

# Environmental Implications of Energy Policy in China

NATHANIEL T. ADEN & JONATHAN E. SINTON

Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

**ABSTRACT** *Acquiring and using energy damages the environment more than almost any other set of human activities. However, increased energy usage does not necessarily lead to environmental degradation. As China's energy system undergoes sporadic bouts of market liberalisation, decentralisation, internationalisation, and urbanisation, governance plays an important role in influencing environmental outcomes. A review of institutional reforms since 1978, focusing on coal, hydropower, and rural energy, illustrates the role of government policy, implementation, and institutions in augmenting and abating the environmental degradation that can accompany expanded energy usage. This article explores the interaction between energy, governance, and the environment in China, and identifies key variables that can influence the environmental impacts of future energy usage.*

## **Energy, Governance, and Environment in China**

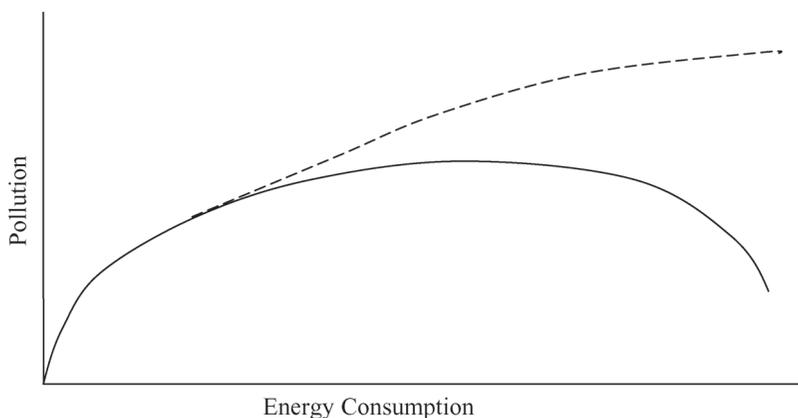
Acquiring and using energy damages the environment more than almost any other set of human activities. However, as Deng Xiaoping stated in 1980, 'Energy is the priority issue in the economy'. Given the strong positive correlation between energy consumption and income, the environmental Kuznets curve (EKC) provides a useful theoretical framework for evaluating the relationship between energy and environment in China. Simon Kuznets unveiled his eponymous, inverted U-shaped curve in 1955 to conceptualise the relationship between income inequality and development. In 1993, Grossman and Krueger adapted the original Kuznets curve to describe pollution trends at various stages of economic development.<sup>1</sup> The substitution of energy consumption for per-capita income generates an energy–environmental Kuznets curve (EEKC), which illustrates the range of relationships between energy, governance and environmental outcomes in China.

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*Correspondence Address:* Nathaniel T. Aden, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, 90R4000, Berkeley, CA 94720, USA. Email: ntaden@lbl.gov

At the initial stages of development, energy consumption increases at the cost of environmental degradation. The EEKC model predicts that environmental degradation will subside as the economy reaches higher per capita energy consumption (and income) levels. However, the optimistic logic of the EEKC (represented by the solid line in Figure 1) is disputed by ‘race to the bottom’ proponents, who foresee an ongoing positive relationship (along the dotted line) (Dasgupta *et al.*, 2002). For the purpose of environmental analysis, the EEKC model is path dependent and dynamic: energy systems vary by region according to local economic, demographic, and geographic conditions, and the shape of each region’s EEKC is mutable according to government policies, implementation, and institutions. In light of recent economic growth trends and the environment’s already parlous condition, the positive or negative slope of China’s aggregate energy–environmental Kuznets curve will have important implications for future generations.

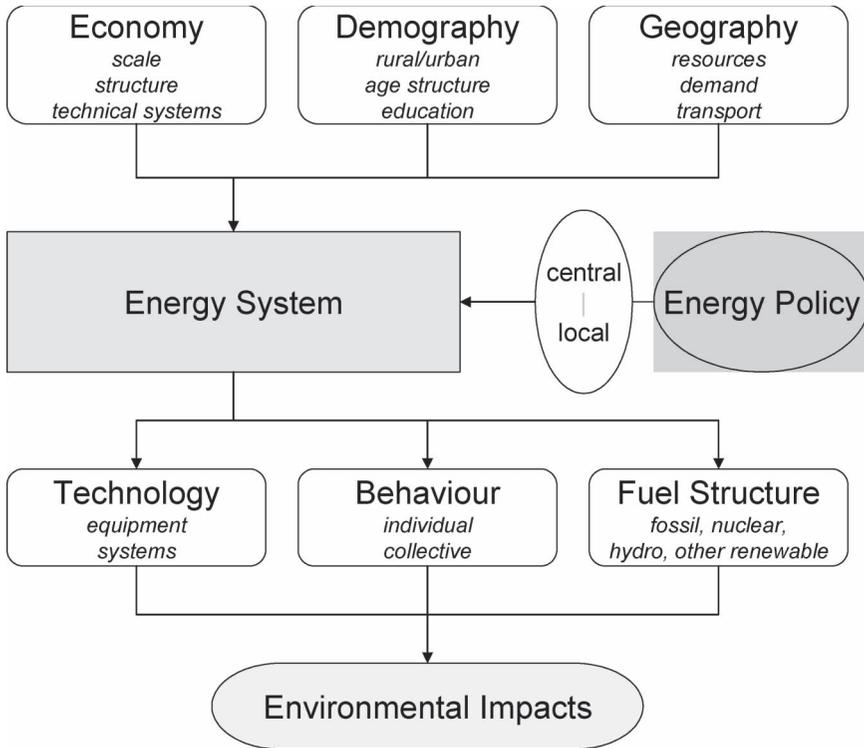
As with many economic theories, the causal logic of the EEKC is largely contingent on full information and low transaction costs. For example, increasingly energy-consuming, wealthy citizens’ ability to perceive the costs of environmental degradation, organise collective action, and address pollution problems provides an essential mechanism for abatement. While local citizen action is limited by political restrictions, lack of full information and high transaction costs do not necessarily relegate China to a future of environmental calamity. Rather, the Chinese Communist Party’s ongoing restrictions on information and collective action increase the importance of government policy, implementation, and institutions in determining the shape of China’s EEKC. For evaluation of the environmental effects of energy usage, the utility of the EEKC model is derived from its aggregation of driving factors, including exogenous economic, demographic, and geographic variables, as well as local usage factors including available technology, consumer behaviour, and



**Figure 1.** The energy-environmental Kuznets curve (EEKC)

prevailing fuel structures. Within the context of China’s gradual move towards liberalised energy markets, decentralised administration, internationalised energy politics, and ongoing urban growth, government policy, implementation, and institutions play an important role in determining the EEKC slope.

Figure 2 illustrates the interconnected range of factors involved in the formation of the energy system as well as intervening variables that influence the environmental impacts of energy usage. The energy system is primarily shaped by China’s economy, demography, and geography. Among these key variables, availability of energy inputs is perhaps the most obvious foundational factor. China has extensive domestic energy reserves, particularly in coal and hydropower. The precise extent of China’s energy endowments varies according to the system of calculation. Table 1 illustrates the range of reserve estimates between internationally standardised ‘economically recoverable reserve’ estimates and Soviet-derived ‘proven technologically-recoverable reserves’. Regardless of the system of measurement, the data in Table 1 clearly show that hydropower, of which China has the world’s largest electricity generation potential, and coal make up the vast majority of domestic energy resource endowments.



**Figure 2.** Key variables in China’s energy–environment system

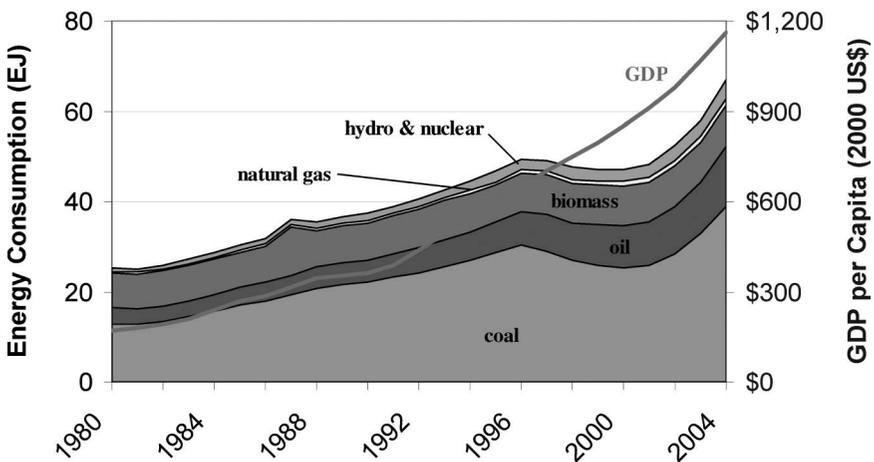
**Table 1.** Estimates of China's energy resource endowments

Source	Coal	Oil	Gas	Hydro	Biomass
1999 estimates of the World Energy Council (2004)	114.5 billion tons (12 per cent global reserves)	4.8 billion tons (3 per cent global reserves)	1368 billion m <sup>3</sup> (0.9 per cent)	1260 billion kWh (17 per cent)	28 million tons (not including 130 Mt firewood)
China Energy Development Report (2003)	724 billion tons	13.7 billion tons	2250 billion m <sup>3</sup>	1923 billion kWh	N/A

Beyond domestic endowments, access to secure, internationally-traded resources further defines China’s energy and environmental choice set. Openness to trade, security of supply, and access to technology inform domestic energy strategy. For example, the leadership’s strategic ability to shift to cleaner, more efficient fuels such as natural gas is delimited by the internationalisation of China’s energy politics. Within these resource parameters, China has formulated energy policies and organised institutions to maximise low-cost production, and thereby fuel economic growth.

Since the initiation of economic and political reforms in 1978, institutional restructuring has generated increased energy supply. New institutions reflected the state’s gradual withdrawal from the economy and its prioritisation of economic growth as the chief source of legitimacy. Property rights reform in particular served to emphasise individual-level production incentives over ideology. Within the energy sector, production was stimulated by the clarification of mineral exploration rights, the diversification of management structures, the increase of investment sources, the development of transport infrastructure, and the liberalisation of energy markets, including pricing, taxes, environmental and safety regulation, opening to trade, and the abandonment of full employment. Figure 3 illustrates the growth of national energy consumption and per-capita GDP since the initiation of China’s extensive reforms.

Between 1980 and 2004, China’s aggregate energy consumption grew by 166 per cent, from 25.2 EJ to 67 EJ, and per-capita GDP rose from \$172 (2000 RMB) in 1980, to \$1161 in 2004. While shares of hydropower, nuclear, and natural gas have grown, coal remains China’s dominant source of energy. In

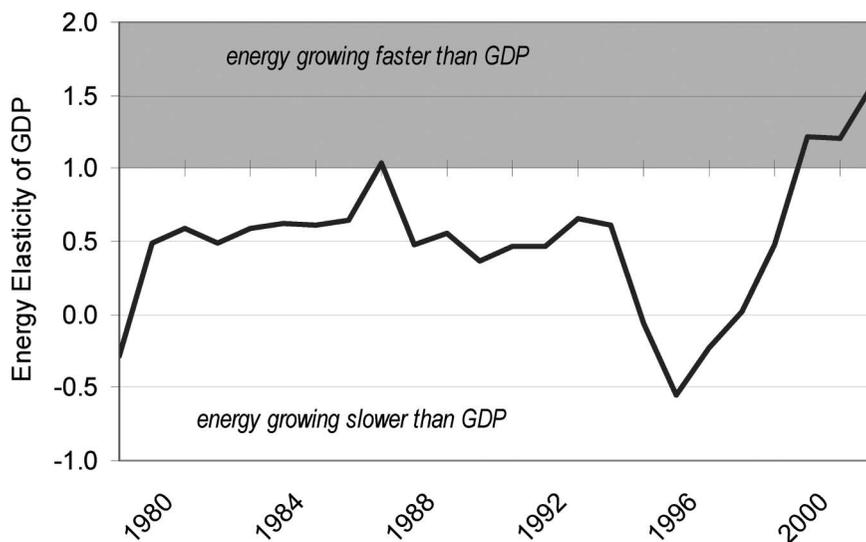


**Figure 3.** China’s energy consumption by fuel, 1980–2004. *Source: China Statistical Yearbook (various years); China Statistical Abstract (2005)*

fact, the proportion of coal in China's energy mix increased from 51 per cent in 1980 to 62 per cent in 1996 – a year when the economy was expanding particularly quickly. Institutional reforms account for the aggregate growth of energy production, as well as the ongoing dominance of coal in China's energy portfolio.

Energy intensity (EI), and particularly energy elasticity of GDP, provides a metric for understanding the nature of China's expanding energy usage. During the early reform period, institutional restructuring facilitated remarkably energy efficient economic growth. GDP grew more quickly than energy usage during the 1980s and 1990s, as augmented property rights provided incentives for increased productivity and competition-driven efficiency. However, energy consumption began to grow more quickly than GDP in 2001 as a result of changing leadership priorities and macroeconomic shifts to more heavy industry. The data in Figure 4 illustrate the low energy elasticity of GDP from 1980 through 2000, at which point economic growth became more energy intensive. Energy usage, and particularly coal consumption, is likely to have been under-reported in the late 1990s; however, recent shifts towards increasingly energy intensive economic growth underscore the importance of effective governance for internalising the costs of environmental degradation.

The environmental implications of ongoing energy sector growth have been mediated by a series of regulatory oscillations between state and market-based



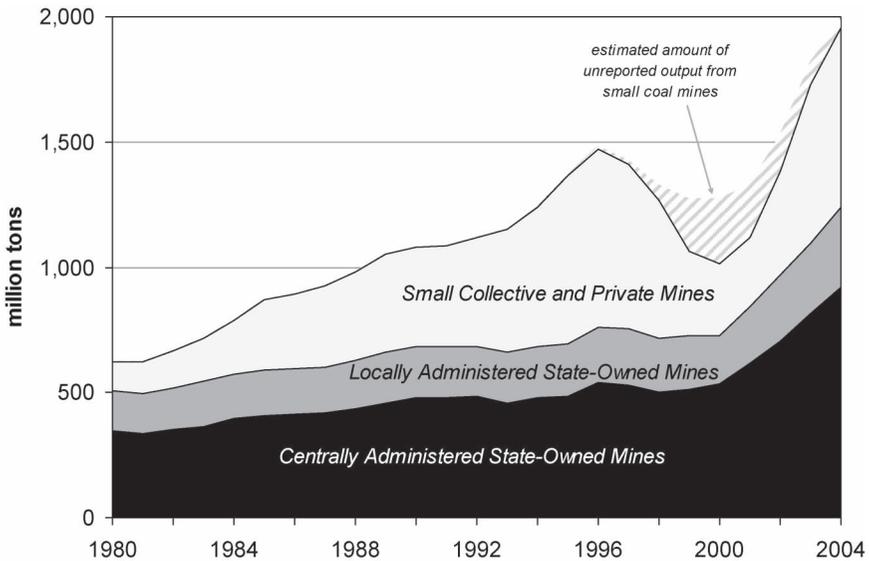
**Figure 4.** Energy elasticity of GDP (the ratio of growth in energy use to growth in GDP), 1980–2003. *Source:* National Bureau of Statistics (various years); *China Statistical Yearbook* (Beijing: China Statistics Press); NBS (2005) 'China statistical communique of the People's Republic of China on the 2004 National Economic and Social Development' ([www.stats.gov.cn](http://www.stats.gov.cn))

approaches. The juxtaposition of these diverse regulatory mechanisms with energy and environmental outcomes provides data for evaluating some components of China’s EEKC. These relationships are most clearly illustrated in an historical review of China’s energy strategy and institutions. In the next sections we examine developments in the coal sector in detail, and survey rural energy and hydropower as well. After evaluating recent changes in the organisation of government organs of energy administration, we offer some thoughts on key institutional factors likely to influence how energy policy will affect environmental quality in the coming years.

**Coal Sector Reform: Decentralisation and Market Liberalisation**

Institutional restructuring in the initial reform period was driven by fiscal decentralisation and the gradual expansion of rural property rights. In 1983, ‘township and village enterprises’ began to replace ‘commune and brigade enterprises’, thereby increasing local fiscal autonomy and introducing incentives for growth. Within the coal industry, these reforms stimulated the expansion of small collective and private mines from 18 per cent of total production in 1980 to more than 48 per cent in 1996 (Figure 5).

During the 1980s the central government enacted a series of laws, measures, and plans to stimulate coal production, thereby compensating for disappointing returns in the domestic petroleum sector (Levine & Sinton, 2004). In 1983,



**Figure 5.** Coal production by ownership, 1980–2004. *Source: China Energy Databook (2004); Coal Industry Yearbook (various years); Interfax China Energy Report Weekly (4(4), p. 14)*

the Ministry of Coal Industry issued a 'Report on Eight Measures to Accelerate the Development of Small Coal Mines', as well as a 'Notice of Further Relaxation of Policies and Development of Local Coal Mines' the same year. Gradual price liberalisation and regulatory 'relaxation' encouraged local and small scale coal production. A three-tier system of 'plan', 'indicative', and 'negotiated' (market) prices was established, and in 1984 state-owned coal mines were permitted to sell 5 per cent of their output at negotiated prices. Small coal mines, on the other hand, were free to determine amount of production and level of product pricing. Regulatory decentralisation further benefited small and local producers insofar as the local governments that supervised small mines were also dependent on them to generate scarce tax revenue – a situation that persists in many localities.

Beyond the structural implications of fiscal and regulatory decentralisation, coal industry production was stimulated by central government investment and industry subsidies. For example, the Sixth Five Year Plan, which was adopted in 1982, articulated investment and production goals for the expansion of a Shanxi Energy Base for national coal production. Industry-wide production incentives were provided by low taxes and subsidies, including the central government's 'coal replacement of oil' programme. According to government budget statistics, these coal subsidies grew from 940 million RMB in 1983 to 2.3 billion RMB in 1990.<sup>2</sup>

While industry subsidies grew, the passage of the Mineral Resource Law in 1986, and the coal industry corporatisation in 1988, extended the central government's withdrawal from energy sector management. The Mineral Resource Law constituted an ex-post-facto reassignment of coal exploration rights from central to local governments and local entrepreneurs. Rather than defining a strong institutional framework, this law codified central government non-intervention – the Rules for the Implementation of the Mineral Resources Law were not published until eight years later, in 1994. In 1988 the Ministry of Coal Industry (MOCI) was transformed into the China National Coal Corporation, the Northeast Inner Mongolia United Coal Industry Corporation, and the China National Local Coal Mine Development Corporation, thereby echoing the transfer of property rights to small collective and private mines on a national level. The regulatory functions of MOCI were transferred to a newly created Ministry of Energy under the State Planning Commission. Given the dearth of rural capital, coal corporatisation encouraged the establishment of small, low technology/investment mines with minimal overhead.

During the initial reforms and into the 1990s, a rough balance was achieved between the costs and benefits of small coal mine proliferation. Aside from dramatically increasing aggregate low-cost energy production, small mines stimulated rural employment and economic growth while reducing bottleneck pressure on limited rail and water transport capacity. However, the environmental, human safety, and market distortion costs of local mining became more evident as the coal sector continued to boom in the 1990s. In raw

cost-of-life terms, the perilous nature of small, local coal mining is reflected in its average death rate of 10.33 miners per million tons of coal produced between 1995 and 2003, compared to 1.27 for miners in large, centrally-administered state-owned mines during the same period.<sup>3</sup> Coal consumption is also associated with a range of health problems, primarily caused by combustion of mineralised coal, which can lead to arsenic, fluorine, selenium, and mercury poisoning (Finkelman *et al.*, 1999). Anecdotal evidence also abounds on the deleterious impacts of mines on land and water resources, which have been the cause of numerous environmentally-motivated disputes. Moreover, local governments' dependence on small mines for revenue resulted in lax regulation. An exclusive focus on production and revenue led to sub-optimal levels of investment and poor environmental, health, and safety performance, thereby undermining the market for coal produced by larger, properly regulated mines.

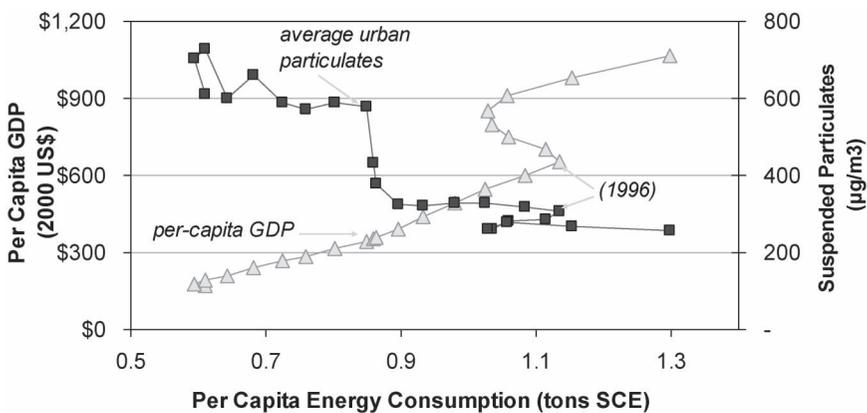
When export demand began to wane with the 1997 Asian financial crisis, the central government initiated a spate of structural reforms intended to improve government cost-effectiveness and state-owned enterprise (SOE) competitiveness. Within the energy sector, the 1998 reforms were oriented around bureaucratic restructuring and industry consolidation, including an extensive campaign to close down small unregistered coal mines. Flagging demand and more rigorous government regulation combined to steeply reduce coal production, particularly from small collective and private mines, between 1996 and 2000. Changes in the coal sector were reflected in structural reform of the central government bureaucracy. China's energy bureaucracy had been marked by periodic decentralisation and reconsolidation: in 1993 the Ministry of Energy was dissolved in favour of more specialised oversight by the Ministry of Coal Industry, only to be taken over by the State Administration of Coal Industry (SACI), an office of the State Economic and Trade Commission (SETC), in 1998 (Levine & Sinton, 2004). In addition to cutting government costs, the 1998 reforms were intended to separate economic regulation (SETC), strategy (State Development Planning Commission (SDPC)), and management (local governments and the Ministry of Land and Natural Resources (MLNR)) of the energy sector, and particularly the coal industry. As such, the reforms included the transfer of large SOE coal mines from SACI to provincial authorities. Although the 1998 reforms served to reduce central government costs rather than introduce effective local regulation *per se*, they did provide impetus for subsequent measures to increase competitiveness and level the producer playing field.

The principal thrust of the 1998 reform process was an enforced consolidation of mining enterprises into larger conglomerates. Agglomeration complemented the transfer of large mining assets to provincial governments and the hardening of budgetary constraints. The 1998 reforms, as well as more recent central government enforcement of mine safety regulations, have facilitated the gradual internalisation of health and environmental externalities into China's coal pricing system. By increasing producer competition and strengthening local regulatory mechanisms, these reforms presented an

opportunity to improve the environmental performance of China’s coal sector, provided that local state ownership, policy-making, regulation, and management functions were kept separate (Andrews-Speed, 2004).

*The Environmental Consequences of Coal Industry Growth*

Coal mining and combustion are associated with a range of environmental costs including land subsidence, degeneration of water quality, air pollutant emissions, and acid rain. Three key measures of environmental air quality are the concentration of total suspended particulates (TSP), carbon dioxide emissions, and sulphur dioxide emissions. Within China, TSP levels are measured by city environmental bureaux. Figure 6 illustrates the annual decline of average urban TSP levels as a function of rising per capita energy consumption between 1980 and 2003. According to Chinese government data, average urban TSP levels declined from their peak of 729  $\mu\text{g}/\text{m}^3$ , at 0.61 tons of standard coal equivalent (SCE) per capita energy consumption (in 1982), to 256  $\mu\text{g}/\text{m}^3$  at 1.3 tons SCE in 2003. The data in Figure 6 also illustrate the reported decline of annual per-capita energy consumption between 1996 and 2000 as a result of the central government’s mine closure campaign and a decline in economic demand that was exacerbated by the 1997 Asian financial crisis. TSP abatement represents one downward-sloping China air-pollution EEKC. Market competition functioned as a central driver for the downward slope of China’s coal-TSP EEKC by increasing demand for more efficient, higher-quality coal. Other drivers included coal substitution of less-efficient biomass energy sources, increasingly effective end-user regulation, and availability of new combustion technologies.

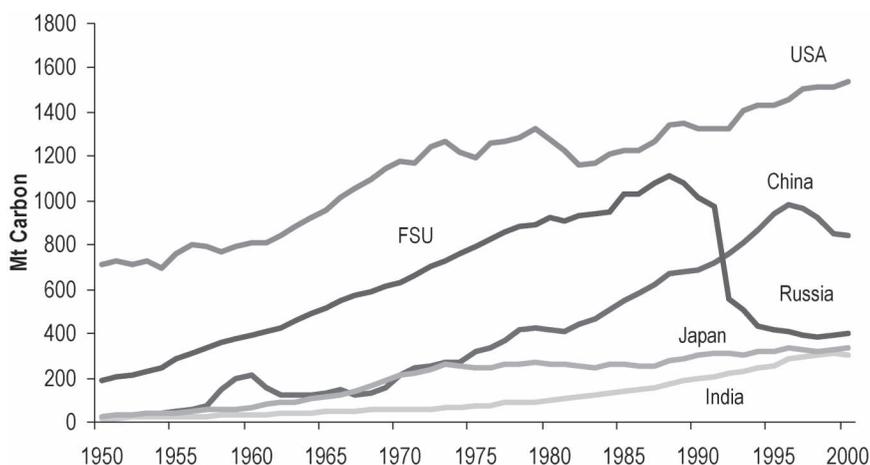


**Figure 6.** Per capita GDP and suspended particulates as a function of energy consumption, 1980–2003. *Source:* National Bureau of Statistics (various years); *China Statistical Yearbook* (Beijing: China Statistics Press); *China Environment Yearbook* (various years)

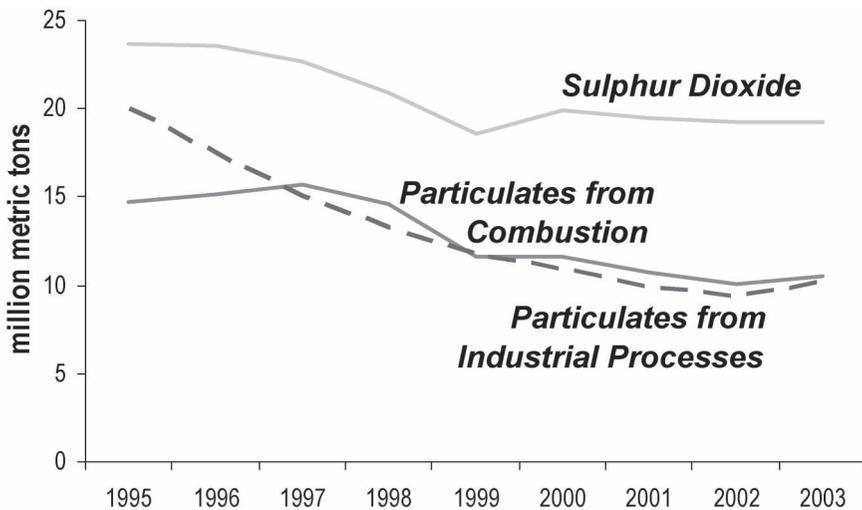
The downward slope of China's coal-TSP EEKC (Figure 6) has been offset by increased carbon dioxide and nitrogen oxides emissions. China is currently the second largest contributor of anthropogenic carbon dioxide emissions, accounting for 12 per cent of worldwide emissions in 2001 (IEA, 2004; Figure 7). With continued growth of coal combustion, China may become the world's largest emitter of carbon dioxide before the middle of this century, contributing one of the largest increments to global greenhouse gas emissions. Meanwhile, increased motor vehicle usage has driven an increase in  $\text{NO}_x$  levels in ambient air from 65 to 90  $\text{Mg}/\text{m}^3$  (Chen *et al.*, 2004).

Sulphur dioxide and particulates are considered by many environmental experts in China to be the air pollutants of gravest concern, and efforts at controlling air pollution have focused on them (Figure 8). Since the 1980s, the fraction of China's coal that has been washed has been stable, and flue gas desulphurisation is only now becoming widespread. However, sulphur content in delivered coal has declined as efficiencies have improved, and better particulate removal has captured some sulphur dioxide, so overall emissions have fallen. A growing fraction of coal is used in power plants with tall stacks, and less in residential and small industrial applications, and much coal-using industry has been relocated outside cities. Ambient concentrations of sulphur dioxide in cities have consequently fallen; although in many places levels exceed China's air quality standards. Simultaneously, the regional problem of acid precipitation had become more serious. Acid precipitation affects over 40 per cent of the country's land area and causes damages of US\$1 to 2 billion annually.

As more becomes known about the health impacts of airborne particulates, especially very small particulates that are drawn deep into the lungs, they are



**Figure 7.** Carbon dioxide emissions of six major economies, 1950–2002. *Source:* International Energy Agency (2004)



**Figure 8.** Sulphur dioxide emissions and particulate emissions, 1995–2003. *Source:* Editorial Board of the China Electricity Yearbook (various years); NBS (2004)

considered responsible for a greater share of the world's ill health than was previously thought (WHO, 2004). Particulate emissions from combustion and physical processes (like industrial grinding) fell rapidly in China in the 1990s as relatively inexpensive particulate controls were installed on a larger share of industrial facilities. In recent years, however, rising coal use and industrial activity have led to an upturn in particulate emissions. Ambient particulate levels show very similar trends, especially since particulates from motor vehicles and construction activities have replaced falling industrial emissions in many cities. Most residents of China's northern cities live with annual average particulate levels about twice as high as national standards, and some cities experience much higher averages.

The impacts of a coal-dominated energy economy are felt all along the fuel chain. About 6000 miners die each year in accidents in China's coal mines, according to official statistics, though the actual number may be substantially higher. An unknown number die from occupational diseases. Coal gas and coking plants are also associated with high incidences of cancer. While new combustion technologies and improved regulation will help to abate some of the most egregious health impacts, the ongoing dominance of coal portends continued environmental costs associated with expanded energy usage.

### Rural Energy

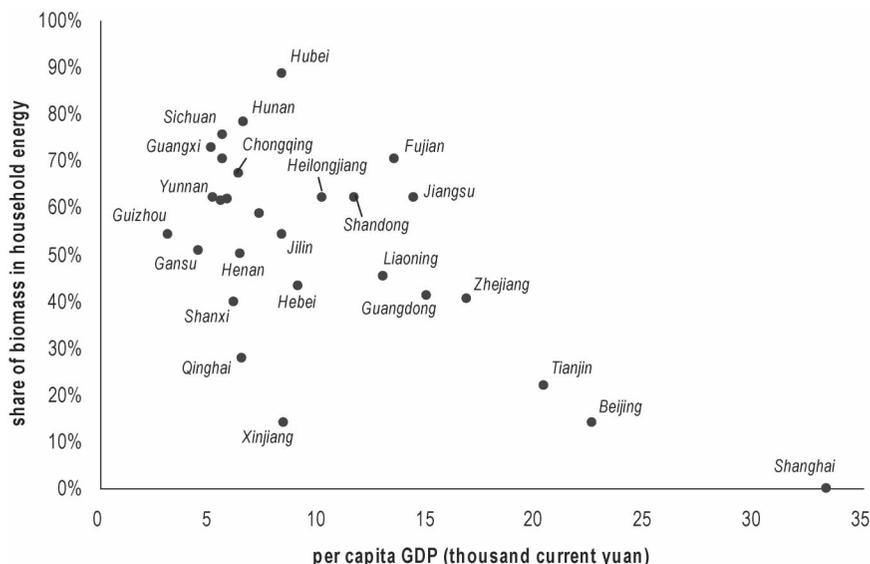
The pattern of energy use in rural households reflects several decades of industrialisation and vigorously pursued rural energy and economic policies overlaid on traditional patterns established over millennia. Even with rapid

urbanisation, nearly 60 per cent of China's population still lives in rural areas, where they rely on biomass for 80 per cent of their energy needs and coal for a further 10 per cent (NBS, 2005a, b). Per capita energy demand is smaller than in urban areas, but the average rural dweller still uses the equivalent of 600 kg of coal each year, mainly in the form of crop wastes, wood, and coal. Typically, these are burned indoors in a bewildering variety of hand-built stoves, often with inadequate ventilation.

Agricultural activities currently produce about 705 million tons (Mt) of biomass by-products in the form of crop stalks, straw, and hulls each year (Sinton *et al.*, 2005). In 2000, about 194 Mt of this was used as livestock fodder, 106 Mt as fertiliser, and 19 Mt for industrial materials. Rural households are the largest consumers, and directly burned about 288 Mt (41 per cent) of agricultural biomass in 2000. Farmers often burn the remaining agricultural biomass directly during the harvest seasons, which not only causes local air pollution but also affects air and road transportation. The forestry sector contributes approximately 170 Mt of biomass annually in the form of firewood each year. About 20 Mt is consumed by rural industry and 150 million tons by rural households for cooking and space heating. There is widespread concern that this level of use represents overharvesting of China's wood resources, leading to soil erosion, degraded water quality, and increased flooding.

The solutions to persistent rural energy problems include providing greater access to higher quality fuels and to electricity, and improving the ways that available solid fuels are used. China has pursued many initiatives aimed at implementing these solutions in different ways. Perhaps the ultimate method of dealing with such issues is to raise rural incomes to a level approaching urban wealth. Other things being equal, greater wealth leads to a lower reliance on biomass (and other solid fuels), as is especially evident in China's wealthiest provincial-level cities (Figure 9). In areas where biomass resource endowments are scarce, such as the dry northwest, reliance on biomass is also lower than average. But in those areas people do without rather than switch fuels. Until the distant goal of making everyone wealthy is realised, rural energy policies will remain in the government's tool kit.

Concern about rural energy came to the fore in the early 1980s, when serious and chronic energy shortages emerged. By the early 1980s, China already had substantial experience with rural energy programmes, including fuel wood plantations and promotion of household- and village-scale biogas systems (Taylor, 1981). These had already established a pattern by which a national programme was used to mobilise mainly local resources through local branches of the agricultural bureaucracy, with a focus on training locally based technical personnel who had responsibility for implementing programmes in accordance with specific regional conditions. This experience was used in carrying out a large-scale programme to introduce more-efficient stoves, with the aim of reducing pressures on biomass resources (Smith *et al.*, 1993). At the same time, local mines were allowed to flourish, as discussed in the previous section, supplying households as well as the growing rural segment of industry. In the



**Figure 9.** Per capita GDP and share of biomass in rural household fuels by province, 2002. *Source:* NBS (2004); *China Energy Statistical Yearbook* (Beijing: China Statistics Press)

1990s, rural energy programmes, still run mainly by the Ministry of Agriculture, but also through other lines of authority, began to focus more on incorporating technical solutions, like improved stoves and household- and village-scale biogas equipment, into integrated programmes for improving the well being of rural dwellers. Such schemes often included financial components, like access to small-scale loans, to allow investment in better dwellings, improved sanitation, and equipment for agricultural production and small-scale industry. Programmes have exhibited great regional variation, since county-level authorities have considerable autonomy in details of implementation, as well as responsibility for fund raising.

In parallel with these activities, the various incarnations of the electricity ministry ran programmes to extend the grid to as many villages as possible. Heavily subsidised by the central government, construction of power transmission and distribution systems and, in some parts of the country, small hydropower stations, gave at least minimal access to electricity to over 98 per cent of China's households by 2002 – a significant achievement for a developing country (Editorial Board of the *China Electricity Yearbook*, 2004). Where grid extensions have not been possible, wind and solar systems, often supported by international assistance projects, and with contributions from recipient households as well as various levels of government, have brought electricity to many communities.

Unlike electricity, however, household access to modern fuels has been left mainly to the market. While diesel for agricultural applications – tractors and

irrigation pumping, mainly – remains subsidised, households that wish to buy LPG must often go to great trouble and expense. Most rural households with access to LPG use both gas and solid fuels at different times, depending on circumstances. Since LPG is expensive and cash incomes are relatively low, households tend to use significant amounts of ‘free’ biofuels and relatively cheap coal, balancing expensive convenience with cheaper inconvenience.

After the failures of the biogas programmes of the 1970s, biogas began to receive renewed policy attention in the 1990s (Dai, 1998), garnering the high-level support and enthusiasm once accorded to improved stoves. High-profile successes in R&D and pilot applications have led to efforts at replication across the country, accompanied by sometimes extravagant claims for its potential to transform rural energy systems. The benefits of well-run biogas digesters can indeed be significant, and are epitomised by the recently developed ‘four-in-one’ systems, in which greenhouses are constructed to house crops in one part, and a livestock pen in a smaller part, underneath which is installed a biogas digester that provides gas to the greenhouse or nearby homes and fertiliser (digester waste) to the greenhouse. Such systems are complicated and expensive to build and run, however, and their long-term viability on a large scale has yet to be demonstrated. By 2003, biogas accounted for nearly 1 per cent of rural household energy, about the same as LPG, but still far from offering a comprehensive solution (NBS, 2005a).

In general, the political salience of rural energy issues *per se* is not high. Since coal became widely available in most places by the early 1990s, sufficiency of supply has not been considered a problem. It is the relationship of energy to more pressing issues, such as distributional inequality, social stability, and, to a certain extent, urgent environmental issues, that brings it to the attention of political leaders.

Some of the most urgent issues are nearly invisible, in a political sense. For instance, if ambient air pollution is a serious matter, then air quality indoors, where people spend most of their time, is even graver. Even after two decades of gradually rising availability of cleaner fuels and the spread of improved stoves, most rural residents are exposed to even higher levels of suspended particulates, carbon monoxide, and other pollutants than in the country’s most polluted cities (Sinton *et al.*, 2004a). Ambient air pollution in villages, due to low heights of household flues and the persistence of solid fuels, is also a growing issue.

The link between biomass energy use and land and water quality remains a potentially significant issue. In fact, the link between the household use of wood and charcoal and the over-harvesting of forests is probably of much less concern in most areas than the burgeoning demand for wood products for construction. Moreover, coal has replaced crop wastes to such an extent in many areas that there is a surfeit of biofuels. Nevertheless, there are some communities where poverty and geography make obtaining fossil fuels difficult, and do put household demand in conflict with environmental quality. The former State Development Planning Commission (SDPC), in response to

destructive flooding along the Yangtze River in 1998, initiated the Yangtze River Valley Environmental Protection Project to reduce soil erosion by instituting logging bans and afforestation projects. In some areas, the programme included promotion of improved stoves to reduce demand for fuelwood. In some areas, this led to greater use of other biomass (mainly crop wastes) and coal (widely available in these areas), and reliance on purchases from woodlots permitted to harvest and sell wood for fuel (Sinton *et al.*, 2004b). Elsewhere, however, there appeared to be little impact on fuel structure.

After decades of rural energy policy activity that has aimed to reduce biomass use and to increase the availability of modern fuels, the share of biofuels had fallen to about 15 per cent of total primary energy consumption in 2003 – slightly more than half its share in the late 1970s. However, after declining slightly in the 1990s, the total amount of biomass used began to grow again in 2000. This may be in part a response to the long-running campaign to close the small, polluting, and unsafe rural mines that supply farming households with coal, forcing families to turn back to biomass. If so, this increase would exemplify how initiatives to improve environment and safety can have unintended environmental consequences in other arenas. With the demand for biomass resources from China's long-stressed rural environment once again on the rise, and few large-scale alternatives within the geographic and economic reach of most rural residents, meeting rural China's energy needs in an environmentally sustainable manner remains a significant challenge for China's policy makers.

### **Hydropower**

China's ability to harness its superlatively large hydro-electricity generating potential has been limited by institutional, financial, and environmental obstacles. Whereas fiscal decentralisation and augmented rural property rights stimulated the proliferation of small, local coal mines, the number of small hydropower stations continuously declined from its 1979 peak of 90,000 projects.<sup>4</sup> Fiscal decentralisation, a dearth of rural capital, and a general shift from political to economic investment criteria served to undermine hydro development. Large up-front investment requirements combined with low, government-controlled retail electricity prices and technical transmission difficulties to give hydropower a low rate of return on investment (ROI), especially compared with small scale coal mining (Li, 2002). Over the course of the reform period, these institutional and financial obstacles shifted hydro expansion from small to large, centrally-administered projects – in 2002, for example, the government announced plans to invest \$35 billion to double national generating capacity by 2010 (Andrews-Speed, 2004).

In spite of its high investment cost and low ROI, hydropower continues to be promoted by the government on the basis of energy security and environmental considerations. According to China's National Energy Strategy and Policy

(NESP), the country aims to install 200 to 240 GW of hydro-electricity by 2020, which means adding 7 to 9 GW of capacity per year – the equivalent of one Three Gorges Dam every two years (Sinton *et al.*, 2005). An annual addition of 7 to 9 GW hydropower is estimated to require \$13 to \$23 billion of capital investment per year.<sup>5</sup> Investment costs are further complicated by the need for inter-provincial cooperation on large-scale hydro projects. The promotion of Chongqing municipality to provincial status, for example, served to streamline the financing and administration of the Three Gorges Dam.

Hydropower development has also been limited by environmental complications and electricity transmission limitations. Whereas the environmental costs of coal based power are often externalised, as with widely dispersed air pollutant emissions, hydropower efficiency is directly contingent on environmental quality. Droughts and severe silting of watercourses diminish hydro effectiveness and make hydropower less dependable than coal burning power plants (Thomson, 2005). China's hydro potential is also disproportionately dispersed around the south of the country – the four provinces of Sichuan, Guangdong, Fujian, and Yunnan account for nearly 60 per cent of overall capacity. The geographic distribution is compounded by the difficulty of storing and transmitting hydro-electric power.

Although its efficiency is contingent on water and ecological quality, hydro development is associated with a range of social and environmental costs. Water and land environmental quality are directly affected by the flooding, erosion, silting, and accumulation of toxic waste generated by new hydro development. However, environmental degradation caused by hydro development is often eclipsed by the social and economic impacts of relocation and downstream displacement effects. Recent development of the Lancang (Mekong) and Nu (Salween) Rivers in Yunnan, for example, have become international disputes between Chinese power companies and rural communities in Vietnam, Laos, Cambodia, Burma, and Thailand (Stanway, 2005). The involvement of local stakeholders in these disputes and the contingency of hydropower on local environmental quality are two factors that can help to generate a downward slope for China's hydro-EEKC.

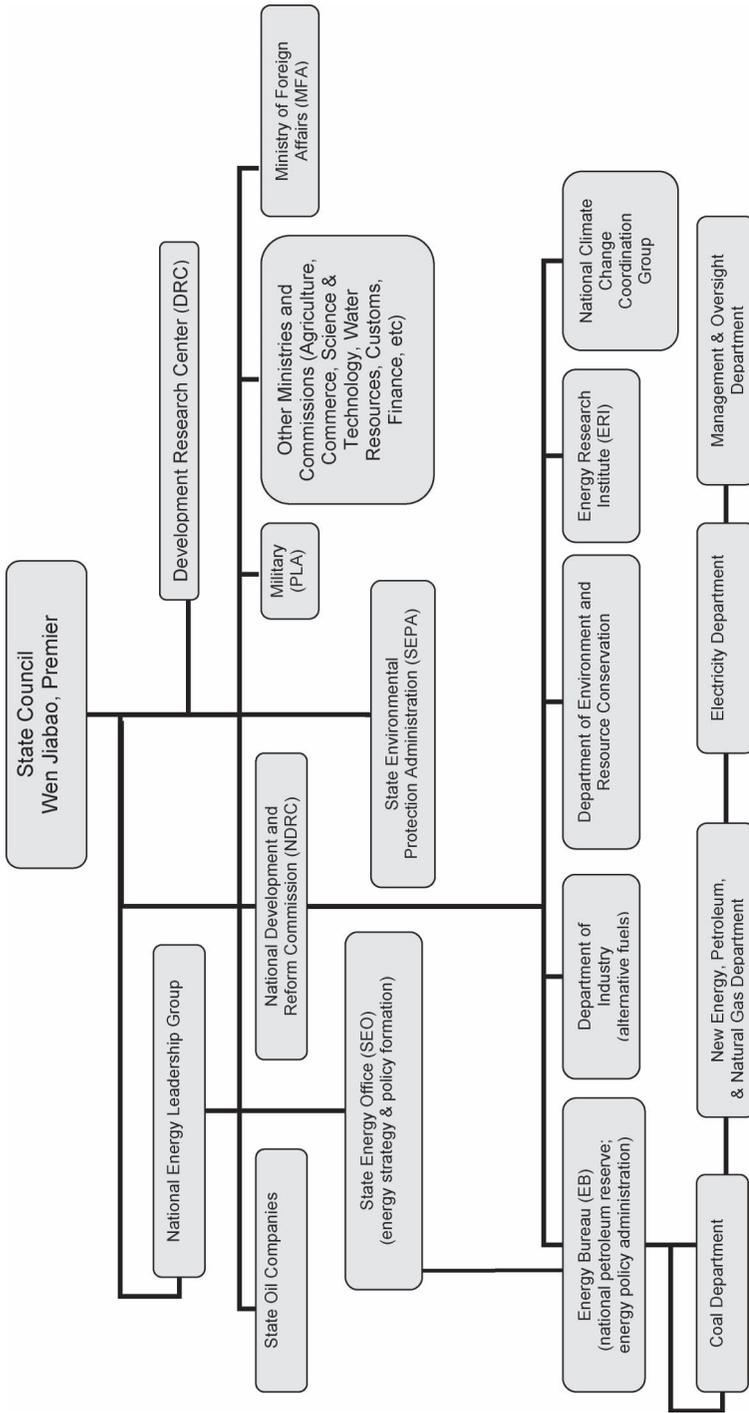
Despite the barriers, regional authorities and the country's large, nominally independent power generators are scrambling to claim a share of the remaining sites suitable for large dam projects. Environmental rules have been invoked by the newly vocal State Environmental Protection Agency (SEPA) to halt development projects, including many hydropower projects, but the stoppages have been only temporary, and the fines levied on projects out of compliance have been vanishingly small compared to total investment costs. Even if China takes maximum advantage of opportunities to improve the efficiency of its transmission and distribution system and the potential to raise efficiency in end uses, large increments to generating capacity will be needed. The large, but focused environmental impacts of hydropower projects may come to be seen by China's policy makers as less dire than the consequences of the main alternative: coal-fired power generation.

### **Recent Developments in China's Energy and Environmental Politics**

Starting in the summer of 2004, China has experienced sustained electricity, petrol, and coal shortages – 24 provinces and municipalities have been ordered to reduce consumption to assuage the ongoing crisis (Thomson, 2005). Rapid growth in energy demand, driven by a boom in manufacturing of materials needed for buildings, infrastructure, and consumer products for domestic and overseas markets, has collided with high international energy prices. The roots of the current energy crisis, however, are primarily institutional. The partial liberalisation of China's energy pricing system – coal prices are largely market-oriented while electricity rates remain subject to strict controls – has created price differentials between suppliers and retailers that generate inter-sector conflict (Thomson, 2005). The same problem has arisen between oil producers and domestic refiners; while crude prices have risen, retail prices for oil products remain tightly controlled, squeezing refiners and marketers. Wholesale, retail, domestic and international price disparities have also created problems for coal transport as railroad operators are not able to determine prices freely, thereby limiting rates of return to levels too low to attract necessary investment for capacity expansion.

The ersatz liberalisation of China's energy pricing system can be traced to lack of strategic coordination within the energy bureaucracy. In 2005, the central government moved to address energy bureaucracy dysfunction by restructuring its policy-making and regulatory structure. The Energy Bureau (EB) of the National Development and Reform Commission (NDRC) had done an ineffectual job coordinating energy sector development and regulating powerful state-owned energy companies. The first problem was the EB's lack of sufficient resources or authority to override vested supplier interests. This problem was addressed by creating a National Energy Leadership Group composed of Premier Wen Jiabao, and Vice Premiers Huang Ju and Zeng Peiyan, as well as high-level representatives from the State Environmental Protection Agency (SEPA) and the People's Liberation Army (PLA) (Qiu, 2005). The inclusion of Xie Zhenhua, the director of the SEPA (at that time) in the cabinet's energy coordination task force signalled the importance of environmental considerations in China's energy politics. Directly under the Leadership Group, a State Energy Office (SEO) was created in order to provide bureaucratic coordination, formulate strategy and policy, and enforce existing policies. Meanwhile, the EB remained under the NDRC, but was also placed under the purview of the SEO. The SEO has a broad decision-making mandate, while the EB is charged with policy administration and enforcement. Figure 10 illustrates the current structure of China's energy bureaucracy.

The 2005 reorganisation was a domestic iteration of the leadership's larger focus on issues of energy supply. This focus has also been reflected in the compilation of a National Energy Strategy and Policy (NESP) document with domestic supply targets through 2020 (Development Research Centre, 2004). Within China's foreign policy, this orientation has manifested itself in the



**Figure 10.** Bureaucratic structure of China's national energy policy apparatus, 2005. *Source:* NEDO (2005); Downs (2004); Asia Times Online (<http://www.atimes.com/atimes/China/GF03Ad01.html>)

'going out' strategy of seeking energy resources abroad. In the summer of 2005, this policy stirred up a hullabaloo in the US Congress as politicians scrambled to block the attempted takeover of Unocal by CNOOC, a partially state-owned Chinese oil company. Perceptions of scarcity and zero-sum competition serve to sharpen the leadership's focus on energy security and efficiency. However, these ongoing discussions have yet to produce clear, effective mechanisms for reducing the environmental costs of increased energy consumption.

The disappointing returns of China's 'going out' strategy have reinvigorated government investment in innovative domestic supply sources such as coal liquefaction, nuclear power, and renewable energy. Coal liquefaction (CL) is a process whereby high-quality coal is either directly or indirectly converted into liquid fuel that can be used as a gasoline product. The largest and most advanced CL project in China is run by the Shenhua Group in Shanxi province. The Shenhua Group was planning to float an IPO on the Hong Kong Stock Exchange in 2005, but the company was already estimated to have raised more than \$9 billion of aggregate investment, compared to total construction investment in the coal industry in 2002 of \$1.3 billion (Nolan *et al.*, 2004). By substituting for oil imports and domestic coal combustion, CL is attractive on security and environmental grounds. However, current CL technology is not a long term solution because the conversion process has negative energy return on energy investment, is highly water intensive, and currently requires 3–5 tons of coal input to produce one ton of oil (Nolan *et al.*, 2004). In spite of its energy inefficiency, CL investment and research are advancing in China, with more than a dozen pending project proposals.

Intersecting goals of energy supply security and environmental improvement have also advanced government promotion of nuclear power and renewable energy. According to the NESP, China is planning to build six to eight nuclear reactors per year over the next twenty years with the goal of quadrupling nuclear capacity by 2020. In the same vein, the government has articulated ambitious goals for renewable energy growth of 90 to 100 GW by 2020, to eventually comprise 10 per cent of national energy supply. A lack of transparency makes official claims of an excellent safety record for China's nuclear power plants impossible to evaluate. In any case, plans to raise the capacity of nuclear generators to 40 GW by 2020 add urgency to the need to implement a publicly credible system to protect safety through the entire fuel cycle (Sinton *et al.*, 2005). In spite of its large environmental safety risks and high costs for waste disposal, nuclear power may be seen by the government as a cleaner alternative to coal combustion.

In 2005 Chinese policy makers restructured the energy bureaucracy and released a spate of policy incentive programmes and future targets designed to address national energy needs. However, ongoing fuel and electricity shortages, an increase in deadly mining accidents, and sustained environmental degradation reveal fundamental energy problems yet to be solved. Within the larger milieu of China's energy system, the publication of the Chinese Communist Party's 'suggestions' for the Eleventh Five Year Plan (2006–2010)

indicate that the central government is embracing the optimistic logic of the EEKC. In contrast to earlier plans, the Eleventh FYP thus far only articulates two quantitative targets: the doubling of year 2000 per capita GDP by 2010, and the reduction of aggregate energy intensity (EI) of GDP by 20 per cent between 2005 and 2010. While diminished EI is conducive to economic competitiveness and efficiency, it is not clear that the Eleventh FYP's gestalt approach to energy governance will generate a downward curve for China's EEKC.

### **Future Determinants of China's EEKC**

Since the initiation of reform in 1978, three major themes in China's energy sector have been decentralisation, the shift to liberalised markets, and internationalisation. According to specific energy sector dynamics and local characteristics, these processes have had positive and negative effects on the slope of China's EEKC. Decentralisation, for example, stimulated the proliferation of dirty, unsafe, and inefficient local coal mines, thereby pushing up the coal EEKC. On the other hand, decentralisation combined with gradual liberalisation to increase economic competition, energy efficiency, and substitution towards cleaner, more efficient fuels. Within national narratives of decentralisation and liberalisation, the central role of the state in China's EEKC is illustrated by the importance of regulatory effectiveness. Two examples of strong state regulation pushing down China's EEKC are the government-mandated transition from leaded to unleaded vehicle fuels and the replacement of cfc-using refrigerators. The importance of governance effectiveness is further illustrated by the structural and systemic discontinuities (e.g., pricing) arising from the lack of a powerful, coordinated Ministry of Energy.

Neither a strong state apparatus nor a fully liberalised market economy will necessarily facilitate the achievement of a downward sloping EEKC. Rather, an effective regulatory mechanism is necessary to override vested interests and prevent free-rider problems. Between the false dichotomy of command-and-control economies and liberalised markets, community-based environmental monitoring is likely to provide the most cost-effective method for improving China's environmental quality with increased energy consumption. Gradual adoption of more liberalised energy markets can influence China's EEKC in combination with local political reform: increased economic liberalisation without expanded rights or accountability is likely to augment supply-side dominance and an upward-sloping EEKC.

The reported absolute decline of China's aggregate energy consumption from 1997 to 1999 serves as a reminder that governance is but one among several variables determining the environmental impact of energy usage. Energy system structure is also dependent on exogenous economic, demographic, and geographic factors, and environmental outcomes are also conditioned by usage factors including technology, behaviour, and fuel

structure. Within this array of variables, the leadership's recent moves toward energy market liberalisation have further empowered vested interests to ignore environmental costs and push up China's EEKC. Nonetheless, energy market liberalisation provides central and local governments with timely opportunities to avoid some deleterious environmental consequences of unregulated growth.

## Notes

1. The environmental Kuznets curve (EK) was developed in Grossman and Krueger's analysis of the environmental effects of NAFTA.
2. All RMB values are in deflated year 2000 RMB unless otherwise noted; source: *China Energy Industry Yearbook* (1991).
3. Mortality data are derived from *Coal Economic Research*, 2005 edition, p. 24, chart 23.
4. This decline of micro-hydro is masked by constant upward revisions of the statistical parameters of 'small hydro' (Smil, 2004).
5. This range is based on an average capital cost of \$1900 to \$2600 per kW; IEA (2004).

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