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China: Energy and Economic Growth [redacted] 25X1

A Research Paper

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A Research Paper

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China: Energy and Economic Growth

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Overview

Information available as of 30 January 1984 was used in this report.

China has made exceptional progress in the past five years in improving the efficiency with which its economy uses energy. This has allowed fairly rapid economic growth and a large increase in energy exports despite slow and erratic growth in the production of energy. Unlike most countries, China has done this without sharp increases in energy prices.

Energy conservation has not come without costs, however. Use of capital equipment is down sharply because of fuel and electricity shortages. Some indexes of economic progress, such as the share of farmland plowed mechanically, have actually declined. Moreover, in terms of energy consumption, China's vast rural population remains one of the most impoverished in the world.

We anticipate that pressures on China's energy supplies caused by economic growth will increase through the rest of the 1980s:

- Offshore oil production may not be available soon enough to offset an expected decline in production from the country's large but mature onshore oilfields—especially Daqing.
- Coal, because it is being counted on to substitute for oil wherever possible, will be hard pressed to provide the energy needed to fuel economic growth.
- Electricity shortages, caused by insufficient investment in recent years and surging demand, may be the most critical short-term bottleneck to economic growth.

Beijing must resolve these and other potentially divisive problems if satisfactory growth is to be attained. Two important decisions being debated are whether to reduce or even eliminate oil exports—20 percent of the country's foreign exchange earnings—and how to build the political consensus that is needed to raise domestic energy prices sharply.

Nevertheless, the government's strong control mechanisms and the high priority placed on energy conservation should allow the economy to increase at a modest 4- or 5-percent rate through the 1980s—slower than in the past but faster than that initially planned by Beijing. We doubt that the much faster growth expected by Beijing for the 1990s can be achieved without putting undue strain on both energy producers and consumers.

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China's 1978 decision to forgo self-reliance and bring in foreign investment, both to spur energy production and to improve the efficiency of energy use, appears firmly on track. We believe the need for technology and capital will act as an important and continuing underpinning to China's opening to the West, especially to the United States. Commercial opportunities for US energy companies in China should continue to expand and help to strengthen political links between the two countries.

The depth of such cooperation—and China's long-term ability to meet its energy requirements—is critically dependent on large oil discoveries being made in China's offshore regions. Should the Western firms that are preparing for intensive drilling this spring not find the oil deposits they expect, China may have to decide between importing oil in the 1990s—at great expense to the country's international financial position—or returning to the more self-reliant and isolationist policies of the past.

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China: Energy and Economic Growth

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Five years ago the People's Republic of China sharply reduced its long-term expectations for increasing energy production—particularly petroleum—and began to address the problem of energy shortages that have increasingly become an obstacle to economic growth. Looming energy shortages were an important factor behind Deng Xiaoping's major economic "readjustment" of 1979, when it became apparent that Soviet-style growth led by heavy industry—without the Soviet Union's huge energy resources—could prove disastrous. Premier Zhao Ziyang, in his December 1982 speech announcing the Sixth Five-Year Plan (1981-85), reiterated those concerns and stated that expected energy shortages were a major reason for the plan's low economic targets. A deputy director of China's Academy of Social Sciences recently was more explicit, saying, "Whether or not China solves its energy problem will determine the direction of Chinese economic progress over the next 20 years."

Beijing since 1978 has countered the energy problem on three fronts. First, it has attacked the country's wasteful energy consumption habits by restructuring industry, closing inefficient plants, and placing quotas on energy use. Political considerations and a lack of flexibility in its price system have prevented China from raising energy prices sharply, the single most effective measure taken by other countries to curb energy consumption. Nevertheless, the program has been successful. Energy consumption has increased by only 1.9 percent per year between 1978 and 1982 while industrial growth averaged more than 7 percent annually. In the first three decades of the PRC's existence, energy consumption rose at a faster rate than industry as a whole.

Second, China has tried to correct policies that pressed energy industries to meet short-term production goals at the expense of developing the resource base. Higher priority, at least in theory, is now being given to exploration and infrastructure development. We believe that Beijing has not been satisfied with results thus far. There are no indications, for instance, that the long-term decline in proved oil reserves has been stemmed. Also, a recent surge in demand for coal, caused by a sharp rebound in heavy industrial output, is leading coal mines to produce as much as possible and neglect investment in long-term coal capacity. Capital-intensive hydroelectric and nuclear projects, moreover, have been slow to move out of the planning phase.

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Third, and of the most interest to the United States and other foreign countries, Beijing has opened important segments of its once highly protected energy industries to Western and Japanese investment. In a remarkable turnaround, the Petroleum, Coal, and Electric Power Ministries, once bastions of Mao Zedong's ideology of self-reliance, have become leading proponents of Western investment in China. Projects already under way will, in our opinion, foster long-term commercial links between China and the non-Communist world. A nagging problem, however, is that some in the leadership, with the intention of reasserting self-reliance at some later date, will attempt to import technology at a pace we believe will be too rapid for proper absorption.

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This three-pronged policy is aimed at doubling both energy output and the efficiency of energy use between 1980 and the year 2000, thus allowing a quadrupling of GNP by that date without the need for importing energy. These goals imply growth rates of 3.5 percent per year for energy output and 7 percent per year for the economy as a whole.

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Analytical Approaches

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In analyzing China's energy situation, we looked both at production and at demand to determine how realistic Beijing's goals are and what problems it will face in reaching them. Data recently released by the Chinese make possible a good understanding of how

energy is produced and consumed in China.

Forecasting future energy demand is more difficult. Data limitations and the lack of market mechanisms make standard econometric forecasts of dubious value for China. Static input-output matrixes, on the other hand, also require large amounts of data and tend to underestimate the potential for efficiency gains. These shortcomings are compounded by the need to differentiate between oil, coal, gas, and hydroelectricity in order to avoid assuming too large a degree of substitutability between fuels.

We looked at potential energy demand by breaking the economy into the key energy-consuming industries and, using available Chinese plans, by forecasting the growth of output in these industries and the coal, oil, gas, and electricity required for such growth. These individual industry studies provided the data to make the energy/GNP elasticity judgments—the percent change in energy required for a given percentage change in GNP—that we believe may be applicable to the entire economy. In this way we hope to avoid the common but often unwarranted assumption that energy demand increases in a 1-to-1 relationship to GNP, that is, an elasticity of 1. At the same time we examine the implicit assumption by China's planners that energy demand will increase at only one-half the rate of increase of GNP, that is, an elasticity of 0.5.

Our results suggest that the Chinese economy will have an overall energy elasticity of between 0.65 and 0.70 for the remainder of the 1980s and the 1990s—that is to say that energy consumption will increase at between 65 and 70 percent as fast as national income. This, we believe, is an encouraging coefficient—smaller than what is expected for most major countries and much smaller than China's historical record. It is slightly higher than China's performance since 1978 because considerable restructuring has occurred since that date. We are optimistic, however, only because we believe the Chinese Government will continue to exert great control over the use of energy—particularly oil and electricity. We believe uncontrolled demand for energy, even at sharply higher prices, would force China to import energy, a situation the country can ill afford. 25X1 25X1 25X1

We expect the use of oil to increase only 45 percent as fast as national income in the 1980s, rising to 80 percent in the 1990s as opportunities for switching to coal are reduced. This still will allow substantial growth in the petrochemical industries. Coal consumption will increase about 75 percent as fast as national income in the 1980s, falling to 60 percent in the 1990s, with a large part of the increase going to the electric power industry. For electric power itself, we agree with Chinese estimates that electricity consumption will increase at the same speed, if not faster, than national income. 25X1 25X1

These results suggest, based on anticipated gains in energy output, that the economy will grow no faster than 5 percent per year over an extended period. This is not much different than earlier studies by both the CIA and the World Bank.[1] Our results show that even 5-percent annual economic growth will put more strain on the coal and electric power industries than it will on the petroleum industry—despite anticipated slow growth in petroleum output—as long as Beijing is willing to reduce oil exports. Unlike World Bank estimates, we do not believe China will have to import oil unless the offshore exploration program brings on line substantially less than the 50 million tons of annual capacity (1 million barrels per day) that several major oil companies believe is likely. In the near term, a shortage of electric power appears to be the most likely constraint on economic growth. 25X1

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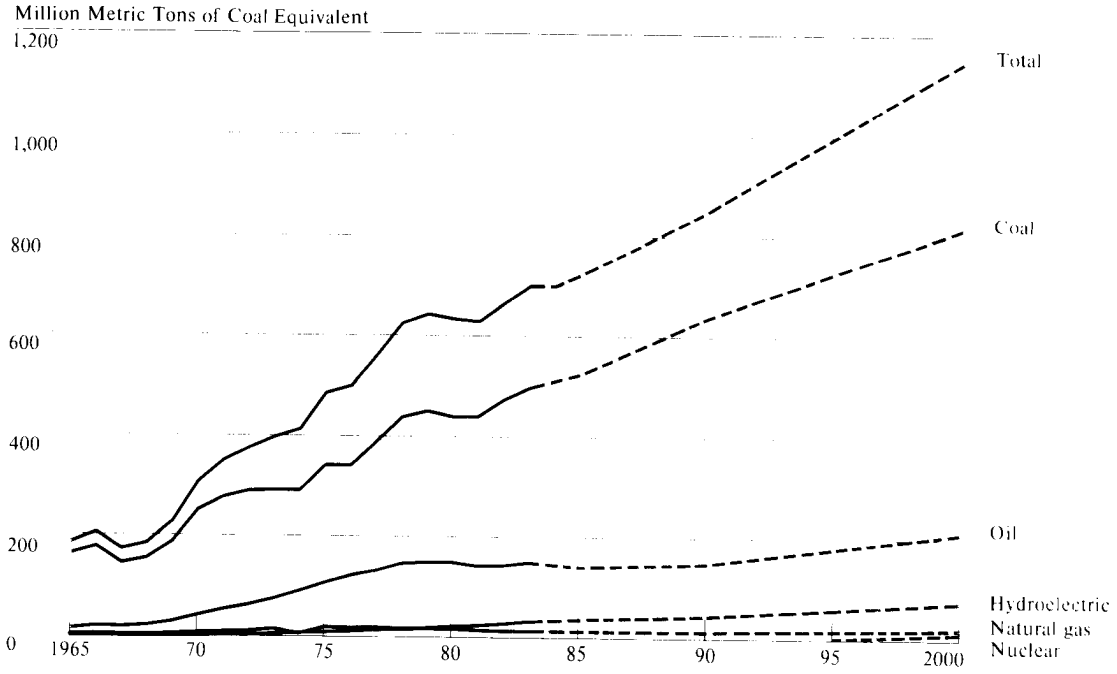
China's Energy Supply

China produced about 700 million tons of coal equivalent (MTCE) commercial energy in 1983, up about 5 percent from 1982. Energy output in the past five 25X1

Figure 1
China: Energy Production, 1965-2000



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years, however, has increased at an average annual rate of only 2 percent, in marked contrast to the 6-percent annual growth registered in the preceding two decades. The steady erosion of coal's share of energy supply that occurred from 1950-78 has been reversed; coal's share of energy output rose from 70 percent in 1978 to 71 percent in 1983. Petroleum, with output flat since 1978, has lost about 4 percentage points and is now providing 18.8 percent of national energy supply. Hydropower has gained steadily to provide about 4.4 percent of the country's energy, while natural gas has declined to only about 2.5 percent. In addition, Chinese economists estimate that agriculture and forestry provide about 300 MTCE in the form of crop stalks and firewood, which is consumed in rural China on a noncommercial basis. On the basis of these figures, China ranks third in world energy output, following the Soviet Union and the United States. In per capita energy production, however, China ranks in the bottom one-third of all countries in the world.

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China's Sixth Five-Year Plan (1981-85) and less definite but widely quoted long-range plans indicate that energy output will continue to grow slowly through the end of the century. Table 1 includes what we consider the most realistic energy-sector targets. The 1985 targets are revised official Sixth Five-Year Plan goals and appear reasonable. For 1990, we have used our own estimates, which are generally based on unofficial Chinese projections. For 2000 we have used projections made in 1982 by the Shanghai *World Economic Herald*, a Chinese Academy of Social

Table 1
China's Energy Production [a]

	1980	1981	1982	1983	1985 [b]	1990 [c]	2000 [d]
Total million TCE	**637**	**632**	**668**	**702**	**725**	**855**	**1,151**
Coal							
Million tons	620	620	666	700	740	900	1,150
Million TCE	442	442	475	500	527	641	821
Oil							
Million tons	106	101	102	106	100	105	150
Million TCE	152	145	146	151	143	151	214
Gas							
Billion m^3	14.3	12.7	11.9	12.1	12	12	18
Million TCE	19	17	16	16	16	16	24
Hydropower							
Billion kWh	58.2	65.5	74.4	87.8	95	115	187
Million TCE	24	27	30	35	39	47	77
Nuclear power							
Billion kWh	0	0	0	0	0	0	36
Million TCE	0	0	0	0	0	0	15

[a] We use the Chinese definition of coal equivalent energy to aggregate various energy types. One ton of coal equivalent energy (TCE) is defined as the amount of fuel that is required to provide 7 million kilocalories of heat energy. It is equivalent to 1.4 tons of raw coal, 0.7 ton of crude oil, 752 cubic meters of natural gas, and 413 kilowatt-hours of electricity.

[b] Chinese targets.
[c] CIA forecast.
[d] Shanghai's *World Economic Herald* forecast, 1982.

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Sciences publication. The *Herald* also made projections for 1985 and 1990, but these appear overly pessimistic in the light of a strong performance in 1982 and 1983. These projections fall slightly short of Beijing's general guidelines for doubling the availability of energy by the year 2000. They imply growth rates of 2.9 percent a year through the rest of the 1980s and just over 3 percent a year in the 1990s.

Achievement of these energy production targets will require a sharp boost in investment. Energy investment now accounts for about 45 percent of industrial investment, and Beijing's efforts to control its overall investment outlays have strongly affected the energy sector. Despite considerable emphasis on the energy problem, Beijing reduced state investment in energy development from 11.4 billion yuan in 1978 to only 9.0 billion yuan in 1981 and 10.2 billion in 1982 (see table 2). The Sixth Five-Year Plan (1981-85), moreover, included only a 2-percent-a-year increase. The sharpest decline occurred in the petroleum sector—probably because China's expensive offshore exploration has been picked up by Western companies—but declines were also registered in coal and electric power.

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Only within the last year has Beijing allowed energy investment to rebound. Eleven-month data for 1983 indicate energy investment reached close to 13.6 billion yuan for the year, up about 35 percent from 1982. The largest increases went to the electric power industry.

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Table 2
China: Energy Investment [a]

Billion yuan
(except where indicated)

	1978	1979	1980	1981	1982	1983 [b]	Annual Average Investment for the Sixth Five-Year Plan, 1981-85 (*percent*)
Total investment	**50.1**	**52.3**	**55.9**	**44.3**	**55.5**	**64**	
Industry	27.3	25.7	27.6	21.6	26.1	30	24.0
Energy	11.4 [c]	10.7	11.3	9.0	10.2	13.6	10.8
Coal	NA	3.2	3.3	2.3	3.0	NA	3.6
Crude oil	NA	2.7	3.2	2.7	2.6	NA	3.1
Exploration	NA	1.3	1.5	1.3	2.2	NA	NA
Development	NA	0.9	1.1	0.9	0		
Refining	NA	0.5	0.6	0.5	0.4	NA	NA
Electricity	NA	4.8	4.8	4.0	4.6	5.4 [d]	4.1
Hydropower	NA	NA	1.8	1.3	1.5	NA	NA
Thermal	NA	NA	1.9	1.5	1.8	NA	NA
Transmission	NA	NA	1.1	1.2	1.3	NA	NA

[a] Basic capital construction investment in plant and equipment by state-owned units. From State Statistical Bureau and other official sources.
[b] Projected from six-month data. Industry breakdown is not available.
[c] The World Bank quotes Chinese sources for energy investment in 1978 of 12.1 billion yuan, including 3.3 billion for coal, 3.8 billion for oil, and 4.9 billion for electricity.
[d] Plan for 1983.

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Coal—China's Energy Foundation

The 71-percent share of China's energy provided by coal is the highest for any major country. As suggested in table 1, that share will probably rise even higher in the next decade as China strives to double its coal output. China certainly has the coal reserves to meet that goal—official Chinese estimates of 600 billion tons are some 900 times current annual output. Beijing, moreover, has recently begun an investment program that should allow substantial growth in coal output.[2] However, much of this growth will depend on whether China holds to the present course—China's coal policies have fluctuated greatly over the past two decades.

China's coal output increased by 7.4 percent in 1982 to reach a record 666 million tons of raw coal (475 MTCE). Output in 1983 again increased substantially, meeting the 1985 target of 700 million tons two years early.

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The improved performance comes after a difficult period in 1980 and 1981 during which coal investment was reduced and output dropped. This decline can be attributed in part to diminished demand by heavy industrial users during the 1980 and 1981 Chinese recession. Heavy industry rebounded strongly in 1982 and in 1983, along with coal output. The decline was also caused by government policies that encouraged investment in profitmaking industries at the expense

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Figure 2
Coal Industry

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of industries, such as coal, that often operate at a loss because of low prices arbitrarily set by the state. Low prices are a continuing problem for the industry, but Beijing has substantially increased central government investment. The 1981-85 Plan allocated 17.9 billion yuan (approximately $10 billion) to coal—32 percent more than in the preceding five-year period—despite the fact that overall industrial investment was scheduled to decrease. Coal's share of the capital construction budget was thus set to rise from 6.1 to 7.8 percent. Actual expenditures will probably be considerably higher. In addition, the industry has been opened to foreign investment—largely Japanese, European, and US—which may add the equivalent of 1 billion yuan by 1985.

Two years ago Beijing set targets of 700 million tons of coal output by 1985, 850 million tons by 1990, and approximately 1,200 million tons by 2000.

Beijing now hopes to exceed the planned targets and reach 740 million tons by 1985 and 940 million tons by 1990. We believe that rapidly increasing demand, and possibly sharp price increases, will spur China's mines into meeting this 1985 target. They may produce as much as 900 million tons by 1990, a figure projected in an authoritative article in the Communist-affiliated Hong Kong newspaper *Wen Wei Bao*. The railroads, however, may not have the capacity to transport the coal.

Beijing's strategy for increasing coal output includes:

- Encouraging the development of small mines to meet local and short-term coal requirements. These mines accounted for about two-thirds of the increase in national coal output during the past two years. They are slated to increase output from 350 million tons in 1982 to 500 million tons in the year 2000.

- Significantly expanding and developing new state-controlled underground mines—especially in Shanxi, Shandong, Anhui, and Guizhou Provinces—using domestic, Japanese, and European financing. These mines will increase production capacity from about 350 million tons in 1982 to 600 million tons in 2000.

- Opening five very large open pit mining areas using large amounts of US and European investment. These new mines will produce 200 million tons by 2000. 25X1

Of the 600-million-ton increase in capacity, at least 130 million tons will be developed in cooperation with Western and Japanese firms. Problems in marketing the foreign company's share of coal from these projects have come up in the past year as a result of a sharp drop in the international coal prices. Final agreement on the large Occidental Petroleum joint venture for development of the Pingsuo open pit mine, for instance, has been delayed. These, and the transportation problems that constantly plague the industry, may prevent Beijing from meeting its targets. 25X1
Given the high priority currently afforded the coal 25X1
industry, we believe, nevertheless, output will increase substantially. 25X1 25X1

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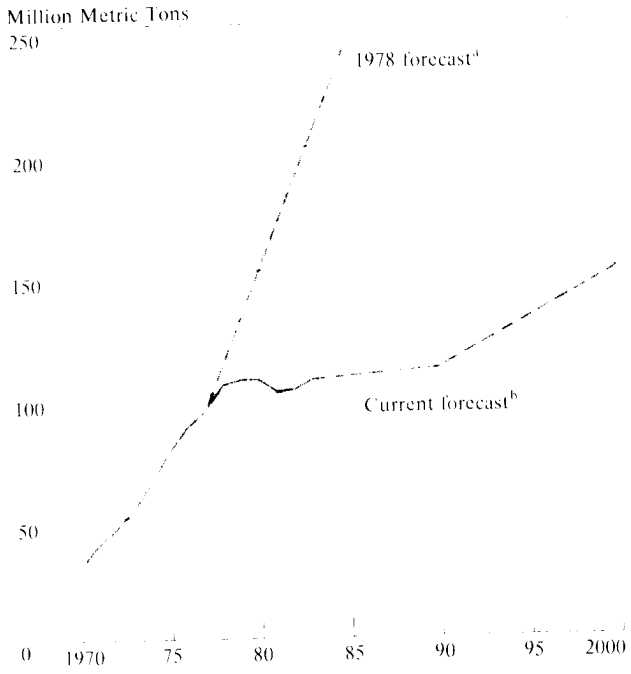
Petroleum—Depending on Offshore Discoveries

China's oil production peaked in 1979 at 106 million tons[3] a year (152 MTCE per year) and declined slightly in 1980 and 1981. China has since recouped most of the loss and is now the seventh-largest producer in the world, about the same as Venezuela and the United Kingdom. 25X1

Beijing expects little growth in production through 1990; after that it has high expectations for offshore 25X1
production. Without further technical study we are not in a position to challenge those expectations and have included an estimate of 105 million tons (2.1 million b/d)—the same as 1983—for 1990. This would include a small amount of new offshore oil by that point. Given the limitations of the country's proved oil reserves, however, we believe there is a chance that oil production will decline by 1990. If offshore oil is not as abundant as initial signs indicate, the 1990s could see further declines. The forecasts of the Shanghai *World Economic Herald* for 150 million tons (3 million b/d) by 2000 is reasonable, however, if

[3] This is equivalent to 2.1 million b/d at the average conversion factor for Chinese oil of 7.3 barrels to 1 ton. 25X1

Figure 3
China: Petroleum Output, 1970-2000



[a] Official Chinese forecast.
[b] Shanghai: World Economic Herald.

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offshore oil production is successful. We believe only an exceptionally successful offshore oil program and a large increase in exploration activity in western China would make the 200-million-ton (4-million-b/d) official target attainable.[4]

Beijing, as recently as early 1978, had much higher expectations for oil production. According to the official plan at that time, as outlined by Vice Premier Yu Qiuli, production was slated to reach 150 million tons in 1980 and 240 million tons by 1985. These plans were apparently made by simply extrapolating the rapid growth of production in the 1970s, without regard to actual oil reserves. 25X1

China does not publish official statistics on oil reserves, and we believe that many figures quoted in both the Chinese and Western press are far too high. An October 1980 edition of a 25X1 journal published by the Chinese Academy of Social Sciences included what appears to be the most definitive calculation of reserves to date. It cited a reserve-to-production (R/P) ratio of 14.6 to 1, which at the 1980 output rate of 106 million tons (773 million barrels) is equivalent to 1.5 billion tons (11.3 billion barrels) of reserves. This is another way of saying that China, without any new discoveries, has enough reserves to last less than 15 years at current production rates.[5] Reserves by the end of 1983 were probably down slightly as Chinese statements indicate oil is being produced faster than it is being found. Officially, the Ministry of Petroleum states that it has found *geological* oil reserves in excess of the volume of oil it has produced in the last two years, but typically in oil industry experience only about 40 percent of this category of reserves is ever produced. We estimate that the current oil reserves figure is below 1.5 billion tons (11 billion barrels) and that the R/P ratio is about 14 to 1. 25X1

This marks a doubling of reserves since 1965, but, because production has increased so rapidly, the ratio has plunged. Most of the increase in reserves came before 1977 with expansion of the Daqing oilfield in Manchuria and the Shengli oilfield in North China and discovery of the Liaohe and Renqiu oilfields, also in the North China Basin complex. Since then we know of only one significant commercial onshore discovery—the Zhongyuan fields, which the World Bank is helping to develop. At least one and possibly four or five offshore fields have been discovered in the last two years but exploration is not far enough along 25X1 25X1 25X1

[5] Western estimates for proved and probable reserves include 13.2 billion barrels by the World Bank, 9.48 billion barrels by a Japanese source, and 17 billion barrels by the US Geological Survey. Chinese and Western press articles, on the other hand, have quoted figures as high as 440 billion barrels, which is higher than Saudi Arabian reserves. 25X1 25X1

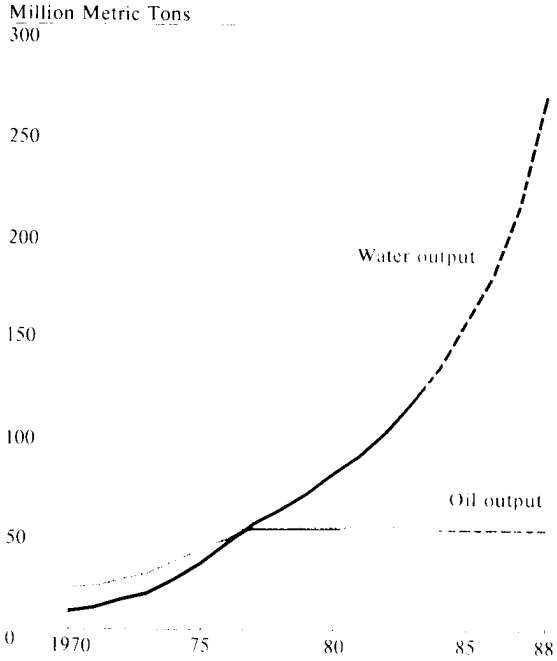
to determine reserves. these discoveries are relatively small and will not have a significant impact on the countrywide reserves. New fields have also recently been discovered in the Qaidam and Tarim Basins in western China, but we doubt those can currently be considered commercially viable because of their isolated locations.

An R/P ratio of less than 15 would not necessarily be a major problem for a country such as China with large, relatively unexplored regions offshore and in its far west. The R/P ratio for the United States, in comparison, is approximately 9 to 1. China does have a major problem with the location of its reserves. Much of China's proved reserves—the World Bank estimates about 20 percent—are in Qinghai Province and the Xinjiang Autonomous Region where poor transportation hampers production. The Xinjiang regional government estimates that oil production in the west will quadruple from 5 million tons per year (100,000 b/d) to 20 million tons per year (400,000 b/d) by the year 2000; even if that target is reached, the entire west will produce only slightly more than the Shengli producing area's current output.

Most of the remaining reserves are in mature oilfields that are increasingly difficult to exploit. Daqing oilfield, which produces half of the country's oil, is the most critical. Over its 24-year production history, it has withdrawn about 650 million of the 1.3 billion tons that Beijing hopes ultimately to recover. Output has been held steady at 50 million tons (1 million b/d) for the past six years by massive waterflooding of the reservoirs. Oilfield administrators and the Minister of Petroleum, say the field will maintain this output rate until 1986 or 1987 before starting to decline.

Analysis performed by Daqing Oilfield's Research and Planning Institute, published in a Chinese technical journal in July 1983, indicates that waterflooding of the reservoirs had caused the share of water produced with the oil to reach 64 percent of total fluid production by 1981. This water-cut ratio is increasing by 3 percentage points a year and by the end of 1985—the last year of the Institute's projection—is projected to reach 75 percent if oil output is to be maintained at the 50-million-ton-per-year level. Figure 4 includes the Institute's projections for water and oil production through 1985. We have extrapolated it

Figure 4
China: Oil and Water Output, Daqing Oilfield, 1970-88



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to show the accelerating volume of water that must be injected and processed if the current volume of output is to be maintained through 1988. Clearly, at some point, the accelerating costs associated with handling this geometrically increasing volume of water will cause the oilfield to abandon the goal of level production. After that, it appears that the field will face a rapid decline in production.[6]

Other major fields, particularly those in the Shengli producing area, are in similar stages of production (see table 3). Nationwide, production from existing

[6] A technical study of the field is under way that should be available in mid-1984.

Table 3
China: Oil Output by Major Producing Areas

Million tons

	Total	Daqing	Shengli	Renqiu	Dagang	Yumen	Kolomayi	Liaohe [a]	Other
1960	**5.20**	0.79				1.70	0.23		2.48
1961	**5.31**	2.00				1.60	0.21		1.49
1962	**5.75**	3.22	0.05			1.30	0.20	0.03	0.96
1963	**6.48**	4.43	0.32			1.01	0.31	0.06	0.35
1964	**8.48**	5.77	0.60			0.71	0.42	0.10	0.89
1965	**11.31**	7.11	0.74			0.41	0.52	0.13	2.41
1966	**14.55**	8.78	2.00			0.41	0.47	0.16	2.73
1967	**13.88**	9.04	2.67		0.20	0.42	0.42	0.20	0.94
1968	**15.99**	9.30	3.33		0.34	0.42	0.37	0.23	2.00
1969	**21.74**	12.83	4.00		0.48	0.42	0.32	0.71	2.98
1970	**30.65**	21.18	4.67		1.02	0.49	0.38	1.19	1.72
1971	**39.41**	22.14	6.50		1.75	0.54	0.50	1.84	6.14
1972	**45.67**	25.55	8.45		2.48	0.62	0.60	2.48	5.48
1973	**53.61**	28.30	9.50		3.22	0.68	0.73	3.13	8.07
1974	**64.85**	34.61	11.02		3.95	0.71	1.04	3.77	9.75
1975	**77.06**	46.26	16.72		4.68	0.69	1.38	4.42	2.90
1976	**87.16**	48.28	17.12	4.00	3.91	0.67	1.73	4.49	6.95
1977	**93.64**	50.31	17.52	12.30	3.15	0.65	2.08	4.56	3.07
1978	**104.05**	50.38	19.47	17.23	3.00	0.62	2.43	5.66	5.25
1979	**106.15**	50.75	18.88	17.33	2.90	0.60	1.78	6.61	7.29
1980	**105.95**	51.50	17.59	16.03	2.91	0.58	3.13	7.09	7.12
1981	**101.22**	51.75	16.11	12.22	2.88	0.56	3.48	6.88	7.34
1982	**102.21**	51.90	16.35	11.31	3.02	1.38	4.03	7.24	6.98
1983	**105.99**	52.00	18.35	NA	NA	NA	NA	NA	NA

[a] Includes Fuyu oilfield with output of about 1 million tons in 1982.

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wells is declining at an annual rate of about 10 million tons (200,000 b/d) or 10 percent of production. This has been offset by drilling 2,000 new production wells a year, at a cost of 1 billion yuan, and by increasing water injection. This massive effort has come at the expense of some exploratory drilling and is a major reason for Beijing's increasing willingness to enlist the help of Western oil firms for secondary and tertiary production technology.

Natural Gas—Unknown Potential

Natural gas production has dropped by 17 percent since 1979, and, like oil, the industry faces cloudy prospects because of limited proved reserves. Official data are not available, but unofficial Chinese sources placed reserves at about 180 billion cubic meters in 1981. The World Bank, on the other hand, estimates that in 1981 China had proved gas reserves of 131.5 billion cubic meters including 58 billion cubic meters of associated gas found in oilfields and 73.5 billion cubic meters of nonassociated gas. This is enough gas for only 11 years at current production rates.

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About 45 percent of China's gas is produced from gasfields in Sichuan Province. Many of these are having severe difficulties maintaining current production rates. US firms have been invited into Sichuan to

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Figure 5
Oil and Gas Basins

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give technical advice and sell some improved production equipment. Prospects for these fields do not appear good, but more intensive exploration of southeastern Sichuan and Guizhou Provinces could turn up large new deposits. The remainder of China's gas output is produced as associated gas in the major northeastern oilfields, with Daqing, Liaohe, and Shengli the major contributors (see table 4).

Natural gas output relative to oil output is unusually low in China, particularly because of the country's largely continental hydrocarbon source rocks, which many geologists believe should be conducive to gas formation. much of the gas that was created escaped to the surface in China's

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Table 4
Natural Gas Production

Billion cubic meters

	1978	1979	1980	1981	1982	1983
Total	**13.73**	**14.51**	**14.27**	**12.74**	**11.93**	**12.1**
Sichuan	6.15	6.52	6.33	5.78	5.24	NA
Daqing	3.20	3.31	3.39	2.90	2.78	NA
Liaohe	1.80	1.86	1.88	1.53	1.26	NA
Shengli	1.40	1.50	1.42	1.04	0.97	NA
Other	1.18	1.32	1.25	1.49	1.68	NA

typically highly faulted basins. Others believe there is a great deal of gas potential, particularly at extreme depths, but that Chinese drilling technology is not sophisticated enough to find it.

These differing views make it difficult to predict gas production even in the short term. A gradual increase appears reasonable because of new imported technology. Several significant gas discoveries since 1980 have already allowed a small turnaround in gas production this year. The most important onshore find is in the Zhongyuan area that the World Bank is helping to develop. Gas resources in Zhongyuan's eight identified oil and gas fields might total as much as 36 billion cubic meters. Output in 1983 was probably about 300 million cubic meters, accounting for most of the gain nationwide. By 1985 the area is to produce 500 million cubic meters a year.

Gas discoveries have also recently been made offshore in the Bohai, the East China Sea, and in the Yinggehai Basin south of Hainan Island. The Yinggehai discovery, made by Atlantic Richfield in its concession area, is particularly promising.

Many other structures in the Yinggehai Basin—which geologists believe is one of the few gas-prone rather than oil-prone offshore basins—remain to be drilled.

Offshore gas, particularly when it is not associated with oil, however, is very expensive to develop. it will cost a minimum of $89 per thousand cubic meters to deliver Yinggehai gas to Hainan and $123 per thousand cubic meters to the mainland. These costs may be too high to warrant development, even if large resources are confirmed.

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Electric Power Supply—Increasing Shortages

China's economic planners admit that electricity consumption in the long term must increase at close to if not even faster than the overall economic growth rate. Over the past three decades, electricity consumption in China has risen twice as fast as industrial growth. China's broad goals for "modernizing" the country thus include a guadrupling of electric power availability by the year 2000—an annual growth rate of more than 7 percent. This represents a massive challenge for the industry but not necessarily an impossible one.[7]

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China, however, has two major disadvantages that we believe will prevent it from raising capacity by anything more than 5 percent per year for the indefinite future. First is the limited availability of domestic capital and high worldwide interest rates if China should decide to borrow capital. Second, limited supplies of oil and gas and much higher costs for nuclear power plants are forcing China's power development to be rather narrowly focused on coal-fired thermal and hydroelectric power plants.[8]

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Slowdown in Capacity Expansion. In the 1970s, electric power output in China increased at an 11-percent annual rate, reaching 300 billion kilowatt-hours (kWh) by 1980. Generating capacity rose by 11

[7] Chinese economists point out that the United States, from an electric power base in 1947 that was equivalent to China's current base, quadrupled power output and capacity by 1965. The Soviet Union accomplished a similar expansion in only 15 years in the 1960s and 1970s. China, moreover, can take advantage of the important technological improvements in power technology—particularly in the use of larger turbine/generator units—that have occurred since the 1950s and 1960s.

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Table 5
Electric Power Capacity

	1978	1979	1980	1981	1982	1983 [a]	1985 [b]	1990 [b]	1995 [b]	2000 [b]
Total capacity *(thousand megawatts)*	**57.1**	**63.0**	**65.9**	**69.3**	**72.4**	**75.9**	**81.0**	**103.0**	**130.0**	**165.0**
Thermal	39.8	43.9	45.6	47.4	49.4	52.5	56.2	73.0	90.0	110.0
Hydroelectric	17.3	19.1	20.3	21.9	23.0	23.5	25.0	30.0	37.0	45.0
Nuclear	0	0	0	0	0	0	0	0	2.5	10.0
Total average annual growth *(percent)*	[c]	**10.3**	**4.3**	**5.1**	**4.5**	**5.0**	**3.4**	**4.9**	**5.0**	**5.0**
Thermal	[c]	10.3	3.9	4.0	4.2	6.3	3.5	5.4	4.3	4.1
Hydroelectric	[c]	10.4	6.3	7.9	5.0	22	3.1	3.7	4.3	4.0
Nuclear	0	0	0	0	0	0	0	0	[c]	32.

[a] Planned.
[b] CIA projection.
[c] Not applicable.

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percent per year to reach 66,000 megawatts (MW) in 1980, sixth largest in the world. Beijing's modest Sixth Five-Year Plan (1981-85) called for an increase of 12,900 MW of generating capacity by 1985, which would represent a capacity growth rate of only 3.6 percent per year, only one-third the rate of increase in the 1970s. This figure probably does not include increased capacity from small hydroelectric plants that are built by villages and are not tied into Ministry of Electric Power grids. If these are included, an estimated 2,000 MW should be added to the five-year plan targets for a total of 14,900 MW, and the growth rate raised to a 4.2-percent annual rate.

Actual expansion in 1981 and 1982, including small-scale hydro, was 3,400 MW and 3,100 MW, respectively—generally in line with the Five-Year Plan. The 1983 plan called for a 3,180-MW increase in large- and medium-sized plants, which combined with an estimated 400-MW increase in small-scale plants, would increase total capacity to about 76,000 MW, an increase of 5.2 percent. Including small-scale hydro, the balance remaining under the Five-Year Plan would be only about 2,500 MW of new capacity each year in 1984 and 1985—an annual increase of only about 3 percent.

These increases are much smaller than the peak additions of 5,048 MW and 5,900 MW in 1978 and 1979, respectively. The slowdown can be directly attributed to cutbacks in electric power investment as Beijing has tried to control its investment budget. As table 2 indicates, investment in the industry was slashed by 20 percent in 1981 with only partial recovery in 1982. Investment in electric power increased sharply in 1983, far above the Sixth Five-Year Plan allocations.

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Despite the slowdown in the growth of generating capacity, power output growth has slackened only slightly. Output increased by only 2.9 percent in 1981, when industry was depressed, but achieved a steady increase of about 7 percent each year in 1982 and 1983. Capacity utilization, particularly for hydroelectric facilities, has grown very fast, removing a cushion that had developed in the 1970s. Power demanded by a rapidly growing industrial sector may now be raising capacity utilization to unsustainable levels. If so, and if capacity increases in 1984 and 1985 are no

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more than the current Five-Year Plan suggests, annual increases of power output may slump to 3 percent per year, a severe limitation on an industrial sector already starving for electricity.

Longer term prospects are somewhat better, provided Beijing is willing to increase steadily its budget allocations. China now has approximately 23,000 MW of capacity under construction that is slated to come on line after 1986. We estimate that about 22,000 MW of net new capacity will be commissioned during 1986-90; this estimate allows for new projects that will be started in the next few years, for retirement of some existing plants, and for a carryover of several thousand megawatts of hydropower capacity that will not be completed by then. This is an annual growth rate of about 5 percent.

Thermal Power. Thermal power plants account for approximately 52,000 MW or 70 percent of China's power capacity and contribute 77 percent of power output. They include an estimated 43,000 MW of coal-fired and 7,000 MW of oil-fired plants. Relative to power industries in other countries, China's industry is characterized by hundreds of small plants that use inefficient 50-, 100-, and 200-MW turbine/generator units. Even in the current Sixth Five-Year Plan period, most new plants are installing only 200-MW units.

The lack of larger scale generators reflects the inability of China's machine-building industry to produce large numbers of more efficient 300-MW turbine/generator units. After more than a decade of development, only five indigenously developed 300-MW units are in operation. In any case, China's transmission system has been unable to handle large loads.

Both of these conditions are now changing rapidly as China imports needed technology from the West. In 1978, Westinghouse and Combustion Engineering signed contracts making available to China 300- and, eventually, 600-MW turbine/generator technologies that are already beginning to have an impact. We expect these units will form the basis for capacity expansion in the industry in the late 1980s and in the 1990s. China is also rapidly expanding its 500-kilovolt (kV) transmission capabilities with some imported equipment.

These efforts are particularly important in developing large power plants at mine locations that we think offer China the best chance of keeping up with its power needs. These plants not only alleviate the need for transporting coal, they can be located in rural areas and will not contribute to already major pollution problems in China's cities. Currently, only 15 percent—6,880 MW—of China's coal-fired plants are located at mine mouths. At least 9,000 MW of new mine-mouth capacity is now under construction or is in advanced planning stages. 25X1

Hydroelectric Power. China has developed only a tiny share of what is generally accepted as the world's greatest hydroelectric power potential. Hydroelectric generating capacity now totals about 24,000 MW, of which 8,000 MW are small-scale rural plants not tied into any grid systems. Hydroelectric output totaled 74.4 billion kWh in 1982, 23 percent of total power output. Hydro's 13-percent increase over 1981 was the only reason the Ministry of Electric Power met its annual goals; thermal plants missed their target as a result of a fuel shortage. Hydroelectric output did even better in 1983 with production through November up 18.6 percent over the same period in 1982. 25X1

Several major hydroelectric projects have been completed since 1979 and have provided a major boost to output. These include the 965-MW first stage of Gezhouba, the first dam constructed on the Chang Jiang; 300-MW of the first stage of Baishan, located in Manchuria; and the 630-MW Wujiangdu project in Guizhou. Another factor behind the surge in hydroelectric output is heavy rainfall over the past two years that has allowed a surge in production, especially from small-scale plants that are heavily dependent on timely rainfall. Output from these plants was up 34 percent in the first three quarters of 1983. 25X1

Beijing, in keeping with its goal to quadruple electricity supply by the year 2000, has ambitious goals for the hydro sector. According to figures published in a Ministry of Electric Power journal, hydrocapacity will increase by 4,000 MW between 1980 and 1985 (most of this has already been achieved); by 9,000 to 10,000

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Table 6
China: Hydroelectric Power Plans [a]

	Planned Capacity (*MW*)	Average Annual Capacity Growth (*percent*)
1980	21,000	
1985	25,000	3.5
1990	34,000-35,000	6.3-7.0
1995	47,000-51,000	6.7-7.8
2000	62,000-71,000	5.7-6.9

[a] Official Chinese targets.

MW in the Seventh Five-Year Plan (1986-90); by 12,000 to 16,000 MW between 1991 and 1995; and an astonishing 11,000 to 20,000 MW between 1996 and 2000. Included in these plans for the 20 years (1981-2000) are 12,000 MW of additional hydropower from small plants and 28,000 to 38,000 MW from medium and large plants. This is an annual growth rate of about 5 percent in the 1980s, accelerating to more than 6 percent in the 1990s.

We believe achievement of these goals is highly unlikely. Currently, 27 large- and medium-sized power plants with designed capacity totaling more than 12,000 MW are under construction; most have only recently been started and will not produce electricity until the late 1980s and early 1990s. With a minimum of 12 years required to construct a hydroelectric plant, the 1990 and 1995 targets already seem out of reach.

Some Chinese economists, moreover, appear to be questioning the advisability of heavy emphasis on long-term, capital-intensive hydroelectric projects when power shortages are a daily phenomenon. Major criticism has been focused on the large numbers of people displaced by manmade lakes—one major project now on hold, the Three Gorges dam on the Chang Jiang, would generate 25,000 MW of power but would require advanced technology and the relocation of 1.2 million people. There is also considerable criticism of small-scale hydroplants, for their high per unit capital costs and for unreliable service.

Under these circumstances, we believe China will do well to sustain an increase of 4 percent per year in hydro capacity through the 1990s. This estimate, based on an assumption that all existing projects will be completed by 1995 and that the rate of increase from small-scale hydro will remain flat at 400 MW per year, would bring capacity up to about 30,000 MW by 1990 and close to 37,000 MW by 1995. Output growth may be slightly more rapid as more integrated grid systems lead to higher utilization rates.

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Nuclear Power. China has been actively considering the development of nuclear power since at least 1970 but thus far has made little progress. One small (300 MW) domestically designed plant is in an initial stage of construction near Shanghai with a completion target of 1988. The Ministry of Water Resources and Electric Power (MWREP) has also negotiated with Western firms for two 1,800-MW turnkey plants, one for Guangdong Province that would share power with a Hong Kong utility, and a second plant near Shanghai. The Guangdong plant has received State Council approval, and, if MWREP can settle with the French firm, Framatome, construction could begin within a year. Framatome has signed a preliminary agreement, but China continues to state it prefers a US supplier if US nonproliferation concerns are worked out. The plant could not be complete until the early 1990s when it will supply only about 1 percent of the nation's power.

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These plants will give China practical experience with a technology that some Chinese planners believe is the only solution to China's long-term energy requirements. For the next 20 years, however, we believe—and official Chinese plans reflect—that nuclear power will be too capital intensive and too expensive an energy source for China to depend on. Some estimates

for the Guangdong plant, for instance, range as high as $5 billion, more than five times the cost of an equivalent coal-fired plant.

Beijing last year cut its plans to have 20,000 MW of nuclear capacity onstream by 2000 by half. This new 10,000-MW target appears feasible and is one that will still offer substantial sales of Western technology and equipment. However, it will contribute only about 6 percent of the nation's electric power output and about 1 percent of total energy supply at the end of the century; the investment required will probably total more than $20 billion in 1982 dollars.

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China's Demand for Energy

China has slowed the rate of increase in energy consumption in the last five years. Unlike in many Western economies, this conservation has taken place in a period of fairly rapid economic growth. Energy consumption in China increased at an annual rate of 1.9 percent from 1978 through 1982 while national income increased at a 6.2-percent rate. This energy elasticity of national income of 0.30 is in sharp contrast to an elasticity of 1.47 for the Chinese economy from 1965 to 1978 (see figure 6).

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Most observers, in China or in the West, doubt this low elasticity can be maintained. Much of the improved energy use between 1978 and 1982 has been the result of economic restructuring caused by rapid growth in energy-efficient light industry and agriculture and very slow growth in energy-intensive heavy industry. Beijing officially attributes two-thirds of the energy savings to structural change and only one-third to conservation. This suggests that, had the structural, change not occurred, energy consumption would have been 12 percent higher in 1982—76 MTCE energy—twice the level of energy exports in that year.

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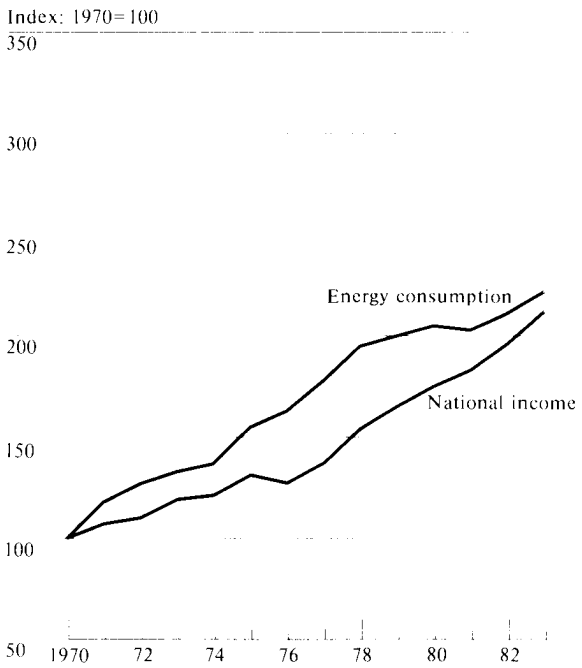
The separation of structural change from a more narrowly defined efficiency gain—that is, reduced energy consumption for production of a given product—is important in forecasting China's future demand for energy because Beijing's plans call for more or less balanced growth between heavy industry and light industry and somewhat slower growth for agriculture. Heavy industry provides the investment and

Figure 6
China: Energy Consumption and Economic Growth, 1970-1983



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intermediate goods required for producing light industrial goods and cannot continue to lag light industry indefinitely. If efficiency gains continue along recent trends, this balanced growth would suggest an elasticity close to 0.75, which is not consistent with Beijing's planned 0.50. It would imply that if energy supplies double by the year 2000 as planned the overall economy could increase at a rate of only 4.8 percent per year, not the planned annual rate of 7.2 percent.

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Although these broad elasticity statistics are useful in providing a general idea of China's energy problem, they can be misleading on two accounts. First, there can be considerable structural change within these

broad sectors that can have a strong but, without careful study, ambiguous impact on energy demand. Second, they do not differentiate between types of energy. Oil, coal, and electric power output are not likely to increase at the same rate nor can we assume that demand for these energy sources will increase at the same rate. To the extent that these fuels cannot be readily substituted for each other, bottlenecks will occur as a result of a shortage of one fuel, even though in more aggregate terms the country might have plenty of energy.

To improve our ability to analyze China's energy demand, we have disaggregated China's energy consumption by energy type and energy-consuming industry as shown in tables 7 and 8. The 1978 data are taken largely from a Chinese publication, which, although not official, appears to contain offical data we have not seen published elsewhere. No similar source is available for 1982; hence, we have had to include a mixture of official data, where they are available, and our own estimates. In table 8, where we have no basis for making an estimate, we have used "NA." Electrical energy consumption by industry is treated as an intermediate product and is not included in the table. The distribution of electric power consumption can be found in table 12, page 27.

China's Demand for Coal

China's demand for raw coal reached 637 million tons in 1982, up from 565 million tons in 1978—an annual rate of increase of about 3 percent. In terms of standard coal equivalent, these figures are 454 million tons and 404 million tons, respectively. In 1981 when China's heavy industrial output slumped, coal consumption actually declined but rebounded strongly in 1982 with a 5.2-percent increase. Preliminary data indicate that coal consumption may have increased even faster in 1983, possibly more than 6 percent. The resurgence in coal demand results largely from two factors: resumption of rapid growth in heavy industry and sharp rises in retail sales of coal to households and local industries as economic reforms have removed some restrictions on the private mining and selling of coal.

Industrial Demand. The five industries discussed below—electric power, iron and steel, synthetic ammonia, building materials, and railroads—accounted for 45 percent of China's coal consumption in both 1978 and in 1982. We estimate that, consistent with a 5-percent annual growth rate in the value of production for the group as a whole, their coal consumption will increase at annual rates of about 3.6 percent in the 1980s and 2.5 percent in the 1990s (see table 9). The apparent improvement in the rate of efficiency gain in the 1990s is actually the result of structural change in the use of energy. In the 1980s, coal will be substituting for oil in the generation of electric power; in the 1990s, nuclear power will be substituted for some coal. If this group of industries remains representative of Chinese industry in general, industrial consumption of coal will rise to 686 million tons a year by 1990 and 880 million tons by the year 2000.

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The *electric power* industry is China's largest industrial consumer of coal, accounting for about 140 million tons or 22 percent of the nation's total demand in 1982. Power plants have increased coal consumption by approximately 5 percent a year over the past five years, slightly faster than the output of thermal electricity because of the gradual conversion of oil-fired plants to coal. Despite the high priority in fuel allocations given to the electric power sector, the lack of coal on occasion has constrained electricity supply. This was particularly true in 1981 when thermal power plants were unable to meet their annual targets because of a lack of fuel.

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Over the past three decades, the power industry has steadily improved the efficiency with which it burns coal. Coal consumption per kilowatt-hour has dropped from 700 grams in 1949 to 400 grams in 1983, an average gain in efficiency of about 1.7 percent per year. This gain has leveled off to about 1 percent per year recently, a rate of improvement that, according to articles in Chinese electric power journals, Beijing hopes to maintain through the 1990s. Large-scale production and installation of more efficient 300-MW and 600-MW turbines and generators in new plants should make this efficiency gain possible.

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Table 7
China: Primary Energy Consumption, 1978

	Energy		Coal		Petroleum		Gas		Hydropower	
	Total (*MTCE*) [a]	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)
National total	**571.3**	**100**	**404**	**100**	**129.7**	**100**	**18.1**	**100**	**19.4**	**100**
Industry	313.6	54	225	56	73.0	56	15.6	85		
Heavy industry	269.6	47	196	49	58.0	45	15.6	85		
Metallurgy	65.9	12	56	14	8.2	6	1.7	9		
Ferrous	63.2	11	54	13	7.5	6	1.7	9		
Nonferrous	2.7	1	2	NEGL	0.7	1	NEGL	NEGL		
Chemicals	55.7	10	35	9	11.0	8	9.7	53		
Ammonia	30.2	5	20	5	0.5	NEGL	9.7	53		
Petrochemicals	3.5	1	NEGL	NEGL	3.5	3	NEGL	NEGL		
Building materials	18.2	3	17	4	1.2	1	NEGL	NEGL		
Cement	10.0	2	9	2	1.0	NEGL	NEGL	NEGL		
Energy	31.9	6	16	4	12.1	9	3.8	20		
Coal	16.0	3	16	4	NEGL	NEGL	NEGL	NEGL		
Oil	15.9	3	NEGL	NEGL	12.1	9	3.8	20		
Machine building	16.3	3	15	4	1.3	1	NEGL	NEGL		
Light industry	43.7	8	29	7	14.7	11	NEGL	NEGL		
Transportation	36.0	6	20	5	16.0	12	NEGL	NEGL		
Rail	19.0	3	18	4	1.0	1	NEGL	NEGL		
Motor vehicle	15.0	3	NEGL	NEGL	15.0	11	NEGL	NEGL		
Agriculture	16.5	1	2	NEGL	14.5	11	NEGL	NEGL		
Household/commercial	78.5	14	76	19	NEGL	NEGL	2.5	14		
Electric power	126.6	22	81	20	26.2	20	NEGL	NEGL	19.4	100

[a] Million tons of coal equivalent.

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We calculate that, if China succeeded in quadrupling power output by the year 2000, even assuming realization of hydroelectric and nuclear power plans, coal consumption would rise to about 450 million tons a year, despite improved efficiency. This would represent a doubling of the power sector's share of coal consumption—to about 40 percent and a rate of growth of 6.7 percent per year, which we believe is highly unlikely. If, on the other hand, thermal power capacity rises at the rate of between 4 and 5 percent per year that we project (see electric power supply section, page 12), the power sector's demand for coal will increase by a more manageable 3- to 4-percent rate.

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The *iron and steel industry* is China's second-largest industrial consumer of coal. In 1978 it consumed about 76 million tons of raw coal, 13 percent of the nation's total. Consumption declined to less than 68 million tons in 1981 despite a 12-percent increase in steel output. This represents a total efficiency gain of 25 percent in the three-year period—from 2.0 tons of coal per ton of steel in 1978 to 1.6 tons of coal in 1981. Much of this improvement was the result of closing hundreds of small steel plants. Also, better use

Table 8
China: Primary Energy Consumption, 1982

	Energy		Coal		Petroleum		Gas		Hydropower	
	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)	Total (*MTCE*)	Share of Total (*percent*)
National total	**615.7**	**100**	**454.0**	**100**	**115.9**	**100**	**15.8**	**100**	**30.0**	**100**
Industry	326.8	53	246.0	54	66.0	57	14.8	94		
Heavy industry	265.8	43	201.0	44	50.0	43	14.8	94		
Metallurgy	57.8	9	51.0	11	6.3	6	0.5	3		
Ferrous	54.8	9	49.0	11	5.3	5	0.5	3		
Nonferrous	3.0	NEGL	2.0	NEGL	1.0	1	NEGL	NEGL		
Chemicals	NA	NA	41.0	9	NA	NA	10.8	68		
Ammonia	36.8	6	24.0	5	2.0	2	10.8	68		
Petrochemicals	5.0	1	NEGL	NEGL	5.0	4	NEGL	NEGL		
Building materials	NA	NA	NA	NA	NA	NA	NEGL	NEGL		
Cement	17.0	3	16.0	4	1.0	1	NEGL	NEGL		
Energy	41.5	7	18.0	4	20.0	18	3.5	22		
Coal	18.0	3	18.0	4	NEGL	NEGL	NEGL	NEGL		
Oil	23.5	4	NEGL	NEGL	20.0	18	3.5	22		
Machine building	NA	NA	NA	NA	1.0	1	1.0	6		
Light industry	51.0	8	35.0	8	16.0	14	NEGL	NEGL		
Transportation	38.0	6	21.0	5	17.0	15	NEGL	NEGL		
Rail	22.0	4	21.0	5	1.0	1	NEGL	NEGL		
Motor vehicle	15.0	2	NEGL	NEGL	15.0	13	NEGL	NEGL		
Agriculture	16.0	3	2.0	NEGL	14.0	12	NEGL	NEGL		
Household/commercial	88.0	14	87.0	19	NEGL	NEGL	1.0	6		
Electric power	146.9	24	98.0	22	18.9	16	NEGL	NEGL	30.0	100

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of pig iron in making steel saved considerable energy. In 1982 and 1983 the efficiency gains have been much less—probably about 1.5 percent per year, because of fewer plant closings.

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The steel industry will continue to offer China one of its best opportunities for saving coal. With only modest goals for steel production and large efficiency gains still available—particularly through the use of modern integrated mills such as the Baoshan steel mill now under construction—we believe the industry's coal consumption need increase only by about 1 percent per year through the end of the century.

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China's *chemical* sector also offers substantial coal savings. In 1978, chemicals consumed 49 million tons of coal—9 percent of the nation's total—28 million tons of which were used as feedstock for *synthetic ammonia*. By 1982, we estimate coal consumption in the chemical sector had risen to about 57 million tons, including about 34 million tons in making synthetic ammonia. Growth targets for the chemical industry show that fairly rapid expansion is planned through the rest of the century, but we believe much of the increased energy demand will be met by petroleum

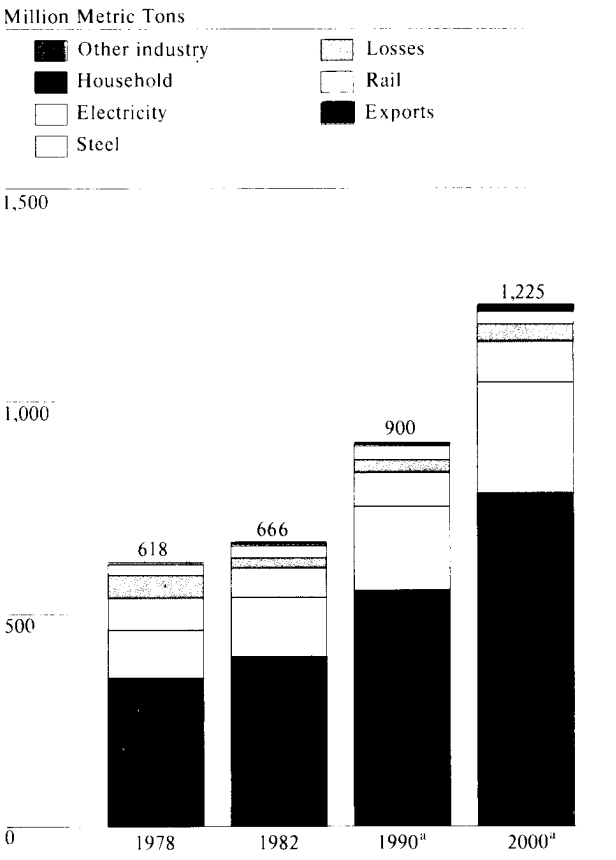
Table 9
China's Coal Demand [a]

Million tons

	1978	1982	1990	2000
Total demand	**565**	**638**	**864**	**1,170**
Industry demand	465	517	686	881
Steel	76	69	80	96
Ammonia	28	34	38	43
Cement	15	22	41	67
Electricity	113	137	198	260
Rail	25	29	32	30
Other	208	224	297	385
Household demand	100	122	178	289
Production	618	666	900	1,150-1,300
Losses and stocks	53	24	30	40
Total supply	**565**	**642**	**870**	**1,110-1,260**
Net exports	**1**	**5**	**5**	**−60 to 90**

[a] Because of rounding, components may not add to totals shown.

Figure 7
China: Coal Consumption, 1978-2000



[a] Projected.

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rather than coal. Chemical use of coal will probably increase at a rate of only 1 or 2 percent annually, again making substantial amounts of coal available for use in other sectors.

Building materials, particularly *cement*, are likely to take up some of these savings. We estimate that the cement industry consumed 22 million tons of coal in 1982. Rapid expansion of the industry—much of it in relatively inefficient small plants—will probably increase its coal consumption at a rate close to 8 percent per year through the 1980s, and perhaps a 5 percent per year annual rate of increase in the 1990s.

China and India are the only major countries that continue to use steam locomotives as the primary power source for their *railroads*. About 75 percent of China's freight is pulled by steam locomotives. These locomotives consumed 25 million tons of coal in 1978 and an estimated 29 million tons in 1982. Efficiency gains by steam locomotives have lagged in recent years. Coal consumption per ton-kilometer of freight actually increased slightly in 1982.

China's railroad sector over the past decade has been unable to keep up with economic growth. Freight movements, as measured in ton-kilometers, increased by only a little more than 4 percent per year. The resulting bottlenecks have been particularly troublesome for coal transport and are causing Beijing to reconsider its dependence on steam locomotion. Ultimately, we believe China will be forced to move toward diesel and electric locomotion. The reasons, as

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expressed in Chinese energy and transportation journals, are the efficiencies of energy and capital that diesel and electric offer. The changeover will be gradual—70 percent of locomotive production is still steam engines, which typically last 30 years. The Chinese press, however, has speculated that China's single remaining steam locomotive plant—the largest in the world—will change to diesel electric production sometime in this decade.

Household Demand. Retail sales of coal reached approximately 150 million tons in 1982, up sharply from only 100 million tons in 1978. This 10-percent-a-year increase has been a major stimulus to coal production by locally owned coal mines, which in 1982 increased output by 20 million tons—an increase of 15 percent. In 1978, almost all retail sales of coal went for household consumption, at least according to one Chinese publication, which gave figures of 60.98 and 39.65 million tons for urban and rural household consumption, respectively, in that year. Liberalization of controls on the private mining and selling of coal and the proliferation of private and collectively owned industry since 1978, however, suggest that only a portion of the increased sales went toward household consumption. We estimate households increased consumption of coal by 5 percent per year over the period, the same rate that was officially reported for 1979. This brings household consumption to 122 million tons in 1982 (see table 9).

Coal still provides only about a fourth of the energy used in China for heating and cooking—plant materials including firewood and crop stalks provide almost all of the rest. The effort required for peasants to gather these materials and the extensive ecological damage caused are now often cited among rural China's most pressing problems.

Under these circumstances—and with the relatively cheap price of coal—household demand for coal is practically inexhaustible. The central government can attempt to control this demand by refusing to sell coal produced in state-owned mines for local use. The Ministry of Coal, however, plans to increase production from locally owned coal mines—which now provide most of the rural household coal supply—by only about 2 percent per year through the year 2000, a rate of increase that is very unlikely to satisfy rural household demand. We estimate that, at a minimum, the state will have to allow household coal consumption to increase at the same rate as the economy as a whole, particularly given its concern over the "quality" of economic growth and the improvement in living standards. To provide this coal, Beijing either will have to allow local mines to increase output at a much higher rate than the planned 2 percent per year—at considerable investment cost and at the risk of some damage to coal reserves—or will have to begin selling state coal to rural household customers. 25X1 25X1

Implications. As illustrated in table 9, the above analysis suggests that demand for coal will increase by about 3.9 percent per year through 1990 and about 3.1 percent per year in the 1990s—presuming an economic growth of 5 percent per year. Total demand, including losses, would thus reach about 900 million tons in 1990 and 1,200 million tons in 2000. The 1990 consumption estimate helps explain the boost Beijing gave in 1982 to its 1990 coal production target. The new target of 940 million tons would allow China to surpass its export goal of about 20 million tons. The original 850-million-ton target would have left a shortfall of about 50 million tons. 25X1

The *Wen Wei Bao* projection of 900 million tons of coal output in 1990, which is 100 million tons greater than that predicted by the Shanghai *World Economic Herald* and which we believe is about the maximum attainable, would just meet this demand projection and leave no room for exports. Beijing would probably squeeze out some exports anyway to meet commitments to Western and Japanese joint venture partners. 25X1 25X1

Given our assumptions of less substitution of coal for oil in the 1990s and the emergence of nuclear power, the longer term outlook is considerably better. Our estimate of 1,200 million tons of coal demand in 2000 would allow a significant boost in coal exports if the official production target is reached. Even in the 1990s, however, economic growth faster than 5 percent would quickly result in a strain on coal supplies. 25X1 25X1

Demand for Petroleum

China's annual oil consumption declined by 11 percent—10 million tons—between 1978 and 1982, a remarkable achievement given the country's substantial increase in industrial and agricultural output. Despite a 2-million-ton decline in oil output, Beijing was able to boost annual exports by 7 million tons to take full advantage of the 1979 jump in oil prices. The value of oil exports thus rose from little more than $1 billion in 1978 to about $5 billion in 1982, an important element in China's greatly improved international financial situation.

The decline in consumption was made possible by shifting from oil to coal in many boiler and furnace operations and by Beijing's extraordinary control over the disposition of petroleum products. Consumption of gasoline and diesel fuel actually declined despite a 40-percent increase in the stock of motor vehicles and tractors. Although forcing some improvement in the efficiency of fuel use, Beijing's policies have greatly reduced the utilization rate of motorized vehicles and machinery.

We believe that, although savings still can be made in China's oil consumption habits, the easiest gains have been made and that Beijing will be forced to allow a gradual increase in consumption. An upward trend may in fact have already begun. Preliminary production and export statistics suggest that consumption in 1983 may have increased by as much as 5 percent. By our calculations—as follow in a sector-by-sector analysis—if the economy is to grow at a 5-percent annual rate, a minimum 2-percent annual gain in consumption will be required to meet the needs of the consuming sectors. We thus calculate an elasticity for oil consumption at about 0.5. Oil consumption will then reach just under 100 million tons per year by 1990. If our output projections are correct, China would have to eliminate almost all crude oil and product exports by that time.

Product Structure. China's crude oil and petroleum product structure is included in table 10. In 1982, China refined only 72 million tons of the 99 million tons available after oilfield use and losses. This was down about 3 million tons from the 1980 peak.

Table 10 *Million tons*
China: Petroleum Product Output

	1978	1979	1980	1981	1982
Crude oil	104.05	106.15	105.95	101.22	102.21
Refinery throughput	70.70	71.46	75.38	71.46	72.06
Product yield	66.68	66.99	70.27	66.97	67.51
Light products	33.54	35.43	34.77	36.22	36.35
Gasoline	9.91	10.70	10.49	11.12	11.14
Naphtha	NEGL	NEGL	NEGL	2.32	2.75
Kerosene	3.56	4.09	4.00	3.50	3.50
Diesel	18.26	18.73	18.28	17.78	17.46
Lubricants	1.81	1.91	2.00	1.50	1.50
Fuel oil	28.14	28.16	28.00	28.18	23.86
Other	5.00	3.40	7.50	2.57	7.30

Approximately half of the remaining crude oil was exported; the rest was burned directly in electric power plants and other large boiler or furnace operations.

China's refineries yield an unusually heavy and low-value range of products because of rather heavy crude oil varieties and inadequate cracking facilities in the refineries. Output of high-value light products—gasoline, kerosene, diesel fuel, lubricants, and naphtha amounted to only about 36 million tons in 1982, about half of refinery throughput. Fuel oil production and fuel consumed by refineries themselves accounted for most of the balance.

Industrial Fuel Oil Consumption. Beijing's primary effort to reduce oil consumption has been to cut back sharply the direct burning of crude and fuel oil in power plants and industrial boilers and furnaces. In 1980 the country burned 40 million tons in these operations, about 12 million tons of crude oil and 28 million tons of fuel oil. This was particularly wasteful of the crude oil that could have been distilled and cracked into a higher value range of products.

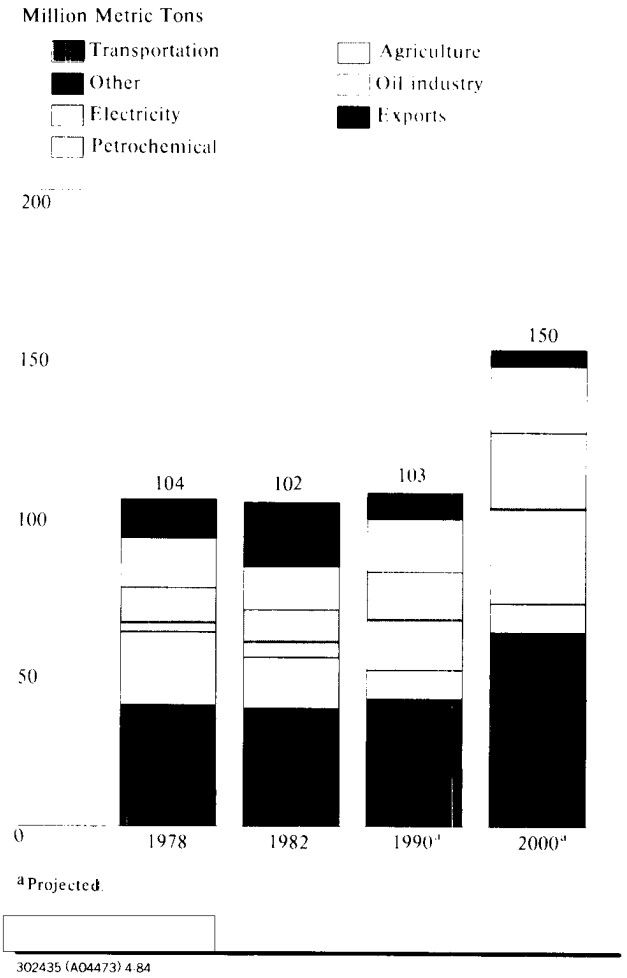
Table 11
China: Demand for Oil [a]

Million tons

	1978	1982	1990	2000
Oil production	104	102	105	150
Domestic consumption	91	81	97	145
Industry	63	54	58	71
Oil	16	14	17	21
Oilfield use	2	2	4	5
Transportation loss	7	6	5	5
Refinery use	8	6	8	12
Boiler and furnace	44	35	25	20
Electric power	23	16	9	9
Other	21	19	16	11
Petrochemical	3	4	16	30
Transportation	11	12	18	40
Agriculture	11	10	15	24
Other	6	5	6	9
Available for export	12	21	8	5
Foreign company share	0	0	3	10
Net exports	12	21	5	−5

[a] Because of rounding, components may not add to totals shown.

Figure 8
China: Oil Consumption, 1978-2000



[a] Projected.

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In 1981 and 1982 the State Council imposed strict regulations on such waste—including a tax of 40 to 50 yuan per ton on fuel oil—and by 1982 oil burning had declined to 35 million tons. Beijing has called for an annual reduction of 2 million tons per year through 1990 in the direct burning of petroleum in order to reduce the waste of crude oil to 20 million tons. The high cost of converting units to coal—1.6 billion yuan were spent in 1981 and 1982 alone—and slower-than-planned conversion of power plants thus far suggests that China will do well to reduce crude and fuel oil consumption to 25 million tons by 1990.

Coal-fired *electric power* plants have always dominated China's power industry, but in the late 1960s through the mid-1970s China constructed large numbers of oil-fired stations and converted dozens of coal-fired units to oil to take advantage of the country's booming oil production. This was particularly true in the Shanghai area and in the industrial northeast provinces where transportation and environmental conditions discouraged the use of coal. By 1978 the country had a total of 12,000 MW of oil-fired capacity—21 percent of total power capacity—that consumed 18.3 million tons of crude and fuel oil and about 500,000 tons of diesel fuel.

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With prospects deteriorating for oil production, Beijing after 1978 began to focus on conversion and reconversion of these plants to coal. Just over 4,100 MW of capacity were planned for conversion by 1985

for a general savings of more than 8 million tons; most of this capacity had probably been coal fired originally and thus much easier to convert. By the end of 1981, 2,000 MW had been converted and annual oil consumption had dropped by 4 million tons. However, the rate of conversion has slowed as easier units were completed first, and in 1981 only 340 MW were converted. No figures are available for 1982 and 1983, but if the conversion program continued at the 1981 rate it would not be complete until 1988. We calculate that oil consumption in the power sector will decline by about 800,000 tons each year through 1988 and then will flatten out at about 9 million tons of fuel oil and about 750,000 tons of diesel oil.

Metallurgy, *chemicals*, and *light industry*—particularly the papermaking industry—account for most of the remaining fuel oil consumption. Beijing plans to reduce oil burning by these industries by about 1 million tons a year through 1990—a 5-percent decline in 1983 rising to a 10-percent rate of decline by 1990.

Fuel consumption in these industries declined by 3 million tons in 1981 and 1982, but we do not believe this success can be sustained. The easiest savings have already been accomplished. In the steel industry, for instance, heavy oil is no longer mixed with coking coal for blast furnace operations. Most of the remaining oil is consumed in rolling operations that will be much more difficult, if not impossible, to convert to coal. New plants, moreover, will need to burn some oil. Baoshan steel mill, for instance, will require 300,000 tons of fuel oil annually when second-stage operations begin in 1988. Chemical industries can probably still make significant efficiency gains, but light industrial use of fuel oil may increase with the burgeoning demand for light industrial products.

Petrochemical Feedstocks. China's discussions concerning the optimal use of its oil focus on the need to rapidly increase the share processed into high-value fertilizers and petrochemical products. These are currently large import items that are particularly important in US-Chinese trade. Only about 5 million tons of oil, largely diesel fuel and naphtha, were used for these purposes in 1982, up from about 3 million tons in 1978. this demand will rise to about 16 million tons by 1990 and perhaps to as much as 30 million tons by 2000.

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Three large ethylene plants are currently under construction that when operational—probably by the end of 1986—will consume 4 million tons of crude oil annually to provide materials for synthetic fiber and plastics production. We also anticipate a rapid increase in the production of synthetic ammonia using residual fuel as the primary feedstock—a shift away from coal-derived feedstock technology that consumes large amounts of electricity.

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Demand for Light Petroleum Products. China's output of light products—excluding naphtha, which is either used as petrochemical feedstock or exported—has remained steady at about 35 million tons annually since 1978. Exports of these products more than doubled to 5.3 million tons between 1978 and 1982, however, so that products available for domestic consumption declined by 7 percent (2.5 million tons). The largest decline came in the supply of diesel fuel—from 18.3 million tons to 17.5 million tons. Ample reporting indicates that diesel is now the fuel in shortest supply. Gasoline output increased from 9.9 million tons to 11.1 million tons in the same period, but all of the increase went to exports—most of it to the United States. Domestic consumption of gasoline has held steady at about 9.7 million tons a year.

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Agricultural Demand. Consumption of light petroleum products by the agricultural sector totaled 10.4 million tons in 1978, including about 8 million tons of diesel fuel and 2 million tons of gasoline—46 percent and 20 percent of total demand for these products. Chinese sources state that agricultural use of these products declined through 1982, although no specific statistics are available.

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This decline in petroleum consumption has little to do with improved efficiency of farm machinery nor does it reflect a reduction in demand for these products. The stock of agricultural machinery—particularly

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tractors and irrigation pumps—increased approximately 40 percent (measured by total horsepower in use) between 1978 and 1982, and peasant demand is nowhere near satisfied. Chinese journals and newspapers increasingly carry complaints that the peasants are not getting maximum use out of new machinery because of fuel shortages. One author in *Guangming Ribao*, for instance, complains that agricultural "modernization" is impossible given the shortage of fuels. The result, as shown in official statistics, is a slowdown, even to the point of a reversal, in farm mechanization and powered irrigation. We believe that Beijing will soon have to allow an increase in agricultural fuel supplies—perhaps by about 5 percent annually.

Transportation Demand. China's transportation sector consumed approximately 12 million tons of petroleum products in 1982, including 7.5 million tons of gasoline and about 3.5 million tons of diesel fuel.[9] We estimate that fuel consumption has increased by about 3 percent per year since 1978; annual efficiency gains of 3.6 percent in the use of gasoline and 2.6 percent in the use of diesel fuel have allowed a 6-percent annual rate of increase in total freight carried.

These efficiency gains notwithstanding, Chinese transportation continues to face severe fuel shortages, largely the result of the government's determination to increase exports of these products. Nationwide, the annual allocation of gasoline and diesel fuel declined from 7.1 tons per truck (about 2,200 gallons) in 1979 to only 4.5 tons in 1983. In 1981, in response to widening shortages, the State Council imposed strict quotas on the amount of fuel allocated per vehicle. Transport units in Fujian, for example, complained they were given three-month quotas of 800 liters of gasoline (210 gallons), enough for only 20 days of normal operations. In addition, provinces were told to mothball about 10 percent of their motor vehicles. The program had an impact; Liaoning and Xizang Provinces alone mothballed 10,000 and 1,600 trucks, respectively. These measures reflect Beijing's intense focus on saving energy without, in our view, adequate attention to the very high economic costs of idling transport capacity.

A Chinese economist, writing in a recent edition of *Neng Yuan (Energy)*, calculates that transportation services in China must increase about 1.37 times the rate of increase of industrial and agricultural production. In recent years, transportation's relatively slower growth has caused major bottlenecks. We anticipate that, consistent with this analysis and with the current rate of increase in the stock of locomotives and motor vehicles, transportation services will increase at about 7 percent per year.

Efficiency gains are expected to continue at a 2- to 3-percent annual rate,[10] but this will be offset by the railroads' increased consumption of diesel fuel as they gradually shift away from coal. On balance we estimate that the use of gasoline and diesel fuel will

China's Automotive Fuel Consumption

The lowly position of the automobile in China illustrates both the severe limits to reducing discretionary fuel consumption in China and the potential for unbounded growth in fuel consumption if the economy were to develop rapidly and without constraints. China's stock of automobiles, 267,000 in 1982, is approximately the same as that of the District of Columbia. It is only slightly larger than that of South Korea. Even with such few automobiles, Beijing imposes such severe quotas on fuel consumption—70 kilograms or 22 gallons a month—that Chinese taxis coast downhill whenever possible. China's automobiles thus consume only 69 million gallons of gasoline a year; China, meanwhile, exports about 490 million gallons of gasoline per year to the United States.

[9] Aggregate statistics in the transportation sector can only be estimated because Chinese official data refer only to Ministry of Communication and Transportation activities, which include only about one-third of total motor vehicle activity.

[10] Major gains can be achieved by improving China's 70-octane gasoline, and negotiations are under way for importing US terepthalic lead technology. Paving roads and gradually shifting from gasoline to diesel-powered trucks will also allow major gains in efficiency.

increase at about a 5-percent rate, rising to about 16 million tons in 1990 and perhaps to as high as 38 million tons by 2000.

Military Consumption. We have no firm estimates of petroleum use by the military. Presumably such use is contained within the 6.1-million-ton "other" category in the 1978 consumption statistics. That figure, however, also includes other government fuel consumption and a very small amount of fuel burned by urban households. Fuel production statistics can provide some further indications. Kerosene and jet fuel production in 1981, less exports and rural lighting consumption, for instance, leaves about 1.6 million tons unaccounted for, a good share of which probably was consumed by the Air Force.

The military has not been spared in the conservation effort. In 1981, according to the Chinese press petroleum supply was cut by 20 percent.

Demand for Electric Power

China consumed 350 billion kWh in 1983, up from 257 billion in 1978. Power consumption rose by more than 7 percent in both 1982 and 1983, far above the annual planned increase, but still far short of demand. Despite the high priority being given to the power sector, in the short and medium term, we believe electricity shortages will be the most important energy-related impediment to economic growth.

Electric power is one of, if not, the leading growth industries in China, having grown at an average annual rate of 12 percent over the past 25 years. Perhaps more so than in any other major country, this growth has served industrial consumers; households account for only about 5 percent of total consumption. Approximately 40 percent of China's population has no access to electricity, and the vast majority of those that do are allocated only enough power for very limited lighting. The World Bank estimates that the average Chinese household consumes only about 0.2 kWh a day—even less electricity than households in India.

Even with the high priority afforded industry, Vice Premier Li Peng has stated that industrial demand for electricity now exceeds power supply by about 50 billion kWh. The Ministry of Water Resources and Electric Power and provincial authorities have very strong control mechanisms in place to allocate power in ways that generally prevent blackouts and brownouts. These controls, however, exact a considerable economic cost, particularly in underutilized capital. In many regions, Chinese factories operate only four days a week to save power. Priority is given to light industry—particularly export-related plants—but even Western joint venture operations have been affected. The Chinese press complains that, nationwide, industry operates 20 percent below capacity because of power shortages.

The distribution of electricity consumption by sector and industry is shown in table 12 and in figure 9. We obtained these data from Chinese economic yearbooks and other published sources, Only partial data are available for 1982.

Industry, particularly heavy industry, dominates power consumption, receiving about 75 percent of the net available power in 1982. The chemical and metallurgical sectors are by far the most important consumers; each accounts for about 16 percent of national power consumption. Power consumption increased by only 1.8 percent in metallurgy between 1978 and 1982, the result of intensive efforts to save electricity.

Rural electricity consumption—much of it provided by small hydropower plants—has maintained a 14-percent annual rate of increase since 1978. A large share of the increase has gone to supply the booming rural enterprise sector and to increase electrically powered irrigation. Municipal power consumption—mostly for lighting and water pumping—has also increased rapidly.

Prospects—Further Tightening. We believe, and most Chinese economists writing on the subject seem to agree, that national income over an extended length of time will not increase more rapidly than the available electric power supply.

Table 12
China: Electric Power Consumption, 1978-82

	Billion kWh					Percent Average Annual Consumption Growth, 1978-82	Consumption as Share of Power Output, 1981
	1978	1979	1980	1981	1982		
Total	**256.6**	**282.0**	**300.6**	**309.3**	**327.7**	**6.3**	**100**
Power industry consumption	46.3	48.4	43.3	45.9	47.9		15
Line loss	18.0	NA	23.0	25.0	NA		8
Industry demand	166.0	185.0	196.0	197.0	209.0	6.0	64
Heavy industry	138.0	149.6	164.3	162.1	170.6	5.4	52
Coal	15.1		17.5	17.8			6
Petroleum	7.4		10.2	10.3			3
Ferrous metals	29.2		30.5	29.3	45.0 [a]	1.8	9
Nonferrous metals	13.0		15.7	16.0	[a]		5
Metals processing	17.7		20.8	20.4			7
Chemicals	43.0		52.5	52.5			17
Building materials	8.0		10.7	11.3	11.0	8.3	4
Light industry	28.0	35.1	31.8	35.4	38.0	7.9	11
Paper	15.3		5.7	5.7			2
Textiles	8.9		12.2	14.0			5
Foodstuffs	3.8		5.2	6.0			2
Transportation	2.3	1.3	1.5	1.6	1.8	−5.9	1
Rural demand	28.7	32.5	37.4	41.6	48.8	14.2	13
Irrigation			16.5	17.3			6
Agricultural processing			9.7	9.9			3
Enterprises			5.4	7.8			3
Other			5.8	6.6			2
Municipal demand	9.0	11.2	16.6	18.2	19.9	10.0	6
Water and sewage			3.3	3.6			1
Lighting			7.9	8.8			3
Industrial lighting			2.7	3.5			1
Other	4.2	3.6	5.8	5.6	0.3		1

[a] 45.0 is the total for ferrous and nonferrous metal for 1982.

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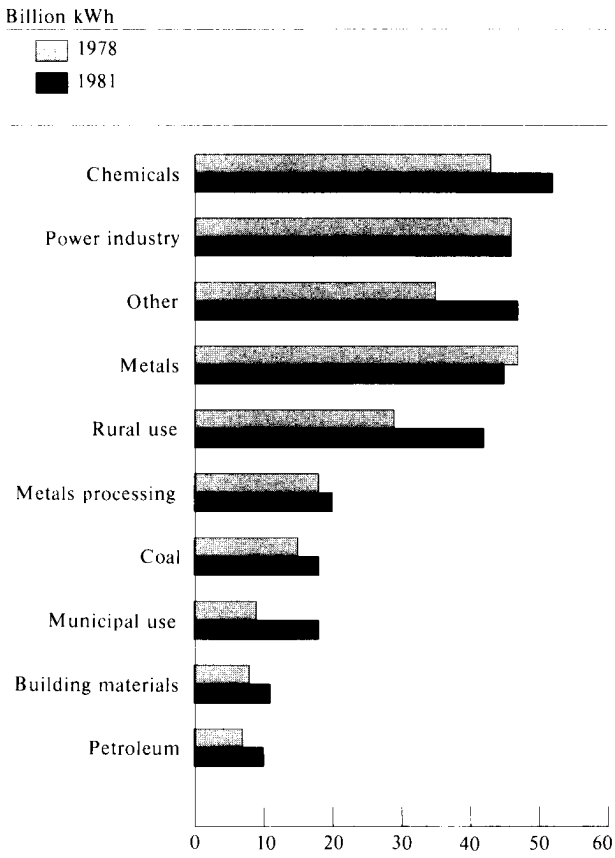
Over the past 25 years, power consumption has increased at more than twice the rate of increase of national income—an elasticity of 2.25—and 1.25 times as fast as industrial output. Since 1978, these elasticities have improved to 1.0 and 0.86 for national income and industrial output, respectively, but this has been accompanied by more stringent controls and greater shortages. It has also been a period of much more rapid growth for light industry, which consumes less electricity per unit of value than does heavy industry. It is by no means clear that this relatively slow increase in industrial electricity consumption can be maintained, particularly as heavy industrial growth picks up. We expect that both capacity and fuel

Figure 9
China: Electric Power Consumption,



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limitations will hold increases in electricity supply to at most 5 percent annually for the next decade. Output growth in 1984 and 1985, moreover, could be considerably below that rate. If this analysis proves correct, Beijing will have to slow the rate of increase of electric power consumption to less than that of national income if it is to come anywhere near its long-term growth targets.

Table 13 gives some indication of the difficulty of China's task. Industry will have to provide the bulk of efficiency and structural gains. Yet, for the 24-year period between 1957 and 1981, in no single industry

Table 13
Economic Growth and Electricity Consumption, 1957-81

	Average Annual Growth *(percent)*		Elasticity of Electricity Use to National Income
	Output Value	Electricity Use	
National income	5.4	12.2	2.25
Gross value industrial output	9.4	11.8	1.25
Heavy industry	9.7	12.6	1.30
Coal	6.3	9.3	1.47
Oil	16.0	16.7	1.04
Metallurgy	8.5	11.0	1.29
Machine building	11.7	12.7	1.08
Chemicals	14.2	15.8	1.11
Building materials	9.3	12.2	1.31
Light industry	8.9	9.3	1.04
Textiles	7.8	8.7	1.11
Paper	5.8	8.5	1.46
Foodstuffs	5.3	9.3	1.75

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did electricity consumption increase more slowly than the gross value of output for that industry. In fact, only in the petroleum industry and in overall light industry—but not for subgroups such as textiles—did the value of output keep pace with electricity consumption.

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A more careful look at the prospects for electricity consumption in several key industries offers somewhat more hope. The chemical sector, particularly the synthetic ammonia industry, can cut back electricity consumption by shifting from coal-based to petrochemical-based products. Similar improvements can probably be made in other chemical industries. The steel industry will probably increase its electricity consumption per unit of steel output, but, because of low growth targets for this large electricity user, the annual rate of increase in power consumption will probably be only 2 or 3 percent. The machine-building industry will also probably show only small

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increases. These gains will be partially offset, however, by the nonferrous metals industry, which will probably increase power consumption by 5 percent annually, and by expected continued sharp increases in small-scale local industrial output.

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A key problem will be supplying power to meet nonindustrial needs—particularly household consumption. Beijing is giving high priority to the production of goods that will improve the standard of living. The production of many of these goods—television sets, electric fans, washing machines, even small refrigerators—is giving a tremendous boost to the industrial production statistics and, because of the low electricity consumption per unit of output, is helping to lower the electric power elasticity of industrial output. These items are, however, causing a rapid increase in the demand for electricity in the commercial and household sectors. Between 1978 and 1982 we estimate that nonindustrial consumption increased by 13 percent annually.

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So far, the problem has not been a major one because of the low base from which nonindustrial demand is rising. However, we anticipate this will be an increasing problem through the 1980s and perhaps a severe problem in the 1990s when electricity supply will be distributed more widely to the population. Beijing can limit the expansion of nonindustrial electrical consumption by fiat; but only at considerable cost to one of the fundamental goals of the modernization program—the improvement in living standards.

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Table 14
Energy Balances Forecast [a]

	1978	1982	1990	2000
Coal *(million tons)*				
Production	618	666	900	1,150-1,300
Consumption [b]	618	662	894	1,200-1,210
Net exports	1	5	5	−60-90
Petroleum *(million tons)*				
Production	104	102	105	150
Consumption	92	81	97	145
Exports	13	21	8	5
Imports	1	NEGL	NEGL	NEGL
Foreign company share [c]	0	0	3	10
Electric power *(billion kWh)*				
Production [d]	257	328	482	786
Consumption [e]	257	328	482	786

[a] Assumes a 5-percent annual increase in national income. Because of rounding, components may not add to totals shown.
[b] Includes losses and stock building.
[c] Includes both capital recovery and profit oil.
[d] Assumes capacity increase of 5 percent per year; fuel is taken into account in coal and oil consumption.
[e] Power demand assumed to increase at least as fast as national income—that is, 5 percent.

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Implications

Economic predictions concerning energy supply and demand in both market and nonmarket economies have frequently been off the mark over the past decade. The foregoing analysis of China's energy situation could also prove erroneous. Particularly in a state-controlled economy, however, where fixed prices do not force an equilibrium between supply and demand and where government policy is the key determinant of future production and consumption conditions, long-range planning is vitally important. Our analysis attempts to present China's energy situation in ways that we believe Chinese policymakers must look at the situation, so that we can better anticipate decisions that face Beijing.

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Table 14 summarizes our analysis of supply and demand for oil, coal, and electricity that we project if China has an annual 5-percent economic growth rate. No major gaps are evident, but there is a definite tightness in the energy balances that will probably require Beijing to make difficult decisions in allocating energy supplies. These calculations also allow only a little room for energy exports—currently more than 20 percent of China's foreign exchange earnings.

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Economic growth faster than 5 percent would, we believe, quickly cause serious energy shortages unless China was prepared to import substantial volumes of energy. If our energy elasticities of coal, oil, and

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electric power demand—0.8, 0.5, and 1.0, respectively—are anywhere close to being accurate, a 7-percent annual rate of growth would require several adjustments:

- The elimination of oil exports even to the point of repurchasing—in effect importing—the offshore oil that the Western oil companies expect to take out as their profit share.
- Resolving a 100-million-ton shortfall in annual coal supplies by 1990.
- Coping with a further 15- to 20-percent shortfall in electricity supplies.

By the same token, long-term annual economic growth of only 3 or 4 percent would probably not run into an energy constraint. Energy exports could be kept at current levels and perhaps even increased.

Even with slower growth, however, Beijing's planners must prepare for the possibility that energy supplies, particularly oil, will not increase as fast as predicted. Chinese oil ouput predictions are based on the assumption that offshore oil will come onstream in time to offset and then surpass the anticipated decline in major onshore fields by the end of the decade. We believe, however, that Daqing, and perhaps other onshore fields, will start to decline before significant offshore production can begin. Of greater concern is the possibility—always present when exploring a new area—that China's offshore regions will not yield the large, highly productive fields necessary for commercial development.

Beijing—Tough Choices Ahead

Weakness in China's supply of energy has already forced Beijing to make major changes in the country's long-term political and economic policies. The measures taken so far have helped to push China's economy away from its Stalinist and Maoist heritage and to bring it somewhat closer to Western-style economies. We believe, for instance, that the Deng-Zhao economic readjustment and reforms program was given a strong impetus by the 1978 revision in oil supply projections. The new leadership was quick to realize that China did not have the resources and capital to continue to support a massive Soviet-style industrial buildup and hence opted for a more consumer- and export-oriented economy led by light industry.

Equally important was the realization that China could not solve its energy problems by itself. At least for the energy sector, self-reliance as a guiding principle was discarded to allow the introduction of Western capital and technology in ways that the leadership's Maoist predecessors would have considered "exploitationist." Offshore oil is the most dramatic example, but Western and Japanese firms are increasingly becoming involved in everything from onshore seismic surveys to nuclear power development. 25X1

Our judgment that China's energy balances will continue to tighten through the rest of the decade will strengthen China's need to cooperate with the West. At the same time, however, it will force Beijing to make difficult and politically divisive decisions about the allocation of increasingly scarce energy resources. These decisions may threaten the leadership consensus that has allowed Beijing to make bold decisions on the importation of Western capital and technology and the unavoidable "capitalistic" and "bourgeois" influences that come with it. This danger will be particularly evident if major programs—such as the offshore exploration effort—are unsuccessful. We discuss briefly in the following sections some of the key areas that will require controversial energy-related decisions over the next decade. 25X1

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Investment Strategy. The relatively modest but steady growth that we believe is possible if there are no major energy problems is not a cause for alarm in Beijing. It will, however, require the central government to consider its investment programs carefully in order to make sure the growth occurs in the most beneficial sectors. Even within the energy sector, Beijing is now grappling with tough investment decisions that will have a large impact on future energy supply: 25X1

- In the electric power sector, whether to emphasize long-term, capital-intensive but fuel-saving hydroelectric and nuclear power development or faster and cheaper coal-fired capacity. In the past few years, the long-term approach appears to have had an edge, but that may change if severe power shortages occur in 1984 and 1985.

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- In oil exploration, whether to emphasize areas where discoveries can be exploited quickly or areas, such as the Tarim Basin, with better prospects but which will take decades to exploit.

- In coal mine development, whether to continue the rapid development of small, non-state-owned coal mines or step up investment in large, state-owned, mining operations.

A key difficulty in making investment decisions is the lack of a rational interest rate structure. The very low domestic rates tend to encourage capital-intensive projects, particularly nuclear and hydroelectric plants, whereas the large differential between domestic and international market interest rates tends to discourage borrowing from the West.

Energy Prices. This brings into focus one of the key problems in China's economy—the lack of a pricing mechanism that allocates scarce resources efficiently. China's energy prices are by almost all accounts far out of adjustment. To preserve price stability, Beijing has held energy prices relatively constant since the 1950s despite clear changes in domestic and international supply and demand conditions.

Crude oil and coal are currently priced at only 25 percent and 20 percent, respectively, of the international price. Gasoline is priced close to the international level, but diesel fuel is inexplicably priced at only 40 percent of the price of gasoline. Heavy fuel oil is also very cheap. Although the international prices may not be a perfect indicator of supply and demand within China, Chinese economists are increasingly turning to them to illustrate the inadequacy of Chinese prices.

Also the price system does not take into account the differences in quality among types of crude oil and coal. Washed coal, for example, is sold at the same price as unwashed coal, which creates a disincentive for mines to clean up their production. This also forces the railroads to haul tons of rubble along with the coal.

In the Maoist system—at least in theory—the relative price of energy made little difference because energy was simply allocated according to plan and enterprise profits were returned to the state. In the emerging "mixed" economy that some of the economic reformers are trying to bring about, prices are much more important. Numerous articles in Chinese economic journals now attack what their authors see as imperfect decisionmaking based on an irrational price system. Typical complaints are:

- The abnormally high profits garnered by petroleum refineries—the result of cheap crude prices and high product prices—have caused the buildup of redundant refining capacity.
- Industry is encouraged to burn the relatively cheap crude and fuel oil.
- Oilfields and coal mines are encouraged to export crude oil and coal at much higher world market prices rather than sell it to domestic customers.

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Prominent Chinese leaders have recognized for years the need to increase energy prices, and some steps have been taken. In 1981, for example, after coal output dropped, in part because of the inability of most of the country's coal mines to make a profit, the government increased prices for small-scale coal mines, which helped boost output. More recently, taxes have been imposed on crude and fuel oil to discourage such use. When questioned in 1982 about the need for much larger and more comprehensive energy price adjustments, however, Premier Zhao acknowledged the need but stated that politically such a move was impossible.

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Whether the political climate has improved or not, Beijing is now formulating a sharply higher schedule of energy prices,

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the increases will probably come in stages so they will not create too large a shock, but obviously they will not be welcomed by the public.

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Oil Exports. China's ability to increase exports of crude oil, petroleum products, and coal during 1978-82 is remarkable and a major factor behind the country's strong international financial position. Table 15 includes the volume and value of China's energy exports beginning in 1978 and their share of total export earnings.

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Table 15
China: Energy Exports

	1978	1979	1980	1981	1982	1983
Exports *(million tons)*						
Petroleum	13.5	16.4	17.5	18.4	20.5	NA
Crude oil	11.3	13.4	13.3	13.8	15.2	15
Products	2.2	3.0	4.2	4.6	5.3	NA
Coal	3.1	4.6	6.3	6.6	6.4	6.4
Exports *(billion US $)*						
Total exports	10.16	13.49	18.94	21.54	23.50	NA
Energy exports	1.34	2.63	4.62	5.01	5.14	NA
Petroleum	1.24	2.45	4.36	4.67	4.79	NA
Crude oil	0.96	1.75	3.01	3.29	3.40	NA
Products	0.28	0.70	1.35	1.38	1.39	NA
Coal	0.10	0.18	0.26	0.34	0.35	NA
Energy share *(percent)*	13	19	24	23	22	NA

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Our analysis suggests, however—and this is increasingly reflected in Chinese energy journals—that China may have to phase out oil exports. Indeed, by eliminating oil exports by 1990, and, if the planned petroleum output targets are reached, domestic consumption could rise by the 2-percent annual rate that we calculate will be necessary for a 5-percent rate of economic growth. Coal exports will probably rise because of contractual arrangements with Japan, but can only be expected to replace a small share of current oil earnings.

Premier Zhao Ziyang stated in his report on the Sixth Five-Year Plan that China will under no circumstances import oil. We also believe China will not import oil—and our analysis suggests imports will not be necessary unless the offshore exploration program finds much less oil than we expect. It is significant, however, that Zhao did not rule out a reduction of oil exports.

the top leadership is currently deliberating over what would be a very difficult decision to reduce oil exports or slow economic growth.

High-level concern over a possible reduction or even an elimination of a commodity that currently provides 20 percent of the nation's foreign exchange earnings may also be a reason for China's reluctance to boost its general level of imports, despite the large current account surpluses of recent years. We regard some conservatism as prudent, particularly until a better idea can be obtained of what oil resources will be discovered offshore.

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Household Demand. An issue that we believe will come to the forefront later this decade and in the 1990s is the limited degree to which China's commercial and modern energy supplies are allocated for direct household and personal use. Table 16, from a paper presented in 1982 by a scientist from the Chinese Academy of Sciences, includes a breakdown of energy sources used for household and production activities by the rural population—80 percent of China's total population.

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Table 16
China's Rural Energy Consumption, 1981

	Million TCE	Share of Total Rural Energy Consumption *(percent)*	Share of National Energy Output *(percent)*
Total	**420.3**	**100.0**	
Noncommercial			
Crop stalks	215.0	51.2	100
Firewood	57.8	13.8	100
Cattle waste	54.7	13.0	100
Small coal	59.3	14.1	80
Mini hydro	5.2	1.2	100
State supplied			
Kerosene	1.6	0.4	46
Diesel/gasoline	14.0	3.3	12
Electricity	12.7	3.0	2

The government, through its unified energy distribution system, provides only 7 percent of rural energy supplies and almost all of that is used for production processes—only kerosene, for lighting, is used by households. Nearly half of the production from small coal mines, moreover, is consumed by local industry. Therefore, of the total energy consumed by households for heating, cooking, and lighting, only 17 percent is provided by what are considered commercial energy sources—coal and electricity.

The scientist states that total rural energy consumption for household purposes falls 7 percent below what the Academy of Sciences calculates as necessary to sustain minimal living standards. As a result many peasants must use roots and tree bark for their winter heating. He concludes that the rural energy situation is "an exceedingly unfavorable development in China's rural economy and is of extreme inconvenience to the peasants' livelihood" and goes on to say that it is a matter of "urgency" to find ways to resolve the grave shortage of rural energy supplies.

Deng Xiaoping's modernization program and the increasingly available supply of modern consumer items—many of which require electricity—must be raising expectations among Chinese peasants that Beijing will have considerable difficulty meeting.

Implications for the United States

China's need for new technology, both to explore and develop new energy resources and to improve the efficiency with which the country consumes energy, was one of the most important reasons for Beijing to open up strong commercial links with the Western world. China, we believe, sees the United States as the best source for much of this technology and thus makes access to it a pivotal consideration in its official dealings with the United States. This technology can thus form a relatively stable underpinning for China's opening to the United States. Beijing did not, for instance, allow the mid-1983 political and economic controversies with the United States to hamper the offshore oil contract negotiations that were occurring during the same period.[11]

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There are a number of areas in which energy technology is already forging important commercial links between the two countries:

- Offshore oil—a dozen US firms are taking the lead in exploring China's promising South China Sea continental shelf. If successful, this exploration will lead to long-term—up to 35 years—commitments by the firms to work in China in an industry of vital importance to Beijing.

- Onshore oil—China is actively negotiating for, and purchasing, US technology needed to maintain output at increasingly mature fields.

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- Technology for the generation and transmission of electric power—US firms are increasingly becoming involved in upgrading China's obsolete technology. China's power industry will probably expand at a faster rate than in any major country over the next two decades, offering a continuing source of business.

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- The coal industry, in which China also has probably the most ambitious development program in the world, is also creating a demand for US production equipment and the technology to burn coal cleanly and efficiently.

Two areas of potential cooperation—contingent on solving difficult investment and political problems—include hydroelectric and nuclear power development, which some Chinese view as the dominant energy sources in the next century.

In most of these areas China believes the United States holds the most desirable technology. US firms, however, usually meet fierce competition from European and Japanese firms. China, moreover, has proved adept at playing competitors against each other. This competition will probably become more intense, particularly when it comes to the financing of energy projects—an area in which the United States appears at considerable disadvantage.

Despite the development of what must be considered an overall advantageous commercial relationship for the United States, China's energy issue also has the potential for creating problems. China's current leadership has placed a great deal of its prestige on achieving economic progress. A willingness to experiment with more capitalistic, decentralized economic policies and a general openness to foreign trade and investment are key features of the government's modernization strategy.

if energy shortages were to retard the process of economic growth severely, a marked change in leadership policy could result. Although speculative, it is possible that energy shortages could be blamed on inadequate state planning, while measures to limit the economic damage of such shortages, by raising energy prices, for instance, could raise political unrest. Leftists could then point back to a period of cheap and plentiful energy in the 1960s and early 1970s and call for a return to more self-reliant, Maoist economic policy. Oil output did, after all, increase from 10 million tons a year to 90 million tons during the decade of the now-despised Cultural Revolution.

Our analysis suggests, however, that, with carefully chosen policies that limit the increase in energy consumption, and with only average luck in discovering new oil resources, China can maintain a reasonable economic growth rate that will limit the need for major policy reversals.

Even without major changes in policy, one likely problem is that trade and financial tension between the United States and China will rise should Beijing decide to reduce sharply its oil exports. Beijing would try to offset this loss by increasing exports of more sensitive goods—textiles, for instance—and by requesting more financial support from international aid agencies.

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