts as China struggles to define the needs and priorities of its huge population in a world that is changing almost as rapidly.

Figure 1 - Reported Growth Rates of GDP and Primary Commercial Energy Use in China



Source: *Zhongguo Tongji Zhaiyao 2000* [China Statistical Abstracts], State Statistical Bureau. *China Statistical Yearbook 1999*, State Statistical Bureau; Figures for 2000 based on preliminary data in "China Statistical Information Network," State Statistical Bureau.

Table 1 - Reported Primary Energy Consumption in China (MTCE)

	Total	Coal	Petroleum	Natural Gas	Hydro
1985	766.8	581.2	131.1	16.9	37.6
1986	808.5	612.8	139.1	18.6	38.0
1987	866.3	660.1	147.3	18.2	40.7
1988	930.0	708.6	158.1	19.5	43.7
1989	969.3	736.7	165.8	19.4	47.5
1990	987.0	752.1	163.8	20.7	50.3
1991	1037.8	789.8	177.5	20.8	49.8
1992	1091.7	826.4	191.0	20.7	53.5
1993	1159.9	866.5	211.1	22.0	60.3
1994	1227.4	920.5	213.6	23.3	70.0
1995	1311.8	978.6	229.6	23.6	80.0
1996	1389.5	1037.9	250.1	25.0	76.4
1997	1381.7	987.9	281.9	23.5	85.7
1998	1322.1	920.2	284.3	29.1	88.6
1999	1220.0	818.6	285.5	34.2	81.7
2000	1229.8	804.3	294.0	37.2	94.0
AAGR (%)	3.2	2.2	5.4	5.3	6.1

Note: Figures for 2000 estimated by author. Rounding may make some totals appear different from sums. All other data from SSB, 1999 and SSB, 2000. China also consumes a small amount of electricity generated from nuclear reactors. AAGR means average annual growth rate.

Table 2 – Forecasts of Primary Energy Consumption in China (MTCE)

	2000		2020	
	Coal	**Total**	**Coal**	**Total**
ADB[1]	1054	1491	1517	2435
World Bank[2]	1124	1561	2214	3301
UNEP[3]	1072	1505	1626	2545
CCCS[4]	1169	1562	1982	2778
ALGAS[5]	1169	1562	2022	2920
Average of Forecasts	1118	1536	1872	2796
Reported*	805	1230	1345	2273
Revised*	905	1345	1445	2373

* Year 2000 primary energy consumption is based on preliminary production statistics. Values for 2020 in the reported and revised row assume future growth rates for energy consumption as given in the Climate Change Country Study report. Natural gas consumption in the revised case is projected to rise to 200 billion cubic meters in 2020, in line with new government forecasts. Revised energy consumption assumes that unreported coal and petroleum use of 100 MTCE and 15 MTCE, respectively, in 2000.

1. East-West Center, Argonne National Laboratory, and Tsinghua University. 1994. *National Response Strategy for Global Climate Change: People's Republic of China.* Manila: Asian Development Bank.
2. Joint Study Team. 1994. *China: Issues and Options in Greenhouse Gas Control*. Washington DC: The World Bank.
3. United Nations Environment Program and National Environmental Protection Agency. 1996. *Incorporation of Environmental Considerations in Energy Planning in the People's Republic of China*. Beijing: China Environmental Science Press.
4. Research Team of China Climate Change Country Study (CCCS). 1999. *China Climate Change Country Study.* Beijing: Tsinghua University Press.
5. China State Science and Technology Commission. 1999. *Asia Least Cost Greenhouse Gas Abatement Strategy (ALGAS): China*. Manila: Asian Development Bank.

Table 3 - Forecasted Emissions of Carbon Dioxide in China (MTC)

	1990 Actual	1995 Actual	2000	2020
ADB			907	1354
World Bank			987	2045
UNEP			1027	1636
CCCS			915	1584
ALGAS			915	1695
Average – BAU			**950**	**1663**
Average – Policy			**882**	**1370**
Reported Trends	**567**	**740**	**724**	**1265**
Revised Estimate			**800**	**1449**

BAU means "business as usual"
Revised estimate assumes unreported coal use of 100 MTCE and petroleum consumption of 15 MTCE in 2000.