

# **CHINA'S ENVIRONMENT AND THE CHALLENGE OF SUSTAINABLE DEVELOPMENT**

Foreword by N.T. Wang

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## — Chapter 7 —

# Environmental Implications of China's Energy Demands

## An Overview

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Over two decades of rapid economic growth, energy demand in China has increased tremendously. In 1980 the total primary energy consumption in China was 17.3 quadrillion Btu, and in 2001 it increased to 39.7 quadrillion Btu.<sup>1</sup> Energy is the physical driving force behind industrialization. In developing countries, energy demand is closely correlated with economic growth. A robust economy, in turn, leads to prosperity. As living standards rise, people increase their spending on home appliances for air conditioning, refrigeration, cooking, and space and water heating, as well as on automobiles and other energy-intensive products. Energy consumption in China is expected to increase continuously. At an average annual rate of 3.5 percent, it is projected to reach 90.8 quadrillion Btu in 2025.<sup>2</sup> China is the world's most populous country, and its energy production and consumption give rise to significant health and environmental impacts both domestically and globally. Because production of energy generally is associated with adverse environmental impacts, this chapter examines the availability of energy sources in China in the future and assesses the environmental effects of increased energy consumption.

In the next section, we present an overview of China's current energy situation and its future prospects. We begin with a discussion of coal, China's primary source of energy. In 2001 coal constituted about 64 percent of China's energy consumption. This statistic reflects China's abundant reserves of coal and limited reserves of oil and natural gas. Many of China's energy-related environmental problems—particularly acid rain and air pollution—result from the country's reliance on coal. Another major contributor to air pollution is

urban smog caused by automobiles. China's transportation sector is expected to grow significantly as a result of its admission to the World Trade Organization (WTO), and we will discuss China's efforts to address the resulting environmental impact through regulatory efforts and the use of clean fuel sources.

The future energy mix will be influenced by many (often mutually conflicting) factors, including economic growth, environmental concerns, regulatory changes, and technological progress. A consequence of improved personal wealth is a yearning for greater personal freedom. Therefore, an important factor in China's near future is the social impact of energy production—particularly the use of coal, nuclear power, and hydroelectric projects. In the third section, we identify several variables that could impact China's future energy consumption trends.

### China's Energy Outlook

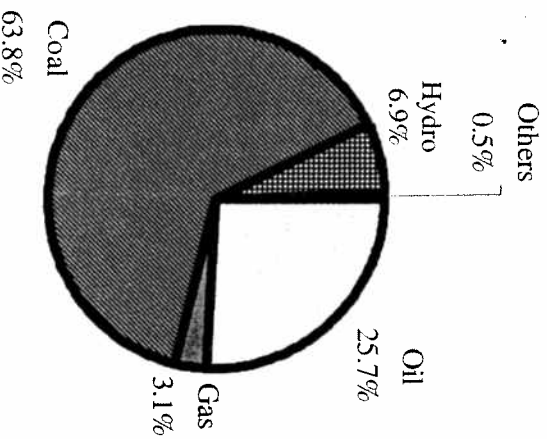
China has a population of 1.285 billion and had a gross domestic product (GDP) in 2001 of US\$1.2 trillion, an increase of 7.3 percent over 2000.<sup>3</sup> With an enormous and still-growing population, and a strong desire to raise living standards, China's energy consumption is expected to double within the next two decades. Total primary energy consumption in China in 2001 was 39.7 quadrillion Btu, putting it second in the world. A breakdown of China's energy consumption by source is shown in Figure 7.1.

As indicated above, coal is the dominant source of energy in China, 64 percent, followed by oil, 26 percent. Hydroelectric power, 7 percent, and natural gas, 3 percent, contribute the rest of China's energy needs. The "others" category corresponds to merely 0.18 quadrillion Btu, which is essentially composed of nuclear power. We detail each source below.

#### *Coal*

China is the world's largest consumer and producer of coal. In 2001 China consumed 1.25 billion metric tons of coal, more than 26 percent of the world's total consumption.<sup>4</sup> The United States is another heavy coal user, with consumption comparable to China's: 0.96 billion metric tons in 2001. While most coal in the United States is used for electric power generation, which is subject to clean air standards, coal in China has been used primarily in the industrial sector, for steam and direct heat (mainly in the chemical, cement, and pulp and paper industries); and for the manufacture of coal coke for the steelmaking process. Coal is also used directly by households for heating and cooking. Because coal consumption is spread so broadly among a range

Figure 7.1 China's Energy Consumption, 2001



of end users; coal-related emissions in China traditionally have not been subject to clean air standards. This situation has impeded the enforcement of environmental regulations.

Coal combustion results in several types of emissions that adversely affect the environment, particularly ground-level air quality. The main emissions from coal combustion are carbon dioxide ( $\text{CO}_2$ ), sulfur dioxide ( $\text{SO}_2$ ), nitrogen oxides ( $\text{NO}_x$ ), particulates, and mercury ( $\text{Hg}$ ).  $\text{SO}_2$  and soot caused by coal combustion are two major air pollutants, forming acid rain, which now falls on about 30 percent of China's total land mass. Industrial boilers and furnaces are the largest single-point sources of urban air pollution. Coal mining also has direct effects on the environment: strip mining affects land and causes subsidence; coal piles and slag heaps generate considerable quantities of pollutants. In addition, the coal mining process takes a high human toll. Over the past decade, nearly 10,000 mining deaths have been reported annually.<sup>5</sup>

China has limited reserves of oil and natural gas, as we will discuss later, and it has expressed a strong interest in coal liquefaction technology, particularly given the potential to apply such technology as a substitute for petroleum used in the transportation sector. The first pilot coal liquefaction plant became operational in coal-rich Shanxi Province in late 2001. In addition, Royal Dutch/Shell signed an agreement in late 2001 for a coal gasification project in Hunan Province that will be used to replace naphtha as a

feedstock for a large fertilizer plant. Liquefaction and gasification require high temperature and pressure, and some of these processes emit toxic organic compounds such as polynuclear aromatic hydrocarbons, organonitrogen, and sulfur compounds. Widespread use of these technologies might result in significant environmental impacts due to the formation and dispersion of toxic substances into the air and water.<sup>6</sup>

The emission of  $\text{CO}_2$  is another significant by-product of coal combustion. On a per-unit-of-energy basis, coal combustion produces more  $\text{CO}_2$  than natural gas or most petroleum products; nearly 80 percent more than natural gas and approximately 20 percent more than residual fuel oil (the petroleum product most widely used for electricity generation). In 2001 the United States and China were the world's dominant coal consumers and also the two top emitters of  $\text{CO}_2$ , accounting for 24 percent and 13 percent, respectively, of the world's total emissions. Forecasts based on differing economic growth rates and shifting fuel mixes result in the prediction that by 2025, the United States' share of world  $\text{CO}_2$  emissions will decline to 22 percent, while China's share will increase to 18 percent.

Furthermore, the common use of coal for household heat and energy has led to indoor air pollution. There are numerous accounts of coal-related health hazards.<sup>7</sup> Documented examples of health effects include numerous cases in Guizhou Province of cancerous skin lesions, deformed limbs, arsenic poisoning, and fluorosis, which can soften and disfigure teeth and bones. Only in the past few years have scientists determined the source of the arsenic and fluorine: coal. Damp and cool autumn weather makes it impossible to dry corn, chili peppers, and other crops outside, so families bring them indoors to dry over coal-burning heat sources. The coal used in Guizhou Province contains unusually high concentrations of arsenic and fluorine. Compounding the problem of the contaminated fuel is that most homes have no chimneys. As a result, volatilized elements from the coal collect indoors. While scientists now understand the source of the health problems, most residents have no alternative to using coal.

Although there is nearly universal agreement that China's coal pollution must be addressed, there is little doubt that coal will continue to play a dominant role in China's energy mix for the foreseeable future. As is the case for residents of Guizhou Province, much of China simply has no choice but to continue using coal despite the detrimental health and environmental consequences. While China's reserves of oil and natural gas are limited, it has coal in abundance, approximately 12 percent of the world's total. Therefore, coal demand is projected to rise significantly, at an annual rate of 3.2 percent. Consumption is projected to reach 2.65 billion metric tons in 2025, more than double current consumption levels. Although removal of pollutants such

as  $\text{SO}_2$  from flue gases is technically feasible, it is expensive. A twofold increase of coal consumption is likely to result in a significant increase in pollution.

## Oil

China is the world's third largest oil consumer, behind the United States and Japan. Consumption of petroleum products totaled 0.68 million metric tons per day in 2001, up from 0.66 million metric tons per day in 2000.<sup>8</sup> Within the next decade, China is expected to surpass Japan as the second largest oil consumer, making the former a significant player in the international oil market. Figure 7.2 shows the current major players in the international oil market.

China's demand for oil has grown with increased motorization and switching from coal and traditional noncommercial fuels to oil in the residential and service sectors. In 2001, in the transportation sector, vehicle ownership in China was 13 per 1,000 people. This figure compares with 779 per 1,000 people in the United States. China's accession to the WTO in 2001 is expected to increase competition in China's automobile sector, stimulating passenger car sales and demand for fuel.<sup>9</sup>

With strong growth in its automobile industry, the Chinese government has become increasingly concerned about air quality issues, particularly in urban areas. Since 2000 China has banned leaded gasoline, and the country is moving toward national emissions standards. Beijing has led the way in many initiatives, in part to prepare for its role as host of the 2008 Olympic Games. This progress includes compliance with the Euro 2 Emission Standard by Beijing as of January 1, 2003, and expected compliance by 2005 for the rest of the country.<sup>10</sup> The target date for implementing the Euro 3 Emission Standard in Beijing was January 1, 2005, and possibly 2010 for the rest of China. To meet these standards, the Beijing municipal government is ordering city vehicles to convert to liquefied petroleum gas and natural gas, as discussed below.

At a projected annual growth rate of 3.3 percent, China's oil consumption will reach 1.47 million metric tons per day by 2025.<sup>11</sup> China has estimated oil reserves of 2.5 billion metric tons—less than 3 percent of the world's reserves for a country with 22 percent of the world's population.<sup>12</sup> China has been a net oil importer since 1993. Imported oil accounts for more than 30 percent of its current consumption, a dependence that is expected to grow over the next two decades (Figure 7.3).

China's leadership is concerned about the country's increased reliance on oil imports and has been taking measures to ensure its energy security. The

Figure 7.2 Oil Consumption and Domestic Supply of Major Players in the International Oil Market, 2001

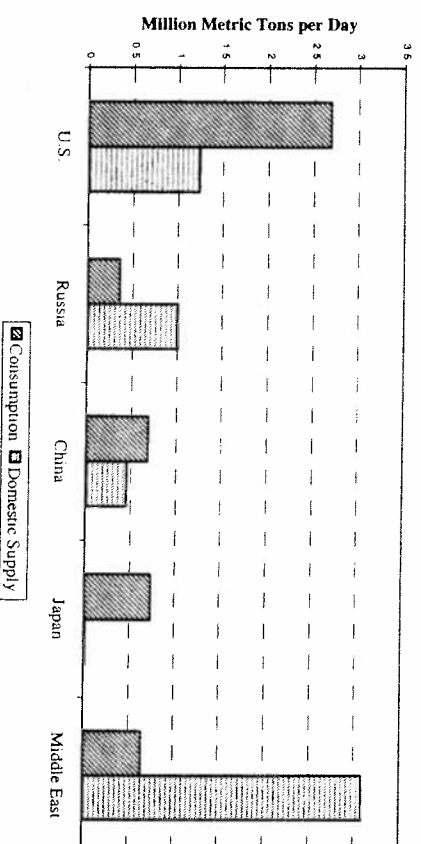
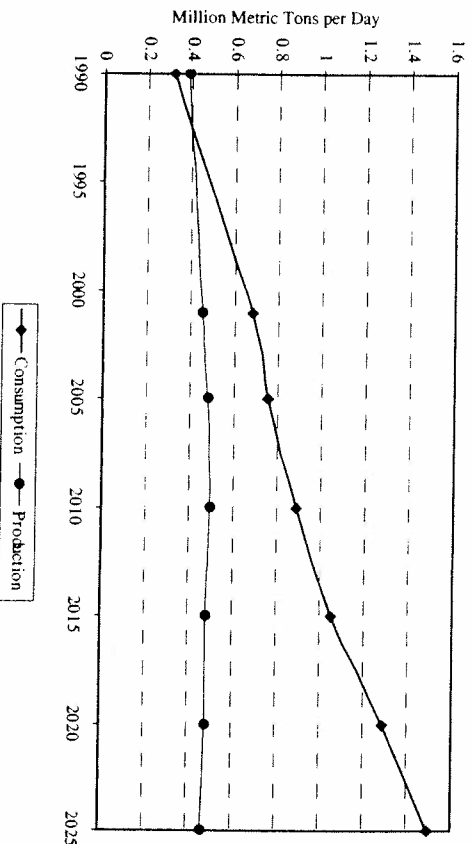


Figure 7.3 China's Consumption and Production of Oil, 1990–2025



Chinese government regards oil imports as a strategic vulnerability that could be exploited by foreign powers seeking to influence China. China has been strengthening relationships with oil-exporting countries and fostering the development of oil reserves in and seeking the establishment of stronger economic, political, and possibly military ties with Central Asia and Russia.<sup>13</sup> Despite these efforts, China is fundamentally reluctant to deepen its reliance on foreign oil. So long as this reluctance persists, China is not likely to replace coal with cleaner fuels on a large scale.

### *Natural Gas*

Historically, natural gas has not been a major component in China's energy mix. Until the 1990s, natural gas was used largely as a feedstock for fertilizer plants, with little use in power generation. In 2001 it accounted for only 3 percent of the country's energy mix. Among fossil fuels, natural gas produces the least pollution and the fewest greenhouse gases. Because of the environmental benefits of natural gas, China has made several moves toward increasing its use, including replacing polluting household-based cooking and heating coal stoves with natural gas stoves in major urban centers such as Beijing and Shanghai.

Handling gaseous fuels requires more sophisticated arrangements than for liquid fuels, and China's natural gas infrastructure remains rudimentary. Thus, transporting natural gas costs about four times more than transporting crude oil. Although natural gas can be cooled and compressed into liquid form for shipping by tanker, the conversion facilities are large and potentially dangerous. These challenges notwithstanding, China has been aggressively exploring its own natural gas resources. It has begun constructing liquefied natural gas (LNG) regasification terminals and has initiated several gas pipeline projects.

China has plans to increase natural gas supplies substantially and to expand its natural gas pipeline network despite the fact that it remains commercially unprofitable. The country's largest natural gas reserves are located in western and north-central China, necessitating a significant additional investment in pipeline infrastructure to carry it to densely populated eastern cities. The most ambitious of planned pipelines is the 4,184-kilometer (km) West-East Gas Pipeline under construction, which will connect gas fields in China's sparsely populated west to urban markets in the east. The pipeline will initially run from the Tarim Basin in Xinjiang Province to Shanghai and subsequently connect to Beijing through a 322-km link. This project represents a convergence of economic, political, domestic, and foreign policy interests and underscores the political and economic significance of Xinjiang.<sup>14</sup>

The share of natural gas used for power generation and residential cooking and heating is expected to increase significantly. The Chinese government anticipates that Beijing's natural gas infrastructure will be fully operational in time for the 2008 Olympic Games. Shanghai has announced that it will stop building coal-fired electric power plants and speed up the construction of natural-gas-fired plants. Guangdong Province has launched a project to build six 320-megawatt (MW) gas-fired power plants and to convert existing oil-fired plants with a capacity of 1,800 MW to liquefied natural gas.

To reduce air pollution, the Chinese government has been promoting the use of alternative fuel vehicles (AFVs). Many programs have been initiated in large cities, including Beijing, Shanghai, Tianjin, Chongqing, and Guangzhou. The Beijing municipal government is ordering city vehicles to convert to liquefied petroleum gas (LPG) and compressed natural gas (CNG). The capital's 5,100 buses and 32,000 taxis run on these alternative fuels, and seventy-five gas stations offer these two types of clean fuel. Similarly, Shanghai has 400 buses and 30,305 taxis that use alternative fuels and eighty-seven refueling stations to service these vehicles.<sup>15</sup>

It is expected that natural gas will gain market share from coal in the residential and commercial sectors. Consumption of natural gas is expected to increase more than sixfold by 2025, at a projected annual growth rate of 7.9 percent. Such growth requires increases in domestic production. Development of the natural gas industry is an element in China's quest for energy security, but China's natural gas supply is even more limited than its oil reserves. Its natural gas reserves are listed as 1.51 trillion cubic meters or 0.97 percent of the world's total.<sup>16</sup> Imports of natural gas to China, by pipeline and in liquefied form, will be necessary. China is projected to begin importing natural gas around 2005, and the share of imports in China's natural gas consumption is expected to reach 30 percent by 2020.<sup>17</sup>

### *Hydroelectric Power*

Over the next decade, China has extensive plans to expand its hydroelectric capacity above the current 79,000 MW of installed capacity. The Three Gorges Dam project, currently under construction, remains the world's largest and most ambitious hydropower project. With the displacement of more than one million people living around the construction site and reservoir, and submergence of significant archaeological sites, it continues as among the most controversial projects in the world today. In November 2002, work on the Three Gorges Dam project reached a significant milestone with the successful blocking of the Yangtze River. The river's waters are now being channeled through diversion holes in the partially completed dam. The dam's reservoir began to fill in June 2003.<sup>18</sup> By the end of 2003, it began generating electricity with the installation of the first four 700-MW generators. The project plans for a total of twenty-six generators, with a capacity of 18,200 MW, which are expected to become fully operational in 2009. The official cost of the Three Gorges Dam is set at US\$25 billion, although the actual cost is likely to exceed this figure.

At present, few attempts have been made to address concerns regarding the accumulation of toxic materials and other pollutants from industrial sites

that will be inundated after construction of the dam. Given China's scarcity of clean water, the extent to which dams and reservoirs improve or reduce water quality is a major concern. Despite criticism from the international community, the Chinese government argues that the dam is needed to provide electricity, claiming that it will replace ten large coal-fired power stations that otherwise would burn fifty million tons of coal, or the energy equivalent of twenty-six nuclear plants. By doing so, the government asserts, the dam will result in environmental benefits. In addition, the dam should reduce flooding on the Yangtze River.

In addition to the Three Gorges, the Chinese government has several other large-scale hydroelectric projects either under construction or in the planning stages. The Yellow River Water and Hydroelectric Power Development Corporation (YRWHD) is developing twenty-five hydropower projects on the Yellow River with a combined 15,800 MW of installed electric capacity. In July 2001 construction began on the 5,400-MW Longtan project on the Hongshui River, which is expected to begin operating in 2007. Other large-scale projects under construction include the 1,350-MW Dachaoshan hydroelectric project, scheduled for completion by the end of 2003, and the 4,200-MW Xiaowan project, scheduled for completion in 2012. The last two are located on the Mekong River. Proposals have been submitted for the 14,000-MW Xiluodu project (on the upper portion of the Yangtze River, known locally as the Jinsha River); 6,000-MW Xiangjiaba project (Jinsha River); 5,000-MW Nuozhadu project (Mekong River); and 1,500-MW Jinghong project (Mekong River).

As with the Three Gorges Dam, information on the actual consequences of dams and other water-related infrastructure on China's natural systems is limited; there are few comprehensive reviews. Based on experience elsewhere, some of the main physical and ecological concerns center on the loss and fragmentation of land, habitat, and species and the loss or degradation of many of the ecosystem functions that natural rivers provide. These include wetlands functioning as carbon sinks, nutrient recycling, and water purification.

### *Nuclear Power*

Although nuclear power represented just over 1 percent of total electricity generation in China in 2001, it has an important role in supplying the rapidly industrializing coastal provinces, which are remote from China's coalfields.

China's tenth Five-Year Plan (2001–5) incorporates the construction of nuclear power plants. New facilities under consideration include two additional 900-MW units at Lingao, and up to six 1,000-MW reactors at Yangjiang, Guangdong Province. Additional developments are to take place in Shandong

Province, with two 1,000-MW units planned for Haiyang. Also proposed are two 1,000-MW reactors at Hui An, Fujian Province and two 1,000-MW units at Sanmen, near Qinshan in Zhejiang Province.

In 2001 China had only three nuclear power units in operation: Guangdong 1 and 2 (944 MW each) and Qinshan 1 (279 MW). Four new units were opened in 2002, adding a total of 3,151 MW of nuclear capacity: Lingao 1 and 2 in Guangdong Province (938 MW each), Qinshan 2-A (610 MW), and Qinshan 3-A (665 MW) in Zhejiang Province. Four nuclear reactors are under construction: Qinshan 2-B (610 MW), Qinshan 3-B (665 MW), and Tianwan-1 and Tianwan-2 in Jiangsu Province (1,000 MW each). The last are scheduled to be completed in 2005. These projects involve Canadian, French, and Russian contractors.

Nuclear power is considered by some technically trained people to be the most benign of all energy sources in terms of environmental impact. However, nuclear waste is an extremely sensitive issue. Thus, projections of nuclear power capacity are fraught with economic and political uncertainty. If the projects outlined above come on line, China's nuclear capacity is projected to grow from 2,167 MW in 2001 to about 20,000 MW in 2025—the largest projected increase of any country in the world.

### *Nonhydroelectric Renewable Energy*

In 2001 nonhydroelectric renewable energy contributed merely 0.01 quadrillion Btu, or 0.02 percent of China's energy mix. With assistance from international donors, China has undertaken a multimillion-dollar effort to develop wind and solar projects. One example is the Brightness Program, launched in 1996 to encourage the use of solar panels and wind turbines for electricity generation using low-cost loans. Pilot projects under the program have been set up in Gansu, Inner Mongolia, and Tibet. The ultimate goal of the program is to provide electricity to eight million people by 2005 and to twenty-three million people by 2010.

In an effort to boost interest in wind-powered power generation, the Chinese government has announced that it will cut the value-added tax on wind-generated electricity by half, reducing the average cost of wind generation by between US\$6 and US\$7 per MW hour. The Asian Development Bank (ADB) is providing loans worth some US\$58 million to establish wind projects in Heilongjiang, Liaoning, and Xinjiang provinces. One of the projects is a 200-MW wind farm in Xinjiang, which is China's largest wind installation.

Current utilization of solar energy includes small-scale uses, such as household consumption, television relays, and communications. Solar energy consumption has been increasing steadily. For example, the number of solar kitchen

ranges in use has been climbing, a significant fact considering the negative environmental and health effects of coal-burning stoves mentioned earlier.

In addition to these material developments, energy efficiency is often considered an energy resource. There is huge potential in China for energy efficiency. Based on World Bank estimates, 10 percent of total Chinese industrial energy demand can be met through energy efficiency efforts by 2010. China has made impressive progress in raising energy efficiencies in both production and end uses.

### *Environmental Policy*

Over 90 percent of China's SO<sub>2</sub> emissions are attributable to coal-fired boilers. The government has been focusing on emissions from power generation and large industrial facilities, enacting a range of regulations and policies. In 1982, a SO<sub>2</sub> pollution levy was introduced, which became the cornerstone of national SO<sub>2</sub> control. The levy system proved only modestly successful at controlling emissions for two reasons: (1) the levy applied only to medium-sized and large sources and was set too low to encourage significant SO<sub>2</sub> abatement, and (2) the fee was rarely reinvested in new abatement activities. To improve the system, in 2000 the levy was changed from a fee based on excess emissions to a charge on total emissions. Moreover, in 2002 China implemented a new coal policy that increases the pollution levy to RMB 5 (US\$0.604) per ton and requires power companies and large industrial facilities to install desulfurization equipment. It mandates that smaller facilities use low-sulfur coal or cleaner fuel alternatives. The new policy is expected to reduce SO<sub>2</sub> emissions nationwide by 10 percent from 2000 levels within five years, and by 20 percent within specified "control zones," including Beijing, Shanghai, Tianjin, and 197 other cities. The control zones account for 11.4 percent of China's land area but for 66 percent of the 20 million tons of SO<sub>2</sub> emitted each year.

In a parallel effort to encourage a switch to cleaner burning fuels, the government has introduced a tax on high-sulfur coals. In Beijing, officials aiming to phase out coal from the city center have established forty "coal-free zones" and have made plans to construct natural gas pipelines. Similar efforts are underway in other major Chinese cities. In addition, pilot SO<sub>2</sub> emissions trading programs are underway in Taiyuan, Shanxi Province; Benxi, Liaoning Province; and Nantong, Jiangsu Province.<sup>19</sup> In early 2002 the State Environmental Protection Administration (SEPA) announced that the provinces of Shandong, Shanxi, Henan, and Jiangsu; the special administrative regions of Macau and Hong Kong; and three cities (Shanghai, Tianjin, and Lijuzhou) would pioneer China's first cross-provincial border emissions

trading pilot. Rules and a timetable for the pilot emissions trading programs are being developed.

While the Chinese government is concerned with the country's environmental problems, it tends to prioritize issues that directly impact its population, such as particulate matter and SO<sub>2</sub> emissions, rather than long-term concerns such as global warming. It is undertaking initiatives to lessen emissions of pollutants such as SO<sub>2</sub> and nitrogen oxide through improved pollution controls on power plants as well as policies designed to increase the proportion of natural gas in the country's fuel mix. China is a non-Annex I country under the United Nations Framework Convention on Climate Change, meaning that it has not agreed to binding targets for reduction of CO<sub>2</sub> emissions under the Kyoto Protocol. China's contribution to world CO<sub>2</sub> emissions is expected to increase in the coming years, with some forecasts suggesting China's emissions may exceed those of the United States by 2025.<sup>20</sup> Thus, any effort to curb greenhouse gas emissions will be futile without China's involvement.

### *Projections*

Figures 7.4 and 7.5 summarize the projections of China's primary energy consumption through 2025. The growth rate of hydroelectric power and oil is consistent with the growth rate of overall total energy usage. Hence, their projected share of China's energy mix remains unchanged at 7 percent and 26 percent respectively. The phenomenal growth in natural gas consumption results in a significant increase in its share in China's energy mix, from 3 percent in 2001 to 8 percent in 2025. Although the projected growth of China's nuclear capacity is no less spectacular if it materializes, its share in the energy mix increases from essentially zero in 2001 to just 1 percent in 2025. As a result, nuclear energy will do little to offset the anticipated rapid growth in electricity demand or CO<sub>2</sub> emissions. Increases in natural gas and nuclear energy result in a decline in the share of coal from 64 percent to 58 percent. On an absolute scale, however, coal consumption in China will increase tremendously. While the world's coal use has been in a period of slow growth since the 1980s due to environmental concerns, China is a key exception. China's share of the world's total consumption is projected to rise from 26 percent in 2001 to 39 percent in 2025.

### **China's Future Energy Sources**

Based on the *International Energy Outlook 2003 (IEO2003)* forecast, China's consumption of every primary energy source will increase over the next twenty-five years, but the basic structure of China's energy mix will not change

Figure 7.4 China's Projected Energy Consumption, 2025

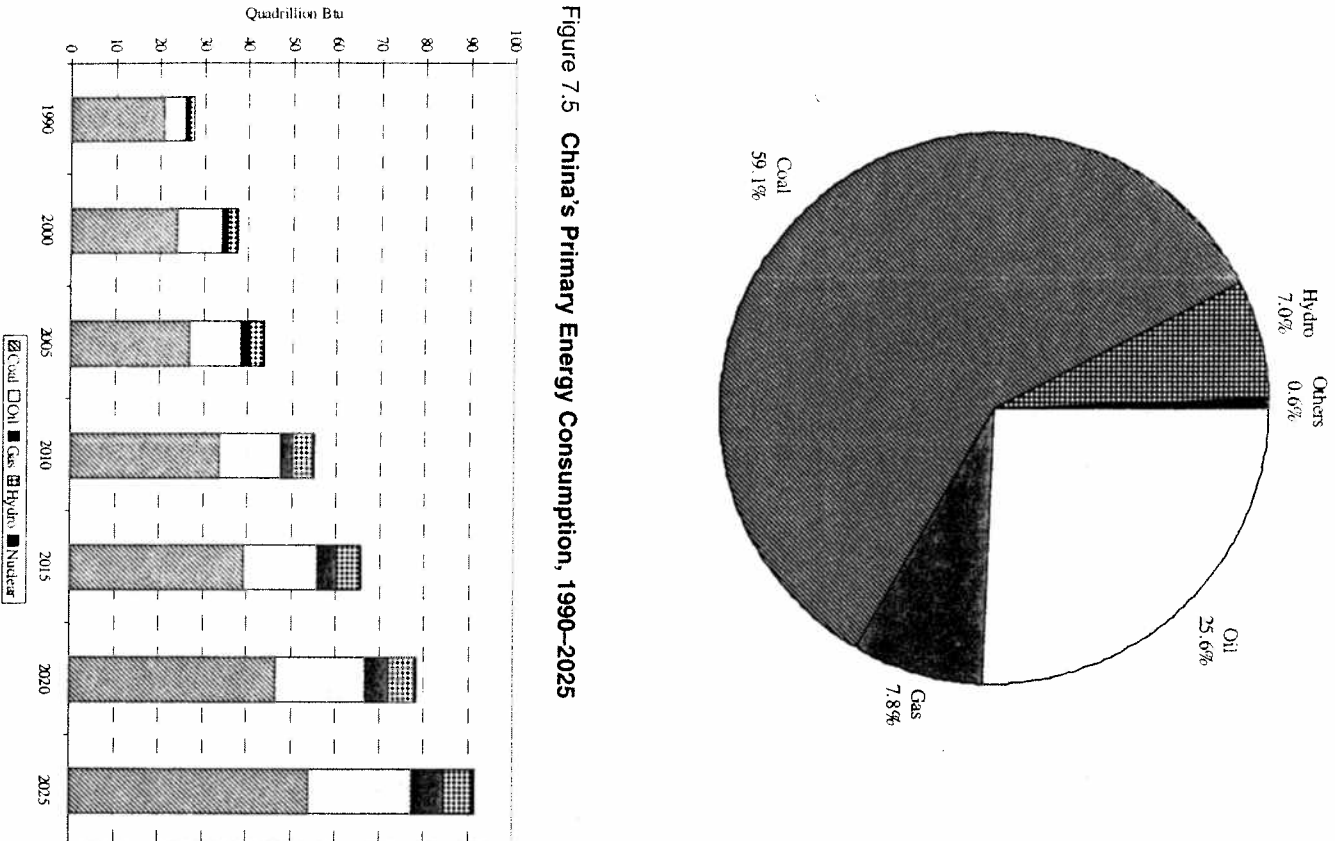


Figure 7.5 China's Primary Energy Consumption, 1990-2025

significantly. Much of the increase in its future energy demand is projected to be for fossil fuels, because it is expected that fossil fuel prices will remain relatively low and that the cost of generating energy from other fuels will not be competitive. Because the share of fossil fuels in China's overall energy consumption is expected to remain by far the greatest (more than 90 percent), CO<sub>2</sub> emissions will increase accordingly, from 832 million metric tons in 2001 to a projected 1,844 million metric tons in 2025. China is unlikely to place a high priority on efforts to reduce or stabilize CO<sub>2</sub> emissions.<sup>21</sup>

Among fossil fuels, coal will continue to play the dominant role, despite the resulting environmental damage. From the preceding discussion, it is apparent that a decline of coal's share in the energy mix, from 64 percent in 2001 to 58 percent in 2025, is more the result of high growth in other sources than a reduced reliance on coal per se. Because the *IEO 2003* projections are influenced by numerous variables, they are subject to considerable uncertainty. In the following section, we discuss issues that might lead to even heavier coal usage, and discuss the challenge posed by China's reliance on coal.

### *Future of Oil and Natural Gas*

To develop a basis for understanding the future consumption of oil and gas in China, we can consider the historical trends of energy consumption in developed countries. Oil consumption increased sharply in the United States and Europe after World War II, in part as a response to environmental crises. For example, London suffered from "killer fogs" linked to coal burning. In response, "smokeless zones" were established, in which the burning of coal for home heating was banned, and in 1957 Parliament passed the Clean Air Act, which favored oil. Similarly, a smog crisis in New York City on Thanksgiving in 1966 precipitated passage of the Air Quality Act the following year.<sup>22</sup> Within two years, Consolidated Edison, the utility serving New York City, switched to oil.

In 1955 coal met 75 percent of Western Europe's energy needs, and oil 23 percent. By 1972, coal's share shrunk to 22 percent, while oil consumption rose to 60 percent, nearly a complete reversal.<sup>23</sup> The situation was not as dramatic in the United States, because the United States is rich in coal reserves. Nonetheless, the proportion of coal in the United States energy mix dropped from 37 percent in 1949 to 17 percent in 1972.<sup>24</sup> However, the major reason for the switch from coal to oil in Western Europe and the United States was *cost*: in the 1950s, with repeated price cuts, oil was more cost effective than coal. While Japan had a later start, inexpensive oil proved to be the fuel of choice, and it became the energy source that powered Japan's remarkable economic growth.

Unfortunately, cheap oil is not an option for China. As global consumption rises and oil supplies are restricted, economics dictate that oil prices will rise. Therefore, *cost* is a primary factor preventing China from substituting oil for coal. Oil price shocks in the 1970s sent the major economies into recession, highlighting the vulnerability of Western economies stemming from their reliance on oil. Today, a large and growing portion of the world's oil supplies comes from relatively unstable locations, including the Middle East and the former Soviet states surrounding the Caspian Sea. There are no guarantees of an uninterrupted oil supply, another factor that discourages China from shifting from coal to oil.

A more fundamental problem is that global oil supplies are finite. It is difficult to say with certainty how long supplies will last. A pessimistic prediction asserts that, at current rates of production and consumption, the world's oil will last another forty-five years; an optimistic projection asserts another 100 years.<sup>25</sup> As reserves diminish and become more costly to extract, it seems reasonable to assume that oil quantities will be severely restricted at some point within this time frame. The most feared potential consequence of declining oil supplies and rising prices is a long-term economic downturn. Projected to be the second largest oil consumer in the world, China must be prepared to deal with severely limited oil supplies and adjust to a post-oil economy.

Natural gas is part of China's energy diversification strategy to reduce its dependence on oil. Unlike oil, natural gas supplies are geographically dispersed, not concentrated in the Middle East. Natural gas, a clean-burning fuel, offers an attractive option for China. However, the high costs of exploration, development, and transportation hinder China's switch to natural gas. It is difficult to gauge supply needs, which are affected by economic cycles and weather patterns, and the lack of such information makes it difficult to forecast profitability and attract capital investment.

Technology may offer a partial solution. The industrial process used to convert natural gas to a liquefied form has improved. Today, natural gas can be converted to liquid fuels at prices that are only about 10 percent higher than crude oil. Modest technical improvements should broaden the exploitation of this commodity in coming years, and such developments will also provide remarkably clean fuels.<sup>26</sup> Experts say that the price per million Btu needed to justify new investment is in the range of US\$3–4.50. In late 2003, the price hovered around US\$6, although few expect it to stay that high.<sup>27</sup> Liquefied natural gas (LNG) can be used in place of petroleum to generate energy. The need for fuel for the transportation sector is the single most important factor driving China's increasing demand for oil. If advanced methods of producing liquid fuels from natural gas can be made profitable and scaled up quickly, natural gas may become the next major source of transportation fuel, thereby meeting some of China's vital energy needs.

### *Future of Nuclear Energy*

Nuclear energy was once regarded as the realization of a dream for cheap, unlimited electric power. This attitude has changed significantly following the Three Mile Island and Chernobyl nuclear disasters. In recent years, efforts to curb CO<sub>2</sub> emissions have put nuclear power back in the spotlight.<sup>28</sup> A study suggests that the only reasonably sure way to cut emissions in China substantially over the next thirty years is through the massive construction of nuclear power plants.<sup>29</sup> However, under most economic assumptions, nuclear power is a relatively expensive option for electricity generation when compared with natural gas or coal, particularly given China's access to inexpensive coal.<sup>30</sup>

In addition, the fate of nuclear power is closely linked to public attitudes.<sup>31</sup> While the ability of people in China to protest may be limited, it is unrealistic to discount the possibility of popular opposition. It is worth noting that environmentalism was the most important rallying point for the democratic movement in some countries. Nuclear power plays a uniquely sensitive role in politics, and it is too soon to say whether China will fulfill its ambitious plans to increase its nuclear capacity as projected.

### *Future of Renewable Energy Sources*

At a time when many countries throughout the world are dismantling hydroelectric dams, China has been making tremendous investments in hydroelectric power. While hydroelectric power can make a substantial contribution to China's energy supplies, it has limitations that make it a less attractive option. Constraints include the geographic concentration of dams (primarily in the center and southwest of the country), sizable capital investment required, and long lead time, as well as substantial social and environmental risks. As noted previously, more than one million people were displaced by the Three Gorges Dam project. A less publicized fact is that, since 1985, five large dam projects (supported by World Bank loans), with a total installed capacity of 7,040 MW, displaced approximately 343,000 people.<sup>32</sup> Many existing dams were built at a time when environmental and social standards were largely absent. However, based on reactions in recent years, it is almost certain that future large-scale projects will not proceed without strong opposition.

For the foreseeable future, renewable sources such as solar and wind power are not sufficiently technologically advanced to meet more than a fraction of China's needs. As discussed earlier, an array of international programs are promoting renewable energy in China, but the effect of these programs is largely symbolic. They are unlikely to make a significant impact on China's energy needs or its environment.

### Future of Coal

Coal is the most plentiful fuel in China, and at present rates of consumption, China has sufficient reserves to last another 100 to 200 years. If energy development projects from other sources are not fulfilled, coal is likely to fill the gap. China has been researching converting coal to gas or liquid fuels to create a substitute for vehicle fuels. However, not only is this process expensive, but doing so on a significant scale would require enormous mining projects and create vast environmental damage. These actions could roll back China's commitment to adopting vehicular emissions standards.<sup>33</sup>

While there are claims that "switches to low-sulfur coal, scrubbers and other air-pollution control devices have today removed the vast part of sulfur dioxide and nitrogen dioxide emissions,"<sup>34</sup> it is important to read between the lines. Looking at the United States, for example, emissions of nitrogen oxides from coal-burning electric power plants were 6.1 million short tons in 1980 and 5.4 million short tons in 1998; emissions of SO<sub>2</sub> were 16.1 million short tons in 1980 and 12.4 million short tons in 1998. Although these modest reductions are welcome, they hardly qualify as the "vast part" of the emissions.<sup>35</sup> The improvements in the United States followed significant investments in pollution-reducing equipment. Plants in the United States had an incentive to invest in such technology: a plant owner faces fines of up to US\$2,000 per ton of emissions.<sup>36</sup> By comparison, China's new pollution policy has increased the pollution levy to only RMB 5 (US\$0.604) per ton of SO<sub>2</sub>.

Therefore, even if China enforces its pollution policy effectively, it will generate limited funding for equipment upgrades. So long as China continues to rely on coal, it is unclear how the country will attain a clean air standard and mitigate the environmental impacts. In addition, China is grappling with the high human toll of coal mining. China's coal industry has an appalling record: Beijing's work safety bureau reported that at least 4,500 fatalities occurred in coal mines last year, although unofficial estimates put the figure as high as 10,000.<sup>37</sup> Less dramatic, but just as devastating, is the severe damage to human health by black lung disease. These problems are pressing social issues that the country must address.

### Conclusion

As its economy continues to expand, China's energy needs escalate. To increase its energy production, China faces a range of unpleasant choices. There is no costless solution for energy production, and all energy sources create their own sets of issues. Coal is an undesirable yet unavoidable option. China's aggressive energy development projects in the areas of hydroelectric power,

natural gas, and nuclear power tend to be risky. Some of these projects have been criticized as monumental environmental gambles.

Replacing dirty coal with cleaner oil has played a pivotal role in environmental preservation in the United States and Europe during their post-World War II economic expansions. At present, the high cost of oil has caused serious economic problems for all nations, but China suffers especially acutely because it must pay for imported energy supplies with precious foreign exchange. When the issues are presented starkly as "economic growth versus clean environment," the pressure on Chinese politicians to allow industry to defer pollution control measures seems irresistible. We can only hope that technological advancements provide affordable solutions to minimize energy-related environmental degradation.

On the brighter side, the coming of the 2008 "green" Olympic Games has increased China's awareness of the need for environmental protection, and this awareness has been reflected at the policy level. China's adoption of vehicular emissions standards is a positive first step. Coming at the dawn of an era of fast growth in automobile ownership, an early start is the most effective means of ensuring future air quality control.

### Notes

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1. In comparison, total primary energy consumption in the United States in 2001 was 97.1 quadrillion Btu.

2. U.S. Energy Information Administration (EIA), *International Energy Outlook 2003 (IEO2003)* (Washington, DC: Government Printing Office, 2003), 181. The projection cited here is the reference case, which assumes the annual growth rate of gross domestic product (GDP) to be 6.2 percent.

3. Much material in this section is taken from *IEO2003*, published by the U.S. Energy Information Administration. All subsequent quotes and statistical data are assumed to be from this source unless otherwise indicated. Energy-related data and forecasts are difficult tasks and are the subjects of numerous studies and disagreements. Another authoritative, perhaps more commonly cited, source is the *World Energy Outlook* published by the International Energy Agency (IEA). We have adopted information from *IEO* due to its easy access over the Internet. A key omission in this chapter is the topic of biomass consumption. Biomass is composed chiefly of crop wastes, fuelwood, and dung. Because it is collected and used as fuel outside of formal markets, biomass is not reflected in official energy statistics. Although it is poorly understood, one estimate suggests that biomass accounts for about 15 percent of China's actual total energy consumption. This estimate reflects the general limitation of data relating to rural conditions in China—a major caveat, given that half of China's population, or 640 million people, still live a fundamentally rural existence.

4. We made a conversion of the *IEO2003* data using 1 short ton = 0.907 metric ton. In terms of energy, the gross heat content of coal depends on country and year. For China in 2001, the conversion factor is 18,512 thousand Btu per short ton (U.S. Energy Information Administration, *International Energy Annual 2003*, 146).
5. BBC News, "Scores Dead in China Mine Blast," Sept. 28, 2000.
6. Advanced coal gasification technology exists that will enable easier control of pollutants. See, e.g., Ni and Sze, "Energy Supply and Development in China." Economic viability remains a major concern.
7. E.g., Peng et al., "Indoor Air Pollution from Residential Energy Use in China." This paragraph closely follows Simpson, "Coal Control," 20.
8. A conversion of the *IEO2003* data using a factor 1 metric ton = 7.3 barrels is used; see *International Energy Annual 2003*, 137.
9. Bradsher, "China's Factories Aim to Fill the World's Garages," A8.
10. Under this standard, in the near future, nitrogen and oxygen compound emissions from light-duty vehicles should decrease about 55 percent, and particulates from heavy-duty vehicles should decrease by 55 percent. See *People's Daily*, "Beijing to Apply Euro 2 Emission Standard Next Year," July 29, 2002, english.peopledaily.com.cn/200207/29/eng20020729\_100511.shtml.
11. In comparison, oil consumption by 2025 is projected to be 4.0 million metric tons per day in the United States and 0.89 million metric tons per day in Japan.
12. From the most recent estimates in PennWell Corp., *Oil and Gas Journal*, 52.
13. This subject has been studied by various groups, e.g., Downs, *China's Quest for Energy Security*.
14. Andrews-Speed, Liao, and Dammreuther, "Searching for Energy Security," 13–28.
15. Lun Jingguang, "Clean City Vehicles in China."
16. PennWell Corp., *Oil and Gas Journal*, 52.
17. Downs, *China's Quest for Energy Security*, 9. See also references therein.
18. Kahn, "A River Rises Through It, Washing Away the Past," 14.
19. Chapter 6 in this volume details the emissions trading program in Taiyuan.
20. Bradsher, "China's Boom Adds to Global Warming Problem," A1.
21. May, "Energy and Security in East Asia," 16–19.
22. "Smog Here Near the Danger Point," *New York Times*, Nov. 25, 1966, 1.
23. Yergin, *The Prize*, 545.
24. U.S. Energy Information Administration, *Annual Energy Review 2002*, www.eia.doe.gov/newuaer/tx/1801b.html.
25. Campbell and Laherrère, "The End of Cheap Oil," 78; PennWell Corp., *Oil and Gas Journal*, 52; Smith, *Energy, the Environment, and Public Opinion*, 54–58.
26. Fouda, "Liquid Fuels from Natural Gas," 92.
27. Wald, "In Natural Gas's Future," C2.
28. Rhodes, "Nuclear Power's New Day,"
29. Lu, "The Role of Nuclear Energy in the CO<sub>2</sub> Mitigation Strategy of the People's Republic of China," 20.
30. A Massachusetts Institute of Technology study suggests that the cost of nuclear power is 6.7 cents per kilowatt-hour, compared to 4.2 cents for coal and natural gas (without assigning a cost to CO<sub>2</sub> emissions); see Deutch and Moniz, "How to Prevent the Next Energy Crisis."
31. See, e.g., Nordhaus, *The Swedish Nuclear Dilemma*.

32. Fugle and Smith, "Experience with Dams in Water and Energy Resource Development in the People's Republic of China," www.dams.org/report/.
33. There are potential merits to the coal gasification technology mentioned earlier. One major advantage is the possibility of CO<sub>2</sub> capture and geological sequestration. For additional information see www.fossil.energy.gov/programs/sequestration/geologic/.
34. Taken from Holdren, "Energy: Asking the Wrong Question," which quotes Lomborg, *The Skeptical Environmentalist*, and USEPA, *National Air Pollutant Emission Trends 1900–1998*.
35. *Ibid.*
36. Kubasek and Silverman, *Environmental Law*, 166.
37. BBC News, "Blast Hits China Mine," May 14, 2003.

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