China's Energy and Environment in the Roaring '90s

A Guide for Foreign Participants

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Jessica Hamburger

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Pacific Northwest Laboratory
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Executive Summary

This paper seeks to provide U.S. participants in China's energy sector with a deeper understanding of China's energy problems and potential solutions, a clearer idea of what both China and its foreign partners have done so far to promote cleaner, more efficient, and less carbon-intensive energy use, and a set of recommendations for future action.

The Chinese people are caught between the desire to use more energy to fuel their growing economy and the realization that current energy patterns are having a negative impact on their quality of life. Rising rates of power failures and air pollution are pressing problems, as are acid rain, the resettlement of people to make way for large hydropower projects, the depletion of soil and forests through excessive reliance on wood and crop waste for heating and cooking in rural areas, and the lack of electric power in many remote villages.

China's complex and interlocking energy, economic, and environmental problems can be addressed through four main avenues: improving energy efficiency, exploiting natural gas, developing renewable energy, and strengthening environmental law. Efficiency is perhaps the most attractive in terms of its great potential and cost-effectiveness for consumers and the economy as a whole: the country can reduce coal transportation, cities can save capital by postponing part of their new power plant construction, and enterprises can increase profit margins by reducing energy bills. And every ton of coal saved through efficiency improvements means associated reductions in environmental damage. Switching from coal to natural gas also presents significant environmental benefits, such as cutting emissions of carbon dioxide and nitrous oxides in half while totally eliminating sulfur dioxide emissions. Solving rural energy problems will require employing sustainable forestry practices, improving the efficiency of wood stoves, increasing the use of solar cookers and water heaters, and using small hydropower and wind power to avoid the need to extend the power grid to remote areas. Stricter environmental rules for power plants can help encourage alternative energy options by shifting part of the cost of coal combustion from the environment to the producers and consumers.

The Chinese government has already taken steps in all four areas to improve energy use, but much work remains to be done. The government has promoted energy efficiency through direct investment and through energy price reform and institutional reform, including deregulating coal prices and allowing foreign and domestic private investment in the electric power sector. Government support for renewable energy is expanding to include not only small, distributed rural applications such as tree planting, efficient wood stoves, solar water heaters, and mini-hydropower turbines, but also large, grid-connected installations such as wind farms. The government has allowed foreign involvement in the natural gas sector to include inland as well as offshore gas exploration, and the National People's Congress is considering legislation to require desulfurization equipment for all new power plants.

U.S. involvement in China's energy sector could do far more to steer it toward cleaner and

more efficient patterns. Restrictions on U.S. assistance to China imposed after Tiananmen Square unintentionally contributed to the U.S. government's failure to develop an explicit policy to focus energy export promotion in areas that reduce greenhouse gas emissions and promote sustainable development. Despite the restrictions, some U.S. government agencies have led projects that reduce greenhouse gas emissions while delivering local economic and environmental benefits. The World Bank, which is partially funded and influenced by the U.S. government, has studied China's energy and environmental problems in depth and has lent over $800 million for environmental projects. However, the World Bank has lent $3.4 billion for energy supply expansion and scarcely any for energy efficiency, and has not promoted utility demand side management. By contrast, Japan has provided over $200 million in environmental and energy efficiency assistance, and the Asian Development Bank not only explicitly encourages Chinese utilities to implement demand side management techniques, but will devote 15 percent of its power sector loans to energy conservation over the next three years. In comparison to that of Japan and several Western European nations, U.S. policy toward China's energy sector shows some signs of environmental awareness, but falls short of integrating strategic goals, including promoting exports, reducing global greenhouse gas emissions, preserving biodiversity, alleviating poverty, and promoting freedom of speech and rule of law. An effort by the U.S. government to define goals more clearly and develop and adhere to better project selection criteria, including cost-effectiveness and environmental protection, for projects in China could help solve this problem. The Beijing Energy Efficiency Center (BECon) and the Coal Bed Methane Clearinghouse provide models of U.S.-China energy cooperation that satisfy these criteria.

Efforts conducted to date have only scratched the surface of potential U.S. cooperation with China on using energy more cleanly and efficiently. Future work by U.S. nongovernmental organizations (NGOs) and foundations can focus on supporting emerging Chinese NGOs and development of law and public interest science in China. The U.S. government can support the development of energy efficiency policies and demonstration projects, and provide incentives for U.S. companies to promote carbon emissions reductions. The World Bank can create revolving loan funds for energy efficiency and renewable energy, support energy efficiency polices, and stop subsidizing supply side projects. U.S. energy efficiency and renewable energy companies that invest in China can use their clout to encourage policy work that helps create the market for their products, and trade associations can sponsor market studies to give U.S. small businesses that cannot afford to do their own research in China a chance to examine the opportunities. Foreign energy services companies (ESCos) can introduce the ESCo concept to the Chinese government and try to make it work in the marketplace.

Understanding China's energy and environmental problems can help guide future foreign participation in the country's economic development. Initial steps taken by the Chinese government to develop energy and environmental policies and internationally funded institutions have created the basis for foreign cooperation in these areas. While U.S.-China relations are likely to remain fraught with conflict in many areas, increased involvement by U.S. public, private, and nongovernmental organizations in promoting clean and efficient energy use can provide some stability by delivering economic and environmental benefits for both countries.

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Contents

Conversions

Energy[1]

1 gigajoule = 1 x 10^9 Joules
1 exajoule = 1 x 10^{18} Joules

1 exajoule = 0.95 quadrillion British thermal units (Btu)
= 34.1 million tons of standard coal equivalent (Mtce)
= 47.8 million tons of Chinese average raw coal
= 23.9 million tons of Chinese average crude oil
= 26.5 billion cubic meters of standard natural gas
= 25.6 billion cubic meters of Chinese average natural gas
= 84.4 billion kWh of electricity
= 59-71 million tons of air-dried firewood
= 62-83 million tons of air-dried crop residues

1 kilowatt (kW) = 1 x 10^3 Watts
1 megawatt (MW) = 1 x 10^6 Watts
1 gigawatt (GW) = 1 x 10^9 Watts
1 terawatt (TW) = 1 X 10^{12} Watts

Currency

As of January 1, 1994

$1.00 = Y 8.72
Y 1.00 = $0.11

China's Energy and Environment in the Roaring '90s

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The scarcity of information in the United States about China's political, economic, and social issues means that U.S. perceptions of China are shaped in large part by the conflicts that make the headlines, be they human rights abuses, nuclear weapons proliferation, trade deficits, or copyright infringements. As a result, U.S. policy toward China is often reactive, based on short-term necessities rather than long-term strategies. A deeper look into China's goals and problems and the identification of areas where the United States and China both benefit from cooperation can provide the basis for a more consistent and effective China policy.

The development of clean and efficient energy use is one of those areas. China's generous endowment of coal resources, Soviet-style heavy industrial base, shortage of skilled labor, and weak legal system all conspire to limit the country's ability to use energy in ways that benefit both the economy and the environment. China needs to improve end-use energy efficiency, switch from coal to gas and renewable energy, and strengthen its environmental laws in order to conserve the capital being devoured by rapid power plant construction and mitigate the environmental damage being wrought by excessive use of coal and biomass. The benefits the United States can potentially reap by giving China policy and business development assistance in these areas include profits from U.S. energy efficiency and renewable energy equipment sales and business ventures, greenhouse gas reductions, and the development of rule of law in China. Chinese energy managers and consumers and their foreign counterparts have so far captured only a small portion of the potential value of international cooperation in sustainable energy use.

I. PROBLEMS WITH CHINA'S ENERGY USE

A look behind the headlines about China's booming economy and power sector reveals serious flaws in China's current development path. The problems can be measured in terms of energy shortages, capital costs, and environmental damage. The multiple costs of continuing to rely on coal, biomass, and big dams and continuing to use energy inefficiently call for an investigation of potentially less costly alternatives.

China's Energy Profile

China is the world's largest producer and consumer of coal, and its reserves are expected to last for at least another 100 years. China had 719 tons of proven reserves of coal per capita, compared with only 5.2 tons of proven reserves of oil per capita in 1987.[2] Coal accounted for 74 percent of China's commercial energy use in 1994, while oil accounted for 18 percent, hydropower for 5 percent, natural gas for only 2 percent, and nuclear energy for less than 1 percent.[3] China has nearly doubled its coal production from 620 million tons in 1978[4] to 1.2 billion tons of raw coal in 1994, and plans to boost production to 1.4 billion tons by 2000.[5]

Oil production grew more slowly than coal during the reform period, from 100 million tons in 1978[6] to 150 million tons of crude in 1994. Oil consumption actually declined in the early 1980s as China pursued a policy of "Replacing Oil with Coal", that is, exporting oil to earn foreign currency to buy highly efficient foreign coal-fired power plant equipment. Oil consumption resumed its rise in the 1990s in response to growing motor vehicle use, making China a net importer of oil by 1993.[7]

Table 1. Energy Production Mix, 1994

	In Actual Units	In Exajoules	Percentage
Raw Coal	1200 million tons	26	76
Crude Oil	150 million tons	6.3	19
Natural Gas	17 billion cubic meters	0.69	2
Hydropower	170 terawatt-hours	0.60[8]	2
Nuclear	14 terawatt-hours	0.049	0.1
TOTAL		34	100

Source: *China Energy Information*, Beijing Energy Efficiency Center (BECon), 1995.

Industry consumes the lion's share of China's energy, with the nonstate sector leading the way. Almost 70 percent of China's energy was used by industry in 1991. The nonstate sector, which grew at an annual rate of 17.6 percent during the 1980s, is primarily responsible for China's industrial revolution and corresponding increase in overall energy demand. The nonstate share of total industrial output has expanded from 22 percent in

1978[9] to 56 percent in 1994.[10] Although state-owned enterprises still produced roughly one half of industrial output, the meaning of "state-owned" is changing drastically as the government begins to convert these enterprises into joint stock companies and allows foreign investment.[11]

Only a small proportion of nonstate enterprises--individual enterprises and joint ventures--are privately owned and operated. The majority are urban collectives or town and village enterprises (also known as TVEs or rural enterprises), which are owned and run by local collectives and are closely related to local governments. TVEs expanded production and profits at the extraordinary rate of 50 percent between 1992 and 1993, increasing their share of industrial output from 30 percent to an estimated 40 percent in 1993.[12]

Chinese per capita consumption of commercial energy is less than one twelfth that of the United States, and Chinese households consume 36 times less electricity than their U.S. counterparts.[13] Basic needs such as heating and cooking continue to absorb most of the energy used in residential and commercial settings.[14] Central heating is often unavailable and electric heaters and cookware are usually prohibited, so most urban families heat their homes and cook their food with coal stoves. In fact, coal, often unprocessed, accounts for 80 percent of domestic energy use,[15] not including biomass. (See discussion of biomass below.) Coal consumption is currently constrained by price and availability, but as family incomes rise and coal transportation improves, this sector has tremendous potential for growth.[16]

The main reason for coal shortages is transportation bottlenecks. The rail system, transfer stations, and truck supply are all overwhelmed by the growing demand for coal. The central government has responded by investing several billion dollars in two new rail lines linking the coal mines of Shaanxi and Shanxi Provinces with ports in Hebei Province.[17]

Power Shortages and Capital Shortages

Power shortages are not new to China. In fact, China officially claims 24 successive years of power shortages.[18] One reason for the deficit is that electricity's share of final energy demand is relatively low: electric power averages 17 percent of end use in developed countries, but only 10 percent in China in 1990.[19] Efforts to raise this ratio while racing to keep up with economic growth is a major difficulty, a fact confirmed by increasingly frequent blackouts.

Despite growing by over 10 percent in both 1993 and 1994, China's total power production is still less than half that of the United States, and it must be divided among five times as many people. Low per capita supply combined with low efficiency and a high ratio of industrial use leaves China with very little electricity to satisfy growing residential demand. Many urban Chinese are rushing out to spend their growing incomes on refrigerators, air conditioners, washing machines, and other appliances, only to find themselves sitting through power failures in darkened apartments. China produced an estimated 6.8 million refrigerators in 1992, 18 percent more than during the previous year. The share of electricity used by households almost tripled from 3 percent in 1980 to 8 percent in 1991.[20]

Figure 1. Chinese Electric Power Statistics

- Total Net Generation, 1993: 740 terawatt-hours
- Source Mix, 1993: 80 percent fossil fuel, 19 hydroelectric, <1 percent nuclear
- Consumption Mix, 1991: 78 percent industry, 8 percent residential, 7 percent agriculture, 7 percent transportation, commercial, and other
- Annual Per Capita Overall Consumption, 1993: 620 kilowatt-hours
- Annual Per Capita Rural Consumption, 1993: 48 kilowatt-hours
- Installed Capacity, 1994: 180 gigawatts
- Total Planned Capacity Expansion, 1995-2000: 120 gigawatts
- Total Capital Requirement for Capacity Expansion, 1995-2000: $100 billion

Sources: *Country Energy Profile, China* (Washington, DC: U.S. Department of Energy, Energy Information Agency) February 1995; "Electricity to light up poor villages in six years," *China Daily*, 27 May 1994; *Energy in China* (Beijing: Ministry of Energy) 1992; Craig S. Smith, "China Seeks Foreign Support to Generate More Power," *Wall Street Journal*, 16 January 1995..

The level of electricity service is even lower in rural areas. Annual per capita rural electricity use reached 48 kilowatt-hours by the end of 1993, almost 8 times the figure for 1978,[21] but still trailed the national average by a large margin. (See Figure 1). Town and village industry uses 40 percent of rural energy, while irrigation, agricultural product processing, and lighting and other household uses each consume about 20 percent.[22] The meager power supply in rural areas is often interrupted by blackouts, both planned and unplanned, and more than 120 million Chinese farmers still have no electricity at all. Bringing power to areas currently without electricity at the current rural rate of annual consumption would represent an addition of approximately 6 terawatt-hours, or less than a percent of current power consumption. The problem is that most of the people who are currently without electricity live in the poorest and least accessible areas, mostly in Western China.[23]

The Ministry of Electric Power plans to keep the growth of power generating capacity at eight to nine percent per year in order to climb from less than 200 GW to 300 GW between 1994 and 2000. Neither China's domestic production capacity for large power generators nor its capital resources are sufficient to achieve such a tremendous expansion alone. The two factors are related because insufficient domestic production capacity forces China to import more equipment, which costs more than buying domestic equipment. About a third of the power generating capacity installed between 1990 and 1993, or 14 GW, was imported.[24] As the Ministry of Machinery Industry strives to expand production of large generators, the Ministry of Electric Power is struggling to raise the estimated $100 billion to cover the cost of the expansion.[25] The ministry faced a shortage of $1.15 billion, or 15 percent of its annual capital requirement for power plant construction, in 1994.[26] Efforts to attract foreign investment created significant interest, but fewer deals than expected.[27]

Environmental Impacts of Coal

The impacts of coal ripple out beyond the mining areas throughout Chinese society as coal washing plants dump untreated waste water in rivers and streams, and household chimneys and factory smokestacks emit millions of tons of particulates, sulfur dioxide, and carbon dioxide. To the Chinese, the most worrisome aspects of coal use are the respiratory diseases and acid rain caused by particulates and sulfur dioxide, respectively, while the international community tends to focus on the threat of global warming posed by the use of this inherently inefficient, carbon-intensive fuel.

The problems with coal begin with mining. Mine safety standards have slipped with the growth of primitive township mines, resulting in at least 40,000 accidental deaths since 1984, and innumerable mine-related injuries and illnesses.[28] Coal mining causes subsidence (the sinking of land located above coal mines), produces large quantities of harmful solid waste, and releases methane, a greenhouse gas. Subsidence damages overlying buildings and railroads, and reduces agricultural output by destroying land and irrigation projects. Two billion tons of spoil from coal mining have accumulated around the mines, and 100 million more tons are added every year. Sometimes these materials spontaneously combust and burn for weeks, producing fumes which are harmful to human health and the environment. Several cubic meters of methane are released for every ton of coal produced. Only a small portion of coal bed methane is used as fuel, the rest being released to the atmosphere and contributing to the greenhouse effect. Coal washing and coal mining contaminate large quantities of water. In 1989, only 56 percent of enterprises with coal washing plants had a closed system that treated and reused waste water. The remainder discharged untreated water to the environment, a total of 45 million tons. In addition, 1.5 billion tons of mostly unused ground water were discharged from coal mines.[29]

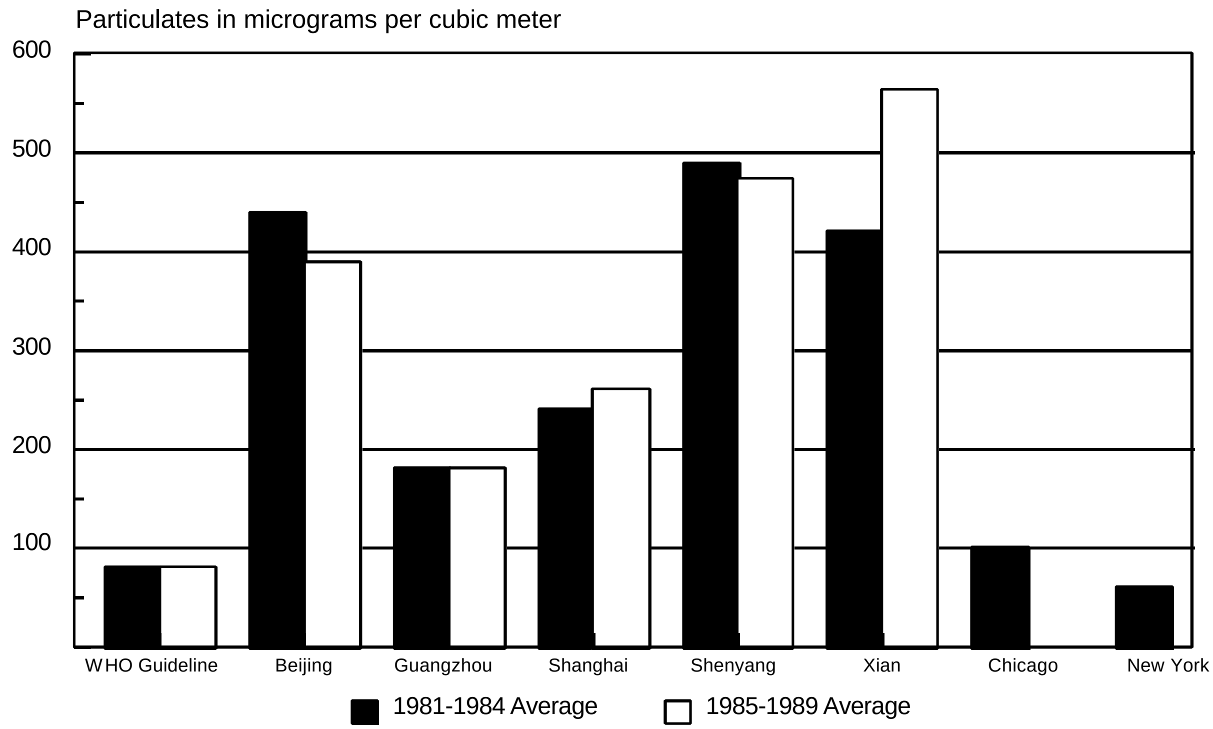
Coal combustion is responsible for most of China's particulate emissions and resulting respiratory problems. The State Statistics Bureau reports that annual emissions of particulates from enterprises alone in the 1980s ranged from 13 to 15 million tons. Although a large share of environmental protection funds was reportedly used to control them, particulate emissions data do not show a downward trend during this period. Pollution control efforts seem to have at least prevented the situation from getting worse as coal combustion steadily increased.[30] The National Environmental Protection Agency reports that, as of 1991, China was emitting 23 million tons of particulates annually, with coal burning accounting for about 17 million tons.[31] The National Environmental Protection Agency number is higher than the State Statistics Bureau number because it includes residential use. China may be burning 1.4 billion tons of coal per year by 2000. At current control levels, that means that annual dust emissions will climb from 23 to over 30 million tons.[32]

If pollution control efforts did not reduce total emissions, they may have at least shifted emissions away from areas with the highest concentrations of total suspended particulates (TSP). Data on TSP trends are sketchy--only a few cities have complete records for the decade of the 1980s, and those that do, like Shenyang in Liaoning Province, were usually the sites of concerted efforts to reduce pollution from an extremely high level and therefore are probably not typical of the nation as a whole. Those cities that made the effort seem to have reduced TSP levels considerably, but this conclusion may be premature because annual variation due to weather is considerable.[33] In any case, those gains in air quality that came as a result of moving factories to rural areas rather than by improving emission controls do not offer much hope for the future of clean air in China. TSP data collection has improved in the 1990s. Concentrations measured in 1993 were well above the World Health Organization guideline, averaging 250 micrograms per cubic meter in southern cities and over 400 micrograms per cubic meter in northern cities that, not surprisingly, burn more coal for heating in the winter.[34] Chinese urbanites might find a breath of relatively fresh air in New York City, where the TSP concentrations are only 60 micrograms per cubic meter.[35] (See Figure 2.)

The citizens of Liaoning Province, located in Northeast China, the home of China's heavy industry, suffer the consequences of inadequate air pollution control. The question is not whether coal smoke damages their lungs, but how much different factors contribute to respiratory disease. Studies done in cities in Liaoning[36] show mortality rates from chronic obstructive pulmonary diseases of 80 per 100,000, 4 times the rates in developed countries. In Shenyang, Liaoning's capital and one of China's most polluted cities, age-

Figure 2

Concentrations of Particulates in Selected Chinese and U.S. Cities



Source: World Health Organization, Global Environment Monitoring System

adjusted mortality from lung cancer is around 50 per 100,000 for males. The rate for females, 29 per 100,000, is among the highest in the world. Air pollution, both indoor and outdoor, accounts for an estimated 60 percent of chronic obstructive pulmonary diseases, and 25 percent of lung cancer. Every year in the Shenyang urban area, an additional 300,000 people are treated and an additional 2,000 people die of chronic obstructive pulmonary diseases due to air pollution.

Another Liaoning study examined the effects of pollution, coal burning, and smoking on the prevalence of bronchitis. Researchers were able to examine independent and synergistic effects of these factors by comparing groups of people exposed to one or more of the factors to a control group composed of nonsmokers living in relatively clean areas who do not burn coal in their homes. In terms of independent effects, heavy pollution was the most serious, followed by smoking, moderate pollution, and coal burning. The effects of heavy pollution can be seen most clearly by noting that the rate of chronic bronchitis among residents of areas of heavy pollution who neither smoked nor burned coal was more than 10 times that of the control group. Those who also burned coal in their homes were more than 12 times as likely as the control group to have bronchitis. Nonsmokers in areas of moderate pollution had 3 times the rate of bronchitis as the control group if they did not burn coal in their homes, and 5 times the rate of the control group if they did.

While particulates and their health impacts are primarily a domestic problem, sulfur dioxide, another emission from coal combustion, is an issue of growing concern for both China and its neighbors because it is a precursor to acid rain. Sulfur dioxide emissions from industry declined from 16 million tons to 12 million tons between 1980 and 1986, but rose again to 16 million tons by 1989. Sulfur dioxide emissions may rise to 20 million tons by the year 2000 as coal use continues to grow.[37] Chinese government officials initially announced that they intended to cap sulfur dioxide emissions at 20 million tons by 2000,[38] but the target has been raised to 21 million and then to 23 million. China would have to spend $2.6 billion, or $520 million annually, to reduce sulfur dioxide emissions by the 2 million tons required to meet the year 2000 target.[39]

China emitted 17 million tons of sulfur dioxide in 1992 according to official figures, but the actual total was closer to 19 million tons if estimated emissions from town and village enterprises are included. The top two sectors producing sulfur dioxide in China are power production and chemical industries. The three main types of equipment producing the most sulfur dioxide are industrial boilers, power plant boilers, and household stoves.[40] Ambient concentrations of sulfur dioxide in cities did not rise as fast as coal consumption because of environmental protection measures and higher smokestacks.

Although more sulfur dioxide is emitted in the north, much of the damage from acid rain occurs in Southwest China, where the soil has less buffering capacity.[41] For example, Guizhou Province in Southwest China suffers from serious acid rain problems. As of 1991, acid rain covered about two thirds of the province's total area. In central Guizhou, the pH of precipitation is below 4.5, and total sulfur deposition is about 2.5 tons per square kilometer per year. Precipitation pH is around 4 in most cities and sulfur deposition reaches 10 tons per square kilometer per year. The lifetime of zinc-plated steel, normally 29 years, is reduced to 4 years in the capital city of Guiyang and 9 years in rural Guizhou. Economic losses due to damage to crops, forests, building materials, and metal are estimated at over $100 million.[42] Losses are estimated at $2 billion nationwide.[43]

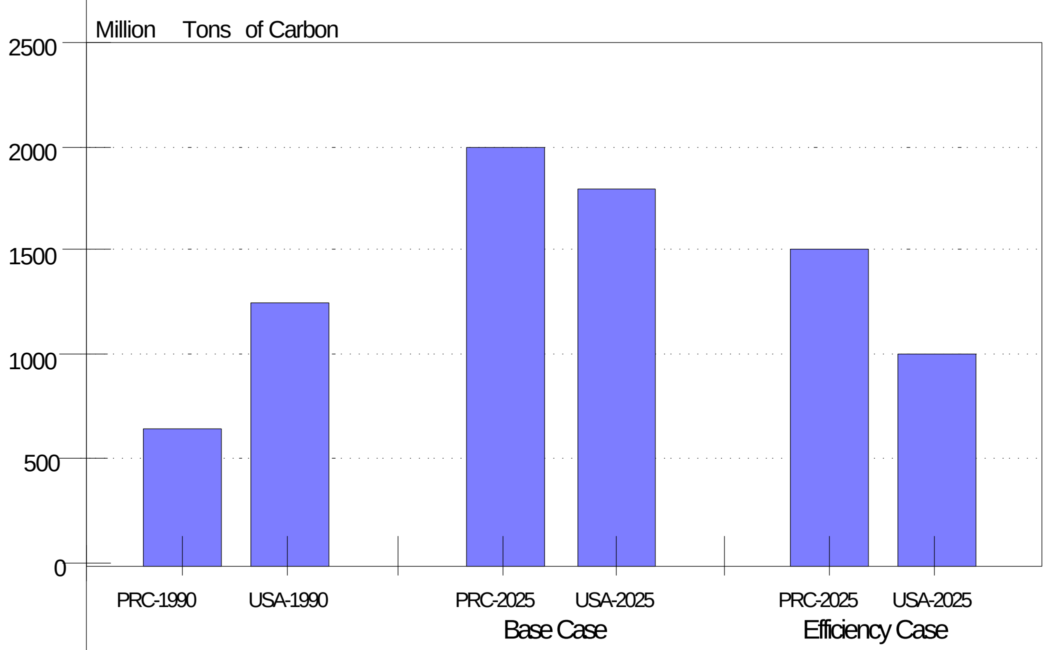
South China is the third largest area in the world seriously affected by acid rain, after

Europe and North America. The affected area has grown from 1.75 million square kilometers in 1985 to 2.8 million square kilometers--or almost a third of China's total land area--in 1993[44] because of increases in energy consumption and the use of high smokestacks. The World Bank reports that sulfur emissions from Asia may surpass those from Europe and the United States combined by 2005.[45] Easily quantifiable losses, such as current damage to forests, agriculture, and buildings, are still a small percentage of local economic output, but losses that are hard to quantify, such as soil deterioration and damage to ancient buildings and statues are likely to have a severe impact on China's well-being in the long run. Chinese research has not yet determined whether China's sulfur dioxide emissions are contributing to acid rain beyond its borders,[46] but China's neighbors fear the worst.

China's growing emissions of carbon dioxide and their potential impact on the global climate have also attracted international attention. The pressure on China to reduce carbon emissions is somewhat unfair because China has only recently become one the world's leading emitters of greenhouse gases, meaning the country's historical contribution is relatively low. Rapid industrialization and population growth over the past 40 years caused carbon emissions from fossil fuel combustion to grow from 22 million tons in 1950 to 580 million tons in 1990.[47] China's energy consumption is much more carbon intensive than the world average because of its reliance on coal[48] (which produces twice as much carbon per unit of energy as natural gas) for three quarters of its energy needs. Nevertheless, China's cooperation will be essential in any global effort to restrain carbon emissions.

The future of China's carbon emissions will be determined by the extent to which China raises energy efficiency and switches from coal to other energy resources. Assuming that China continues to rely primarily on coal and achieves a 5 percent average growth rate for the next 30 years, carbon emissions are expected to grow by 1.5 billion tons in a base case scenario, and by 1 billions tons in high efficiency scenario. In either case, China is expected to become the world's largest carbon emitter by 2025.[49] (See Figure 3.)

Figure 3
Carbon Dioxide Emissions Forecasts



Source: Team led by J. Sathaye at Lawrence Berkeley Laboratory

Forests and Fodder as Fuel

Biomass is the main fuel source in the countryside, where most of China's population lives. Biomass accounts for 70 percent of the energy consumed by China's 900 million rural residents, or one quarter of China's total energy, including commercial and noncommercial sources.[50] Biomass accounted for 86 percent of rural household fuel in 1979, resulting in less than 14 percent efficiency.[51] The growth of town and village coal mines in the 1980s made more commercial energy available to rural residents, but most of it was absorbed by the rural industrial sector. (Rural industry's share of total rural energy use grew from 20 percent in 1979 to 39 percent in 1990.) Thus, rural households still rely on biomass for 79 percent of their energy needs.

Table 2. Rural Household Consumption

	1979[52]		1990	
	Exajoules (EJ)	Percentage	EJ	Percentage
Biomass	6.6	85	7.7	79
Commercial	1.1	15	2.0	21
Total	7.7	100	9.7	100

Biomass resources in China consist of crop waste, firewood, and manure. Crop residues accounted for roughly three fifths of total biomass consumption nationwide in 1988, but this proportion varies substantially depending on local conditions.[53] For example, the share of crop waste, which is primarily grain stalks, but may also include legume, oil crop, and sugar cane residues, reaches 90 percent in deforested and intensively farmed lowlands.[54] China now produces 450 million tons of straw and stalks and 50 million tons of rice husks per year.[55]

Firewood accounts for most of the remaining two fifths of biomass consumption. The definition of firewood covers most tree products, such as wood from fuelwood lots, timber wastes, scattered shrubs, and trees that are planted along the sides of houses, roads, fields, streams, and rivers in accordance with the government's "Four Sides" tree planting policy. China's sustainable annual production of firewood is around 89 million tons, or 110 kilograms per capita. If rural Chinese families were to rely exclusively on firewood, this amount would last only two months per year, or meet 17 percent of total energy needs.[56] Because of this gap between supply and demand, China's firewood consumption far exceeds the sustainable limit of approximately 5.3 million hectares per year.[57] Forty percent of firewood is used for cooking and heating, while the remainder is used for various industrial purposes such as making bricks, lime, ceramics, and charcoal, curing tea, refining sugar, and drying tobacco.[58]

China produces significant quantities of manure, including both human and animal wastes, but this potential fuel source does not add much to the energy equation. Production totaled 260 million tons in 1983, but almost all of it was used as fertilizer. A small percentage of animal dung is dried and burned directly in stoves, mostly by nomadic people in the grasslands of Inner Mongolia, Xinjiang, and Tibet. Human excrement is sometimes combined with other material, such as pig manure and crop waste, in biogas digesters to produce methane, but this process supplies only one percent of rural energy in the areas suitable for its use.[59]

Heavy reliance on biomass for fuel threatens both agriculture and forests. Demand for biomass is three times sustainable yields, resulting in severe fuel shortages and depletion of 200 million tons of forest resources per year. China's biomass resources are not only insufficient to satisfy energy needs, but they are also needed for other economic and ecological purposes. This means that rural families and local leaders are often faced with tough choices. For example, agricultural residues, such as straw and stalks, are not only a major rural fuel, but are also widely used as fodder and organic fertilizer. A family that burns too much of its crop waste as fuel may not have enough left over to feed its animals and/or plow back into the soil. Biogas digesters were once seen as the answer to this dilemma because they are designed to produce both energy and fertilizer, but the design that was disseminated over much of China during the 1970s and 1980s proved to be unsuitable for most of the year in cold areas and difficult to operate and maintain.[60]

Wood resources, like crop waste supplies, are also overtaxed by competing energy, economic, and environmental goals. Current consumption of raw wood exceeds production by 30 percent, resulting in severe deforestation.[61] The specific effects of firewood collection are difficult to measure because deforestation has also been caused by clearing land for agriculture, harvesting timber, and misguided political campaigns. Vaclav Smil, a leading expert on environmental management in China, estimates that inadequate fuel supplies are now responsible for at least half of China's ongoing losses of vegetation.[62] However, the proportion undoubtedly varies according to local conditions. In Fujian Province, for example, every year 71 percent of trees felled are used for industrial and commercial purposes, while the remainder is used by households.[63] In any case, total use is almost double Fujian's annual production. Fujian's losing battle against deforestation is typical of the nation as a whole. Only 30 percent of trees planted between 1949 and 1988 remain, due to mismanagement and looting.[64]

Massive deforestation in China, as in the rest of the world, prevents trees from doing their ecological jobs: holding soil in place, retaining moisture, providing food and shelter to other organisms, filtering pollutants, blocking high winds, and absorbing carbon dioxide. The resulting environmental problems are well known: erosion, biodiversity losses, and wind storms. The worst cases of biodiversity losses have occurred in the tropical areas of Yunnan and Hainan Island, where fuelwood accounts for approximately 90 percent of household energy use.[65]

Big Dams

Hydropower is "clean" power, in the sense that it does not create air pollution, but large dams can completely alter the local ecology and economy, for better or for worse. Economic costs and benefits associated with the environmental changes wrought by dams are difficult to sum up because they often accrue to different, partially overlapping, interest groups. For example, all citizens may enjoy the advantages of smoke-free electric power, irrigation, navigable rivers, and improved flood control, but to those who lose their homes and habitats to planned flooding, the costs far outweigh the benefits.

The Three Gorges Dam is probably the most famous example of the controversy surrounding large dams. In the 75 years since it was first proposed, a large body of literature has emerged detailing the expected results. Social and cultural issues aside, the dam's economic and environmental impacts are still quite uncertain. A report by the Chinese People's Political Consultative Committee disputed the claim that the Three Gorges Dam would control flooding. The report, based on extensive interviews with 400 scientific and technical experts familiar with the project, concluded that the dam would fail to prevent floods, one of its main proposed benefits, because it would control only one of the valley's many tributaries. Moreover, building the dam would inundate parts of ten cities, more than 80 villages, and up to 44,000 hectares of farmland.[66] Disruption of the rhythmic rise and fall of the river would annihilate 80 species of fish, as well as several endangered species, and threaten the livelihood of the people who make a living on the water. The dam may also restrict the river's ability to flush out pollution and replenish nutrients downstream.[67]

Large dams also tie up large amounts of capital for a long time before the power and profits start flowing. The estimated cost of $6.5 billion for Three Gorges, which does not include related infrastructure and resettlement costs, was criticized as too low by an economist who pointed out that the price of building materials has been rising faster than inflation.[68] The dam will not generate electricity until nine years after the project starts, and the following ten years of revenues will total $4.6 billion, less than the project cost in absolute terms, and far less if the money is discounted for inflation and time value of money. The opportunity cost of such a huge, long-term, inflexible investment cannot be ignored. Less famous, but still huge, the Xiaolangdi Dam will cost $1.1 billion and will take 11 years to construct. Seven thousand people will have to be resettled.[69]

II. SOLUTIONS: EFFICIENCY, FUEL SWITCHING, AND ENVIRONMENTAL LAWS

Solutions to China's main energy and environmental problems include raising end-use energy efficiency, switching from coal to gas, switching from biomass to renewables, and tightening environmental standards.

Energy Efficiency

High energy intensity, the ratio of energy consumption to economic output, hints at great potential for improving energy efficiency in China. Studies of specific technologies reveal that China does indeed have tremendous technical potential to raise end-use efficiency. Such improvements can save China money while providing the same or better level of energy service with reductions in environmental impacts. Therefore, energy efficiency can be an important element of a least-cost strategy for heat and electric power development, according to economic analyses at both the national and the municipal level. A market for energy efficiency is beginning to take shape, as evidenced by both case studies of financial internal rates of return on energy efficiency investments and the success of purveyors of energy efficiency products. Thus, energy efficiency appears to be beneficial for both individuals and society as a whole.

Energy Intensity. China's consumption per unit of economic output has been falling steadily since the late 1970s, but is still three times the world average, and twice the average for developing countries.[70] However, energy intensity is disputed as a measure of potential to raise efficiency because exchange rates do not always reflect the purchasing power--and the true value--of different currencies. If the purchasing power of China's currency is greater than its nominal value, then international comparisons may make China's economy appear more energy intensive than it actually is.

Economists also argue about how much of China's high energy intensity is due to two different factors:

- Economic factors: A large share of economic activity occurring in energy-intensive sectors, such as the industrial sector, and energy-intensive industries within those sectors, such as metallurgy, chemicals, and building materials;

- Technical factors: Low efficiency within specific industries caused by incorrect operating procedures, inadequate maintenance and repairs, poor system design, obsolete equipment, and low quality or inappropriate fuel.

The part of China's high intensity caused by economic factors must be addressed through economic means, such as raising energy prices to reflect their true value and introducing hard budget constraints that force firms to lower energy intensity in order to stay in business. Such measures may also indirectly influence the technical factors by creating economic incentives to improve management and technologies. However, the experience of countries around the world has shown that economic incentives to raise technical efficiency work best when used in tandem with institutional support for energy efficiency, such as regulatory and financing mechanisms.

Technical Potential. The question of what role technical factors play in China's high energy intensity can be answered by comparing energy use per unit of physical output rather than economic output in different countries, thus eliminating the problem of inexact exchange rate values. In strictly technical terms, China's energy efficiency still lags far behind that of developed countries like Japan. (See Table 3.)

Table 3. Ratios of Energy Use per Unit of Industrial Output in China and Japan

	China in 1990 : Japan in 1980
Ammonia	2.1
Cement	2.1
Caustic Soda	1.8
Ethylene	1.8
Thermal Power	1.3

Source: National Environmental Protection Agency of China et al., *China, Issues and Options in Greenhouse Gas Emissions Control*, (Washington, DC: World Bank) December 1994.

Studies conducted by the Energy Conservation Division of China's Energy Research Institute conclude that China has the technical potential to save 40-50 percent of the total volume of current energy consumption by raising its industrial energy efficiency to advanced levels. A survey of the energy conservation potential of three major types of equipment--boilers, furnaces, and fans--illustrates the point.[71]

- China's industrial boilers consume 9.1 exajoules of coal annually, about one third of the national total. If boiler efficiency were raised from the current 65 percent average to the 80 percent average attained by developed countries, then 1.7 exajoules of coal could be saved every year.

- Industrial furnaces use about one quarter of China's total energy. Chinese industrial processes such as steel and glass production and copper smelting consume 25-110 percent more energy per unit produced due mainly to the efficiency gap between furnaces in China and advanced ones. If China's furnaces were raised to advanced levels, then China would could save around 40 percent of the energy used by furnaces, or 2.9 exajoules every year.

! China's 3.9 million fans consume one tenth of total electric power. Fan efficiency improvements could save hundred of millions of kilowatt hours every year.

The energy conservation potential described above does not even include town and village enterprises, which use inefficient, polluting, secondhand equipment and are supplied by small, inefficient power plants.[72]

The residential and commercial sectors also present many opportunities to save energy. Combustion of coal and biomass in small stoves for heating and cooking is dirty and inefficient, yet it is the norm for residential energy use. Despite the demonstrated advantages of district heating, it still has not been adopted on a large scale. Efficiency is further hampered by the dearth of building insulation and other measures to protect residents from extreme heat and cold, and inefficient lighting and appliances.

Economic Benefits at the National Level. Once China's technical potential to raise energy efficiency is established, the next task is to investigate the costs and benefits of integrating demand side investments into China's energy development strategy. A recently completed computer model of China's national energy system permits this type of analysis.[73] The model is based on the Coal Transport Study that was jointly developed by the World Bank and the State Planning Commission of China to generate policy recommendations for reducing China's coal shortages. The original Coal Transport Study was designed to minimize the total cost of delivering coal and electricity by deciding how much to invest in coal mines and power plants in different parts of the country. The model selected the type, location, and timing of investments that would make the best use of existing transportation capacity, and provided the cost and the quantity sulfur and ash emissions that would result from those investment choices.

The expanded model added demand side measures, including raising the efficiency of industrial boilers, kilns, residential stoves, electric motors, and lighting, to the set of investment options. The results showed that a combination of supply side and demand side investments in China's energy sector can provide a higher level of energy service at a lower cost than supply side investments alone. In fact, rising demand makes energy conservation increasingly economical because supply side costs accelerate more rapidly than demand side costs. This occurs because rising demand raises resource costs and puts additional strain on an already overburdened transport system. Environmental costs were also lower when demand side investments were incorporated.

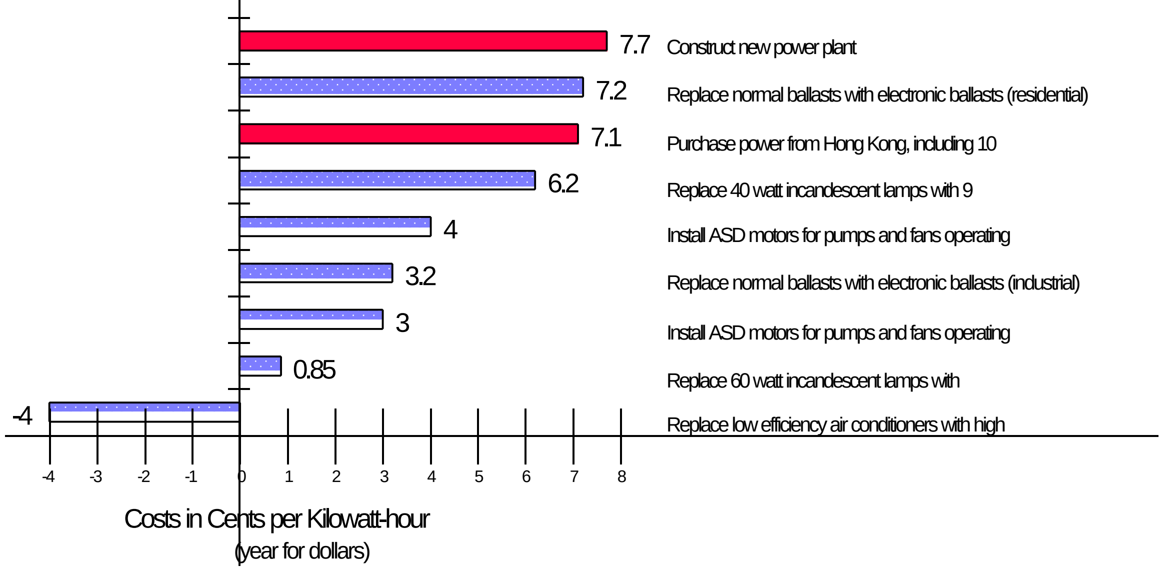
Economic Feasibility at the Municipal Level. National planning is important for setting guidelines for promoting energy efficiency, but decentralization means that localities will only invest in efficiency if they find that it is to their benefit. Rich coastal cities will be the first to make significant investments in energy efficiency because their high electricity prices will make efficiency competitive with supply side investments.

The city of Shenzhen, located across the border from Hong Kong, is a good place to examine the economic feasibility of energy efficiency investment at the municipal level because it has the highest electricity tariffs in China: 5.7 cents/kWh for residential customers, and 8.0-11 cents/kWh for industrial and commercial consumers. Another reason for choosing Shenzhen is that it is a Special Economic Zone, meaning that the central government has allowed it to institute policies that allow market forces and foreign investment play major roles.

A study of the quantity and cost of demand side resources in Shenzhen revealed that the city could save money by shifting funds originally designated for a 600 megawatt generating unit into energy efficiency improvements. The study, known as the "Shenzhen Integrated Resources Planning Feasibility Study," was led by BECon, the Energy Research Institute of the State Planning Commission, the Shenzhen municipal government, and Shenzhen Energy Corporation.[74] The study focused on three major end uses--electric motors, air conditioning, and lighting--because their share of total electricity consumption is expected to grow from 73 percent in 1992 to 85 percent in 2000. The working group determined that switching to cold storage air conditioning systems, adjustable speed drive motors, compact fluorescent lamps, and electronic ballasts could technically save 1.5 terawatt-hours, or 6 percent of total electricity use, and reduce peak load by 1,200 MW, or 24 percent of total capacity demand in 2000. Many of these demand side measures are less expensive than the supply side measures that Shenzhen is considering. (See Figure 4.)

Based on the feasibility study, Shenzhen is designing a demand side management pilot project that will include development of legislation and implementation of demonstration projects. Shenzhen's use of markets and foreign investment place it at the leading edge of China economic reform, and China's other coastal cities that face similar power shortages will be watching the pilot project closely. Shenzhen's efforts to promote investment in energy efficiency has already attracted the attention of other coastal cities, which have requested training in conducting their own studies of the feasibility of conducting demand side management and integrated resources planning.

Figure 4
Cost of Supply and Demand Side Measures



	Measure	Cost in Cents per Kilowatt-hour
1.	Replace low efficiency air conditioners with high efficiency ones	-4.0
2.	Replace 60 watt incandescent lamps with 11 watt CFLs (commercial)	0.85
3.	Install ASD motors for pumps and fans operating 2000 hours per year (industrial)	3.0
4.	Replace normal ballasts with electronic ballasts (industrial)	3.2
5.	Install ASD motors for pumps and fans operating 3000 hours per year	4.0
6.	Replace 40 watt incandescent lamps with 9 watt CFLs (residential)	6.2
7.	Purchase power from Hong Kong, including 10 percent administrative fee	7.1
8.	Replace normal ballasts with electronic ballasts (residential)	7.2
9.	Construct new power plant	7.7

Financial Feasibility at the Enterprise Level. Energy efficiency projects must be attractive to enterprises as well as to state and local governments in order to become a viable solution to China's energy problems. Case studies sponsored by the Global Environment Facility show that financial internal rates of return for energy efficiency investments in Chinese manufacturing enterprises are high enough to justify widespread application. (See Table 4.)

The report also notes, however, that high rates of return are not always sufficient to induce enterprises to implement efficiency projects. A company may only wish to invest in energy efficiency as part of an overall restructuring program, particularly if energy represents only a small fraction of its total expenditure. And, in some cases, very low efficiency may be a sign that the enterprise is generally unhealthy and may soon fail, rendering energy efficiency investments useless.

Indications of a Market for Energy Efficiency. Turning the technical and financial potential into a reality requires implementation through state investment programs, market mechanisms, or both. Now that state investment is tapering off, the market has become essential to the delivery of energy efficiency. Indications of a small but growing market for energy efficiency can be found in the emergence of independent energy conservation centers, energy efficiency trade fairs, and anecdotal evidence of sales and purchases of energy efficiency products.

Table 4. Financial Internal Rates of Return for Selected Energy Efficiency Investments

Investment	Percent
Steel: Conversion of open hearth furnace to basic oxygen furnace	16
Steel: Adoption of continuous casting	19
Steel: Reheating furnace renovation	36
Steel: Blast furnace gas recovery	41
Aluminum kiln renovation	84
Ammonia: Medium-sized plant restructuring	20
Ammonia: Small plant waste heat recovery	71
Caustic soda: Adopting membrane electrolyzer	29
Cement: Medium-sized kiln renovation	15
Cement: Conversion from wet to dry process	19
Cement: Small-scale kiln renovation	35
Pulp and paper: Adoption of cogeneration	25
Pulp and paper: Black liquor recovery	25
Textiles: Cogeneration in printing and dyeing	38
Textiles: Caustic soda recovery	58
Textiles: Computerized energy management system	>100

Source: National Environmental Protection Agency of China et al., *China, Issues and Options in Greenhouse Gas Emissions Control*, (Washington, DC: World Bank) December 1994.

China's local energy conservation centers were originally established to carry out state mandates to conduct audits, install meters, train energy managers, and conduct feasibility studies for energy conservation.[75] After state funding was cut off, many of them managed to survive by transforming themselves into small enterprises. The Nanjing Energy Conservation Center, for example, sells and holds patents for energy efficient products, such as aluminum-skinned fiberglass insulation for industrial heat pipes.[76]

Another indication of the market for efficiency is the popularity of the Shanghai Energy Conservation Trade and Education Fair. Shanghai is very interested in energy efficiency because it gets all its energy from external sources, it suffers from frequent power outages, and it is building a huge new development called Pudong. Shanghai holds an energy efficiency trade fair every year with 60,000 attendees divided into four main areas of interest: electrical equipment, monitoring equipment, insulation and building materials, and home appliances. The fair is sponsored by two branches of the Shanghai municipal government: the Economic and Trade Bureau and the Education Department. Shanghai gets some support from the State Economic and Trade Commission, but the primary reason for holding the fair is that city officials think energy efficiency is good for Shanghai because it saves electricity and promotes development of advanced technologies that are good for economic growth. Most participants get orders for their products at the fair.[77]

A third indicator is the tendency for wealthy enterprises in rich coastal provinces such as Zhejiang and Jiangsu to purchase expensive, high efficiency products. Firms with financial expertise and ability tend to buy high efficiency products. Companies like Johnson Controls, which sells thermostats for luxury office buildings and hotels, have tapped into the upscale market, while companies like Owens-Corning, which sells fiber glass insulation, are attempting to expand their potential market by encouraging energy efficiency policies.

Natural Gas as an Alternative to Coal

Natural gas, like energy efficiency, offers a less polluting, less expensive alternative to coal. Using advanced coal technologies can bring particulate and sulfur dioxide emissions down to levels comparable to those of gas, but at a significantly higher price. Even advanced coal technologies such as fluidized bed combustion and gasification, which is still in the demonstration stage, still produce almost twice as much of the greenhouse gas carbon dioxide as burning natural gas. (See Table 5.)

Natural gas currently accounts for only two percent of China's energy use, and most of it has been used as an input for the chemical fertilizer industry. However, China has long been considered one of the world's largest unexploited regions for gas. The Beijing Institute of Petrogeology now estimates potential resources at 40 trillion cubic meters, not including 16 trillion cubic meters of potential coal bed methane resources.[78]

China's major gas fields include Sichuan, with 360 billion cubic meters of proven reserves, Bohai Bay (230 billion cubic meters), the Shaanxi-Gansu-Ningxia area (200 billion cubic meters), and Qaidam (100 billion cubic meters).[79] The best bets for large new finds are the South China Sea and Xinjiang Province in the far west. Tarim Basin reserves in Xinjiang Province are estimated at up to 2.5 trillion cubic meters, but transporting gas from this remote area is a major challenge.[80]

China claims that only 150 billion cubic meters of its gas reserves are commercially viable, but this estimate may be one fourth or one fifth the actual level, according to at least one prominent U.S. expert. Robert Hefner of the GHK Company believes that China estimates are based on poor exploration and extraction techniques, and that up to 750 billion cubic meters of gas can be commercially recovered using modern technology.[81]

Table 5. Comparison of Options for Power Generation

Technology	Conversion Efficiency (percent)	Emissions NO_x	SO_2	CO_2
			(grams per kilowatt-hour)	
Coal				
Conventional Steam Cycle (without scrubbers)	36	1.29	17.2	884
Conventional Steam Cycle (with scrubbers)	36	1.29	0.82	884
Fluidized Bed Combustion	37	0.42	0.84	861
Integrated Gasification Combined Cycle	42	0.11	0.30	758
Natural Gas				
Fuel Cell	36	0.04	0.00	509
Aeroderivative Turbine	39	0.23	0.00	470
Combined Cycle Turbine	53	0.10	0.00	345

Source: Christopher Flavin and Nicholas Lenssen, *Powering the Future: Blueprint for a Sustainable Electricity Industry* (Washington, DC: Worldwatch Institute) 1994. Data are for particular plants representative of those in operation or under development. Coal plants are burning coal with 2.2 percent sulfur content.

Reducing Biomass Overuse with Renewables

Planting trees, raising the efficiency of biomass combustion, and using alternative energy sources can help relieve rural fuel shortages and the resulting pressures on the environment. Establishing sustainable forestry programs would at least halt, if not reverse, deforestation in China. After years of limited success with public tree planting campaigns, the Chinese government began to allow the planting of private wood lots in 1980. Any tree planting scheme, however, faces the inescapable problems of insufficient rainfall in most of China's northern provinces and scarce available land in the intensively cultivated southern provinces. If an area is suitable for tree planting, profit-oriented farmers are more likely to plant trees for fruit or timber than for fuel.[82] The most attractive alternative is a plan that combines fuel wood planting with other purposes, such as intercropping or using trees as windbreaks along the edges of fields. Other important measures include improving the efficiency of biomass combustion in household stoves--which not only stretches the available supply of fuel, but also reduces emissions of pollutants per unit of energy service--and encouraging the use of solar energy, particularly in China's sunny regions that suffer from severe firewood shortages.

Powering Remote Villages with Renewables

Small hydropower, solar power, and wind power can play an important role in meeting the electricity needs of families who are currently without power, and these energy sources may soon become viable alternatives to constructing additional coal plants and large dams. Small hydropower supplies rural China with about one fifth of its electricity needs. It is a particularly important power source in hilly regions that are difficult to connect to the state electric power grid. China leads the world in small hydropower, in terms of both number of stations and total capacity. Small hydro is defined as stations with capacity of up to 25 megawatts (MW). China had 62,000 stations with installed capacity totalling 12,000 MW as of the end of 1989. Annual production by these stations was 32,000 GWh in 1988, about 6 percent of total power generation.[83] China has installed photovoltaic capacity of 1.2 MW. Around half of the total is deployed in remote and rural areas in power stations, and for direct use in household lighting and television systems, insect trap lights, electric fences, water pumps, and other applications. Most of the remainder is used in the communications and transportation industries, for example, in television transmitters, cellular telephone stations, beacons, lighthouses, and highway and railway signaling systems.[84] China's wind power potential of 470,000 MW is located primarily in the grasslands of the northwest and coastal areas. Wind speeds average six to nine meters per second in the coastal provinces of Shandong and Liaoning, and four to six meters per second in the pastoral regions of Inner Mongolia, Xinjiang, and Qinghai.[85]

Tightening Environmental Controls

Making environmental requirements for energy production and consumption more stringent could have the dual effect of cleaning up existing practices and making alternatives more financially competitive. For example, if the government passes legislation now under consideration to require power plants to use scrubbers and other expensive desulfurization devices, the increase in the cost of coal-fired power production will benefit power producers who use renewable energy and natural gas, while higher electricity prices will benefit consumers who invest in energy efficiency.

III. CHINESE ENERGY AND ENVIRONMENTAL POLICIES

Because funding is limited, solutions that combine environmental protection with economic development, such as energy efficiency, are the most likely to receive government support. However, improving energy efficiency is not a sufficient means to control energy pollution. The Chinese government also officially recognizes the importance of switching from coal to renewables, natural gas and oil, and developing cleaner methods of producing and burning coal and oil.

Background

A brief comparison of energy management systems in the United States and China provides background that may be useful in understanding China's energy and environmental policy. In the United States, fossil fuel is generally produced by private companies and sold at market prices. Electricity is produced and distributed by private, municipal, state, and federal utilities and sold at prices set by state public utility commissions. The U.S. Department of Energy implements energy laws and regulates private and public organizations, for example, setting and enforcing energy efficiency standards for appliances or building design.

China's energy sector, on the other hand, is now in an awkward transitional stage between central planning and a private enterprise system. Energy ministries are becoming energy corporations, but they retain some government functions and no organization like the U.S. Department of Energy has emerged to regulate them. The central government requires state-owned, collective, and private fossil fuel enterprises to sell a certain amount of their product to the state at a state-set price called the "low plan" price. Enterprises can sell amounts above the quota to the state at the high plan price or sell it on the market. Fuel bought by the state is sold at low prices to state enterprises. New power projects are owned by both public and private investors, but prices are chaotic and irrational, and do not encourage efficiency or load leveling. Energy efficiency programs are designed by the

State Planning Commission and efficiency investments are made by the State Energy Investment Corporation. The state is attempting to shift responsibility for energy efficiency investments from itself to enterprises by creating regulatory and market incentives.

China's Energy Efficiency Policies

Long before the studies described above were conducted, the Chinese government recognized that efficiency improvements were essential to meeting its ambitious targets for economic growth and launched a multi-pronged attack on energy waste beginning in the early 1980s. Its efforts were not in vain: a combination of macroeconomic restructuring and technological renovation allowed China's economy to grow twice as fast as energy consumption, an unprecedented feat for a developing country. The current challenge is to transfer the responsibility for energy efficiency investment from the public to the private sector.

Price Reform. China is plagued by energy shortages. In a free market, energy shortages would result in high energy prices, creating an economic incentive to improve demand side efficiency and bringing supply and demand into balance. In China, however, energy prices have historically been kept low and, despite significant price hikes in the last 15 years, they still average below the international market price. Since the late 1970s, Chinese energy prices have often failed to cover the cost of production, forcing state coal mines and other energy enterprises to rely on heavy subsidies from the central government.

As part of the economic reform program, the government stopped paying the coal industry its annual subsidy of $230 million. To make ends meet, China General Coal Corporation, which produces a third of China's coal, raised the percentage of its output sold at market prices (more than twice the plan price) to 57 percent in 1993 compared to only 20 percent in 1992.[86] Coal prices were deregulated as of January 1994, and the government reported that major coal mines began to make profits[87] after laying off over 200,000 employees in 1993 and 1994.[88] Oil price reform, on the other hand, has taken two steps forward and one step back, according to foreign investors. After announcing several measures to open the market beginning in 1992, the government changed course in the summer of 1994 and re-centralized the pricing and distribution system.[89] And the government always reserves the right to adjust other prices as it sees fit. For example, concerned that the ripple effects of energy price reform could cause social unrest, the State Council issued price controls for sale of coal and gas to non-industrial customers in the spring of 1994.[90]

Institutional Reform. Price reform is only half the battle. China's efficiency drive also involves promoting competition and accountability by freeing energy enterprises from state ownership and control. Under traditional central planning, all enterprises were owned and operated in one of two ways: state ownership or collective ownership. Five Year Plans drawn up by the State Planning Commission determined production and allocation of goods from both types of enterprises. Production ministries, such as the Ministry of Coal and the Ministry of Oil and Gas, implemented the plans. Enterprises turned over all profits to the central government and the state subsidized enterprises' losses. Private enterprise was not allowed. Lack of accountability and the absence of a profit motive dampened the incentive to improve energy efficiency.

China has taken some halting steps toward privatization. Rather than selling off state assets to the private sector, China has turned some energy ministries, or parts of ministries, into state energy corporations. Some observers applaud the success of the state-owned Huaneng Group, which built one third of China's power plants in the 1980s with seed money from oil exports, but critics contend that Huaneng is still financially linked to the central government and therefore is not truly accountable. These critics recommend increasing competition by breaking up Huaneng and other large energy corporations like Sinopec, which holds a monopoly in the oil products retail sector.

The emergence of state corporations has been accompanied by the rise of nonstate enterprises. The state's share of production and consumption is declining rapidly, but collective ownership persists, with only a small portion of GDP coming from the private sector. In 1993, 45 percent of China's production and profits came from the nonstate sector, mostly town and village collectives, a slightly different breed from the private businesses officially known as "individual enterprises" (8 employees or less) and "private enterprises" (more than 8 employees). Town and village enterprises (TVEs) are common in the coal industry because coal, unlike oil, does not require sophisticated equipment to retrieve. While the state continues to own and operate large coal mines and gives preference in coal allocation to large state-owned heavy industrial enterprises, such as iron and steel manufacturers, local mines have jumped in to meet the growing coal demand in the nonstate sector.

Decentralization has also occurred in the power sector. Local governments capable of raising sufficient funding, including foreign exchange to import equipment, usually have no trouble getting approval from the central government to build new power plants. Large private enterprises are also allowed to invest in plants that will provide them with power. The new power plants are accountable for profits and losses, and are allowed to charge higher tariff rates than existing plants, but the final price must still be approved by the Ministry of Power.[91]

State Investment in Efficiency. Direct investment in efficiency as well as macroeconomic reform helped China decouple energy use and economic growth in the 1980s. The Chinese government invested significant resources in improving efficiency in key energy-intensive industries, as well as in improving the efficiency of motors, fans, and pumps in all industries. However, total state investment in demand side measures was dwarfed by investment in new power plants. The central government invested approximately $3.8 billion in expanding power supply last year,[92] about ten times what it spent on energy conservation.

There are two main channels for direct state investment in energy conservation: the Energy Conservation Investment Company (under the State Planning Commission), which is responsible for large-scale projects, and the Energy Conservation Technological Renovation Fund (under the State Economic and Trade Commission), which covers small-scale projects. The two organizations changed the form of investment from grants to loans in 1985, but interest rates for energy conservation loans are 50 percent lower than the prevailing rate. The standard rate for energy conservation loans in 1993 was 4.8 percent. Interest rates may be reduced by even more than 50 percent for projects with significant environmental and/or social benefits.[93]

No loan guarantees are required because government agencies administer the loans. In the first step of the process, the enterprise submits a technical proposal for renovating equipment or improving processes to the provincial or municipal energy conservation office. This office then selects the best proposals, about one third of the total, and submits them to either the Energy Conservation Investment Company or the Conservation Fund, depending on the scale of the project. The State Planning Commission and the Ministry of Finance determine the total amount of funding available for energy conservation loans that year and how the total will be divided among the local energy conservation offices and ministries. In effect, the State Planning Commission and the Ministry of Finance give the subordinate agencies permission to borrow a certain amount of money from a state bank, the Industrial and Commercial Bank in most cases, or the Bank of China if foreign currency is needed. The energy conservation offices then distribute loans to the enterprises.[94]

The Energy Conservation Investment Company's funds have grown by 20 percent annually since 1990. The company invested $300 million in 1993. The Conservation Fund administers $70-87 million in loans per year. Central government loans are supplemented by funds from local governments and enterprises. Overall, local governments invest approximately 40 percent as much as the central government in energy conservation projects. The share contributed by enterprises varies. In Beijing, for example, enterprises must contribute half of the investment.[95]

Investment was focused in the following areas in the 1980s:

- Cogeneration

- Replacing small generators with larger ones
- Fertilizer production
- District heating
- Iron and steel recycling
- Continuous casting
- Small cement kiln renovation
- Coal washing and blending
- Use of waste heat to generate electricity.

Small-scale projects included waste heat recovery and use in space heating, small cogeneration, and boiler renovation.

China's energy conservation management system will undergo major changes as China decentralizes and shifts emphasis from planning to markets. The government is expected to create more incentives for saving energy, such as emissions trading programs, and penalties for wasting energy, such as fines for exceeding emissions limits or using inefficient equipment. Government agencies will probably require banks to set aside funds for conservation, but will allow them to fund specific projects based on commercial feasibility.[96] Energy conservation policy will also need to expand to include TVEs, which received no assistance in the 1980s. In fact, much of the old equipment "eliminated" by state and local firms was absorbed by the booming rural industrial sector. In the 1990s, the Rural Energy Department of the Ministry of Agriculture provided some funds for TVE energy conservation, but they are not sufficient. To remedy this problem, lenders will be encouraged to evaluate projects based on technical and commercial feasibility and environmental and social benefits, not based on who operates the firm, thus giving TVEs equal access to energy conservation loans.[97]

Draft Energy Conservation Law. The Chinese government's latest demonstration of its commitment to energy efficiency is its consideration of an Energy Conservation Law.[98] The law was first drafted in 1984 by the Energy Conservation Committee of the Chinese Energy Research Society, and was first considered by the State Planning Commission in 1985, but was not passed by the National People's Congress. The State Council did issue several regulations regarding energy conservation with many references to coal in 1986, and after 1986, several other regulations covering conservation of electricity and oil products were issued as well. These regulations resulted in many pilot projects to raise industrial efficiency, and several other achievements. For example, electricity meters were installed and bills began to be based on individual household consumption rather than calculated as a percentage of consumption by the entire building.

The administrative measures used to achieve these gains became less effective as the basis of the economy shifted from planning to markets. China's energy conservation managers, faced with increasing irrelevant conservation policy tools and another serious energy crisis, held a national meeting in 1989 to urge the passage of the Energy Conservation Law. The National People's Congress was expected to pass the law in 1995.

The Energy Conservation Law is broad in scope, covering enterprises and individuals; public, private, and cooperative; industrial, transportation, and commercial and residential use. Key elements include the following:

- Enterprises using more than 10,000 tons of coal equivalent per year are required to hire an energy management engineer and report their energy consumption to the government on a regular basis.

- Deadlines are set for eliminating old, inefficient equipment.

- Standards are set for fuel consumption per unit of industrial output for various industrial processes.

- Only the central government is authorized to label high efficiency products as such.

- The government has specified the elimination 600 low efficiency products and has identified 600 high efficiency products to replace them, with clear deadlines for enforcement.

- The government will provide low interest loans and tax breaks for energy conservation and renewable energy development.

- The government must provide standards for buildings and individual energy use, public education, training, classroom instruction materials for middle and high schools, prizes for energy conservation achievements, and protection for whistle blowers.

- Existing energy conservation technology service and monitoring centers are authorized to conduct audits and report to the government. (In the future, these organizations may be authorized to act on behalf of the government as well, for example, by collecting fines from enterprises that do not comply with energy standards.)

- Builders must pay a tax equal to 50 percent of the total investment if the energy consumption of their building exceeds the standard.

The last item is based on existing regulations that tend to be more strictly enforced for luxury hotels in big cities. Beijing, for example, is one China's most advanced cities for building energy efficiency. The energy conservation office of the Beijing Construction Commission is currently conducting a five-year pilot project to test external insulation to use in building renovation.

Renewable Energy Policy

The Chinese government has promoted the use of renewable energy primarily in the context of rural economic development for residential and agricultural applications, but foreign involvement may lead to the increasing use of renewables such as wind power in urban, industrial, grid-connected applications.

Forestry. The Chinese government provides support for tree planting by subsidizing seeds and seedlings and supporting research and development. The Sixth Five Year Plan (1981-85) included support for fuelwood plantation development under the State Rural Energy Development Program. Activities included the establishment of a statistical system for monitoring fuelwood plantations, and pilot projects testing the suitability of various tree species to areas with different soils and climates. This work was continued under the Science and Technology Program of the Seventh Five Year Plan (1986-90).[99]

Efficient Stoves. The Chinese government claims to have successfully implemented a massive program to improve the efficiency of stoves. The program benefited over 83 million households, or over of half of the country's rural families. The improved stoves raised efficiency from around 11 percent to between 25 and 40 percent. This improvement was achieved by making fairly simple changes, such as adding grates, reducing the size of the fuel-feed opening, changing the shape of the combustion chamber, and changing the position of the chimney.[100] Each efficient stove saves approximately 400 kgce per year. This means that China's 90 million improved stoves are saving 36 Mtce per year, or approximately 70 million tons of biomass.[101]

One problem with improving the efficiency of stoves in northern China is that the exhaust from these stoves is often channelled to heat a brick bed, or *kang*, before being released to the outside. People sleep on the *kangs* at night and often sit on them during the day as well to keep warm. If more heat is retained by the stove, less goes to the *kang*. Additional efforts to improve the overall efficiency of the stove-*kang* system are needed.

Biogas. Biogas digesters have been a disappointment to those who promoted them as a panacea for China's rural energy woes. About 4.5 million biogas digesters were producing methane from a mixture of human, animal, and agricultural waste in China as of 1985. The gas is burned to produce heat for drying and processing agricultural products as well as for domestic cooking and heating, and the residual product is used in fish farming and as fertilizer. China's biogas program has had many ups and downs partly because the digesters are easy to build but difficult to operate. Although they supply only a tiny portion of total energy consumption, they are regarded as an effective way convert animal and pig excrement to safe fertilizer while deriving a small amount of usable energy from the process.[102]

Biomass Gasification. Two main types of biomass gasification have been developed in China: up draft and down draft. Up draft gasifiers are simple to build and easy to operate, but they have low conversion efficiency and the gas produced contains excessive amounts of water and tar. Down draft gasifiers produce clean, high quality gas, but they are difficult to control, leave excessive carbon residues, and have a high reaction temperature, which means they are less efficient. Use of gasified biomass for power generation is still is at the demonstration stage.[103]

Solar Energy. The Chinese government has supported the development and popularization of solar cookers, water heaters, dryers, and passive solar houses.

Annual production of solar cookers reached 110,000 in 1989. Use of solar cookers is concentrated in Gansu, Hebei and Qinghai Provinces. They are also used to a more limited degree in Inner Mongolia, Liaoning, Shandong, and Heilongjiang Provinces, as well as in the Tibet and Xinjiang Autonomous Regions. The development of solar cookers benefited from a three-year research and development effort organized by the Chinese Academy of Agricultural Engineering Research and Planning in the mid-1980s. A joint team composed of representatives from 18 different organizations improved the performance of solar cookers by using computer assisted design to determine the profile of the concentrator and selecting the most appropriate materials for the shell and reflective surface. The agricultural departments of local governments have played a central role in the dissemination of solar cookers to families in remote rural areas, while the Ministry of Agriculture has assisted them by monitoring product quality and dispatching technical teams to conduct demonstrations, maintenance, and training, and collect customer feedback for manufacturers.[104]

Solar water heaters are also widely used in rural China. Total installed capacity, measured by surface area, is 1.5 million cubic meters, and over 100 solar water heater manufacturers produce an additional 400,000 square meters of heaters annually. They are used primarily in residential buildings.[105]

Passive solar building design, which combines collection and storage of solar radiation with thermal insulation, is currently at the demonstration stage in China. There were 800 passive solar buildings by the end of 1989, including rural homes, urban apartments, schools, hospitals and commercial buildings.[106]

Chinese researchers are also working on developing solar dryers. They are used to dry a wide range of products, including fruit, medicinal herbs, timber, melon seeds, and ceramics. The main types of solar drying facilities are passive greenhouses, devices that heat air and blow it across the objects to be dried, and combined or integrated versions of the two. Solar dryers are a great improvement over traditional open-air drying methods, which often resulted in contamination of the products or incomplete drying in case of rain. Over one hundred solar dryers are currently in use.[107]

China imported seven photovoltaic production lines from abroad between 1984 and 1989, but actual production was only one tenth of production capacity in 1989. The main problems are high price (twice the international market rate), low quality, and lack of consumer confidence. To address these issues, China needs to improve the quality of photovoltaic pumping systems, inverters, process controls, and DC-powered domestic appliances, and invest in demonstrations of photovoltaic desalinization systems, refrigeration systems, and combined photovoltaic/wind systems.

Wind Power. The Inner Mongolian Autonomous Region leads the nation in terms of small-scale wind power development, while the Dabancheng wind power demonstration center in Xinjiang, China's largest wind farm, has attracted large turbines from around the world. Installed wind power capacity was only 23 MW in 1993, but the Chinese government intends to raise the total to 1,000 MW by the year 2000, including 200 MW by 1996. In addition to increasing capacity at Dabancheng, the government plans to build eleven wind farms at Zhurihe in Inner Mongolia, the Liaoning and Shandong peninsulas and the Zhoushan Archipelago in the East China Sea.[108]

Small-scale wind power production soared in the late 1980s in Inner Mongolia thanks to a local government subsidy to windmill manufacturers. Close to 80,000 small windmills were put into operation by the end of 1989 as part of an effort to bring electric power to nomadic herders to "encourage [them] to extricate themselves from natural isolated economy for a modern livelihood." Electric power is expected to lead to decreased reliance on cattle manure for domestic fuel, a practice which has resulted in serious deterioration of the grassland.[109]

The uses of wind pumps for drinking water and irrigation are also important rural applications of wind energy. With 1,600 currently in operation,[110] the Chinese government plans to continue research, development, and dissemination of wind pumps to reach a goal of 10,000 units by the year 2000.[111]

Natural Gas Policy

China's recent decision to open its inland natural gas fields to foreign bidders may start the industry down the road to becoming a viable alternative to coal. Foreign companies were given access to China's offshore gas fields in the early 1980s, but China did not invite foreign participation in inland fields until 1993. The decision to expand foreign participation from offshore to inland gas recovery was accompanied by a 50 percent increase in China's gas exploration and development budget and an increase its estimate of potential gas resources.[112] Arco, in collaboration with China National Offshore Oil Corp and a Kuwaiti partner, has already staked its claim to one field in the South China Sea with reserves of over 100 billion cubic meters.[113] The recent approval of a $250 million World Bank loan for exploration, development, and transmission of gas from existing fields in Sichuan Province may also help the industry take off.

Energy Pollution Control Policy

Dirty, inefficient fossil fuel use is widely recognized as one of China's most pressing environmental problems. Most energy pollution is air pollution, and China's Environmental Action Plan listed fighting air pollution among the top three priorities for urban environmental protection, while treating sulfur dioxide was noted as a key element of industrial pollution control.[114] A recent survey of environmental experts and scientists also put the development of clean and highly efficient coal combustion technologies as a top environmental priority for China, second only to developing cleaner production processes in pollution-intensive industries.[115] China has several general policies that affect air pollution control, as well as measures specifically aimed at energy pollution, such as coal smoke and vehicle emissions control. (See Figure 5.)

Figure 5. Air Pollution Laws, Regulations, and Standards, 1980-89

- Air Pollution Prevention and Control Law of the PRC
- Air Pollution Prevention and Control Measures
- Regulations Regarding Coal Smoke Prevention and Control Technologies and Policies
- Method for Managing Air Pollution Control Regions in Cities
- Method for Developing Residential Coal Briquettes
- Ambient Air Quality Standards
- Boiler Emissions Standards and Monitoring Method Standards
- Industrial Boiler Emissions Standards and Monitoring Method Standards
- Idling Vehicle Emission Standards and Monitoring Method Standards
- Diesel Vehicle Acceleration Exhaust Standards and Monitoring Method Standards
- Diesel Motor Full Load Exhaust Standards and Monitoring Method Standards
- Vehicle Crankcase Emission Standards

Policy tools. The government enforces emissions standards through fines and through orders to curtail operations, relocate, or shut down. Article 18 of the Environmental Protection Law authorized the collection of discharge fees in 1979.[116] Discharge fees are set far below the cost of adopting pollution control technologies, even below the cost of operating pollution control equipment. Fees nevertheless serve the purpose of generating funds to cover environmental protection administrative costs and the cost of improving pollution monitoring. Environmental Protection Bureaus also use fees to establish loan funds to help firms pay for installing pollution control equipment.[117] The discharge fee system covers both air and water pollution, and, beginning in late 1994, factories began to pay to emit sulfur dioxide emissions as well as particulate emissions.[118]

The prospects for tougher environmental legislation, regulation, and enforcement look better than ever. Qu Geping, the chair of the Environment and Resources Protection Committee of China's National People's Congress announced in 1994 plans to introduce 14 new or revised environmental laws over the next few years. He expects strong support from Song Jian, chair of the State Science and Technology Commission and long-time proponent of environmental protection. Air pollution and acid rain have reached the point where even the industrial ministries that have traditionally opposed raising environmental standards are beginning to recognize the need for change. Vice-Minister of Coal Fan Weitang, for example, has conceded the value of developing and deploying less polluting technologies for coal combustion.[119] Some of the changes will address flaws and loopholes in current legislation and regulation. For example, the government plans to improve the discharge fee system over the next few years by assessing fees on all the pollutants a factory emits instead of just one, and by basing charges on total discharge of pollutants rather than density or concentration. Some entirely new laws will also be introduced, such as safety legislation for nuclear power plants and solid waste management laws.[120]

Technical measures. China has made concentrated efforts since the 1980s to reduce residential energy pollution by installing district heating, switching from coal to gas, and distributing coal briquettes. The replacement of household-based heating with central heating had, as of the end of 1989, reduced coal use by 1.5 million tons, reduced dust emissions by 73,000 tons, and reduced sulfur dioxide emissions by 23,000 tons. Replacing 3.5 million tons of coal with gaseous fuels for kitchen ranges has reduced sulfur dioxide emissions by 59,000 tons per year and reduced municipal waste by 1.05 million tons per year. Briquette combustion produces 70 to 80 percent less carbon monoxide and 90 percent less particulate emissions than raw coal combustion. Transforming coal into briquettes also reduces sulfur dioxide emissions by 40 percent when lime or calcium carbide wastes are included in the briquette's binding material.[121]

These efforts have produced noticeable results. In Beijing, for example, the skies were clearer this winter (1993-94), although air pollution levels still exceeded national guidelines. More people have moved from courtyard homes with individual coal stoves to centrally heated apartment buildings with more efficient and potentially cleaner boilers, and the city government is building a pipeline in the western part of the city to supply natural gas to approximately one million households. Emissions from the growing numbers of motor vehicles that now clog the city's streets, however, threaten to erode these improvements in air quality. Environmental protection agencies will impose new vehicle emissions standards soon, but they will have trouble enforcing them.[122]

Technical measures to reduce energy pollution in the industrial sector cover all stages of the coal preparation and use. They include pre-combustion measures such as coal washing; adopting advanced clean combustion technologies (such as circulating fluidized bed combustion); and end-of-pipe solutions, such as electrostatic precipitators, sulfur scrubbers, effluent treatment, and fly ash utilization. China still has a long way to go before these technologies become widespread, and some measures, such as tall chimneys for power plant boilers, may reduce local pollution only at the cost of spreading emissions over a larger area.[123]

IV. CRITIQUE OF FOREIGN INVOLVEMENT

China's current energy path is economically, environmentally, and socially unsustainable, and foreign assistance has done little to redirect it. Insufficient attention to potential benefits of promoting energy efficiency and renewable energy have resulted in an unconscious emphasis on supply side export promotion. We need to take a closer look at what the U.S. government is doing in China's energy sector, set policy goals, and determine the best way to achieve them.

U.S. Government Involvement in China's Energy Sector

The Clinton Administration's decisions to remove the link between trade and human rights and to lift politically-based export controls in 1994 were based on the principle that the U.S. government should act as a help and not a hindrance to U.S. exports to China. However, in keeping with the principle that the U.S. government should continue to punish China for the atrocities of Tiananmen Square, restrictions on development assistance remained in place.

The problem is that, in the case of the energy sector, the convergence of these two principles contributed to U.S. government's failure to develop an explicit policy to focus energy export promotion in areas that reduce greenhouse gas emissions and promote sustainable development. It also prohibited the involvement of government agencies that might have helped implement such a strategy, including the U.S.-Asia Environmental Partnership, the U.S. Agency for International Development, the Overseas Private Investment Corporation, and the Trade Development Agency. These four organizations are all still unable to work in China because of sanctions imposed after the Chinese government crackdown in Tiananmen Square. The U.S. Technology for International Environmental Solutions (U.S. TIES) program, the international component of the Environmental Technology Initiative, is an interagency effort to direct private sector investment toward achieving U.S. global environmental goals.[124] The U.S. TIES project evaluation team has identified China as a priority country for U.S. exports of environmental technology, but there is still uncertainty as to whether the Tiananmen sanctions will affect the China's eligibility.

Despite the restrictions, other U.S. government agencies were able to lead a few projects that reduced greenhouse gas emissions while delivering local economic and environmental benefits. The U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) funded the Beijing Energy Efficiency Center (BECon), an independent nonprofit organization dedicated to promoting energy efficiency policy and business ventures, to promote integrated resources planning, train officials in the implementation of energy efficiency standards, and conduct market studies for energy efficient lighting and motors. EPA established a Coal Bed Methane Clearinghouse in China and is supporting the development of a prototype and field test for a super-efficient chlorofluorocarbon-free refrigerator. An interagency panel is sponsoring China's Country Study, a comprehensive assessment of greenhouse emissions sources, impacts, and mitigation measures. And DOE sponsored missions to China to initiate cooperation in renewable energy research, demonstration projects, and business development.

In the absence of an explicit policy to focus energy export promotion in areas that reduce greenhouse gas emissions and promote sustainable development, however, an unconscious emphasis on large supply side projects has emerged in U.S. government lending and trade promotion. The Export-Import Bank (Ex-Im Bank) has become a leading lender to China, providing $1.1 billion in loans and guarantees in 1994, including $140 million for coal-fired electric power projects and none for energy efficiency or renewable energy.[125] The U.S. Departments of Energy and Commerce co-sponsored several electric power missions and reverse missions between China and the United States in early 1994. Several deals were initiated during the mission that bore fruit in the following months, such as a contract between a U.S.-led consortium and the Chinese government to build an $890 million coal cleaning plant and a slurry pipeline.[126] Commerce Secretary Ron Brown's trip to China in August 1994 also helped advance many supply side negotiations. And the U.S.-China infrastructure conference sponsored by U.S. Chamber of Commerce and the U.S.-China Business Council in November 1994 facilitated deals for U.S. companies on large supply side energy projects, including the Three Gorges Dam.

Recent developments indicate that the U.S. government is trying to integrate environmental goals into lending and export policy. Ex-Im Bank issued environmental guidelines for projects in January 1995 and had several renewable energy loans in the pipeline in February 1995. Secretary of Energy Hazel O'Leary's "Sustainable Energy and Trade Mission" in February 1995 includes representatives from nonprofit environmental organizations and executives from energy efficiency and renewable energy companies as well as executives from the fossil fuel, electric power, and nuclear industries. This evidence of environmental awareness is encouraging, but falls short of the type of explicit policy that is needed.

Influence of U.S.-Funded Multilateral Agencies on China's Energy Development

While direct U.S. government support for energy development in China has been constrained, large amounts of indirect support have been flowing to China through U.S. contributions to the World Bank, the Energy Sector Management Assistance Programme (ESMAP), the United Nations Development Programme (UNDP), and the Global Environment Facility (GEF). The World Bank, as its name implies, is a lending institution, ESMAP provides policy advice, UNDP provides technical assistance, and GEF funds projects related to the International Conventions on Climate Change and Biodiversity protection.[127]

The World Bank has the largest budget of the four, and the most leverage. The Bank has lent China $3.4 billion for energy supply expansion since the loans began in 1981. Of total energy loans, almost four fifths went for power plants, about half thermal and half hydroelectric. The remaining fifth funded mostly oil and gas exploration and development. The Bank does not lend to projects with the exclusive purpose of improving energy efficiency, but some loans, such as "Fertilizer Rehabilitation and Energy Saving," do have efficiency components. The absence of designated demand side efficiency projects makes it difficult to determine exactly how much is being spent, but it is safe to assume that the total is a tiny fraction of what is being spent on supply expansion.

The World Bank's China staff is very knowledgeable about China's energy and environmental problems, having sponsored and/or participated in extensive studies of the environmental impacts of coal in 1991[128] and greenhouse gas emission control in 1994.[129] World Bank spending on environmental projects, which began in 1992, reached $810 million by 1994.

UNDP gave China $10 million for energy assistance during the 1980s. Almost all of the money UNDP provided during the 1980s was used to upgrade oil production technologies and techniques, but the agency shifted its focus toward efficient and environmentally sound uses of coal in the early 1990s.

ESMAP is funded by the World Bank, UNDP, other United Nations organizations, and bilateral contributions from industrialized nations.[130] ESMAP's work in China has included funding World Bank staff to help the Ministries of Agriculture and Forestry develop training courses in integrated rural energy planning for local officials. The courses covered random sampling techniques, cost/benefit and least cost analysis, and use of relevant computer software.[131] This project was not connected to any concurrent World Bank loans, and did not lead to any subsequent loans, but it may have improved how energy policy decisions are made at the local level in rural areas.

ESMAP's support for integrated energy analysis did not extend to suggesting such an approach when advising the Minister of Electric Power and the Vice Minister of Finance on overall power sector reform. The summary of a workshop with World Bank and high-level government officials on options for power sector reform in China made no mention of the potential for adopting utility demand side management as part of a strategy for meeting energy needs in an inexpensive and environmentally sound manner. The summary made only passing mention of environmental concerns.[132]

GEF was established in 1991. Projects accounting for 60 percent of GEF funds worldwide are actually managed by regular World Bank staff and half of these are attached to other Bank projects.[133] The remaining 40 percent of GEF funds are managed by UNDP. GEF has approved five projects in China: coal bed methane development, biodiversity preservation, greenhouse gas control strategies, gas development and conservation in Sichuan Province, and ship waste disposal. The last two projects are attached to World Bank projects. Funding for the three energy-related projects totals $22 million. While not insignificant, this level of funding over the past three years of GEF's existence pales in comparison to the $1.5 billion the World Bank has provided for energy supply expansion during the same period. Additional GEF projects aimed at reducing greenhouse gas emissions have been proposed but not yet approved in the areas of efficient industrial boilers,[134] energy efficiency and pollution control in township and village enterprises, energy efficient refrigerators and compressors, vehicle emission control, briquette techniques, and methane recovery from municipal waste.[135]

The World Bank has recognized China's problems of power shortage, biomass shortage, and environmental degradation, and but has not made enough loans in areas that can address these problems in a cost-effective manner, such as energy efficiency, grid-connected wind farms, and small-scale distributed wind and solar technologies for remote villages. The Bank would have difficulty implementing small-scale projects itself, but could lend through an intermediary. GEF has begun to support energy efficiency and coal bed methane development, but its funding level is much lower than that of the Bank. ESMAP has helped improve rural energy development, but could make an even greater contribution to energy policy in China by advocating the use of integrated resource planning methods that allow supply side and demand side investments to compete on an equal basis.

In Comparison: Influence of Other Bilateral and Multilateral Funders

Like the United States, countries around the world have wrestled with the question of how to handle relations with China, given that country's ongoing human rights abuses, large market potential, and severe environmental problems. A few countries have begun to respond to the challenge by designing export promotion and assistance programs that include efficiency and renewables.[136]

Japan has led the way in providing environmental assistance and energy efficient technologies to China since 1992. While Japan's Overseas Development Assistance program has provided $100 million for Japan-China Environmental Center in Beijing, its Ministry of International Trade and Investment (MITI) is working closely with Japanese industry associations to assess China's technological needs and develop inexpensive equipment that is well adapted to local conditions. MITI has already sponsored 14 demonstration projects for a total $183 million. All but one of the projects are aimed at improving energy efficiency or reducing energy-related pollution. Of course, Japan's efforts are not purely altruistic. The Japanese government fears that China's coal burning will affect Japan as well, and they hope to see their companies profit from the footholds they will gain in the environmental business if China attunes its technical standards to those of Japan.[137]

Denmark suspended and then canceled its bilateral development assistance program in China after the events in Tiananmen Square, but set up a concessionary lending arrangement in 1993.[138] Denmark has loaned China $16 million for wind energy projects and $5.6 million for district heating since that time.

Britain's program parallels that of World Bank (on a much smaller scale) in that it supports studies and small grants for environmentally sound alternatives, such as a project for energy efficiency in buildings and a wind-diesel generator, but Britain too places the bulk of its money in power sector expansion. Britain provided $3.5 million in technical assistance grants for a set of four energy efficiency, renewable energy, and energy pollution control projects, while power plant and transmission line loans for the period from 1988 to 1993 totaled $126 million.[139]

The Canadian government supports several energy efficiency and environmental projects in China,[140] including a joint study of greenhouse gas emissions in China, an ecological study of oil- and gas-rich Tarim Basin, transfer of Canadian building energy efficiency standards, and support for the China Council of International Cooperation on Environment and Development. Canada plans to launch a China-Canada energy efficiency center focusing on data collection and analysis, training, information dissemination, cooperative research, and demonstration projects. The Canadian government claims that its companies bring environmental expertise to its hydropower, fossil fuel, and potential nuclear ventures in China, such as the sale of two heavy water reactors for the Qinshan power plant site.

Like the World Bank, the Asian Development Bank's energy sector lending is primarily oriented toward power plant financing (as shown in Table 6), but unlike the World Bank, the Asian Development Bank explicitly includes "encourag[ing] utilities to implement demand side management techniques" in its list of objectives for power projects.[141] The Asian Development Bank plans to back its demand side mandate by devoting 15 percent of its loan funds to industrial energy conservation between 1994 and 1997. The bank is also developing environmental criteria for its energy sector lending. Part of this effort involves funding Harvard University to research whether the level of environmental protection accomplished by adopting coal pollution mitigation measures could be achieved more cost effectively by pursuing other energy supply or demand side options. Clearly, the answer would vary widely, depending on assumptions made about the available resources, technologies, and implementation costs. The analysts are developing models that will allow the bank to assess projects based on various assumptions.[142]

The Asian Development Bank also supports rural energy projects such as feasibility studies for renewable energy in remote rural applications and the development of efficient wood stoves and fuel wood plantations, but rural energy projects account for only 4 percent of total technical assistance and no loans are planned for rural energy within the next three years.[143] (See Table 7.)

Goal Setting

Many governments of developed countries, most notably that of Japan, have acknowledged the serious nature of China's energy and environmental problems and have taken steps to orient assistance and trade promotion toward solving them. The U.S. government, by contrast, has constructed its policy on a relatively ad hoc basis.

Table 6. Asian Development Bank Power Project Loans, 1994-97

Type of Project	Projected Funding Level ($ millions)
Power Sector	1,600
Industrial Energy Conservation	320
Coal Gasification and Environmental Improvement	150
Natural Gas	130

TOTAL	2,200

Table 7. Asian Development Bank Power Sector Technical Assistance, 1994-97

Type of Project	Projected Funding Level ($ million)
Power Project Support	3.6
Institutional Support to Power Companies	2.6
Power Sector Policy Studies and Support	2.1
Operationalizing Build-Operate-Transfer Power Plants	1.8
Power Sector Efficiency and Environmental Improvement	1.2
Industrial Energy Conservation	1.0
Rural Energy Development	0.5
Coal Efficiency and Environmental Improvement	0.4
Coal Gasification	0.65
TOTAL	14

Some might argue that it is not necessary for the U.S. government to set goals for involvement in China's energy sector because China itself should set the priorities. They point to Agenda 21, China's 15-year program for sustainable development, as evidence that the objectives have already been established.

China's Agenda 21 was prepared as a follow-up activity to the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. The State Planning Commission and the State Science and Technology Commission coordinated the formulation of the agenda by over 50 government agencies. The final document includes China's general goals and specific project proposals in areas such as poverty alleviation, clean energy and transport, and improving environmental laws and institutions.

The problem is that no one document could possibly encompass the variously conflicting and converging agendas of the range of participants from the local to international level that will be needed to make sustainable energy use a reality in China. Recognizing this problem, the Chinese government does not intend to limit sustainable energy work to those projects listed in Agenda 21, and it probably does not expect all of the items to get funded.

Figure 6. Energy and Transport Projects in Agenda 21

The project list for Agenda 21 was formulated by a State Science and Technology Commission group chaired by Deng Nan, SSTC vice chair. China plans to contribute 60 percent of the $4 billion needed to implement the first 62 projects identified by the State Council for Agenda 21. The projects are to be incorporated into the Ninth Five-Year Plan (1996-2000). Around 15 percent of the Agenda 21 budget will go to energy and transport, including:

- $398 million for coal (10 percent)
- $77 million for efficiency and renewables (1.9 percent)
- $72 million for nuclear (1.8 percent)
- $65.5 for transport (1.6 percent)

There is only one pure efficiency project--$15.8 million for energy efficiency in buildings--but some of the transport and industrial process projects probably include efficiency components. There are also a few projects related to energy pollution: mine tailings management, oil spill prevention and control, and radioactive waste management.

Source: Editor, "Whither China's Environment?" *China Business Review*, July-August 1994.

Rather than relying solely on Agenda 21, the key is to define problems, set priorities, and solve problems at several levels separately and simultaneously. Then, when areas of common concern are identified, cooperate. According to this decision-making framework, China's Agenda 21 can be seen not as a blueprint for all activities relating to sustainable development in China but as an exercise in identifying projects that serve the nation's current and future environmental, social, and economic interests. In order for Agenda 21 to work, each local and international participant in China's energy sector needs to define individual priorities and identify overlap between the individual project ideas and those of Agenda 21.

Two thirds of the funding for energy and transportation in Agenda 21 has been designated for advanced coal projects. Naturally, U.S. coal and power generation companies will have no trouble (at least initially) finding common ground with the Chinese. However, U.S. government priorities and those of the Chinese government and U.S. coal and power companies do not completely overlap. Support for U.S.-China cooperation in power plant construction that is not balanced by support for energy efficiency, renewable energy, and natural gas (including coal bed methane) misses many profitable opportunities to advance several worthy goals, such as reducing global greenhouse gas emissions, and improving public health, worker safety, and environmental protection in China. The fact that these opportunities are slipping away indicates a need to examine the goal setting and problem solving processes that create U.S. policy in this area.

How to Set Goals

Goal setting should accomplish two things: (1) help individual parties clarify their reasons for involvement and (2) bring out differences in viewpoints between participants who will have to cooperate on projects. The partners can later agree on a compromise that addresses the self interest of each, rather than pretending that all are working toward an abstract "common good." Each party defines its goal by examining the energy/environmental landscape, identifying problems, and prioritizing them in terms of importance and urgency. Participants are assumed to have different definitions of importance and urgency based on differences in self interest and philosophical bent. For example, a small oil spill is very important to someone living next to it, but not very important to an oil company executive, or even to a national environmental administrator. And some people would define "urgent" as having an immediate impact on human health and/or the environment, while others would define it as requiring early intervention. Accepting the subjectivity of the priority setting process does not mean a condoning irrational behavior; it actually encourages more rational debate based a clearer understanding of interests of different parties and the potential for common ground.

Goal setting by the U.S. government should reflect the interests of U.S. taxpayers that relate to energy and the environment in China. These include both self interest and humanitarian concerns.

- Environmental: reducing global greenhouse gas emissions, preserving biodiversity;

- Economic: free trade, profits for U.S. companies, jobs for U.S. workers;

- Social: poverty alleviation, health, education, protection of natural resources on which life depends in China;

- Political: freedom of speech, rule of law, and free elections in China.

Almost all U.S. citizens would support, or least not oppose, efforts to achieve these goals, and U.S. policy should try to incorporate more of them into the project selection process.

Project Selection

Once participants have set their goals for international assistance, the next step is to generate project proposals and evaluate them. Project evaluation might be guided by the following questions.

For investment projects:

1. Is the project financially viable? Would it be financially viable if held to U.S. environmental standards?

2. Does the project provide a net economic benefit after the costs of environmental externalities are subtracted?

For policy projects:

3. Does the project encourage the Chinese government to adopt policies that match our goals?

For all projects:

4. Does the project achieve multiple goals, for example, saving or making money while protecting the environment?

5. Does the project support local experts who will continue to work in the field after the project is completed?

6. Does the project attract other sources of funding in addition to that of the U.S. government?

The first two questions, which relate to the issue of environmental cost of energy investment projects, have been the most neglected by international energy assistance efforts to date. The first is relatively easy, requiring only the calculation and addition of environmental control costs to the total cost. Control costs can be measured in terms of the market price of the required combination of equipment and the cost of its operation and maintenance. The financial viability can then be measured in absolute terms, such as rate of return or payback period, or in relative terms, by comparing costs of energy production using different fuels. If China passes new air pollution legislation now under consideration requiring flue gas desulfurization, such calculations will become essential. Even without such legislation, environmentally responsible U.S. assistance can still use this criteria for project evaluation.

The second question is more difficult, requiring the calculation of the cost of environmental damage, which market prices often fail to capture. Costs of control equipment or other mitigation measures are sometimes used as a proxy for damage costs, but they are really measuring very different things. Environmental damage values can be calculated based the market price of goods lost to environmental damage, medical costs, and salary or productivity foregone because of illness of workers. If these direct costs are deemed inappropriate due to uncertainty or the moral questionability of placing monetary values on human life and health, environmental damage can be measured in terms of society's willingness to pay to avoid the risk of loss. The calculation of environmental costs is often conservative in that it rarely includes less tangible losses, such as the value of biodiversity or a beautiful landscape, and usually measures damage to crops on fields that are still somewhat productive, rather the value of crops that will never even be planted on land that has been completed degraded.

Pace University's review of the literature on the environmental costs of electricity produced the following numbers (see Table 8) suggested as starting points for future research in this area. The cost per pound of each pollutants was calculated based on the cost of estimated health effects and, in the case of particulates, visibility reductions. The cost of carbon dioxide is based on estimates of tree-planting costs.

Table 8. "Starting Point" Externality Costs for Coal-Fired Power Plants

Externality	$/lb	Existing Boiler	AFBC	IGCC	NSPS		
SO_2	$2.03	1.80	0.55	0.48	1.2		
NO_x	$0.82	0.607	0.30	0.060		0.0060	
Particulates	$1.19	0.15	0.01	0.010		0.030	
CO_2	$0.0068	209	209	209	209		
$/kWh Delivered		$0.068		$0.033		$0.028	$0.045

Emissions are expressed in pounds per MMBTU of fuel input. The abbreviations refer to different boiler technologies: atmospheric fluidized bed combustion (AFBC), integrated gasification combined cycle (IGCC), and New Source Performance Standards (NSPS).

Source: Pace University Center for Environmental and Legal Studies, *Environmental Costs of Electricity*, prepared for the New York State Energy Research and Development Authority & United States Department of Energy (New York: Oceana Publications, Inc.) 1990.

The experience of the U.S. power sector has shown that the incorporation of environmental considerations into investment decisions is difficult but not impossible. Utilities in 29 states are now required to incorporate the cost of environmental externalities into their planning and/or bidding processes.[144] They must add on specified amounts per kWh to the price of polluting energy sources or give credit to "noncombustion resource acquisitions," such as energy efficiency and renewable energy. The New York Public Service Commission, for example, requires utilities to add on 1.405 cents per kWh of externality cost to a coal-fired plant meeting New Source Performance Standards (NSPS), and to subtract 1.4 cents per kWh from the cost of programs that promote energy efficiency in order to represent the environmental benefit they provide. Massachusetts set environmental externalities for an NSPS coal plant at 4 cents per kWh, and California put a similar value on the environmental impact of nitrous oxides. Alternatively, rather than specifying exact monetary values for environmental externalities, some regulatory commissions set a percentage "adder." Wisconsin, for example, says that an electric power source that does not require fuel combustion should be favored over a combustion-based source even if it costs up to 15 percent more.

Cost/benefit analyses of international energy assistance projects could use similar methodologies. The value of risk could be based on the cost of damage, for example, crop loss and health care, or willingness to pay in China. Alternatively, the United States could use costs based its own willingness to pay based on experience with environmental consequences.

Models of Sustainable Energy Promotion

The Beijing Energy Efficiency Center (BECon) and EPA's coal bed methane work are models of how to promote sustainable energy use as defined by the goals and criteria described above.

The BECon is an independent not-for-profit organization founded by two U.S. national laboratories, the World Wildlife Fund, and the Energy Research Institute of the State Planning Commission and funded primarily by DOE, EPA, and World Wide Fund for Nature, International. Its main purpose is to catalyze energy efficiency improvements in China by providing policy recommendations and training to government officials, facilitating business ventures, coordinating demonstration projects, and educating the public. BECon is expected to become self-sufficient after its first three years.

U.S. government support for BECon contributes to the four goal areas described above: environmental, economic, social, and political. BECon serves U.S. economic interests by helping U.S. energy efficiency companies do business in China. The center also promotes the U.S. global environmental agenda by slowing the growth of greenhouse gas emissions from the country that ranks second in the world in anthropogenic carbon emissions, and the U.S. humanitarian agenda by reducing local health problems and environmental damage. Finally, support for the center's staff of local experts helps create an independent political voice, laying the groundwork for increased freedom of speech and the creation of a participatory political system.

BECon's work satisfies the project criteria as well. It need not be held strictly accountable to the financial criteria because it is not an investment project, but it nevertheless provides cost-effective results by employing experts of international caliber at rates a fraction of the norm for international consultants, and is expected to pay for itself through increased tax receipts from the profits of companies assisted. BECon provided information and consulting services to more than fifteen U.S. companies in its first year. BECon also satisfies the criterion of encouraging the Chinese government to adopt policies that match U.S. goals--the center has begun a series of energy efficiency standards training courses, and has conducted an integrated resources planning feasibility study that convinced a local government to defer construction of some its planned additional supply capacity. BECon projects inherently embody the principle of multiple benefits because they all involve promoting energy efficiency in a manner that saves money while protecting the environment. BECon's director and staff are all local experts who will continue to work in the field after the project is completed, and BECon has attracted monetary and in-kind support from the Chinese government, and U.S. firms and foundations.

The EPA Global Change Division's efforts to promote the use of coal bed methane as an alternative energy resource in China also exemplifies the goal of combining environmental, economic, and social goals. The coal bed methane program grew out of EPA's recognition that China's tremendous reserves of coal bed methane--700 trillion cubic meters--not only contribute to the threat of global warming, but also represent wasted energy and a safety hazard for miners. The fact that U.S. companies are world leaders in the field makes promoting coal bed methane recovery a good way to achieve an environmental goal while advancing U.S. economic interests. The resulting improvement in mine safety not only serves a U.S. humanitarian interest but also provided the hook for the Chinese mining administrations, which are more concerned about accidents than wasted gas.

EPA's funding for study tours and workshops and the creation of a Coal Bed Methane Clearinghouse successfully leveraged a $10 million Global Environment Facility grant to the Chinese government for a national coal bed methane resource assessment, a training program, and three demonstration projects. The grant provided a foothold in China for two U.S. companies, Gustavson Associates and Resource Enterprises Inc., which won contracts to provide equipment and training for the demonstration projects.

V. RECOMMENDATIONS FOR FOREIGN PARTICIPANTS

Amending U.S. government goal setting and project selection along the lines described above would lead to increased support for energy efficiency and renewables, and ideally to an explicit policy to promote energy exports that reduce greenhouse gas emissions and contribute to sustainable development. Mobilizing private companies, trade associations, foundations, and nongovernmental organizations will be essential to the success of such a policy. Positive changes can include not only shifting the balance from the supply side toward the demand side, but also making all cooperative activities more cost-effective.

Short Term

Short-term efforts can include investment, market studies, targeted trade missions, training programs, demonstration projects, and small business grants to encourage the deployment of sustainable energy technologies until a more favorable policy environment is established.

Private companies have the power to promote energy efficiency and renewable energy both by launching business ventures in those areas, and by choosing to market advanced efficient technologies domestically. Companies like Honeywell, Johnson Controls, Owens-Corning, Armstrong, Electronic Ballast Technologies, General Electric, Whirlpool, Zond Systems, and Flowind can make a significant contribution to putting China on a cleaner, more efficient energy path. In some cases, these companies are trying to reduce their risk by marketing more established products before branching out into advanced efficient technologies. They should be encouraged to move quickly in order to establish their reputations as leaders in their fields. Honeywell and Johnson Controls are already the biggest suppliers of controls in China. Honeywell is just starting to work on district heating, but hopes to soon move beyond district heating to providing control systems for "smart buildings" that maximize efficiency through an integrated approach to water and air heating and cooling. Owens-Corning is planning to invest $80-100 million in 10 plants producing fiber glass insulation and fiber glass reinforced pipe over the next three to five years. The pipes are considered a safer investment, given China's surging demand for new sewer systems, but if China raises and enforces energy efficiency standards for new buildings, the insulation market could also take off. Some of the lighting companies that are now manufacturing efficient lamps or ballasts for export can develop strategies for marketing them to the large domestic market.

Governmental or non-governmental organizations can coordinate targeted trade missions. Too often trade missions waste time and money because they are not focused. Targeted trade missions can follow the International Institute for Energy Conservation's "Deal-Maker Model" by including significant preliminary market research to identify a priority technology in China and then identifying producers of that technology in the United States. U.S. manufacturers can then be briefed on market conditions related to this specific technology in China and then decide whether to take a trip to China to meet with potential partners and relevant officials.

Foundations and government agencies can provide seed grants to sustainable energy entrepreneurs. Start-up grants and loans to entrepreneurs can promote cost-effective local experimentation with alternative energy technologies because only profitable projects will survive and grow. The Rockefeller Foundation is currently funding joint work by the University of Pennsylvania and the Chinese Ministry of Agriculture to identify "dragon heads," or small rural energy enterprises with potential for large-scale commercialization. Oak Ridge National Laboratory is also currently seeking funding for a project to identify and nurture these types of enterprises.

Trade associations such as the National Electrical Manufacturers Association or the Association of Home Appliance Manufacturers or government agencies could support market studies to give U.S. small businesses that cannot afford to do their own research in China a chance to examine the opportunities.

Medium Term

Medium-term efforts will involve promoting policy and institutional changes that create the market for sustainable energy and environmental technologies and practices. The policies to be considered include general market and institutional reforms, such as privatization, price reform, hard budget constraints; specific energy efficiency policies, such as standards, integrated resources planning, and fees and rebates; and environmental policies such as higher emission fees and emissions trading. The institutional changes needed include the creation of loan funds and energy services companies.

The Department of Energy and its laboratories can educate Chinese federal and local officials about the process for developing codes and standards for energy efficient appliances and buildings in the United States. These organizations can also work with the Chinese officials to draft model approaches for the adoption and implementation of similar codes, adjusting for Chinese conditions. Pacific Northwest Laboratory is currently proposing a project that includes training for Chinese officials in the development of energy efficiency codes for buildings. Lawrence Berkeley Laboratory intends to work with China's State Technological Standards Supervision Bureau to develop energy efficiency standards for refrigerators.

Government agencies can also support demonstration projects that are tied to investment projects. Traditional demonstration projects have often failed to live up to expectations of future sales. The reason is that the government provides a subsidy for a project in the hope that merely seeing the technology will encourage people to use it. A demonstration project that involves a company that has already committed to investment in the country can serve as effective complement to technology transfer through commercial arrangements. Owens-Corning is considering participating in a building efficiency demonstration project that would showcase the fiber glass insulation that it intends to start manufacturing in China soon.

Government can also support development of market-based policies like fees and rebates and emissions trading; provide incentives for U.S. companies to promote carbon emissions reductions, through voluntary programs like the U.S. Initiative on Joint Implementation and Climate Challenge; and provide training for Chinese officials in integrated resources planning. The Department of Energy has initiated integrated resource planning/demand side management training in collaboration with Pacific Northwest Laboratory, the Beijing Energy Efficiency Center, and the Electric Power Research Institute.

Energy service companies, or ESCos, can use a variety of financing arrangements to make energy efficiency improvements more feasible and less risky to the consumer. In one typical scenario, the ESCo signs a contract guaranteeing a fixed total monthly energy cost to the consumer. The ESCo then secures a loan and supervises the installation of one or more efficiency improvements. As energy efficiency reduces the monthly energy bill, the consumers pays the monthly savings to the ESCo. The savings must be high enough to pay back the loan with interest and produce a profit for the ESCo. This system guarantees that investments are cost-effective because, if they are not, the ESCo will go out of business. The ESCo Energy Performance Services was able to successfully conduct business in the Czech Republic after working with the Czech Energy Efficiency Center, SEVEn, to explain the ESCo concept to its clients.

Nongovernmental organizations, like Resources for the Future, can train Chinese social scientists in environmental economics. Most Chinese economists have little experience in calculating environmental costs and developing policies that incorporate them, and could benefit from examining the experience of the United States in this area.

Multilateral development banks can create revolving loan funds for efficiency and renewables. Many energy efficiency measures have rates of return of 18-25 percent, yet enterprises interested in investing in efficiency often have trouble getting a loan. Similar problems exist for renewable energy technologies. Creating an energy efficiency and/or renewable energy loan fund would help solve this problem. Once created, the fund would become self-sustaining by charging market interest rates on loans. These funds could be administered by an intermediary to cut down costs to the bank. An example of this model is a $26 million Global Environment Facility grant to the Indian Renewable Energy

Development Agency to finance lending for the commercialization of wind and photovoltaic energy.[145]

Multilateral banks can also include energy efficiency in industrial modernization loans; encourage rational energy pricing; support the development of IRP, energy efficiency standards, and environmental regulations; and stop subsidizing supply side projects.[146] The World Bank has made significant contributions to the institutional development of China's National Environmental Protection Agency, including a $1 million loan to support a pollution study and the improvement of the pollution fee system. The new system requires payment from all enterprises that emit sulfur dioxide.[147]

U.S. companies can support policy work that helps create the market for their products. Honeywell Foundation, for example, has supported energy efficiency centers in China, Russia, and Eastern Europe.

Long Term

The long-term efforts to promote sustainable energy practices in China can include attempts to influence the evolution of China's legal, political, economic, and social systems. Despite the impression created by the Chinese leadership's public protests against interference by outsiders in its internal affairs, many elements of the Chinese government actually share our goals of rule of law and free speech and welcome outside assistance in achieving them. These changes are prerequisites for the establishment of environmental goals as guiding principles for energy use through the creation of a broad-based environmental movement. Such a movement would consist of free flow of environmental information, public participation in creating pressure for stronger environmental laws, and a stronger and more equitable legal system to ensure environmental law enforcement.

Research and advocacy nongovernmental organizations (NGOs) in China can help foster independent grassroots activities to achieve humanitarian goals, such as improvements in health, education, and environmental protection, and can lay the foundations for the eventual expression of independent political ideas. For example, the National Committee for U.S.-China Relations has sponsored numerous exchanges in the areas of environmental protection, such as the visit of Li Xianghui, a State Planning Commission official who spent six months in the U.S. learning about regional cooperation in environmental protection. After interning at the Chesapeake Bay Foundation and the U.S. Environmental Protection Agency regional and field offices, Mr. Li concluded that citizen participation has been essential to U.S. progress in environmental protection, and China needs to encourage similar activities in order to bring its environmental problems under control. Another organization, World Wildlife Fund International, has supported wildlife conservation in China for years and is now expanding its mission to include support for local experts engaged in promoting energy efficiency policy and business development. The International Rivers Network continues to be active in supporting Chinese with an interest in rational development of hydropower. This has included support for Dai Qing, the reporter who wrote about objections of scientists and others to the Three Gorges Project. The International Rivers Network recently hosted a trip to the United States for Dai Qing to receive an award and drum up support for her environmental education-oriented nongovernmental organization, which is not officially recognized in China.[148]

Other roles for environmental organizations can include development of public interest science in China through activities like the Union of Concerned Scientists' Summer Symposium, and building grassroots support for city-to-city cooperation in reducing carbon emissions through mechanisms like the European Climate Alliance.[149]

Foundations can support emerging environmental organizations, such as Friend of Nature, a new group that will promote environmental education. They can also contribute to the development of China's legal system by helping to strengthen legal education, the legislative process and the judiciary. Ford Foundation, for example, funds legal education exchanges, study tours for legislators, and training for judges.[150]

Conclusions

The severity of China's energy and environmental problems merits an explicit U.S. government policy to promote energy exports that reduce greenhouse gas emissions and promote sustainable development. The Chinese government has demonstrated that it is serious about improving energy efficiency, expanding the use of renewable energy, and restricting environmental pollution, and welcomes international assistance in these areas. The U.S. government has sponsored a few projects to meet those needs, but many legal restrictions on U.S. assistance to China remain in place. The U.S. government, working with private companies and nonprofit organizations, can use energy cooperation with China to create U.S. jobs, protect the global environment, and improve the stability of relations between the two countries.

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[136] I would like to thank Daniel Rosen, Daniel Esty, and Seth Dunn for giving me with access to documents they obtained from embassies and project offices detailing international assistance efforts in China's energy and environmental sectors. A comprehensive assessment of these efforts will appear in their forthcoming work on environmental issues in China.

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