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China Power

by

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DISCLAIMER

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PREFACE

This report is the result of a series of trips by Binsheng Li and myself to the People's Republic of China during the 1991-1996 period, and more than a dozen research papers on China prepared in the Coal and Environment Project at the East-West Center. During 1996, Dr. Li spent six months compiling extensive tables and analyses, and in writing this report. The research work leading to this report could not have been undertaken without the sustained financial support of the U.S. Department of Energy through Cooperative Agreement No. DE-FC03-94/FE63313/A000.

This report examines in detail the power sector from the province to the national level. The numerous energy projections in this report will probably prove inaccurate over the longer term, and will need periodic revisions. However, the discussions and analyses of how the Chinese power sector functions, from the level of individual consumers up to national decision making, should be useful for many years.

It is hoped that this report will be a lasting reference to energy experts and non-experts on China's electric power sector. Attention has been given to explaining how investors can enter China's power market, and the most important energy areas needing private sector investments. The sections on energy availability, examine the coal supply chain, and give insights into how this key energy sector functions.

The need for clean coal technologies to reduce atmospheric pollution from power plants is examined, along with a list of Chinese priorities for clean coal technologies. China is projected to become the dominant user of clean coal technologies over the next two decades, however a clear trend to install clean coal technologies in the power sector has yet to be established. The key obstacles to wide-spread use of clean coal technologies are examined.

The continued friendly cooperation of dozens of energy and policy people within various Chinese agencies was essential to the preparation of this report. However, the analyses and views in this study reflect those of the author, and not necessarily those of the U.S. Department of Energy or the Chinese government. Perhaps, the most important goal of this study is to help to bring China and the United States closer together by promoting better understanding between the two nations.

Charles J. Johnson
Head
Coal and Environment Project
March 5, 1998

Executive Summary

Economic Growth and Electricity Demand

- China is the world's fourth largest electric power producer, and is expected to surpass Japan within the next two years to become the third largest power producer. During the past 15 years, China's total electricity generation more than tripled, increasing from about 300 TWh to about 1,000 TWh. Total installed generating capacity grew at an average of 8.2 percent per year, increasing from 66 to 214 GW. The share of China's installed capacity in Asia increased from 21 to 31 percent.

- The Chinese government plans to continue China's rapid growth rate in the power sector. Total installed capacity is planned to reach 300 GW by 2000, which will generate 1,400 TWh of electricity per year. China's long-term power sector development is subject to great uncertainty. Under the middle scenario, total capacity is expected to reach 700 GW by 2015, with annual generation of 3,330 TWh. Under the low and high scenarios, total capacity will reach 527-1,005 GW by 2015.

- The high scenario representing possible demand. To achieve this ambitious scenario, dramatic policy changes in favor of power development are required; however, there is no evidence that such policy changes will occur at this stage. Even under the high scenario, China's per capita annual electricity consumption would be only 3,000 kWh by 2015, less than half of the present per capita consumption for OECD countries. Under the low scenario, electricity shortages will seriously curb economic growth.

- China's electricity is mainly generated by coal. During the past 15 years, the share of coal-fired electricity increased from 61 to 76 percent, the share of hydropower decreased from 19.4 to 17.5 percent, while the share of others (primarily oil-fired) decreased from 19.6 to 6.5 percent. Over the next two decades, coal will remain to be the predominant fuel in

China's power sector, coal's share in electricity generation is projected to decrease to about 70 percent; the share of hydropower is projected to decrease to 16.6 percent.

- China's rapid growth in electricity consumption is primarily promoted by its rapid economic growth. During the past 15 years, China's annual GDP growth rate averaged 9.7 percent, the highest among Asia-Pacific Economies. The driving forces behind China's high economic growth are dramatic increases in effective labor and capital supply. China's annual GDP growth rate is projected to average 8.5 percent during 1996-2000, 7 percent during 2001-2005, 6.5 percent during 2006-2010, and 6 percent during 2011-2015.

- China's high inflation rate in recent years has caused serious concern of the government. A series of anti-inflation measures were adopted including strictly control the scale of investment in fixed assets and direct price controls on selected commodies. These measures have adversely affected the power sector seriously. The combined effects are expected to deteriorate China's electricity shortage situation in the medium term and nagatively affect the country's economic growth. Trying to reduce inflation rate by sacrificing the development of the power industry and squeezing the profitability of foreign investors is a policy mistake.

- Unlike most developing countries, China's electricity consumption growth rate has been below its economic growth rate during the past 15 years. An important reason for the low elasticity of electricity consumption is that electricity supplies cannot meet demand, which has associated great economic losses. The average economic costs of power shortages in 1993 was estimated at about $0.17/kWh. The low elasticity of electricity consumption is also contributed by China's high load factor, improved energy efficiency, and modest transmission and distribution losses. However, the elasticity of electricity consumption is unlikely to decline in the future, if not increase.

- China's electricity is mainly consumed by the industrial sector which account for about 75.4 percent of total electricity consumption; the residential and agricultural sectors account for only 9.4 and 5.7 percent respectively. However, the structure of electricity consumption has been changing rapidly over time. Over the next two decades, the share of the industrial sector is projected to decrease to 55 percent; while the share of the residential sector is projected to increase to 28 percent.

- China's power shortage is estimated at 20 percent. A great deal of power shortages are hidden shortages partially caused by underinvestment in transmission and distribution systems. Switching consumption priority from the production sectors to the residential sector makes the electricity shortages less felt by the general public. The anti-inflation measures has depressed power demand in the short-term. However, underestimate China's power shortages will lead to costly consequences in the longer-term.

- Currently, China's electricity tariffs consist the state base prices, a guidance price differential, and additional fees and surcharges. In order to attract foreign investors and local investors, a new tariff system under which tariffs are determined by the marginal cost of the additional plant plus a "reasonable" profit rate has been adopted in China. However, the definition of "reasonable" is still vaguely defined. China's target return on total capital in the power sector is 10-12 percent in constant terms.

- About two-thirds of electricity distribution companies are separated from the vertical management system of the power industry, and are under the management of local governments. Some of these companies charge very high electricity tariffs. The Chinese government acknowledges the chaotic nature of the current tariff system and the need to continue reforms. In the long run, China will abolish the multi-tiered tariff system.

- China's electricity tariffs paid by consumers vary substantially from consumer to consumer and from place to place. Average tariffs paid by consumers vary in the range of 2.5-5 U.S. cents per kWh, while consumers supplied by diesel generators are charged 9.5 U.S. cents per kWh. In terms of the actual tariffs paid by the consumers, the commercial sector paid the highest tariffs, followed by the small industry, large industry, residential, and agriculture.

- The factors which affects the electricity price charged by power plants include fuel cost, the cost of debt service, return on equity, operating and maintenance costs, and taxes. The cost of fuel is in the range of 0.5-1.4 U.S. cents per kWh depending on coal prices. At the capacity factor of 63 percent, the levelized capital cost is about 1.8 U.S. cents per kWh for foreign joint venture projects and 0.8 U.S. cents per kWh for domestic projects. The equity net return is estimated at about 0.9-1.2 U.S. cents per kWh for foreign joint venture projects and only 0.4-0.6 U.S. cents per kWh for domestic projects. Add all components together, the levelized electricity price is in the range of 4.2-6.2 U.S. cents per kWh for foreign joint venture projects and 2.8-4.5 U.S. cents per kWh for domestic projects.

China's Power Sector Overview

- Between 1949 and 1995, China's installed generating capacity increased 116 times from 1.85 GW to 214 GW. However, per capita installed capacity is only 0.175 kW, which is very low according to international standards.

- China's electricity is mostly generated from thermal power plants, which accounts for three-quarters of total capacity and 80 percent of total generation. China's thermal power plants are predominately coal-fired. The role of oil and natural gas in electricity generation is minimal.

- Increased role of coal in China's power generation is due to the availability of cheap coal. It is estimated that about 4,500 billion tons of coal resources exist to a depth of 2,000 meters, and about 2,000 billion tons exist to a depth of 1,000 meters. The demonstrated coal reserves based on Chinese definition is about 1,023 billion tons. The economics of power generation are also in favor of coal-fired units. Over the next two decades, the share of coal-fired capacity is projected to remain at about the current level of 65 percent. Coal-fired power plants will increasingly be built near coal mines.

- The fate of oil in China's power generation has been determined by the perception of China's potential oil production. As it became obvious that previous estimation of China's oil reserves was too optimistic in the late 1970s, the government took an abrupt policy change to substituting oil-fired units by coal-fired units. According to the government, existing oil-fired units will be converted to coal-fired whenever possible and no new oil-fired power plants will be build in general. However, since oil-fired plants, especially diesel plants, have much shorter construction time, oil-fired plants continue to be build. In the long run, oil's share is projected to decrease gradually.

- Until recently, natural gas has been overlooked as an important source of energy in China, although China's natural gas resources are among the largest in the world. The geographic proximity of gas reserves to major load centers and the under utilization of natural gas indicates a significant potential in an expansion of gas based generating capacity in China. The government has realized the advantages of using natural gas as the fuel to generate electricity. With policy changes in gas pricing, China is likely to move more quickly to gas based power plants.

- China has about 380 GW technically exploitable hydropower resources. Due to government priority on developing hydropower resources, the share of hydropower capacity increased from 9 percent in 1949 to about 30 percent in late 1970s; however, recent power sector reforms provided more incentives to develop thermal power projects. As a result, the share of hydropower capacity declined to about 24 percent. The decentralization of the power industry, the higher capital costs of hydropower plants, the long construction lead time the high discount rate of investors in China, and the remote locations of major hydropower resources are the major factors affecting hydropower exploitations. The share of hydropower capacity is projected to decline to 20 percent by 2015 due to the increased shares of nuclear power and gas-fired power plants.

- Nuclear power development has progressed slowly in China. So far only two nuclear power plants have been built. Imported nuclear power plant is an expensive option for

China, and domestic nuclear technology is still in the demonstration stage. Nuclear power development has recently gained momentum due to environmental concerns and continued coal transportation bottlenecks. A total of 10 GW nuclear power plants will be under construction by the end of this century. Total nuclear capacity is projected to reach 25 GW by 2015. Currently, China's nuclear reactors are mainly imported from French. Letters of intent are also signed with Russia and Canada to import nuclear equipment. U.S. companies are also interested in China's nuclear power market.

- Currently, China's power sector (including steam and hot water production) consumes about 478 Mt of coal, 16 Mt of oil and 70 BCF of gas. Coal consumption in China's power sector is relatively price inelastic. Between 1988 and 1993, due to coal price increases, coal consumption in most other sectors stagnated or declined, while consumption in the power sector increased by more than 60 percent. Over the next two decades, total coal consumption in China's power sector is projected to reach 1,323 Mt; total oil consumption to 37 Mt; and total gas consumption to 969 BCF.

- China's power equipment manufacturing industry has now reached the ability to produce 10 GW large and medium-sized power generating equipment. China now has nine major bases to manufacture thermal power equipment and nearly 100 enterprises to produce hydropower equipment. Currently, domestically manufactured power generating equipment can only meet 70-75 percent of China's needs. This imbalance has created a large market for foreign manufacturers of power generating equipment. Currently about 20 percent of the power plant equipment is imported.

- China's 62 power construction companies are divided into three classes. Only a few of these companies are integrated companies that can do all phases of power plant construction. The 4 first class companies can serve as primary contractor to install 600 MW units; the 20 second class companies can serve as primary contractor to install 300 MW units; and the third class companies can serve as primary contractor to install 100 MW units.

Government Organizations and Policies

- From the central government authorities to the county power bureaus, the administrative system of China's power sector resembles a five-layered pyramid. In addition to the vertical authorities, provincial governments also have powerful influences on provincial power bureaus. China's topmost leaders are generally involved in the energy and environmental policy to a great extent. However, the almost limitless power of senior leaders is changing in China. Now greater initiative and policy formation occurred at lower strata of government.

- The State Planning Commission (SPC) is the highest level planning organization in China. It is responsible for making national energy strategies, policies, and development plans. Along with the general climate of decentralization, the function of the SPC has changed from directly allocating funds for projects to allocating permits. Although the SPC is supposed to further change its function from direct control of the economy to indirect policy guidance, the power sector is still under firm control of the SPC. Large and medium-sized power project (above 50 MW) must obtain SPC approval.

- The Ministry of Electric Power Industry (MEPI) is both an administrative authority and the top business management organization of China's power industry. Compared with the SPC, the MEPI is more like a combination of state enterprise and government authority, while the SPC is basically a regulatory authority. Since the MEPI owns many of China's power enterprises and is hold directly responsible to meet China's power demand, it has the vested interest in the rapid growth and profitability of the power industry.

- The State Development Bank of China (SDBC) is responsible for providing capital to state key development projects. Until the establishment of the SDBC, the SPC had full control over fixed asset investment through six state investment corporations. Credit-worthiness often came in second to political importance, causing excessive over investment in some projects and lack of funding for some key projects. The State Council established the SDBC in order to eliminate this problem.

- China's financial and economic ministries are responsible for ensuring that the nation's economic development proceed in a sound and steady fashion. These ministries, especially the Ministry of Finance, the Ministry of Foreign Trade and Economic Cooperation, People's Bank, and the Ministry of Domestic Trade, are particularly concerned that booming expenditures on energy infrastructure could weaken China financially. Currently, their greatest worry is the high inflation problem. They tend to be more conservative in issues related to foreign investment.

- China's industrial ministries also hold a strong interest in shaping the power sector. This set of interest is concerned with ensuring sufficient electricity supplies to maintain production levels. However, unlike the MEPI, these ministries represent the debt-ridden state enterprises least able to embrace market forces which would force price reforms on them.

- At present, the National Environmental Protection Agency (NEPA) is poorly positioned to protect China's environment. It lacks ministerial status and has a staff of only 300 people. In general, environmental initiatives seem to fall victim to economic development priorities in China. On several occasions power plants which were blocked by NEPA for failing to meet environmental standards have been reinstated by the SPC. Prioritization of energy interest at the expense of environmental considerations has become a hallmark of Chinese government decision making.

- The business management at the regional level is conducted by the regional power groups. They have the authority to conduct direct negotiations for equipment import, to sign contracts and send labor for construction overseas. The power sector reforms intend to make the regional power groups and the provincial power companies independent legal entities, and assuming responsibility for their profits and losses.

- The provincial power companies will remain their importance in China's power industry. The scope of their activity will be restricted by the need to out-source their generation. Their dominant position is ensured by maintaining their own power plants plus by having a complete monopoly over transmission and distribution to ultimate customers. The provincial power companies will be the sole customer of all private power plants.

- With respect to foreign investment in China's power sector, both the MEPI and the SPC have two schools of thinking. The school which against foreign investment emphasizes the high prices of foreign invested power project, while the school in favor of foreign investment emphasizes the economic losses of electricity shortages due to the limited availability of domestic financial sources. The government's attitude toward foreign invested power projects is critically determined by the situation of power shortages.

- In addition to the misleading believe that China's power shortage has been alleviated substantially, China's tough attitude towards foreign investors is also contributed by two misleading assumptions. The first one is power business is risk-free in China; the second one is that "there are a large amount of floating money in the world.

- At present, China's policy on Build-Operate-Transfer (BOT) projects is: (1) to gain experiences through experiment first; (2) to standardize the BOT method based on the experiences gained; and (3) to popularize the standardized BOT method gradually under government guidance.

- After many years of debate, consensus was reached within the Chinese government that energy prices should be subject to market forces. In 1993, reform measures were adopted in six power networks and grids, where electricity prices of newly built power plants would be based on operating costs and debt services. However, government efforts to control inflation has slowed the process of electricity price adjustment.

Investment in the Power Sector

- To meet the huge capital demand in developing its power industry, China is changing the power sector investment mechanism, although the transformation process is conducted slowly and cautiously. Before 1979, investment in China's power industry basically came from central government allocations. Since 1979, China changed its power industry financing from government allocations to loans. New channels of domestic funds are created to substitute central government financing. By 1992, the share of budgetary allocations in total energy investments declined to only 7 percent.

- China began introducing foreign investment in its power sector in 1979. By 1993, China had contracted $14.3 billion of foreign investment in its power sector, including direct and indirect investments. Direct investment including equity joint venture, cooperative joint venture, and sole foreign-funded projects. Indirect foreign investments including international loans, export credit, international renting, and international bonds.

- Equity joint ventures typically have a limited live span of 10-20 years. Profits are shared according to the respective percentage of equity. Foreign investors are required to hold at least 25 percent equity. Almost 40 GW of joint venture power projects are scheduled to start construction before 2000. Existing power plants can also be converted to equity joint ventures. Another type of equity foreign investment is selling stocks in the overseas stock exchanges. However, the performances of the two power company stocks listed in the United States are discouraging.

- Cooperative joint venture project is also called "contract" joint venture project. The main difference between a cooperative joint venture project and a equity joint venture project is that the profits and risks are not shared according to equity shares of the two sides in the case of the cooperative joint venture project, but according to the provisions determined in the contract. Equity joint venture is preferred to cooperative joint venture in China. The Shajiao' B and Shajiao' C projects in Shenzhen are examples of cooperative joint venture projects.

- China started to use international loans to develop hydropower resources in southwest China in 1984. Several billion dollars from the World Bank (WB), the Asia Development Bank (ADB), and foreign governments have been used to finance large hydropower projects in the region. Loans from the WB, ADB, and foreign governments are mostly on concessional terms that provide lower interest rates and longer repayment periods than the commercial banks could offer. However, such loans are usually accompanied by other special requirements imposed by the lender, and the total volume of these loans is limited.

- The ADB loans are divided into ordinary loans and favorable loans. Ordinary loans are for a term of 10 to 30 years plus a four-year grace period. Interest rates are calculated according to the costs to obtain the funds plus 1 percent per year. Favorable loans are for a term of 40 years plus a ten-year grace period with a very low interest rate of 1 percent per year.

- Government loans are favorable loans which are guaranteed by the Chinese government. Generally, government loans have the following features: (1) the loans are on concessional terms with low interest rates and very limited additional fees; (2) the loans have rather long repayment periods, normally 10, 20 or event 30 years; and (3) the loans are associated with additional conditions.

- The interest rates of commercial loans are higher than those of government loans, and their repayment periods are shorter. However, commercial loans are more abundant in sources, and relatively easier to borrow. Commercial loans take two forms. In one case, a Chinese bank or an international trust and investment corporation acts as the borrower and then lends the funds to the Chinese power company. In the other, the foreign bank lends the money directly to the power company, provided an approved Chinese financial institution acts as guarantor. Currently most loans are of the latter type.

- Export credit is provided by foreign governments to promote exports of commodities from their own countries. Export credit is a favorable loan, and the risk of the loan is beard by the exporting country. In China's power sector, the use of export credit is limited to the Huaneng Group.

- China also use bartering to import equipment, technology and service in its power sector. Although bartering may solve the problem of insufficient foreign exchange, the use of bartering is limited by the following factors: (1) the exporters of generating equipment and technologies may not willing to accept the commodities offered by the Chinese side; (2) it is difficult to introduce advanced equipment and technologies using this method; and (3) the sales of the bartering commodity are subject to uncertainty and risk.

- The final target of China's power sector financing system reform is to shift the responsibility of power sector financing from the government to the power enterprises, and the finance of power projects should based on market forces. China is considering to separate its power sector reforms into two stages. The first stage is commercialization, and the second stage in corporatization.

- The financial operating targets of China's power industry are: (1) the capital profit rate should be 10-12 percent after adjusting for inflation; (2) investment from retained profits of power enterprises should account for 35 percent of total power sector investment; (3) the ratio between annual gross income and debt payable of the same year should be greater that 1.5:1; and (4) equity finance should account for 35-40 percent of total investment, while debt finance account for less than 60-65 percent.

- China's total capital requirements for the power sector are conservatively estimated at about $72 billion (in 1995 price) between 1996 and 2000 (averaging $14 billion per year), $204 billion between 2001 and 2010 (averaging $20 billion per year), and $138 billion between 2011 and 2015 (averaging $28 billion per year).

- Due to the transformation of China's investment mechanism, the central government is no longer the major sources of investment in the power sector, and should not be relied on for future funding. Between 1980 and 1992, the share of central government investment in total power sector investment decreased from 91 to 34 percent. At present, the share of central government investment in any new power projects is normally less than 30 percent of total project investment, in many cases, less than 20 percent.

- Most funding today comes from local governments in the form of specialized tariffs charged to electricity users, and stocks and bonds issued to the public, among other methods. In some cities, local governments have raised funds for power sector investment through soliciting funds from enterprises with a promise of electricity quota allocation after the power generating units commence operations. However, raising money from local sources is not a easy job given the present unfavorable investment climate in China's power sector.

- Given the complexity of the approval process and the important role of the Chinese counterparts in the process, a joint venture structure with Chinese partners is recommended. While both cooperative joint venture and whole foreign-owned enterprises are possible, equity joint venture structures have been favored by the Chinese side over cooperative structures.

- The coastal provinces have historically been the focus of much of China's power development, both domestic and foreign-sponsored. In addition to the high demand for power in these provinces due to rapid economic growth, these provinces have been the most credible providers of foreign currency protection for debt and equity returns. Coastal locations will continue to play an important role in the future for these reasons.

- Strong power projects are not limited to coastal provinces. Other areas of China offer different advantages. One of the priorities of the Chinese government is the increased establishment of several large mine-mouth power plants in inner China which will transmit electricity through existing or new transmission lines to the coastal provinces several hundred or thousands of kilometers away. Environmental issues in already crowded coastal regions have provided further impetus to move plants inland and away from major metropolitan centers.

- A total of about 120 GW project proposals which involve private sector investment have been identified in China so far, although some of the proposals are still very preliminary and might be collapsed in the future. About 83 percent of the proposed projects are coal-fired; the remaining projects are mostly natural gas fired (10%); hydropower power projects account for only 3 percent; and all others account for 4 percent. Proposals from the U.S. firms and Hong Kong firms account for about 40 and 30 percent respectively. The remaining part comes mainly from Singapore, Australia, Germany, Thailand, Japan, UK, and France.

Energy Availability and Transportation

- During the past 15 years, China's annual commercial energy production growth rate averaged 4.5 percent, with total energy production increased from 638 to 1230 million tons of coal equivalent (MTCE). During this period, coal's share in total energy production increased from 69 to 74 percent; oil's share decreased from 24 to 17 percent; hydropower's share increased from 4 to 6 percent; and the share of natural gas decreased from 3 to 2 percent.

- Over the next two decades, China's annual commercial energy production is projected to grow at about 3 percent per year, increasing from 1230 to 2213 MTCE. Coal's share is projected to remain at about the current level, oil's share is projected to decrease to about 9 percent, while the shares of natural gas, hydropower, and nuclear power are projected to increase to 5, 7.6, and 3.2 percent respectively.

- China's coal demand is projected to increase to 1,800 Mt by 2005 and 2,500 Mt by 2015. The share of the power sector (including steam and hot water production) is projected to increase from the current 36 percent to 44 percent by 2005 and 52 percent by 2015. It should be noted that actual coal consumption may be lower than the projected demand, due to supply side restrictions and transportation difficulties, which will negatively affect the nation's economic growth.

- China is the largest coal producer in the world. During the past 15 years, annual coal production growth averaged 4.8 percent, substantially below the growth rate over the 1949-1980 period, which averaged 10 percent. China's coal mines are divided into three categories: state mines are primarily large mines managed by the Ministry of Coal Industry; local state mines are mostly medium-size mines managed by provincial, prefectural, and county governments; and TVP mines are mostly small mines owned by townships, villages, and private individuals.

- Since China's economic reform started in the late 1970s, the three types of mining enterprises have increased production at very different rates. Between 1980 and 1993, more than 70 percent of coal production increase was due to the growth of TVP mines. During this period, the share of TVP mines in total production increased from 18 percent to 41 percent, the share of state mines declined from 56 percent to 41 percent, and the share of local state mines declined from 26 percent to 18 percent.

- The key factors behind the rapid growth in small TVP mines are that they require little capital investment, able to avoid many of the safety and environmental constraints required of large mines, able to use large numbers of cheap miners, and higher efficiency because they are managed like private enterprises. TVP mines provide peasants the opportunity to earn more income and therefore are supported by local governments. The major problems of the TVP mines are resource waste, the high death rate of miners, and interference on the production of state mines.

- The Chinese government hopes to rely more on large and medium-size coal mines to meet its coal demand in the long run. However, the current conditions at state mines are not ideal. Major problems plaguing state mines include: (1) serious financial problems and insufficient investment in coal development; (2) low production efficiency and excess labor; and (3) insufficient capacity to transport coal to the demand areas.

- In order to solve the financial difficulties of the state coal mines, the Chinese government decided to release controls on coal prices. The Chinese government also reduced its subsidy to the state mines by 2 billion yuan each year and intends to eliminate all subsidies to the state mines by 1996.

- Coal production in China is currently planned by the government to reach 1.4 billion tons by 2000. However, even under conservative estimations, coal demand in 2000 is likely to exceed 1.5 billion tons. Whether China can close the gap between coal demand and supply through increases in domestic production depends on China's future development policies in the energy and transportation sectors. Based on current policy directions, it is estimated that China will meet most of its energy demand through more rapid development of domestic coal resources. In South and East China, substantial coal imports are likely, due to limitations of domestic transportation capacity.

- According to the national oil and gas resources assessment completed by CNPC in 1993, China's total estimated petroleum resources are 680 billion barrels, and the total estimated gas resources are 1340 TCF. However, China's oil and gas reserves based on world standard are estimated at only about 70 billion barrels and 300 TCF respectively, while proven oil and gas reserves are only 24 billion barrels and 60 TCF respectively.

- China is now the sixth largest oil producer in the world. In 1994 China produced 2.92 million barrels per day (mmb/d) of crude oil. In the first half of 1995, China's crude oil production was 2.95 mmb/d, and natural gas production totaled 302 BCF, representing an increase of 1.4 percent and 3 percent compared with the same period in 1994.

- Xinjiang is the most important potential area for future oil development. The Tarim Basin, Jungger Basin, and Turpan-Hami Basin, which cover a total area of 720,000 square kilometers, are estimated to have 28 percent of China's total oil reserves and 33 percent of total gas reserves. Currently, 38 oil fields with oil reserves of 13 billion barrels and gas reserves of 5.7 TCF have been discovered in this region.

- China's oil demand is projected to increase from the current 3 mmb/d to 4 mmb/d by 2000, while its oil production is projected to remain at about 3 mmb/d. Oil demand is increasing both from the industrial sector and other sectors in the country. High-sulfur crude oil from the Middle East is predicted to occupy 85 percent of China's crude oil imports in 2000. Total Chinese crude imports is expected to reach 1 mmb/d in 2000, 1.6 mmb/d in 2005, and 2 mmb/d in 2010.

- At present natural gas accounts for only 2 percent of China's total primary energy consumption. Limited domestic production and constraints on gas imports are largely responsible for the low share of gas in current energy use. About half of the natural gas output is used in the oil fields, such as in heating oil pipelines and for reinjection for oil recovery. Most of the remaining gas is used in chemical and fertilizer industry. Official policy since 1980 has encouraged the residential use of gas in heating and cooking. Very little gas is burned in power plants.

- Domestic exploration to determine the magnitude of gas resources remains an outstanding issue, since development and exploration have, until recently, been virtually ignored. This reflects not only the Chinese government's underpricing of natural gas, but also the lack of political clout of Chinese natural gas interests in state petroleum companies and the perception of very limited opportunities for regional exports of gas. Foreign assistance could support more aggressive gas exploration and development.

- Renewable energy sources represent a major component of future energy supply. Over the next several decades a range of renewable technologies, including wind, solar, and biomass are expected to become cost-competitive with conventional energy sources. At present, however, renewable energy played a very limited role in China's power generation.

- China's regional distributions of energy resources are highly skewed. Around 86 percent of China's coal resources are concentrated in the Central, North, and West region.

However, these regions are underdeveloped economically. The social output value of these regions only accounts for 8 percent of the nation's total. The South region and the East region account for 12 percent of China's coal resources and 35 percent of social output value, while the Northeast region and Southeast region account for only 2 percent of coal resources but 57 percent of social output value.

- A centerpiece of China's coal development strategy is to increase the coal production and transport capacity from the Energy Base. Although additional railway capacity is one of the most important ways to solve transport bottlenecks, other options can reduce the demand for coal transport, such as coal washing, mine-mouth power plant and long distance electricity transmission. However, development of coal washing and mine-mouth plants are limited by the availability of water resources in the Energy Base.

- The major part of the Energy Base is located in the Central region. Coal production in the Energy Base is planned to reach 540 Mt by 2000 and 1,200 Mt by 2015, of which 800 Mt will be transported to other regions. Current coal transportation capacity from the Energy Base is about 200 Mt per year, planned new transportation projects may add another 300 Mt per year by 2015, and mine-mouth plants are unlikely to convert more than 80 Mt per year of coal from railway transportation to electricity transmission. There is a gap of at least 200 Mt per year of transportation needs to be filled, and transportation capacity shortages will be a long lasting phenomenon in China.

- China's railway system is referred to as "the last virgin territory of the planned economy." In 1994, the railway industry as a whole started to loss money for the first time. In 1995, it is expected to loss around 10 billion yuan ($1.2 billion). The low productivity of the railway system and the rigid transportation prices are two of the most important reasons behind the poor performance of the railways. Until 1995, all the revenues and profits of the railway system were turned over to the higher authorities, with losses subsidized from above. Under such a system, business managers had neither pressure nor motivation to improve productivity and profitability.

- An important strategy for relieving pressure on the railway system is to shift more coal onto the coastal and inland waterways. About 140 Mt of coal (excluding exports) would be shipped in 2000 from north to south, nearly double the amount in 1990. The average distance for coastal shipping can be increased from the 1989 average of about 1,250 km to almost 1,500 km in 2000. All coal transported by water will be shipped at least as far south as Shanghai, except for coal shipped to ports in the Northeast and on inland waterways.

- The role of trucks in short distance transportation is very important. The number of trucks increased 11 percent per year over the 1978-1992 period in China. To support the increased role in truck transportation, China will build 4 cross-country routes. One of the two north-south routes runs from Tongjiang in Heilongjiang, to Sanya in Hainan; the other extends from Beijing to Zhuhai in Guangdong. The first of the two east-west routes runs from Lianyungang in Jiangsu to Korgas in Xinjiang; the second route links Shanghai with Chengdu in Sichuan.

Regional Development of Power System

- China has six major power load centers. These load centers account for 40 percent of China's total electricity consumption. China's power system comprises five regional power networks and 10 provincial power grids, which account for more than 95 percent of China's total generation. The East China Power Network (ECPN) is the largest regional power network in China, followed by the North China Power Network (NCPN), the Central China Power Network (CCPN), the Northeast Power Network (NEPN), and the Northwest Power Network (NWPN).

- The ECPN covers three provinces of Jiangsu, Zhejiang, and Anhui, and Shanghai Municipality, with an overall area of 350,000 square kilometers. This relatively developed region accounts for about 22 percent of China's GDP and 16 percent of its population.

With installed capacity reached 31,750 MW by September 1993, the ECPN is the largest regional power network in China.

- The ECPN is more sophisticated in technology development compared to other power networks and grids. It has constructed a series of power projects of world standards, including China's first two 600 MW super-critical units in Shidongkou, the first 300 MW domestic nuclear power unit in Qinshan, the first 500 kV HVDC transmission line, the first 500 kV AC/DC substation, and the first large underground 220 kV substation.

- To meet the increasing power demand driven by the booming economy and rising standards of living, the ECPN is very ambitious in power development. Total generating capacity is planned to reach 55,000 MW by 2000. To further extend the coverage of the network and transmit electricity from Shanxi Province and the Three Gorges in the long run, more than 3,000 km of 500 kV transmission lines and 15 million kVA of transforming capacity will be added, and total 500 kV transmission lines will exceed 5,000 kilometers by 2000.

- The ECPN is deficient of primary energy resources. Coal reserves here account for only 3.7 percent of the nation's total, and hydropower resources only 0.9 percent. Additional power plants will mainly be coal-fired, although hydropower plants, especially pumped storage plants, and nuclear power plants will also be built. Along the east coast and the middle to lower course of the Yangtze River, the locations of several large thermal power plants have been selected.

- The NCPN covers Beijing, Tianjin, Hebei, Shanxi, and the western part of Inner Mongolia with an overall area of 1.47 million square kilometers. This region accounts for about 12.8 percent of China's GDP and 11.6 percent of population. Total installed capacity of the NCPN was 25.7 GW in 1993.

- This NCPN is rich in coal but poor in hydropower resources. The two major coal bases in this region account for half of China's total coal reserves, while hydropower resources in this region account for only 1.2 percent of China's total. In the future, this region is expected to lead China's coal production and electricity generation. In the power load center of the east region, some power plants will be built to support the stability of the regional power supply. A large group of mine-mouth coal-fired plants will be built in Shanxi and Inner Mongolia to transmit electricity to the east part of the region and to Jiangsu Province in the ECPN.

- Total generating capacity of the NCPN is currently planned to reach 57.5 GW by 2000, although the previous target of 50 GW appear more realistic. A total of 39 power projects with total generating capacity of about 44 GW has been identified to start construction before 2000, which include about 39 GW of thermal plants and 5 GW pumped-storage plants.

- The CCPN covers Hubei, Hunan, Henan, and Jiangxi with an overall area of 730,000 square kilometers. This region accounts for about 15 percent of China's GDP and 21 percent of population. Total installed capacity of the NCPN was 26.2 GW by the end of 1993, of which 16.3 GW were thermal power plants, and 9.9 GW were hydropower plants.

- This region is rich in hydropower resources; however, 84 percent of its 50 GW exploitable hydropower resources are concentrated in the southern provinces of Hubei and Hunan, while 84 percent of its 24.5 billion tons of proven coal reserves are located in the northern province of Henan. Large hydropower plants are located in the west part of the region, but most load centers are in the east. To coordinate the operation of major thermal power plants in the north and hydropower plants in the south, and transmit electricity from the west to the east, a power transmission system has been developed.

- Upon completion of the Three Gorges Project in the next century, 15-17 500 kV transmission lines with a total length of 5,000 km will be built within the CCPN to link the CCPN with other power networks and grids. Coal-fired electricity from the northwest and hydropower from the southwest will be transmitted to the load centers in the east and southeast regions through the CCPN.

- The NEPN covers Liaoning, Jilin, Heilongjiang, and the eastern part of Inner Mongolia with a total land area of 1.2 million square kilometers. Northeast China is China's major heavy industry base. Economic development in the northeast is largely dependent on the development of the electric power industry. Installed generating capacity in the NEPN was 25.8 GW in 1993, of which thermal power accounted for 83 percent, and hydropower accounted for 17 percent.

- The Northeast China lacks primary energy resources. Its hydropower resources account for only 2 percent of the nation's total. Coal reserves in this region is estimated 66 billion tons, of which three-quarters are lignite. Current coal production in this region cannot meet demand and more than 30 Mt of coal has to be imported into this region each year. Lack of primary energy will be increasingly serious in the future, especially in Liaoning and Jilin. Most new thermal power plants in the NEPN will be constructed close to coal mines. Power plants will also be installed close to major ports and railways.

- To meet the increasing power demand, the NEPN plans to increase its total generating capacity to 46 GW by 2000. Thermal power units will mainly include 300, 500, 600 and 800 MW units. The size of new power plants will mainly be 1800-2400 MW.

- The five provinces of Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang are commonly referred to as the northwest region. This region is relatively backward economically. It accounts for about one-third of the nation's total land area, about 7 percent of total population, and only 5 percent of GDP. By the end of July 1993, this region had 434 power plants (0.5 MW and above), of which 259 (5,506 MW) were hydro plants and 175 (8,413 MW) were thermal plants.

- The northwest region is rich in hydropower resources. The theoretical hydropower resources in this region is 84 GW, ranks second in China. This region is also rich in coal resources. Preliminary coal reserves are estimated about 380 billion tons in Shaanxi, 70 billion tons in Ningxia, 8 billion tons in Gansu, and 1,600 billion tons in Xinjiang. The largest natural gas field in China is also discovered here.

- Power development in this region is constrained by relatively slower electricity demand growth. Higher capacity transmission lines will have to be built before electricity can be transmitted to the demanding NCPN and SCPG. The strategic shift of the production of electricity intensive commodities to this region will take time to realize. The low income levels makes the adjustment of electricity tariffs to attract private investors in power development difficult. Total generating capacity of the NWPN is planned to reach 20 GW by 2000.

- In the four southwest provinces of Sichuan, Yunnan, Guangxi, and Guizhou, energy resources are very rich. The four provinces account for more than half of China's total hydropower resources. Coal reserves in Guizhou is estimated at about 50 billion tons. Future power development in this region will focus on hydropower projects. A total of 65 hydropower plants (120 GW) are planned on the rivers of Hongshui River, Jinshajiang River, Yalingjiang River, Daduhe River, Lancangjiang River, and Wujiang River.

- The Guangdong Power Grid (GDPG) is a independent power grid. It enjoys a special status of "non-directly" under the MEPI. In practice, this means that the GDPG has full control over its financing, personnel and materials, but only partial control over project planning and approval process. Guangdong is able to make decisions about types of power plants to develop and time tables for construction. However, all projects are still subject to central government "advice" regarding the availability and use of resources, the arrangement of fuel supply. Projects of 250 MW and above must go through the formal approval process.

- Power sector reforms have promoted Guangdong's power industry development. Installed capacity in the GDPG reached 14.65 GW by the end of 1993, of which thermal power accounted for 76 percent and hydropower 24 percent. Guangdong is very ambitious in future power development. It plans to increase its total generating capacity to 34 GW by 2000 and to 60-80 GW by 2010.

- Shandong was selected by the central government as one of the areas to experiment China's open-door policies, and economic growth in Shandong is above China's average. The Shandong Provincial Power Grid (SDPG) is the second largest independent power grid after the GDPG. Its generating capacity reached 10.7 GW by 1993; however, electricity shortages are still very serious. By 2000, Shandong plans to increase its total capacity to 23 GW.

Environmental Issues

- While every one have acknowledged that there is a need to balance the economic benefits of industrialization with the environmental consequences and costs to society, people give different weight based on their responsibility and personal interest. While government officials in charge of environmental protection tend to emphasize the severity of China's environmental problems, officials in charge of economic growth tend to deny the severity of the environmental situation. The lack of objective measurement of environmental pollution levels makes it very difficult to achieve consistent opinions even within the government.

- China's energy consumption growth has significant local, regional, and global environmental consequences. The local environmental impacts of energy consumption is mainly through emissions of SO_2, NOx, and particulate; the regional impacts are mainly caused by SO_2 spillovers onto neighboring countries; and the global impacts are mainly through emissions of CO_2.

- China already experienced damages from particulate, SO_2, and NOx. Currently, China is home of three of the 10 most polluted cities in the world, and respiratory disease accounts for more than one-quarter deaths in China. Air pollution is one of China's most serious environmental challenges. Although some government officials deny that there exists any real air pollution threat due to political reasons, it is clear that China do have a serious air pollution problem.

- During the next two decades, China's power sector alone is projected to increase its annual coal consumption by 760 Mt, which will add 380 Mt of CO_2 emissions. In comparison, the total CO_2 emission growth of all OECD countries between 1975 and 1987 was only 194 Mt. The global impacts of China's growing energy consumption is a major concern of the international community. However, the issue of CO_2 emissions is very sensitive to international politics.

- China's environmental standards are evolving and already stringent in some cases. The problem is often not weak environmental standards but lack of enforcement. Monitoring of air is unsystematic and infrequent and there are no air quality control districts to plan efficient monitoring and data processing in China.

- China is considering to revise SO_2 emission standards to promote the country's environmental protection effort. More scientific and standard regulations are expected. Tall Chimneys were considered solutions to controlling SO_2 emissions in the past, and asid rain was not taken into consideration at that time. China will first focus control measures on coal-fired power plants and other industrial sectors.

- China produces the largest amount of coal related atmospheric pollution in Asia. China is estimated to account for over 70 percent of Asia's total SOx emissions and about half of the total emissions of NOx and CO_2. Coal is the major source of China's air pollution, it accounts for 90 percent of China's SO_2 emissions, 83 percent of CO_2 emissions, 70 percent of particulate emissions, and 50 percent of NOx emissions. Between 1983 and 1993, China's SO_2 emission growth rate averaged more than 4 percent per year.

- To avoid the ever increasing damages from acid rains, China is very active in developing clean coal technologies (CCTs) in its power sector, and China is projected to become the dominant CCT user in the Asia-Pacific region over the next two decades. However, this trend has yet to develop, and a number of obstacles must be overcome before CCTs will be introduced on a large scale.

- Capital availability is the major factor preventing widespread installation of desulfurization equipment in coal-fired power plants. Since desulfurization equipment will typically add 10-15 percent of power plant capital investment in China, widespread installation of desulfurization equipment is too heavy a burden for the Chinese power sector in the near future.

- Based on China's actual situation, 10 CCTs are selected in China which include: (1) coal preparation; (2) briquetting; (3) coal water slurry; (4) advanced combustion facilities; (5) fluidized bed combustion (FBC); (6) integrated gasification combined cycle (IGCC); (7) flue gas desulfurization (FGD); (8) coal gasification; (9) coal liquefaction, and (10) fuel cells. In addition to these 10 technologies, the technology of coal-fired magnetic fluid electricity generation has been included as one of China's high technology R&D projects.

- China's CCT priorities are: (1) briquetting; (2) coal preparation; (3) advanced combustion facilities; (4) coal water slurry; (5) coal gasification; (6) FBC; (7) IGCC; (8) FGD; (9) coal liquefaction; and (10) fuel cells. The evaluation of CCTs is based on their environmental effects, energy conservation rates, maturity, and economics.

- China is projected to become the dominant CCT user in the Asia-Pacific region over the next two decades. However, this trend has yet to develop, and a number of obstacles must be overcome before CCTs will be introduced on a large scale. The major obstacle facing imported CCTs is their relatively high capital costs, and a successful foreign investor should utilize China's lower cost domestic resources to develop cheaper CCTs.

Chapter 1

Economic Growth and Electricity Demand

Electricity Generation Growth

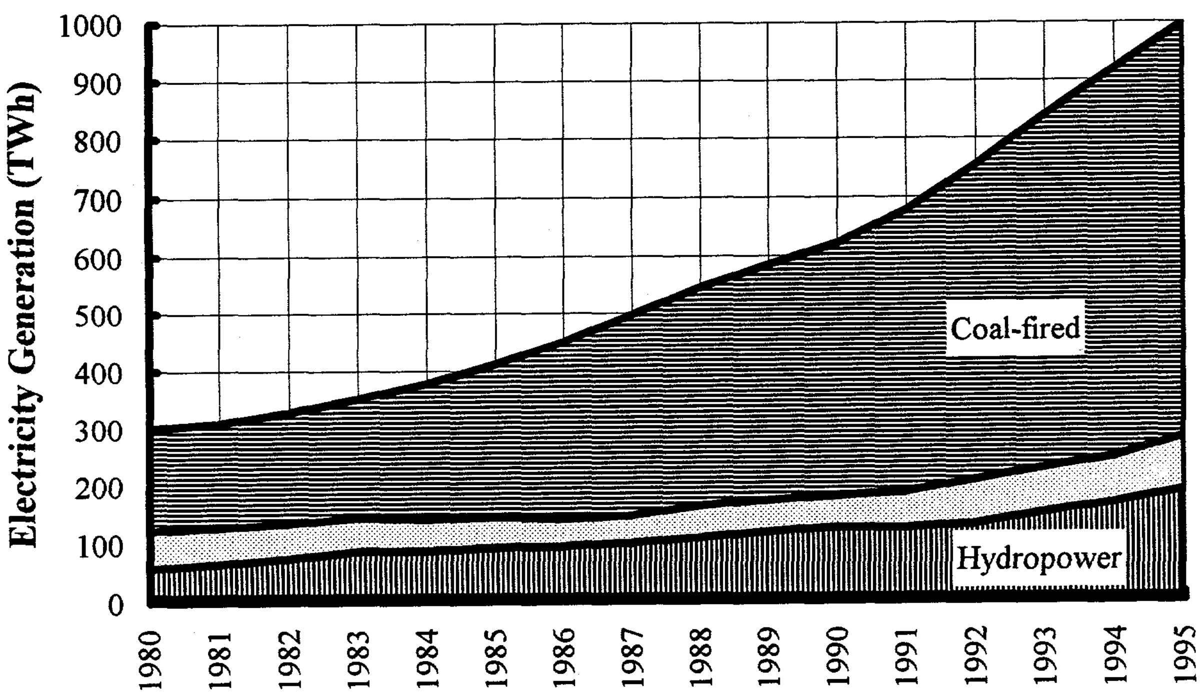

Figure 1.1. China's Electricity Generation 1980-1995

The crucial role of electricity in the modern world cannot be denied. Effective power production and distribution are essential to a country's modernization. Electricity consumption is closely related to a country's economic growth. As expected, China's rapid economic growth has been accompanied by rapid electricity growth. Figure 1.1 shows that, between 1980 and 1995, total electricity generation more than tripled, increasing from 301 Terawatthours (TWh) to 1,000 TWh. Total installed electricity-generating capacity grew at an average of 8.2 percent per year, increasing from 66 gigawatts (GW) in 1980 to 214 GW in 1995.

China is now the fourth-largest power producer in the world and is expected to surpass Japan in the next two years to become the third-largest electricity producer. The relative importance of China's power market is also increasing. Figure 1.2 shows that the share of China's installed capacity in Asia increased from 21 percent in 1980 to 31 percent in 1995, while Japan's share decreased from 46 to 33 percent. Now China's total installed capacity roughly equals the sum of all other Asian economies' generating capacity, excluding Japan's. It is projected that China's share will continue to increase over the next two decades to more than 40 percent by 2015.

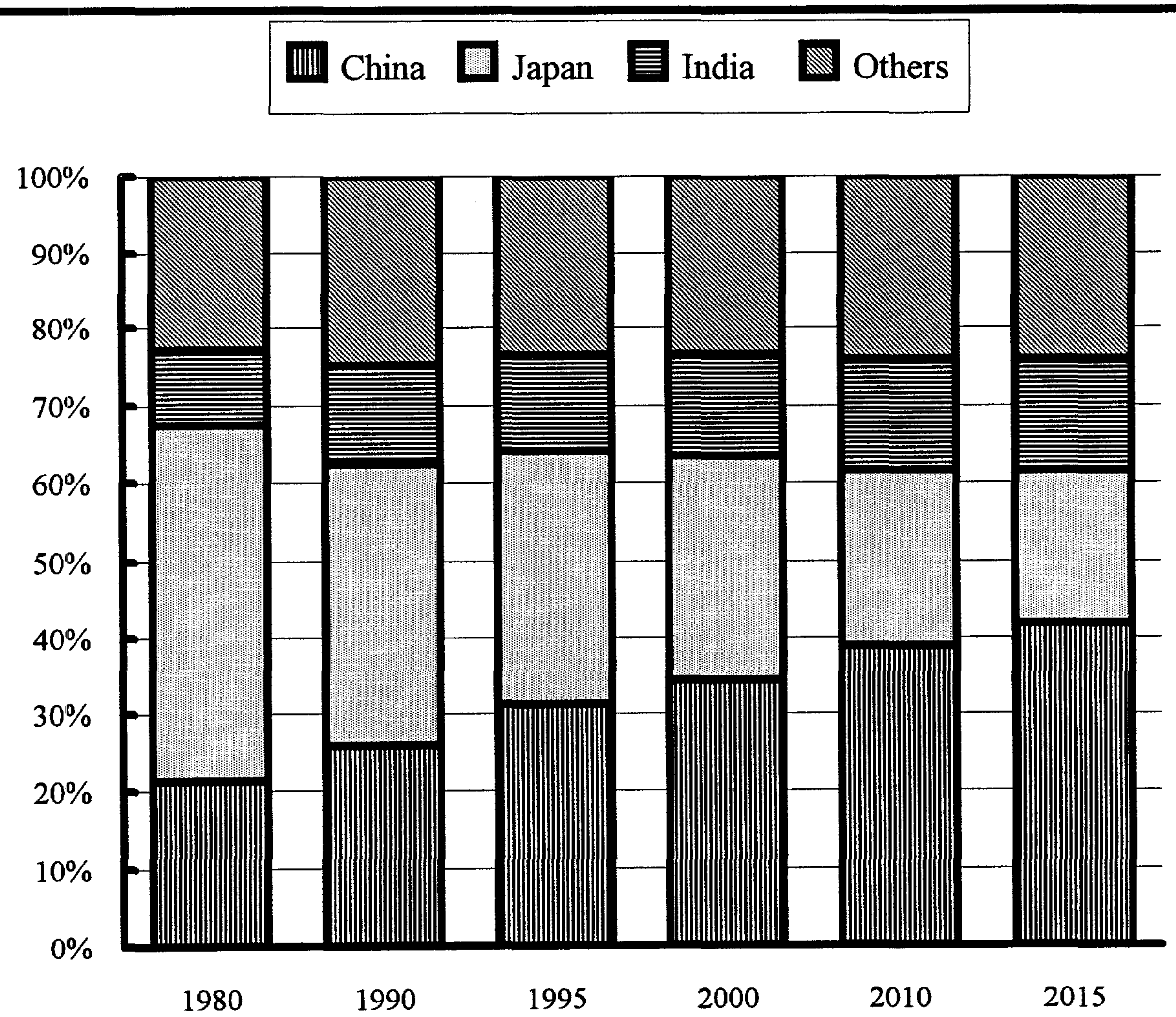

Figure 1.2. Percentages of Installed Capacity in Asia

According to the government plan, China's rapid growth rates in the power sector will continue until the end of this decade, with annual electricity generation reaching 1,400 TWh and installed capacity reaching 300 GW. After 2000, the growth rates of China's power sector are expected to be lower than that of the 1990s, but still rather high compared with other countries in the world. Figure 1.3 shows that China's gross generation is projected to reach 2,500 TWh by 2010 and 3,330 TWh by 2015.

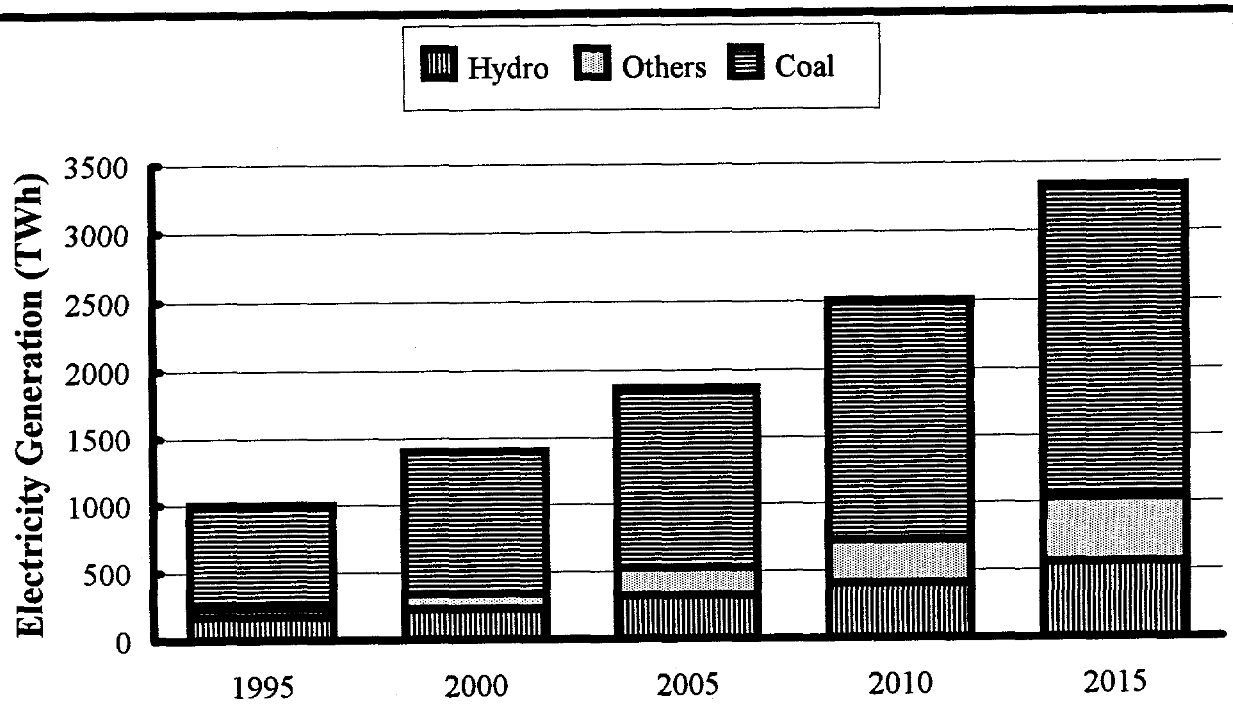

Figure 1.3. Projection of China's Electricity Generation

Due to the uncertainties of future development, three alternative projections of electricity growth are developed, with the middle scenario reflecting the author's choice of the most likely outcome. Under this projection, installed capacity will reach 400 GW by 2005 and 700 GW by 2015. The three scenarios and the underlying assumptions are given in Table 1.1. The highest projection assumes GDP growth will average 9.5 percent during 1996-2000, 8.0 percent during 2001-2005, 7.5 percent during 2006-2010, and 6.5 percent during 2011-2015. It also assumes that electricity growth would follow the same speed of GDP growth. Under this scenario, total

Table 1.1. Projections of China's Power Sector Growth, 1996-2015

Year	Installed Capacity (GW)			Electricity Generation (TWh)		
	High	Medium	Low	High	Medium	Low
1995	**214**	**214**	**214**	**1000**	**1000**	**1000**
1996	235	229	226	1099	1070	1054
1997	258	245	238	1207	1144	1111
1998	284	262	250	1326	1224	1170
1999	312	280	264	1456	1309	1233
2000	**342**	**300**	**278**	**1600**	**1400**	**1300**
2001	370	317	291	1728	1483	1358
2002	400	336	304	1867	1572	1419
2003	432	356	317	2017	1665	1483
2004	466	378	332	2179	1764	1550
2005	**504**	**400**	**347**	**2354**	**1869**	**1620**
2006	542	423	361	2534	1981	1690
2007	584	448	377	2727	2100	1762
2008	628	474	393	2935	2225	1838
2009	677	501	410	3159	2359	1917
2010	**728**	**530**	**427**	**3400**	**2500**	**2000**
2011	777	561	445	3627	2647	2086
2012	828	593	465	3870	2804	2176
2013	883	626	485	4129	2969	2269
2014	942	662	505	4405	3144	2367
2015	**1005**	**700**	**527**	**4700**	**3330**	**2469**

Note: Assumptions for the three scenarios are as follows:

	High		Medium		Low	
	96-2000	2001-05	96-2000	2001-05	96-2000	2001-05
GDP Growth	9.5%	8.0%	8.5%	7.0%	7.5%	6.0%
Generation Elasticity	1.04	1.00	0.82	0.85	0.72	0.75
Generation Growth	9.9%	8.0%	7.0%	6.0%	5.4%	4.5%
Capacity Growth	9.9%	8.0%	7.0%	6.0%	5.4%	4.5%
	2006-10	2011-15	2006-10	2011-15	2006-10	2011-15
GDP Growth	7.5%	6.5%	6.5%	6.0%	5.5%	5.0%
Generation Elasticity	1.02	1.03	0.92	0.98	0.78	0.86
Generation Growth	7.6%	6.7%	6.0%	5.9%	4.3%	4.3%
Capacity Growth	7.7%	6.6%	5.8%	5.7%	4.3%	4.3%

generating capacity would reach about 500 GW by 2005 and about 1,000 GW by 2015. Although the numbers in this ambitious scenario are striking, per capita annual electricity consumption by 2015 would be only around 3,000 kWh, less that half of the present per capita electricity consumption for OECD countries. This scenario represents possible demands for electricity; however, dramatic policy changes in favor of power-sector investors must be introduced to promote power development that will meet this demand. To date, there is no evidence that such policy changes will occur.

The low scenario assumes electricity shortages will seriously dampen economic growth. Under this scenario, the annual average GDP growth rate will be reduced from 11.3 percent during 1991-1995 to 7.5 percent during 1996-2000, 6.0 percent during 2001-2005, 5.5 percent during 2006-2010, and 5 percent during 2011-2015. Electricity growth is assumed to be much slower than the GDP growth, and electricity elasticity with respect to GDP to be between 0.7-0.8.[1] Under the low scenario, total generating capacity would reach 347 GW by 2005 and 527 GW by 2015. Per capita annual electricity consumption would be 1,600 kWh in two decades, less than double the present consumption level. The author believes that the Chinese government will make all efforts to avoid this scenario. And more importantly, the Chinese people will pressure the government to make necessary policy changes to avoid this scenario.

Despite the large size of China's power sector, its energy mix is extremely simple. Coal is the predominant fuel used in China's power generation. During the 1980-1995 period, the share of coal-fired electricity increased from 61 to 76 percent, the share of hydropower decreased from 19.4 to 17.5 , while the share of others (primarily oil-fired) decreased from 19.6 to 6.5 percent. Over the next two decades, coal's share in electricity generation is projected to decrease to about 69.1 percent; the share of hydropower will decrease to 16.6 percent; the share of others will increase to 14.3 percent mainly due to increased shares of gas-fired and nuclear electricity.

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[1] The electricity elasticity with respect to GDP is defined as the ratio between the average annual electricity and the GDP growth rates. The electricity elasticity is smaller than 1 if electricity growth is slower than GDP growth.

Economy, Electricity, and Elasticity

The close relationship between a country's economic growth, represented by GDP growth, and electricity consumption growth, represented by the growth of installed capacity, can be observed in Figure 1.4. During the 1980-1995 period, among 12 of the major Asia-Pacific economies, only 3 had a lower electricity than GDP growth rate, or an electricity elasticity with respect to the GDP below one, and each for their unique reasons. In China, among the factors discussed below, power shortage is the main reason for a low electricity elasticity. In Taiwan, the slower electricity growth is due to the political power of Taiwan's environmental groups and strong public resistance, makeing the establishment of additional power plant very difficult. Power shortages have been developing in Taiwan, which have already caused serious damage

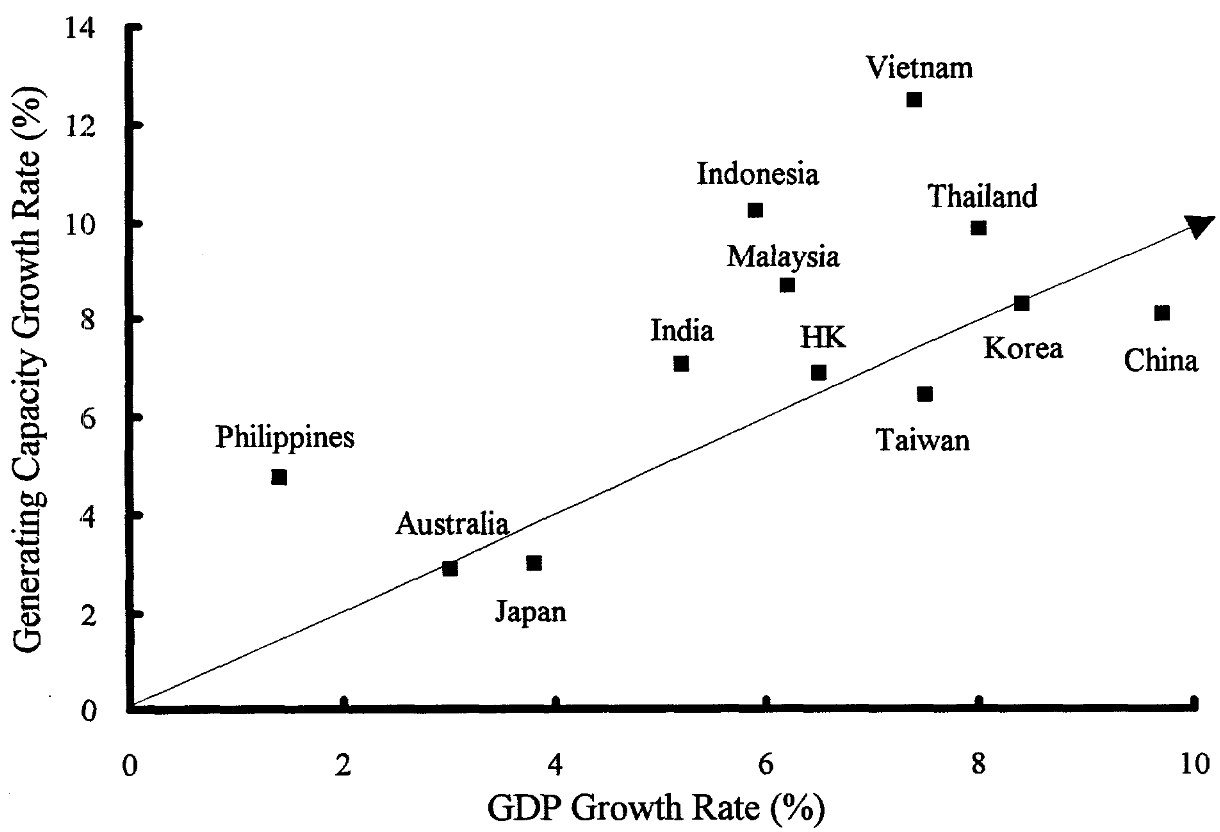

Figure 1.4. Growth Rates of Generating Capacity and GDP (1980-1995)

to the economy. In Japan, in addition to the extraordinarily high electricity tariffs which dampened electricity demand, the high income level is a strong reason for the relatively slower electricity growth.

Electricity is consumed in production of goods and services, as well as in the residential sector to provide power in lighting and electric appliances. Consumption in the production sector is directly related to GDP level, while consumption in the residential sector is more closely related to income levels. If the residential electricity consumption growth rate is higher than the GDP growth rate, then even though electricity consumption growth in the production sector is exactly proportional to GDP growth, the overall electricity elasticity with respect to GDP is still greater than one.

In economies with very low income levels, people cannot afford to buy many electric appliances, and electricity is mainly consumed in the production sector. As income level increases, people consume more household appliances. The growth rate of residential electricity consumption will reach a peak at the income level at which the electricity intensive appliances, such as air-conditioner, refrigerator, and electric stoves, become commonly adopted. Above this income level, the growth rate of residential electricity consumption will start to decline, because most households already own most of the appliances they want. This relationship between income levels and residential electricity consumption leads to an inverted bell-shaped function between income levels and the electricity elasticity.

In the production sector, electricity consumption is also related to the structure of the economy. Normally the manufacturing sector consumes much more energy to generate the same value of GDP than the service and agricultural sectors. For example, to produce the same amount of GDP, China's secondary sector (including all heavy and light industries and construction) consumes 4.6 times as much energy as that of the tertiary sector (including services, transportation, commerce, and the public sector) and 8.3 times that of the primary sector (primarily agriculture). Figure 1.5 shows that, as income level increases, the share of the tertiary sector tends to increase, while the shares of the secondary and primary sectors tend to decline (Li et al, 1995). At very low income level, a country is typically dominated by agriculture. As income level increases, the economic structural shifts are primarily from the primary sector to the secondary sector; therefore, the electricity consumption growth tends to be faster than the GDP growth. As income reaches a relatively high level, the structural changes will be dominated by the switch from the secondary sector to the tertiary sector. This will also lead to an inverted bell-shaped relationship between income levels and the electricity elasticity. Since electricity is a high quality and clean energy source, as income increases, people will likely substitute electricity for other energy sources. This is a counteractive factor to the inverted bell-shaped schedule; therefore, the relationship between income levels and electricity elasticity is expected to be much flatter than that of the total energy elasticity. In addition to the general trend, the electricity elasticity is also affected by factors specific to each economy, for example, the availability of cheap energy sources, electricity tariff levels, historical power development, the density of population, and even the climatic conditions.

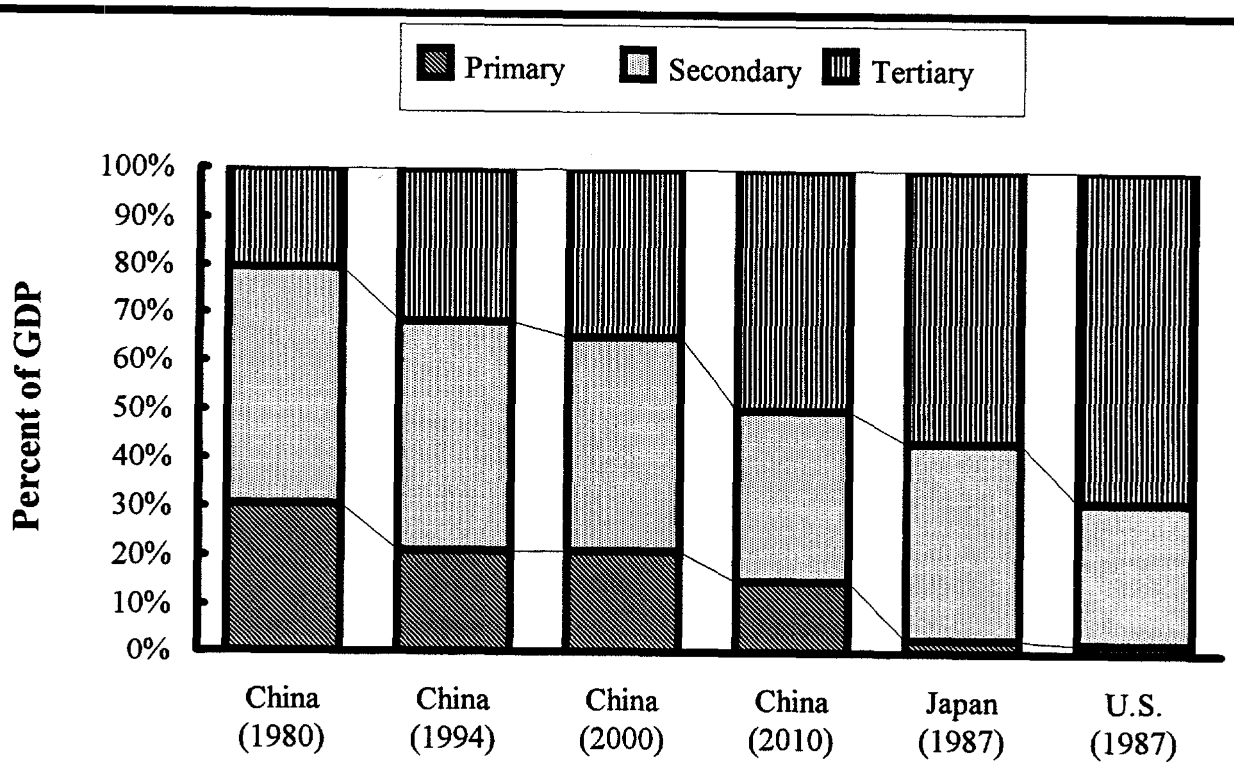

Figure 1.5. Economic Structures in China, the United States, and Japan

With some violations due to specific reasons of the related economies, Figure 1.6 provides an empirical support to the flat inverted bell-shaped relationship between income levels and electricity elasticity. The horizontal axis of Figure 1.6 is arranged according to per capita GDP level. As income level increases, the electricity elasticity tends to increase first, then starts to decrease. The high elasticity in Vietnam, despite its low income, is due to the availability of cheap hydropower. The high elasticity in the Philippines is mainly due to its slow economic growth and its lack of base load capacity. China is an exception, and the reasons will be discussed in detail later in this chapter.

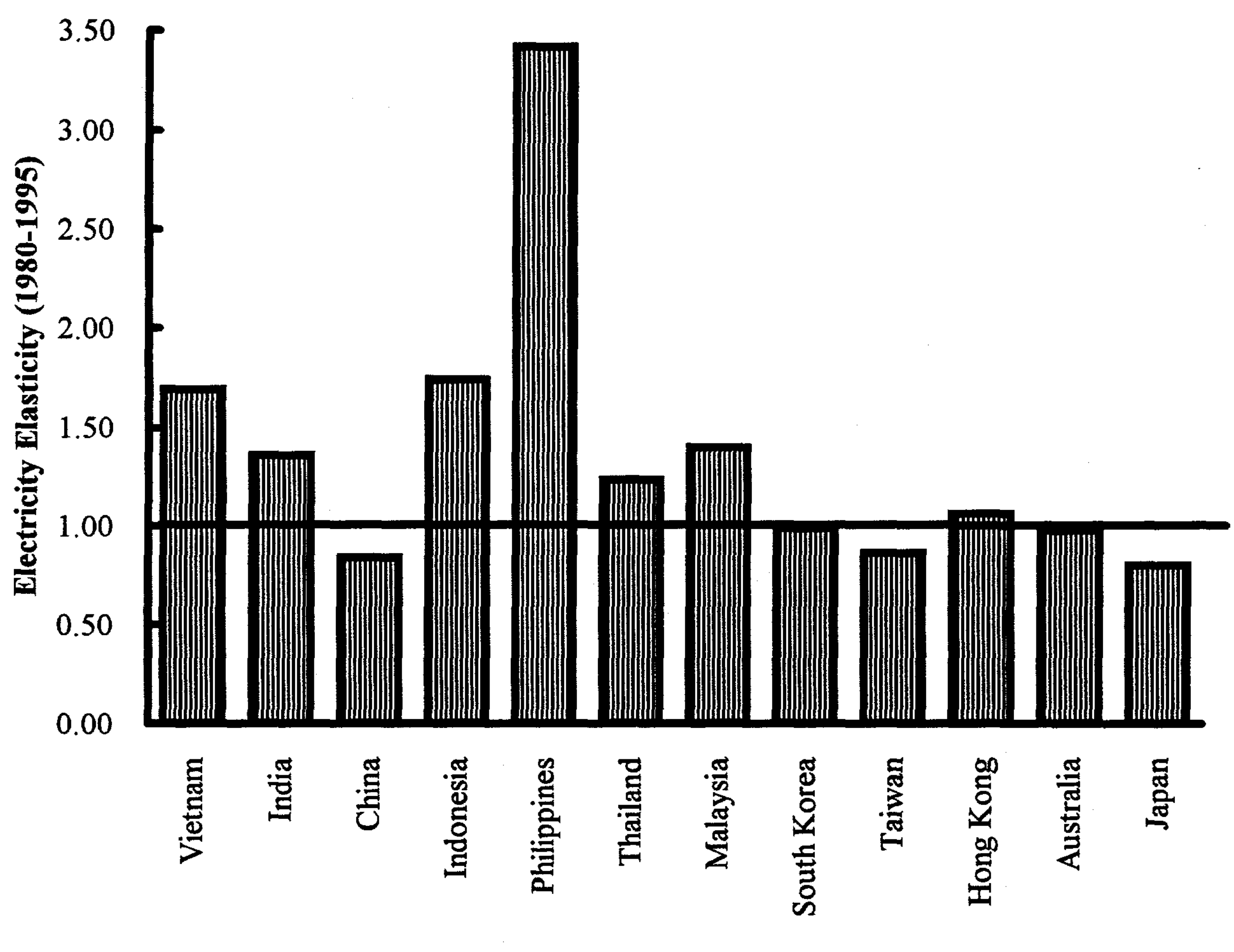

Figure 1.6. Electricity Elasticities in Asian-Pacific Economies.

China's Economic Growth

Since China adopted an open door policy in 1978, its economy has grown rapidly. During the 1980s, China's annual GDP growth rate averaged 8.8 percent, the second highest Asian-Pacific economies after South Korea. During the past 5 years, with deeper economic reforms, China's GDP growth rate averaged 11.3 percent, the highest in the Asia-Pacific. In 1995, facing the pressure of high inflation rate, the Chinese government was seeking a "moderate economic growth" of 9 percent per year and adopted a tight financial and monetary policy; however, the actual GDP growth rate still reached 10.2 percent. In 1995, China's total GDP reached 5,770 billion yuan ($695.2 billion). Figure 1.7 shows that China's GDP growth rate is projected to average 8.5 percent per year for the 1996-2000 period, 7 percent during 2001-2005, 6.5 percent during 2006-2010, and 6 percent during 2011-2015. It should be noted that these projections are on the conservative side.

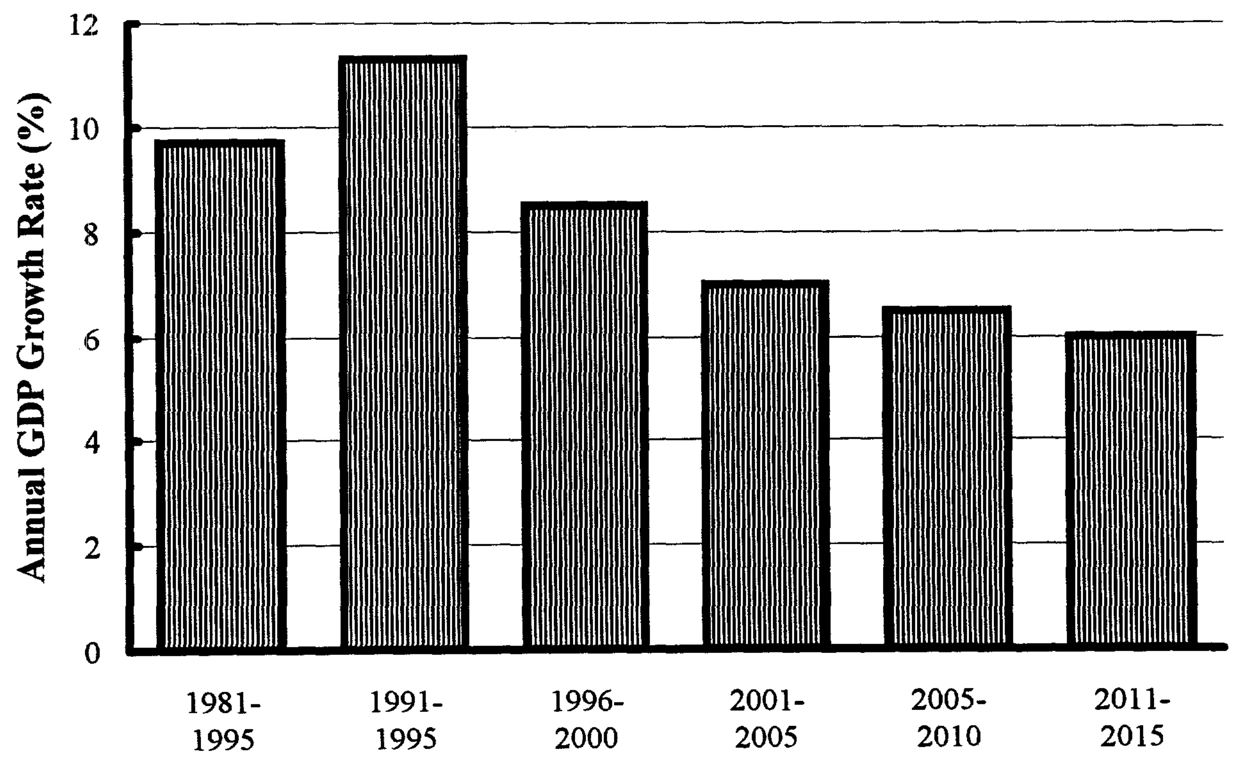

Figure 1.7. China's Average GDP Growth Rate, 1981-2015

The driving forces behind China's high economic growth are dramatic increases in effective labor supply and effective capital stock, as well as improved technology and management levels due to economic reforms and the shift towards a market economy. In addition, China has been able to maintain economic and political stability and an aggressive outward-looking policy. The general trend in policy changes has been in the direction of promoting export-oriented industries, reducing protectionism, increasing economic efficiency and encouraging competition.

<u>The Effective Labor Supply.</u> With a population of 1.2 billion, there is no doubt that nominal labor is probably the most abundant resource in China, perhaps too abundant. However, effective labor, which is a combination of nominal labor, work effort, and skills, is still a scarce production factor. China's wage system reforms has played an important role in increasing the effective labor supply by linking workers' performance with payment. In the next two decades, the effective labor supply is projected to increase continually because (1) there is still substantial room for further reforms of the Chinese wage system that will lead to pay scales more closely related to employee productivity; (2) the relaxation of migration controls from rural to urban areas will accelerate the flow of labor to the more productive urban areas; (3) Chinese state enterprises are over-staffed and labor system reforms will move millions of these workers into more productive activities; (4) differentials in personal income will increase and develop peer pressure on workers to work harder, learn more skills, and earn more money; and (5) at China's low personal income level, the Chinese people are willing to trade leisure for more income as wages increase. In 1995, per capita annual income averaged only 3,855 yuan ($465) for urban residents, and only 1,550 yuan ($186) for rural residents.

<u>The Effective Capital Stock.</u> The effective capital stock, which is a combination of nominal capital and the effectiveness of the capital being employed, has also increased dramatically due to financial sector reforms, the rapid growth of foreign investments, and the high national savings rate. In the next two decades, the effective capital stock is expected to continue its rapid growth because (1) a large potential to improve the efficiency of China's financial system still exists; (2) foreign investment will continue to increase rapidly; and (3)

China's high savings rate is not expected to decrease, at least in the near future.

Under the old central planning system, all major investments came from central government allocations. Enterprises which received the allocations did not need to repay the funds to the state and were not responsible for losses. As a result, very often the funds allocated by the government were not used efficiently. Many projects were invested without careful feasibility studies. Since 1979, government allocations of funds have been gradually substituted by loans, which in principle should be repaid. This reform has provided the enterprises with an incentive to utilize government funds more carefully and improved the efficiency of capital utilization. However, there are still substantial rooms to improve China's financial system.

Before 1994, China's financial reform took place without any clear objectives or a clear direction. Financial reform in 1994, however, was guided by a clear blueprint in the right direction to improve the efficiency of China's financial market. According to the decision adopted by the Third Plenum of the 14th CPC Central Committee, which met in late 1993, the blueprint of financial reform is as follows: (1) Turn the People's Bank of China into a bona fide central bank that genuinely fulfills its duties and responsibilities of formulating and implementing monetary policy, maintaining currency stability, and strictly supervising and monitoring financial institutions to ensure that the financial system operates soundly. (2) Set up policy-oriented banks. Separate policy-oriented banks from commercial banks to put an end to the longstanding problem of specialized state banks having to wear two hats. Institutionally separate the direct links between policy-based loans and the basic currency of the central bank to ensure the central bank's initiative in regulating and controlling the basic currency. (3) Transform specialized state banks into bona fide commercial banks which should operate with the mechanism of a modern commercial bank. (4) Establish a family of financial markets that is unified and open and encourages orderly competition. (5) Reform the foreign exchange control system and bring about the free convertibility of the renminbi (RMB) as soon as possible. (6) Guide the healthy and stable development of nonbank financial institutions properly. And (7) accelerate legal financial construction (He Dexu, in *Economic Dynamics*, March 18, 1995).

Despite some successes, financial reform in 1994 did not produce any significant breakthroughs overall. A number of deep-seated problems which lie at the heart of the financial system have remained intact. As China's central bank, the People's Bank of China has yet to change its organizational structure due to social and economic pressures. Thus, it still lacks the authority to independently formulate and implement a monetary policy and to carry out various macroeconomic regulatory and control measures. The indirect tools available to the central bank to effect regulation and control, such as the reserve fund rate, relending rate, open market operations, and the discount rate, exist only on paper. Even interest rates have not been deployed flexibly to meet the demands of a developing economy. The central bank has to continue the traditional practice of relying on scale control and other administrative means, thus severely undermining the effectiveness of macroeconomic financial regulation and control. In 1995, the "PRC People's Bank of China Law" was approved at the National People's Congress. Promulgation and implementation of the law marks a step toward the building of a legal system for China's finance sector. Along with the reorganization of the central bank, the tools of macroeconomic financial regulation and control will be improved in the near future.

The specialized banks, namely the Commercial and Industrial Bank, the People's Construction Bank, the Agricultural Bank, and the Bank of China, constitute the mainstay of the country's financial system. The four major specialized state banks employ 90 percent of all personnel in the financial industry, account for 98 percent business outlets, 84 percent of assets, and 75 percent of all loans made in China. The extensive monopoly of the four specialized banks enables them to enjoy relatively high monopoly profits, and limits their initiative and efficiency. Currently, China's fund management is still achieved by controlling total volume. The central government lays down the total amount of lending in its plan and every specialized bank must strictly abide by scale control, in effect overlooking the security, liquidity, and profitability of the loans.

Although some moves were made in 1994 to reform the specialized banks, no substantial progress has been made in the conversion of state specialized banks into commercial banks. Through the establishment of three policy-lending banks in 1994 (the State Development Bank, the China Import-Export Bank, and the China Agricultural Development Bank), the specialized banks were liberated from government mandatory lending burdens; however, the specialized banks still have to make loans to state enterprises, both efficient and inefficient ones alike. Of the 2.4 trillion yuan ($289 billion) worth of bank loans currently outstanding, at least 20 percent are problematic loans. They were borrowed years ago and have become practically uncollectible.

With the deepening of financial reforms and the building of merger and bankruptcy methods, the specialized banks will gradually develop into commercial entities operating on internationally accepted practices. China plans to convert its specialized banks into real commercial entities by the turn of the century. The first commercial banking law, which was approved in May 1995, will help facilitate the transformation process. In January 1996, China's first non-state bank, China Minsheng Banking Corporation (CMBC), was established. This move is regarded widely as an important step in China's financial reform since it is the first bank to be set up after the promulgation of the country's Commercial Bank Law in 1995. The bank will start with a modern management system.

Because the links between budget deficits and the central bank's money supply were severed, the Ministry of Finance can no longer overdraw its account with the central bank. To cover the gap between government revenue and expenditures, the government now has to issue treasury bonds. However, the regularization of the capital market has made very slow progress. A sharp increase in the amount of treasury bonds issued (already reaching $12.3 billion) occurred in 1994, but the methods of issue have hardly been improved and a lack of diversity continues to characterize the interest rates they carry, their maturing periods, and the mix of investors. In the future, the bond market is expected to be improved, with the methods of issue and the interest rates better aligned with market principles, and the mix of bond holders more favorable to having the central bank conduct open market operations.

The shareholding system is being introduced in state-owned companies throughout China, which will provide another channel of capital investment. At the end of 1994, China had 15,000 limited-liability joint-stock companies and 17,000 limited-liability companies. Nevertheless, the stock market has even more problems than other financial markets. There is a surfeit of agencies involved in its management. Speculation is rampant. Companies whose stock are traded on the market are not of high quality. Intermediary organizations on the market lack self-discipline. To solve these problems, the stock market will be further standardized. With this large potential for improvements, China's further financial reforms are expected to substantially increase the utilization efficiency of China's capital stock.

Rapid foreign investment growth is another important factor which contributed to the rapid increase in China's effective capital stocks. In 1986, there were only 1,498 direct foreign investment projects in China ($2.8 billion contract value). Foreign investment has grown steadily since then. While investment growth leveled off in 1989 and 1990, it increased again in 1991 (Figure 1.8).

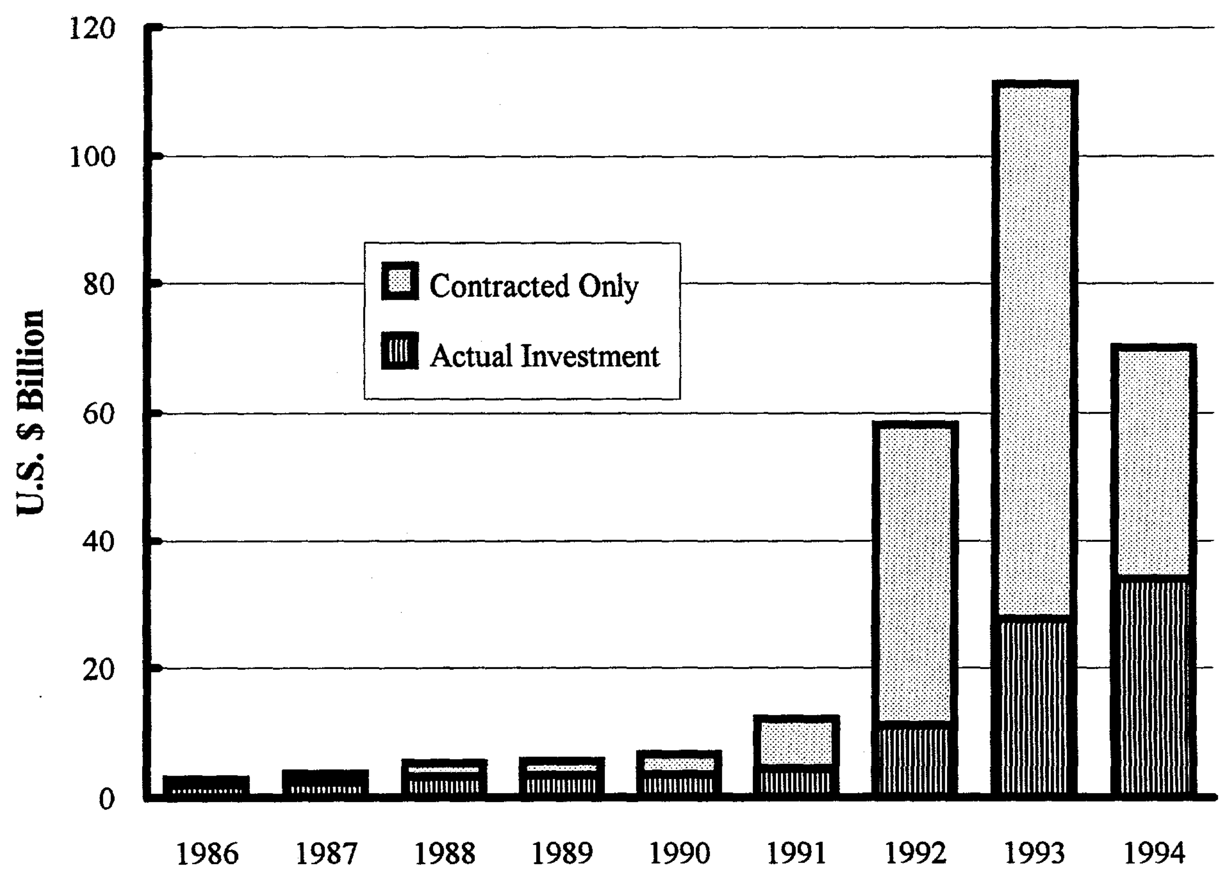

Figure 1.8. Direct Foreign Investment in China

Since 1992, aided by the "grand tour" of the South by Deng Xiaoping, local governments throughout China have been actively soliciting foreign investment. Consequently, foreign investment in China has boomed. In 1992, 48,764 investment projects worth $58 billion in contract value were concluded, and in 1993 a total of $111 billion in contract value were concluded. Actual direct foreign investment increased 150 percent from $11 billion in 1992 to $27.5 billion in 1993.

The foreign investment boom during the 1992-1993 period, especially in 1993, was primarily led by heated speculation in real estate. Among the 83,437 new projects approved in 1993, about 11,400 were real estate business involving $44.5 billion in contracted foreign capital. Although contracted foreign investment ballooned by 150 percent in 1992 and 1993, only one quarter of the funds were actually invested, partly because the Chinese side did not come up with their promised funds.

The contracted foreign investment decreased in 1994 and 1995, partly because of China's restriction on real-estate developments, but actual investment increased. In 1994, the contract value of direct foreign investment dropped to $70 billion, though actual direct foreign investment increased to $33.8 billion. In 1995, actual foreign investment increased to $37 billion, and the country's foreign exchange reserves exceeded $70 billion by the end of the year. Actual foreign investment is expected to continue its increasing trend as more and more contracted foreign investments become actually invested.

Foreign investments are gradually changing from the old labor-intensive processing sectors to financial and commercial sectors. The influx of labor-intensive firms from Hong Kong, Taiwan, and Macao has virtually stopped. However, some sectors which used to reject foreign investors have opened in order to attract more overseas investment and introduce advanced technology and management. These sectors include aviation, transportation, commerce, foreign trade, finance, insurance, stocks, accounting and auditing, legal consultation, and diamond and jewellry exploitation and processing. In an effort to make its industrial policies more transparent, China published a guidebook to identify the sectors in which foreign investment is encouraged, restricted, or prohibited. In manufacturing sectors, where domestic technology has matured, such as in the manufacture of home appliance like colour TVs, washing machines, and air-conditioners, care must be taken in absorbing foreign investment to avoid surplus production capacity.

Recently, the attention of overseas investors has started to shift from the coastal regions to the relatively backward central and western regions. From 1991 to 1994, the share of foreign investment in the coastal region decreased from 92.5 percent to 87.8 percent. The share is expected to decrease to 80 percent in 1996. Investors extended their reach to the inland regions where labor and raw materials are cheaper.

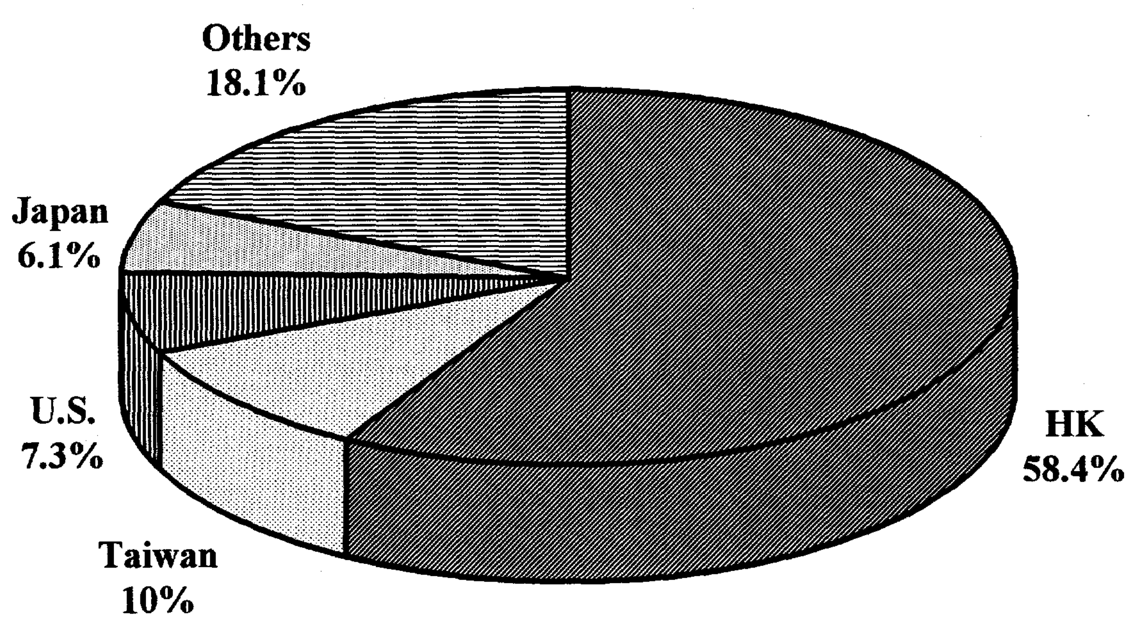

Figure 1.9. China's Direct Foreign Investment in 1994

China's direct foreign investments mostly come from the Chinese diaspora. Figure 1.9 shows that Hong Kong and Taiwan accounted for about 70 percent of direct foreign investment in 1999. In 1994, contracted investment from Hong Kong was $48.7 billion, accounting for about 70 percent of total overseas investment. Taiwan is now the second-largest external investor on the mainland China. By the end of September, 1995, accumulated projects involving Taiwan investment reached 31,104, with contracted investment reaching $28.85 billion. Taiwan's actual investment on the mainland amounted to $11.15 billion (*China Daily* January 2, 1996). Recently, direct investment from the United States is also increasing. So far, U.S. investors have been involved in more than 16,200 projects with an accumulated contracted investment of more than $20 billion, making the United States the third largest investor in China, after Hong Kong and Taiwan.

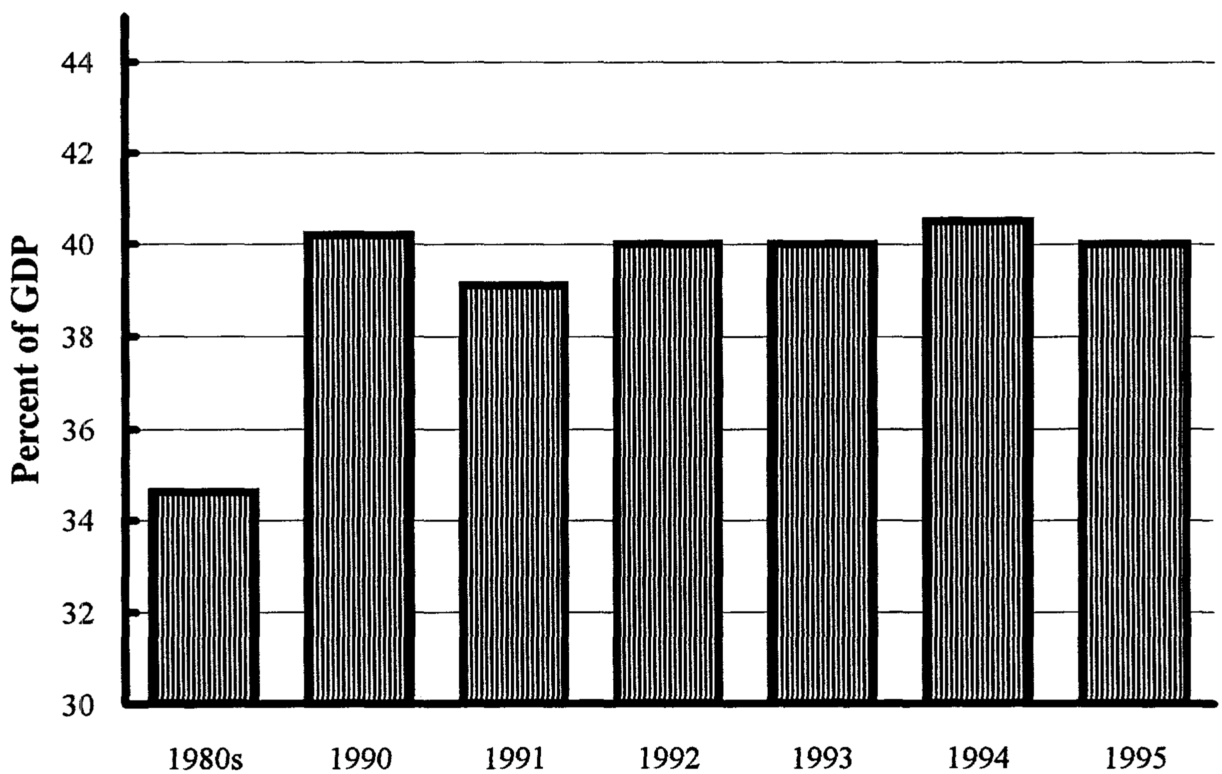

Figure 1.10. China's Gross Domestic Saving as Percent of GDP, 1980-1995

China's high savings rate is also an important contributor to increases in its capital stocks. Figure 1.10 shows that China's gross domestic savings has been around 40 percent of

GDP since 1990. China's total amount of urban and rural savings deposits reached 3,329.6 billion yuan ($401 billion) by the end of March 1996. There are several reasons behind China's high savings rate including (1) China's consumer goods consumption is now in the stage that has a high savings rate; (2) China's social system reforms have caused a higher level of saving; and (3) the Chinese savings psychology is in favor of saving rather than consuming.

People's demand for commodities come in stages. At the present, most Chinese urban households have satisfied their medium-level commodity demand, such as a color TV or a refrigerator, but have not attained the higher consumption level of buying houses (at the market price) and cars. Therefore, people tend to save more and spend less.

The social system reforms have a propounding effects on households' saving behavior. Before the reforms, the government was responsible for education, health care, retirement, and even housing for state employees. The reforms on publicly funded medical care, education, housing, and the pension system, although still in the early stages, have switched much of the governmental responsibilities to the private sector. Now the elderly cannot rely solely on pensions and limited public health care; young people are thinking about buying houses, and they have to save enough money to support the education of their children.

Inflation and Its Effects on Power Development

As shown in Figure 1.11, prior to 1994, China's highest inflation rate was 18.5 percent in 1988, the high inflation rate in 1988 was believed to have contributed to the Tiananmen Square Incident in 1989. Since January 1994, China's inflation rate has been above 20 percent. In October 1994, inflation had climbed to a record 27.7 percent (*China Daily* December 23, 1994). Naturally the high inflation rate has caused serious concern to the Chinese government. A series of anti-inflation measures were adopted including strict control of the scale of investment in fixed assets, a tight monetary policy, and direct price controls on selected commodities. Although the inflation rate decreased to 14.8 percent in 1995, the Chinese government still plans to continue its tight financial and monetary policy in 1996 (*China Daily* January 3, 1996). Since China's inflation problem and the administrative means to control inflation have very serious implications on both the Chinese economy and foreign investors, a closer examination of the nature and causes of China's recent high inflation rate is critical in shaping the strategies of foreign investors in China.

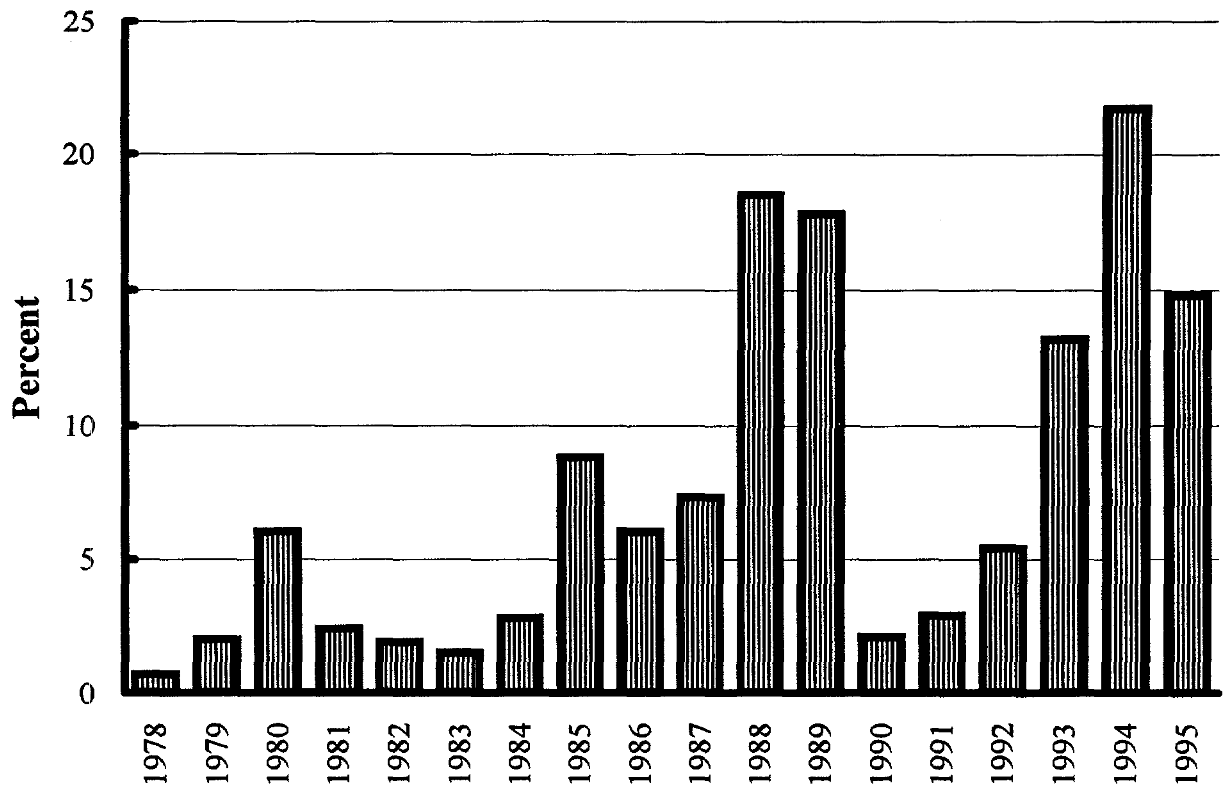

Figure 1.11. China's Overall Retail Price Index, 1978-1995

The inflation in 1994 was entirely different from that of 1988. In the 1988 inflation, retail sales prices, food prices, non-food prices, and production material prices increased uniformly. Excess demand in almost all commodities led to panic purchasing and bank rushes, which in turn generated further excess demand. The 1994 inflation was associated with a calm, even sluggish, market. It was caused mainly by price hikes of basic living necessities, which accounted for 70 percent of the increase in the retail price index (FBIS March 16, 1995). There is little elasticity in the consumption of such commodities. For example, prices of agricultural products increased about 60 percent in 1994 and were responsible for 13 percentage points of the 1994 inflation, while the supply and demand of industrial goods were basically balanced. Some traditionally short-in-supply industrial goods, such as steel, were in excess supply.

Tight fiscal and monetary policies may have a short term effect on inflation caused by overheated investment. However, a belt-tightening policy on all investment projects, good and bad alike, will probable do more harm than good. Inflation in China is essentially institutional, but it is also demand-led, cost-driven, and structural. The key to reducing China's inflation rate is a healthy economic growth. China's electricity shortages have certainly contributed to the structural inflation.[1]

In a speech on the national economic situation on May 28, 1995, Chinese Vice-Premier Zhu Rongji urged governments at all levels to give priority to the control of inflation and take strict measures to control the investment scale in fixed assets (Zhu 1995). Anti-inflation measures have affected the power sector development seriously. Total fixed asset investment in China's power industry in 1995 is about one-fourth less than that of the 1994 level in constant value (Ministry of Electric Power 1995), and many power projects are suspended. Price controls on electricity and the Chinese government's attempts to cap the rate of return of foreign investors in China's power sector at 12-15 percent has started to scare away foreign investors. The combined effects are expected to exacerbate China's electricity shortage and negatively affect the country's economic growth. Threatened by the damages of electricity shortages, many local governments have started to build small power plants to avoid central government interferences; however, the efficiency of small power plants are typically lower than large ones.

In order to reduce the investment scale in fixed assets, a total of 67.6 billion yuan of investment in power construction projects are scheduled in 1995, reflecting a one-fourth reduction from the 1994 level (in constant value). The reduction in power project investments will postpone about 20 GW power projects which are currently under construction. Some projects will have to be suspended, and new large and medium sized power projects will not be

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[1] Structural inflation occurs when some key sectors fail to meet demand, resulting in bottlenecks and in turn driving up the prices of other products.

started in 1995, although the installed capacity and generation targets set by the Eighth Five Year Plan (1991-1995) can be achieved. The actual capacity of power projects under construction can only meet about half of the planned target, and the investment in the transmission and distribution system is also much lower than planned (Ministry of Electric Power 1995). The effects of reduced power sector investment will become more obvious in the near future, as newly completed capacity in 1996-1998 will be reduced to about 10 GW per year (Shi 1995), which is substantially below the projected demand for new capacity of 17 GW per year (Li and Johnson 1994a).

For political reasons, the Chinese government is desperate to reduce the current high inflation rate, which cannot be reduced by sacrificing the development of the power industry and/or squeezing the profitability of foreign investors. As indicated by a Chinese economist: "Inflation in China is described as essentially institutional because the macroeconomy lacks a microeconomic base that is compatible with a market economy (Li 1994)." Although China's inflation is also contributed by excessive investment, the main reason behind the irrational investment is that many local governments and state enterprises do not assume the risk of investment nor do they worry about the returns on their money. Reportedly, by the end of 1993, the enterprises owned by the Ministry of Electric Power Industry had lent 7 billion yuan ($842 million) to other sectors, while the annual return of these loans was less than 1 percent (Shi 1995).

We believe that trying to reduce China's high inflation rate by sacrificing the development of the power industry and squeezing the profitability of foreign investors is a policy mistake, and the costs of the mistake are likely to be paid in the near future. Unless China changes its policies, its power sector will remain an unpleasant environment for foreign investors. However, China's unfavorable investment climate is caused, to a large degree, by policy mistakes rather than the fundamentals, and policy mistakes are able to be corrected overnight. We believe that China will change its policies when the pressure of power shortages becomes more obvious in the near future.

China's Foreign Trade

China's outward-looking policy has achieved great success. Figure 1.12 shows that between 1980 and 1995 the value of total exports increased from $18.12 billion to $148.77 billion, averaging 15 percent per year, and the value of total imports increased from $20.02 billion to 132.08 billion, averaging 13.5 percent per year.

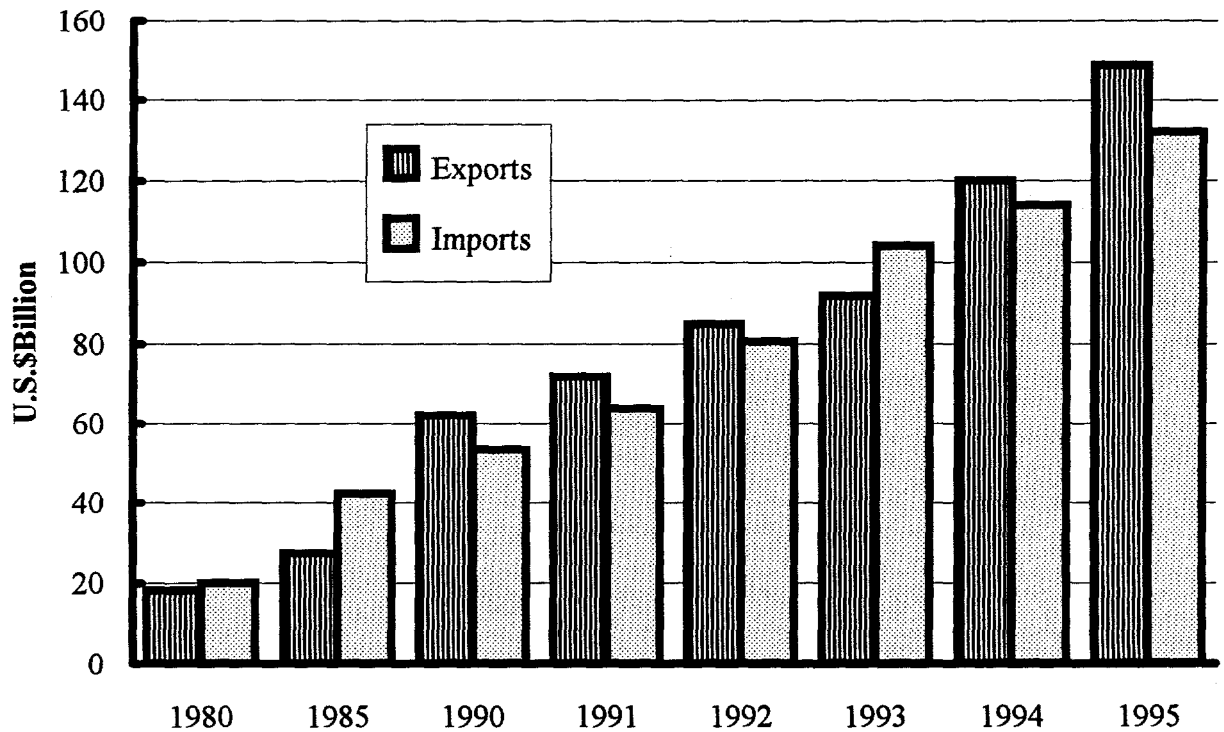

Figure 1.12. China's Foreign Trade

Historically, most Chinese-produced goods had a reputation for being cheap but low quality. This type of goods is called "inferior goods" which is defined as the commodities whose demand decreases as consumers' income level increases. The low quality level harmed their demand in the international market. The lack of marketing experiences is also an obstacle to faster growth of China's foreign trade. As a result, China's foreign trade was historically heavily dependent on the trade of primary products, such as fossil fuels, food, and live animals. Growth in primary product export is limited by resource availability and is typically slow.

According to international trade economics, China has a clear relative advantage in producing labor intensive goods. This relative advantage and the open-door policy adopted by the Chinese government has attracted many foreign investors. Advanced technologies and management skills rushed into China with foreign capital, and improved the quality of Chinese goods, as well as the marketing skills. Of China's $148.77 billion in total exports in 1995, about $47 billion were exported from foreign-funded firms.

Other factors which have contributed or will contribute to the improvement of China's human capital and skill level of employees include the following:

(1) Under the old residential control system and dramatic differences in living standards among cities and rural areas, many capable and talented people were crowded in major cities and wasted their human capital. The relaxation of residential control makes reallocation of human capital possible.

(2) The old Chinese educational system was isolated from production sectors; as a result, many Chinese college students find their training not very useful in their work. Since most Chinese students will have to find jobs themselves instead of being allocated by the government, the links between education and production will be closer.

(3) The young generation of Chinese students are among the most hard working students in the world, this will improve the quality of Chinese employees.

With the improvement of the quality of Chinese goods and marketing skills, China's exports have increased and the dependence on primary products decreased. Table 1.2 shows the composition of imports and exports. Between 1980 and 1995, the share of primary product exports decreased dramatically from 50 percent to 14 percent while the share of primary product imports decreased from 35 percent to 18 percent. Increases in manufacturing product exports were mainly caused by increased exports of miscellaneous manufactured articles, machinery, and transport equipment. Increases in manufactured product imports were mainly led by increased imports of machinery and transport equipment. Major commodities imported (above $1 billion) include: airplanes, automobiles, steel products, crude oil, oil products, chemical fertilizer, chemical raw materials, and equipment sets.

Table 1.2. Composition of China's Imports and Exports

	Export (in $million)		Growth (%/yr)	Import (in $million)		Growth (%/yr)
	1980	1995	80-95	1980	1995	80-95
Total	18119	148770	15.1	20017	132078	13.4
1. Primary products	9114	21486	5.9	6959	24411	8.7
Food and live animals	2985	9954	8.4	2927	6131	5.1
Beverages and tobacco	78	1369	21.0	36	393	17.3
Inedible raw materials	1711	4374	6.5	3554	10158	7.3
Fossil fuels, lubricants and related	4280	5334	1.5	203	5127	24.0
Animal and vegetable oils	60	454	14.4	239	2601	17.2
2. Manufacturing products	9005	127283	19.3	13058	107668	15.1
Chemicals and related products	1120	9094	15.0	2909	17300	12.6
Manufactured goods classified	3999	32243	14.9	4154	28772	13.8
Machinery and transport equipment	843	31391	27.3	5119	52638	16.8
Miscellaneous manufactured articles	3043	54549	21.2	876	8265	16.1
Share in Total Value	Export (%)		Changes in Share	Import (%)		Changes in Share
	1980	1995	80-95	1980	1995	80-95
1. Primary products	50	14	-36	35	18	-16
Food and live animals	16	7	-10	15	5	-10
Beverages and tobacco	0	1	0	0	0	0
Inedible raw materials	9	3	-7	18	8	-10
Fossil fuels, lubricants and related	24	4	-20	1	4	3
Animal and vegetable oils	0	0	0	1	2	1
2. Manufacturing products	50	86	36	65	82	16
Chemicals and related products	6	6	0	15	13	-1
Manufactured goods classified	22	22	0	21	22	1
Machinery and transport equipment	5	21	16	26	40	14
Miscellaneous manufactured articles	17	37	20	4	6	2

Source: China's Customs Statistics December 1995; and China Statistical Yearbook 1994.

Key Manufacturing Industries

The Chinese economy is categorized into three sectors: the primary sector includes agriculture, forestry, animal husbandry, household sideline production, and fisheries; the secondary sector includes all manufacturing industries and the construction industry; and the tertiary sector includes services, transportation, commerce, public services, and all others. Between 1980 and 1994, the share of the primary sector in total GDP decreased from 25.6 percent to 21 percent; the share of the secondary sector increased from 51.7 percent to 54 percent; and the share of the tertiary sector increased from 22.7 percent to 25 percent.

Industry is the backbone of the Chinese economy. As shown in Figure 1.13, the role of industry in the Chinese economy is more important than in other Asian economies. The industrial sector accounted for about 72 percent of total energy consumption and about 75 percent of electricity consumption in 1994.

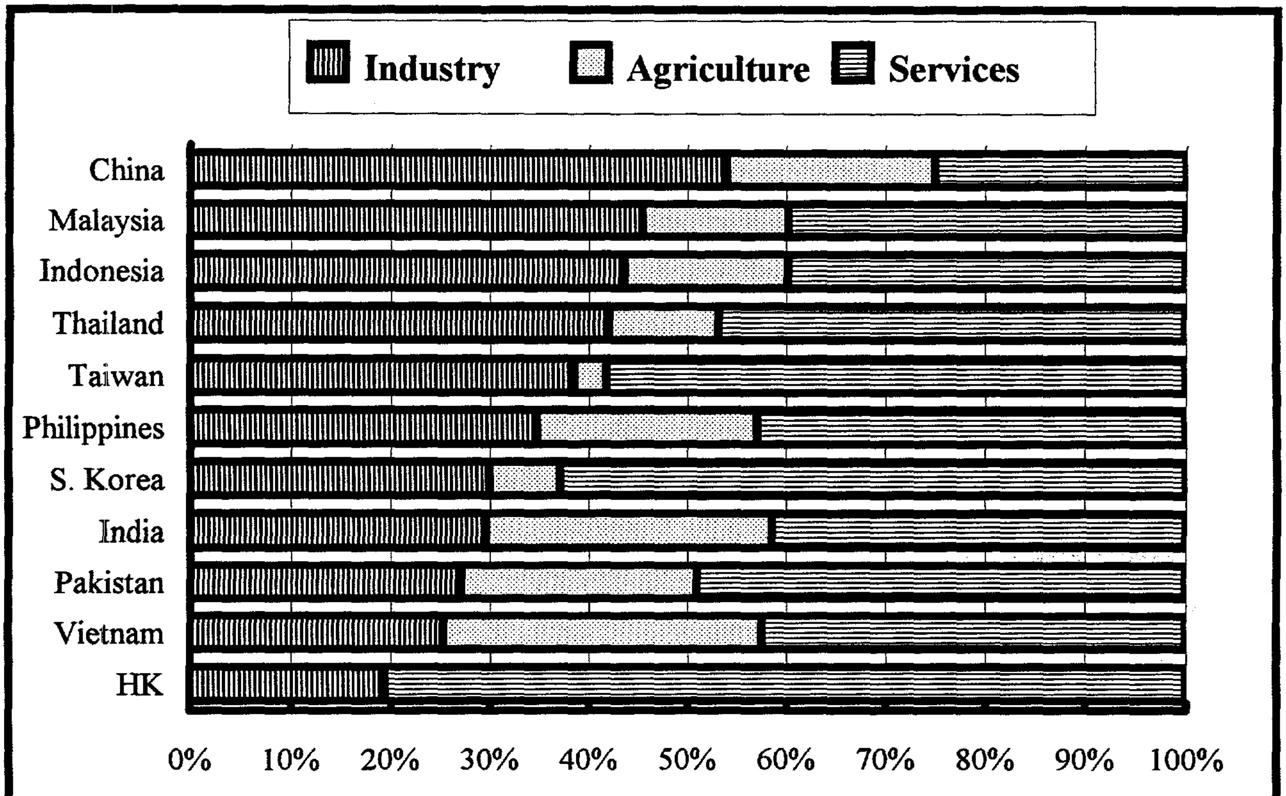

Figure 1.13. Sectoral Share of GDP in 1994

In general, capital intensive heavy industry, which includes mining, raw materials, and processing, is more profitable than light industry. As shown in Table 1.3, China's heavy industry accounts for 58 percent of total industrial output value and 62 percent of total pre-tax profits. However, the profitability within the heavy industry is uneven. Mining accounts for about 6 percent of industrial output value and 9 percent of pre-tax profits, raw materials account for 24 percent industrial output value and 31 percent of pre-tax profits, and processing accounts for 28 percent industrial output value and 22 percent of pre-tax profits.

Table 1.3. Industrial Output Value and Profits in 1994

	Output Value		Pre-Tax Profits	
	(Billion yuan)	(%)	(Billion yuan)	(%)
Total	5135	100	494	100
Light Industry	2167	42	185	38
Heavy Industry	2968	58	308	62
Mining	324	6	47	9
Raw Materials	1223	24	154	31
Processing	1421	28	107	22
Branch of Industry				
Machine, Equipment, Electronics	1170	23	87	18
Textile, Garments, Fiber Products	723	14	31	6
Food, Beverage, Tobacco, Forage	531	10	86	18
Chemicals and Allied Products	468	9	38	8
Ferrous Metal Processing	417	8	53	11
Nonmetal Mineral Products	300	6	31	6
Power, Steam, and Hot Water	202	4	45	9
Petroleum Processing	188	4	22	5
Metal Products	171	3	11	2
Plastic and Rubber	148	3	9	2
Oil and Gas Extraction	136	3	28	6
Non-Ferrous Metal Processing	120	2	8	2
Coal Mining and Processing	104	2	9	2
Paper Making and Paper Products	76	1	5	1
Others	383	7	30	6

Source: China Statistical Yearbook 1995.

Within the industrial sector, the machinery industry (including machine building, transportation equipment, electrical equipment, electronic and telecommunication equipment, instruments, meters and other measuring equipment) is the top contributor to industrial output value (23%); followed by textile, garment and fiber products (14%); food, beverage, tobacco, and forage (10%); chemicals and allied products (9%); and ferrous metal processing (10%). The power industry, which accounts for more than 18 percent of industrial capital assets, only accounts for 4 percent of the industrial output value and 9 percent of the pre-tax profits.

In terms of primary energy consumption (excluding energy converted into secondary energy), the top five industries are the chemical industry, the iron and steel industry, the construction materials industry, the mining industry, and the power industry (Table 1.4).

Between 1980 and 1994, China's chemical fertilizer production increased from 12 million tons (Mt) to 22.7 Mt (4.7% per year), steel production increased from 37 Mt to 92.6 Mt (6.8% per year), and cement production increased from 80 Mt to 421.2 Mt (12.6% per year). China's regional production of major industrial products is shown in Table 1.5.

The rapid growth of the industrial sector has laid the foundation for a sustained economic growth in the future.

Table 1.4. Major Energy Consuming Industries in China

	Percent of Total Consumption (%)					Total
	Chemical and Allied	Ferrous Metals	Construct. Materials	Mining	Electricity Generation	Consumption
Energy*						(MTCE)
1985	10.6	10.0	10.5	7.5	3.3	767
1990	11.1	10.7	9.8	7.9	3.9	987
1994	13.2	12.5	10.2	7.8	5.4	1227
Coal						(Mt)
1985	6.4	8.0	10.6	7.7	20.4	816
1990	6.9	7.7	9.4	8.4	25.6	1055
1994	7.5	9.0	9.5	8.6	31.4	1285
Fuel Oil						(Mt)
1985	14.2	10.9	8.8	2.2	33.6	28
1990	16.3	12.8	9.2	4.2	24.2	34
1994	13.8	13.2	9.0	6.3	22.9	36
Gasoline						(Mt)
1985	3.4	1.3	3.2	7.0	0.6	14
1990	3.0	1.5	2.9	6.8	0.7	19
1994	2.2	1.5	2.8	4.9	1.1	27
Diesel						(Mt)
1985	7.7	0.9	3.0	4.3	6.7	19
1990	2.6	1.2	3.1	5.5	5.0	27
1994	2.7	1.4	2.6	5.8	7.1	38
Natural Gas						(BCM)
1985	32.0	4.0	1.4	28.7	4.5	13
1990	31.8	6.2	1.7	24.8	1.8	15
1994	38.0	1.7	1.2	31.5	1.6	17
Electricity						(TWh)
1985	12.5	8.8	5.4	10.5	14.3	412
1990	11.8	8.9	5.3	10.8	14.2	623
1994	10.1	9.6	6.2	8.3	15.1	926

* Total energy consumption excludes energy converted into secondary energy.

Source: China Statistical Yearbook, 1995, 1992.

Table 1.5. Major Industrial Products Production by Province

	Production in 1994					
	Fertilizer 1,000 tons	Steel Mt	Cement Mt	Fiber 1,000 tons	TV Million	Automobile 1,000
China	22728	92.6	421.2	2803	32.8	1367
Beijing	96	8.3	5.3	35	0.9	147
Tianjin	158	1.9	1.8	91	1.2	123
Hebei	1510	7.2	26.9	62	0.2	24
Shanxi	847	3.3	10.4	29	0.0	3
Inner Mongolia	179	3.4	3.1	7	0.4	0
Liaoning	791	13.4	18.9	179	0.5	32
Jilin	311	1.1	6.4	55	0.1	189
Heilongjiang	410	1.1	6.7	125	0.2	24
Shanghai	260	13.3	3.8	325	5.0	118
Jiangsu	1531	3.3	30.9	743	5.0	130
Zhejiang	741	1.4	27.0	264	4.1	20
Anhui	1960	3.1	16.4	20	1.0	37
Fujian	473	0.6	11.0	50	1.7	3
Jiangxi	318	1.5	9.1	53	0.6	45
Shandong	1663	3.8	50.7	139	1.1	15
Henan	1897	2.4	30.0	78	0.3	16
Hubei	1575	7.2	15.2	46	0.3	180
Hunan	1277	2.2	20.0	44	0.3	15
Guangdong	538	1.8	50.2	281	5.4	24
Guangxi	382	0.8	17.1	22	0.3	72
Hainan	5	0.0	1.4	16	0.0	3
Sichuan	2307	6.6	24.9	71	2.7	106
Guizhou	536	0.7	4.6	5	0.5	4
Yunnan	1051	1.4	8.7	8	0.1	26
Shaanxi	599	0.6	9.2	26	0.7	13
Gansu	339	1.2	5.2	20	0.1	0
Qinghai	284	0.5	0.6	0	0.0	0
Ningxia	345	0.0	1.4	3	0.0	0
Xinjiang	346	0.7	4.5	5	0.0	0

Source: China Statistical Yearbook, 1995.

Elasticity of Electricity

Unlike most developing economies, China's average electricity growth rate has been below its economic growth rate during the past 15 years. As shown in Table 1.6, China's elasticity of electricity to GDP during the 1980-1995 period was only 0.85, the second lowest after Japan among the 12 major Asian-Pacific economies, and also the lowest in Chinese history.

Table 1.6. Electricity Elasticity in Asian-Pacific Economies

	GDP Growth 1981-1995	Capacity Growth 1981-1995	Elasticity 1981-1995
Japan	3.8	3.0	0.80
China	9.7	8.2	0.85
Taiwan	7.5	6.5	0.86
Australia	3.0	2.9	0.98
South Korea	8.4	8.3	0.99
Hong Kong	6.5	6.9	1.06
Thailand	8.0	9.9	1.24
India	5.2	7.1	1.36
Malaysia	6.2	8.7	1.40
Vietnam	7.4	12.5	1.69
Indonesia	5.9	10.3	1.74
Philippines	1.4	4.8	3.42
	GDP Growth	Capacity Growth	Elasticity
China			
1952--1970	6.2	15.2	2.46
1971--1980	5.8	10.7	1.86
1981--1985	10.1	5.7	0.57
1986--1990	7.8	9.6	1.24
1991--1995	11.3	9.2	0.81

An important reason for the low elasticity of electricity is that electricity supplies have increased at a slower rate than demand, which has brought about great economic losses. Due to power shortages, power consumption represents power supply instead of power demand.

Due to generating capacity shortages, industrial electricity consumers are regulated in China to reduce the difference between peak and valley generation. This measure has contributed to China's high load factor. Figure 1.14 shows that China has the highest load factor among Asian economies. This has relieved, to a certain degree, the pressure of electricity (kWh) shortages, at the cost of more inconvenience to consumers and other associated social costs, for example the costs of an employee switching from a day-shift to a night-shift. The effectiveness of load control is affected by the share of residential electricity consumption. At China's current residential electricity consumption level, it is much more difficult to level off the load curve of residential consumers than that of industrial consumers. As shown in Figure 1.15, the share of residential electricity consumption in China is much lower than other major Asian economies. Since the share of residential electricity consumption is projected to increase in the future (see next section), it will be more and more difficult to keep a high load factor through load controls in China.

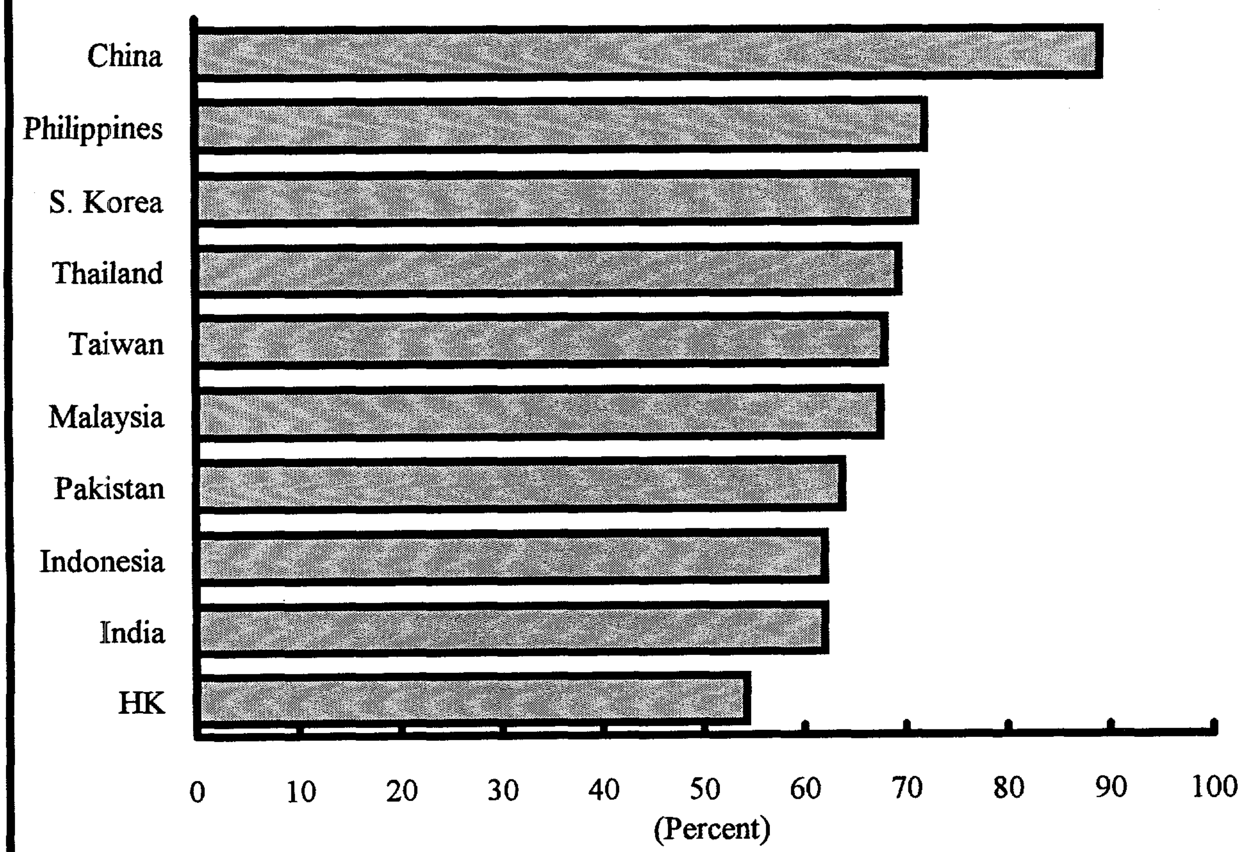

Figure 1.14. Load Factors of Asian Economies in 1990

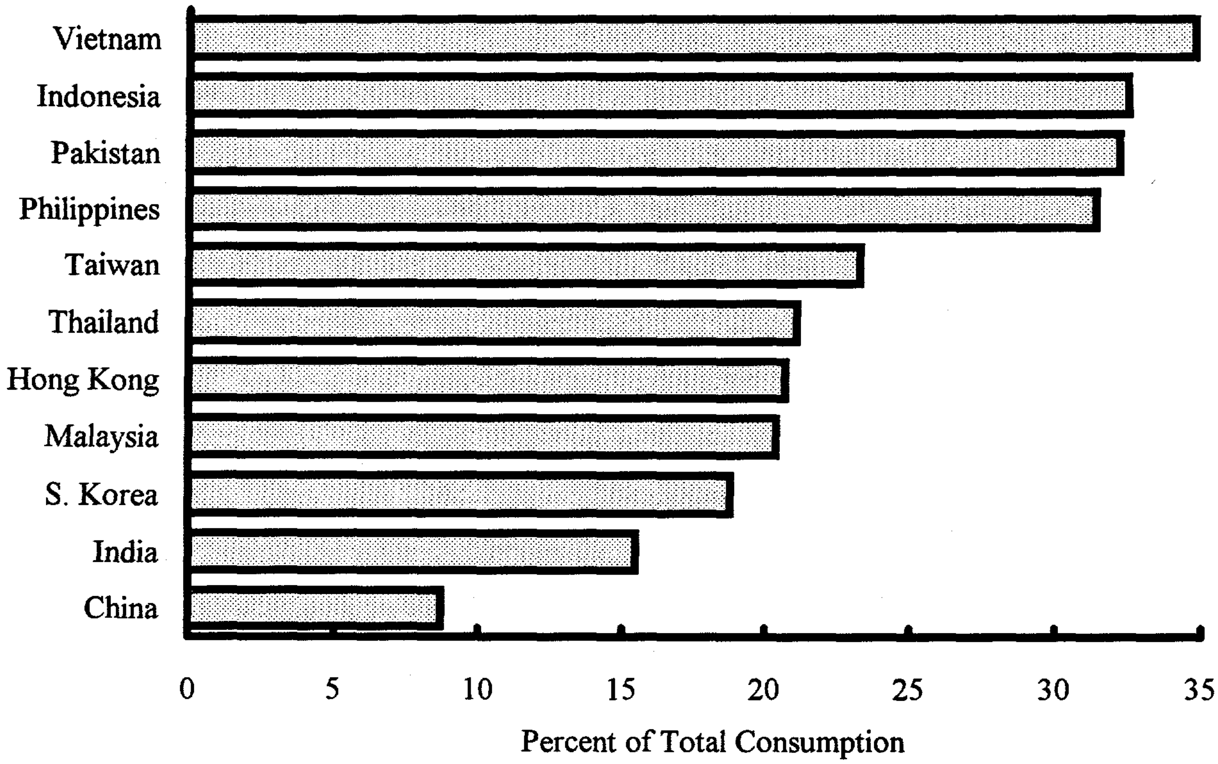

Figure 1.15. Share of Residential Electricity Consumption in Asia in 1990

Another reason that China has had a low elasticity of electricity during the past 15 years is the improvement of energy efficiency. Due to low energy prices, energy efficiency was low and consumers had very little incentive during the 1970s to reduce energy waste. Substantial reductions in unit energy consumption was possible because of the movement toward greater energy conservation in the 1980s. However, the easy gains in reducing energy waste of the past 15 years will be more difficult in the future.

As shown in Figure 1.16, China's electricity transmission and distribution (T&D) losses are quite modest compared with other Asian economies based on the land areas and the share of T&D system investment in total power investment. (See Chapter 4 for further discussion of T&D investment) The relatively low T&D losses have also contributed to a low electricity elasticity. However, the low T&D losses are caused by the fact that China's electricity is mainly used by industrial consumers, which have lower demands for electricity distribution than the residential consumers. As the share of residential electricity consumption increases, especially rural consumption, the T&D loss rate is projected to increase. Currently about 120 million rural people have no access to electricity. About one-third of China's 1,890 counties relay on small hydropower plants to supply electricity, and the per capita consumption level is very low. To achieve the target to provide 95 percent of rural households with electricity supply by 2000, the demand for T&D will increase substantially in the future.

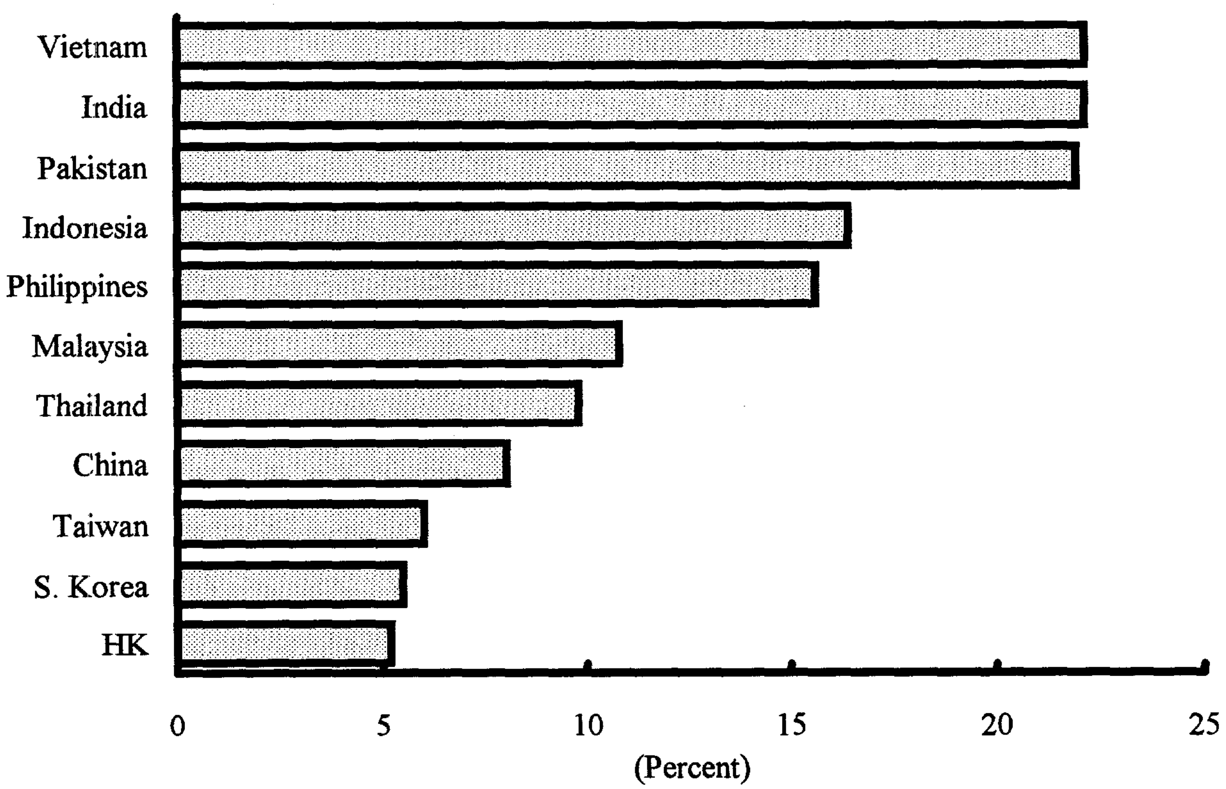

Figure 1.16. Transmission and Distribution Losses in Asia in 1990

For these reasons, we believe that the elasticity of electricity is unlikely to decline in the future. We assumed the elasticity about 1 in the high scenario. Under the medium scenario, we assumed the elasticity remain roughly at the current level in the short-term, but increase gradually to 1 in the long-term.

The Structure of Electricity Consumption

After the discussion of how much electricity will be needed to support China's economic growth, let us now turn to the question of how the electricity is consumed by sectors and by provinces.

As shown in Figure 1.17, China's electricity is mainly consumed by the industrial sector, which accounted for 75.4 percent of total electricity consumption in 1994. The shares of other sectors were: residential sector 9.4 percent, the agricultural sector 5.7 percent, and other sectors (including services, government, construction, transportation, and commerce) 9.5 percent. Within the industrial sector, heavy industry accounted for about 80 percent, while light industry about 20 percent.

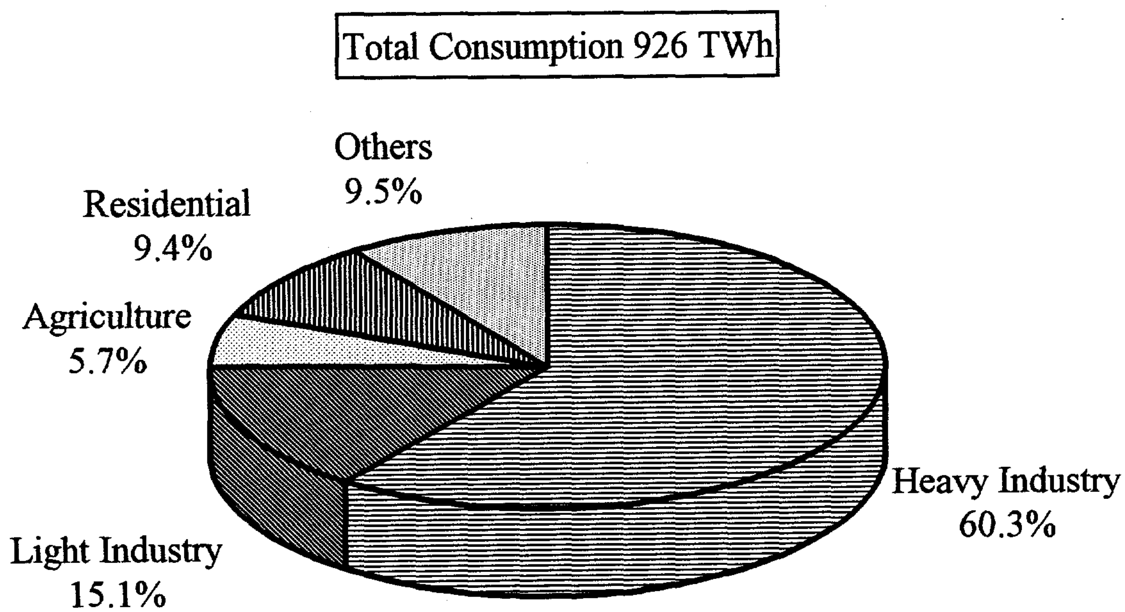

Figure 1.17. China's Electricity Consumption by Sector in 1994

The structure of electricity consumption has been changing rapidly over time. As shown in Table 1.7, between 1980 and 1994, the share of the agricultural sector decreased from 11 to 5.7 percent; the share of the industrial sector decreased from 80.2 to 75.4 percent; while the share of the residential sector increased from 3.5 to 9.4 percent. So far, the top five electricity consuming industries are the power industry (20.1%), the chemical industry (13.4%), the ferrous metal industry (12.7%), the mining industry (11%), and the building materials industry (8.2%). During the past decade, the shares of the power industry, the building materials industry, and the ferrous metals industry increased, while the shares of the chemical industry and the mining industry decreased.

As shown in Figure 1.18, the shares of the industrial and agricultural sectors' electricity consumption are projected to decrease to 54.5 and 2.7 percent respectively over the next two decades, while the shares of electricity consumption in the residential sector and others are projected to increase to 28 and 14.8 percent respectively.

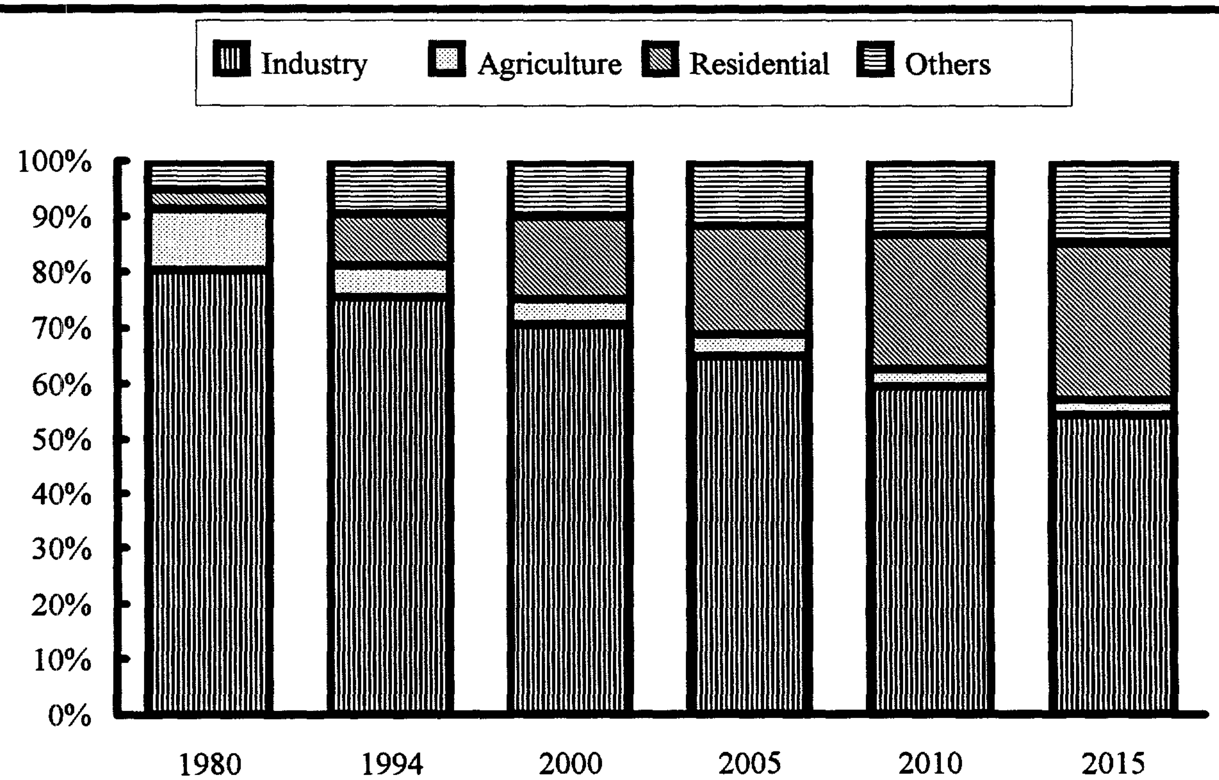

Figure 1.18. Projection of China's Electricity Consumption Pattern

Table 1.7. China's Electricity Consumption by Sector, 1980-1994

	1980		1994		Change in Share
	(TWh)	(%)*	(TWh)	(%)*	80-94 (%)
Total	300.6	100.0	926.0	100.0	0.0
(1) Material Production Sectors	283.2	94.2	800.7	86.5	-7.8
(a) Industry	241.1	80.2	698.3	75.4	-4.8
(b) Agriculture	33.1	11.0	53.1	5.7	-5.3
(c) Transportation	2.7	0.9	16.4	1.8	0.9
(d) Commerce	1.7	0.6	17.9	1.9	1.4
(e) Construction	4.7	1.6	15.0	1.6	0.0
(2) Nonmaterial Production Sectors	6.9	2.3	38.7	4.2	1.9
(3) Residential	10.5	3.5	86.7	9.4	5.9
Share of Consumption	1985**		1994		Change in Share
Within the Industrial Sector	(TWh)	(%)	(TWh)	(%)	85-94(%)
Total Industry	328.3	100.0	698.3	100.0	0.0
Power, Steam, and Hot Water	58.8	17.9	140.1	20.1	2.2
Chemicals and Allied Products	51.4	15.6	93.3	13.4	-2.3
Ferrous Metals	36.3	11.1	88.5	12.7	1.6
Mining	43.3	13.2	76.8	11.0	-2.2
Building Materials	22.2	6.7	57.4	8.2	1.5
Machine, Equipment, Electronics	32.0	9.8	47.8	6.8	-2.9
Non-Ferrous Metals	17.4	5.3	37.3	5.3	0.1
Textile	18.6	5.7	30.8	4.4	-1.2
Food, Beverage, Tobacco, Forage	10.9	3.3	26.7	3.8	0.5
Petroleum Processing	4.0	1.2	18.8	2.7	1.5
Paper Making and Paper Products	8.1	2.5	14.1	2.0	-0.4
Medical and Pharmaceutical	2.3	0.7	9.9	1.4	0.7
Chemical Fibers	3.3	1.0	8.9	1.3	0.3
Other Industry	19.8	6.0	47.9	6.9	0.8

* As percentage of China's total.

** The categorization of industries changed in 1985.

Source: China Statistical Yearbook 1995, 1987.

The Industrial Sector

Although industrial enterprises still consume the bulk of electricity, their share is expected to fall in the future, and the sector's annual growth rate is expected to decrease from 15 percent between 1987 and 1995 to below 10 percent in the 1996-2000 period, and even lower in the long term. The high industrial growth rate in the past nine years was largely due to the exceptionally strong demand for industrial products driven by the investment boom in 1992 and 1993. Investment growth on such a scale is not expected to be repeated.

Increased usage of more advanced equipment, which is generally more energy efficient, and the rapid development of export-oriented light industries that use much less electricity than heavy industries were largely responsible for the decline of the electricity consumption elasticity in the past few years. In fact, the share of light industry in total electricity consumption increased 2.3 percentage points from 12.8 percent in 1980 to 15.1 percent in 1994, while the share of heavy industry declined 7 percentage points from 67.3 to 60.3 percent. These factors will continue to affect the industrial electricity consumption, although to a lesser degree.

As an example, China has about 7 million industrial fans and 30 million pumps, which account for about 30 percent of China's total electricity consumption. The average efficiency of industrial fans is only 50 percent, while designed efficiency is 70 percent; the average efficiency of pumps is 41 percent, while designed efficiency is 65 percent (Wang 1993). Efficiencies of fans and pumps in developed countries are typically around 80 percent. The low efficiencies of fans and pumps are mainly caused by a mismatch of load, obsolete equipment, and poor maintenance. Today, China gives a high priority to the conservation of electricity in fans and pumps. Major energy conservation measures in this area include (1) selecting the right equipment that properly matches the load of the production system; and (2) encouraging the use of variable-speed technology. These measures can reduce electricity consumption by an estimated 20-30 percent.

Looking ahead, with the anticipated gradual liberalization of electricity tariffs, industrial enterprises are expected to further increase their use of more energy-efficient equipment. However, we do not expect a drastic decline in the electricity consumption elasticity in the industrial sector since heavy industries are likely to grow faster in the 1990s than in the 1980s, as heavy industry, a large consumer of electricity, plays a larger role.

As shown in Table 1.8, the growth rate of electricity consumption in the industrial sector was slightly below the overall electricity consumption growth rate over the 1980-1994 period, although the annual growth rate of the industrial sector was much greater than the overall economic growth rate. Industrial electricity consumption is projected to grow at 5.9 percent per year during the 1995-2000 period (compared with 7.1 percent overall electricity consumption growth rate), and reduce to 4.1 percent over the 2000-2015 period.

Table 1.8. Projection of Electricity Consumption by Sector

	Electricity Consumption Share (%)					
	1980	1994	2000	2005	2010	2015
Industry	80.2	75.4	70.5	65.0	59.5	54.5
Agriculture	11.0	5.7	4.5	3.9	3.2	2.7
Residential	3.5	9.4	15.0	19.5	24.0	28.0
Others	5.3	9.5	10.0	11.7	13.3	14.9
	Electricity Consumption TWh					
Industry	241	698	987	1215	1488	1815
Agriculture	33	53	63	72	80	88
Residential	11	87	210	364	600	932
Others	16	88	140	218	333	495
Total (TWh)	301	926	1400	1869	2500	3330
	Electricity Consumption Growth Rate					
	1981-94	1995-00	2001-05	2006-10	2011-15	1995-2015
Industry	7.9	5.9	4.2	4.1	4.1	4.7
Agriculture	3.4	3.0	2.7	2.1	2.0	2.5
Residential	16.3	15.8	11.7	10.5	9.2	12.0
Others	13.0	8.1	9.2	8.8	8.3	8.6
Total	8.4	7.1	5.9	6.0	5.9	6.3

The Residential Sector

The residential electricity consumption depends on two major variables. The first is population growth rate and the share of urban population. Although China's population growth rate is projected to average only 1.1 percent per year over the next two decades, the share of urban population is projected to increase dramatically. China's commercial energy is consumed primarily by the nation's urban population. Economic reforms since 1978 have promoted urbanization. China's urban population increased from 172 (17.9% of the total population) to 343 million (28.6% of the population) between 1978 and 1994. Increases in the share of urban population have a substantial effect on residential electricity consumption, because per capita residential electricity consumption of the urban population is almost four times that of the rural population.

The growth rate of energy consumption in China's residential sector was slightly higher than its urban population growth. While the share of residential energy consumption decreased slightly from 15.9 percent in 1980 to 12.6 percent in 1994, residential consumers began switching to higher quality energy sources during the period. Between 1980 and 1994, the share of coal in total residential energy consumption decreased from 90 percent to 63 percent, while the share of electricity increased from 4.5 percent to 23 percent.

The second variable is household electricity consumption density, which increased significantly in the past decade following increasing penetration rates of electric appliances among Chinese households, particularly in urban areas. As shown in Figure 1.19, for urban households, the penetration of some common appliances like color TV and washing machines is already quite high (92 and 88 per 100 households respectively in 1995), the room for further increases in ownership of these appliances is limited. However, air-conditioners (which require a great deal of electricity), electric hot-water heaters (showers), and electric cooking appliances still have a chance of achieving a significant increase in levels of ownership. Table 1.9 shows that only 5 percent of urban households owned air-conditioners in 1994, and the ownership of air-conditioners varied from a high 30.1 percent in Guangdong Province to zero in some other provinces. A survey of 35 large-and-medium cities in 1994 indicated that about 12 percent of the sampled population own air-conditioners and 28 percent plan to buy air-conditioners (*People's Daily Overseas Edition* May 18, 1994). The ownership level of electric cooking appliances and hot-water heaters also varied dramatically from province to province.

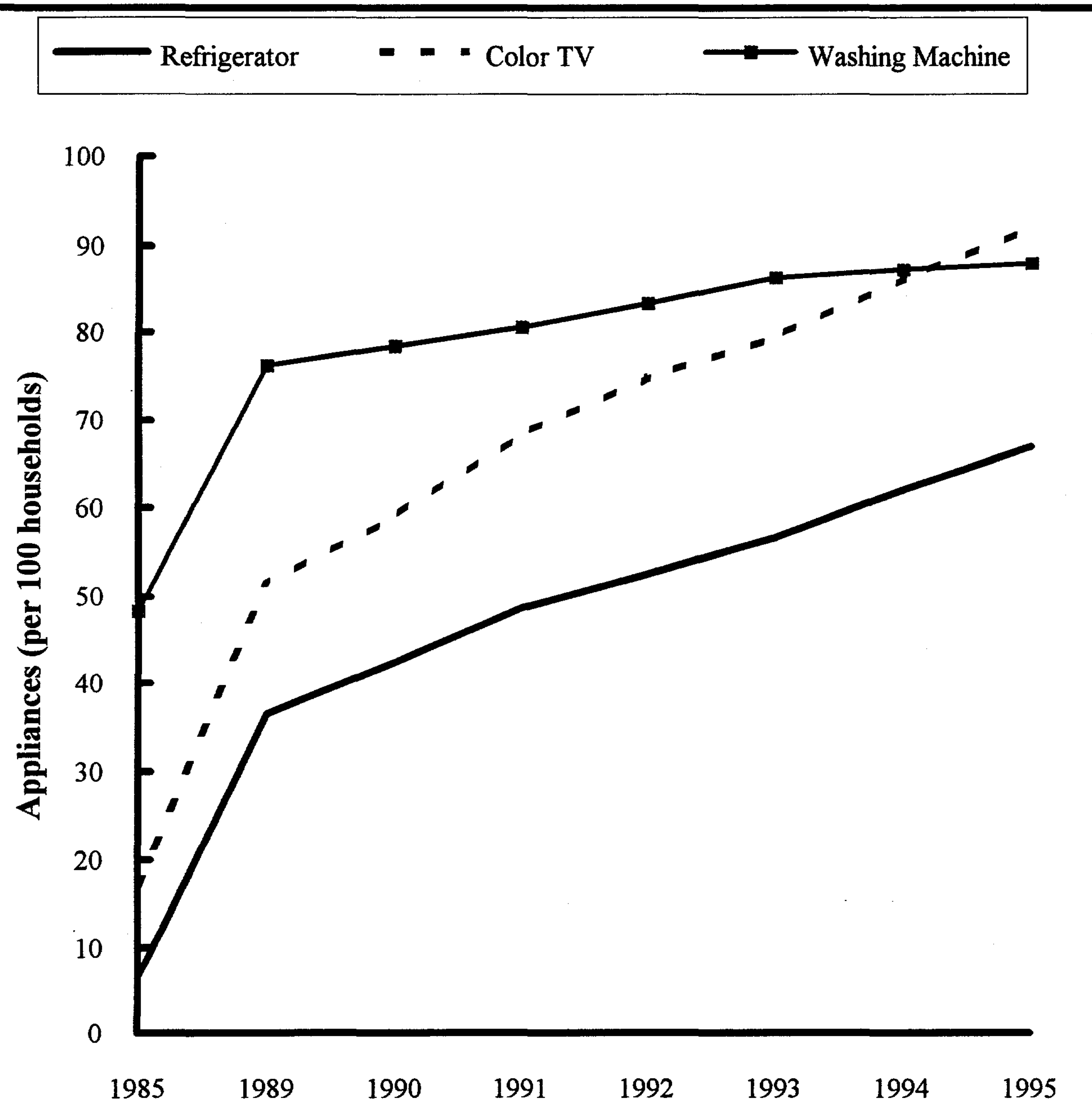

Figure 1.19. Electrical Appliance Ownership of Urban Households

Table 1.9. Electric Appliances by Province: Urban Households

	Possession of Appliances per 100 Households in 1994				
	Air-conditioner	Refrigerator	Color TV	Cooking Appl.	Showers
China	5.00	62	86	75	25
Beijing	5.00	104	112	24	39
Tianjin	6.60	95	101	16	24
Hebei	2.75	70	91	29	22
Shanxi	1.16	44	81	21	7
Inner Mongolia	0.26	39	80	91	7
Liaoning	0.03	63	88	56	26
Jilin	0.00	41	81	118	17
Heilongjiang	0.07	39	78	133	13
Shanghai	19.60	95	101	139	29
Jiangsu	6.95	68	83	101	27
Zhejiang	9.40	93	90	80	40
Anhui	5.52	66	73	58	20
Fujian	2.66	66	87	121	39
Jiangxi	6.86	57	71	56	24
Shandong	2.21	72	88	37	17
Henan	6.11	55	81	27	16
Hubei	7.73	77	79	68	25
Hunan	6.20	77	81	37	29
Guangdong	30.11	70	98	111	66
Guangxi	3.43	61	73	134	38
Hainan	0.90	35	82	110	16
Sichuan	2.32	68	90	93	48
Guizhou	0.84	62	82	77	15
Yunnan	0.31	51	88	157	35
Tibet	2.00	44	63	14	1
Shaanxi	5.17	53	88	32	17
Gansu	0.17	46	90	20	16
Qinghai	0.00	46	97	7	6
Ningxia	0.00	57	99	125	22
Xinjiang	0.79	57	85	73	31

Source: China Statistical Yearbook 1995.

As shown in Figure 1.20, although the possession rates for electric appliances in China's rural household have been increasing, there is still plenty of room for the increase of the penetration ratio within rural households. However, given that income growth among rural households is expected to lag behind urban households, the increase in penetration ratios for electric appliances among the rural population may not be as fast as that of the urban households in the 1980s.

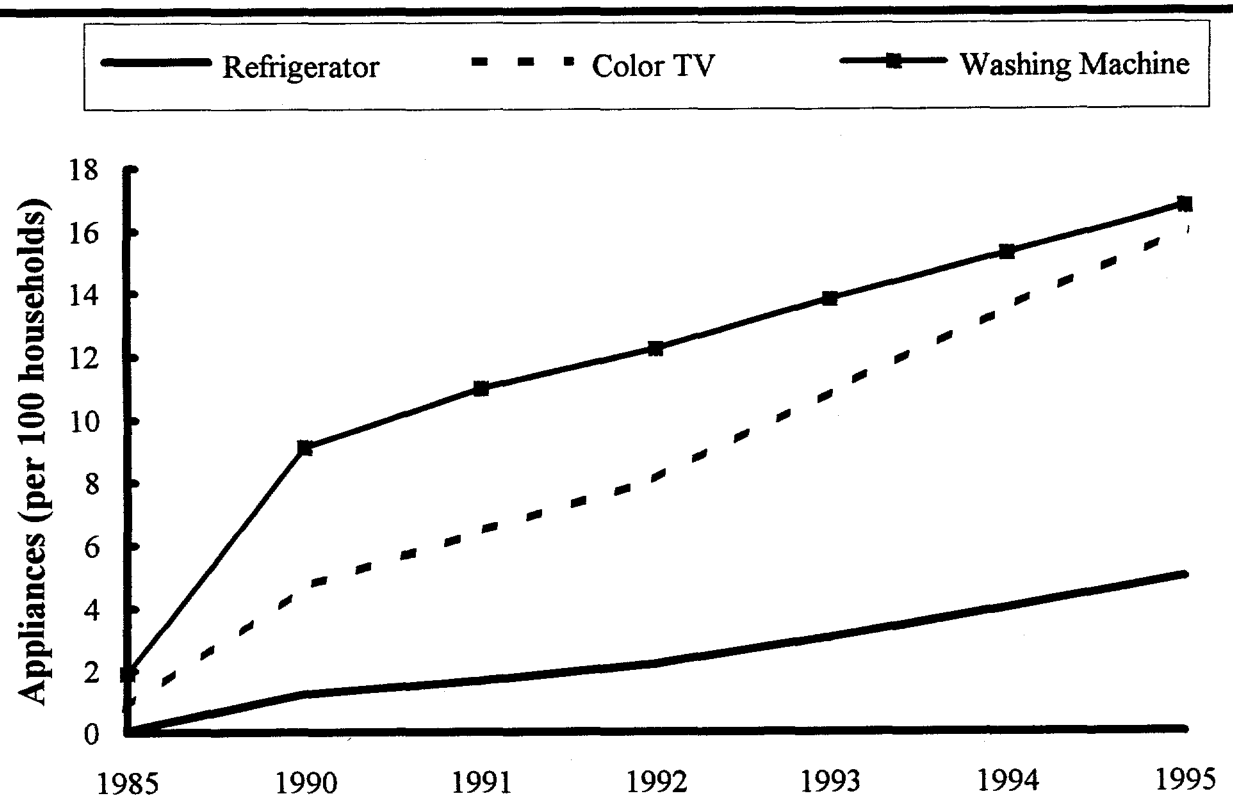

Figure 1.20. Electrical Appliance Ownership of Rural Households

The annual growth rate of electricity consumption in the residential sector averaged 16.3 percent during the 1980-1994 period, almost two times as high as the overall electricity consumption growth rate (see Table 1.8). Residential electricity consumption is projected to grow at 15.8 percent per year during the 1995-2000 period and declining gradually to around 10.4 percent over the 2001-2015 period.

The Agricultural Sector and Others

Agricultural consumption of electricity only accounted for 5.7 percent of total consumption in 1994, and its share is expected to drop to 2.7 percent by 2015. The annual growth rate of agricultural electricity consumption averaged only 3.4 percent during the 1980-1994 period, and is projected to grow at about 2.5 percent over the next 20 years. The cautious projections about the agricultural sector stem from the following factors: (1) rapid industrialization in rural areas, represented by the phenomenal growth of township, village, and private (TVP) enterprises, the property boom in 1992-1993, and the recent wave of construction which substantially reduced the amount of arable land in China; and (2) the vast difference in living standards between farm and non-farm workers driving ever more peasants away from agriculture to other sectors. The government's current efforts to boost the agricultural sector can at best maintain very marginal growth.

Other electricity consumers include nonmaterial production sectors (mainly services and the government sector), transportation, commerce, and construction, accounting for about 9.5 percent of total consumption in 1994. The annual growth rate of electricity consumption in these sectors averaged 13 percent during the 1980-1994 period and is projected to grow at about 8.6 percent over the next 20 years.

Electricity consumption from the service sector will see very strong growth in the remaining years of this decade. The underdevelopment of the service sector is seen in its relatively small 25 percent share of GDP in 1994. This is well below the levels in countries at a similar stage of development (see Figure 1.13). Increasing dominance of market mechanisms as a means of resource allocation will naturally increase the demand for services such as communications, transportation, commerce, wholesale and retail, financial services, trade, and real estate development. Heavy investment in the infrastructure sector by local governments, domestic enterprises and foreign investors will also facilitate the growth in all these sectors. With the anticipated gradual liberalization of electricity tariffs, the governments previous control over the electricity usage of the service sector will be further relaxed.

Other Features of Electricity Consumption

In this section we briefly discuss some of the other features of China's electricity consumption including (1) electricity consumption per unit of GDP; (2) electricity consumption by province; and (3) electricity utilization equipment by province.

Unit GDP and Per Capita Electricity Consumption

China's average electricity consumption per 1,000 yuan of GDP was 173 kWh in 1995 (1436 kWh/US$1,000). Per capita electricity consumption was 825 kWh in 1995. Table 1.10 shows that unit GDP electricity consumption is relatively low in energy-poor areas such as Hainan, Guangdong, Zhejiang, Xinjiang, and Fujian but is relatively high in energy-rich areas such as Ningxia, Gausu, Shanxi, Qinghai, Shaanxi, and Inner Mongolia.

In the near future, China's electricity consumption per unit GDP in constant terms is projected to increase for the following reasons:

(1) Unit GDP electricity consumption is calculated by dividing total electricity consumption by GDP. The residential electricity consumption is also included. Currently, residential electricity consumption is restrained by the government and therefore is very low. In the future, along with the improvement of peoples' living standards, the government will release its restriction on residential electricity consumption and electricity intensive appliances (such as air-conditioners, electric stoves, and electric heaters) will be accepted by Chinese households.

(2) China will become more and more dependent on oil imports. To reduce the reliance on oil imports, electricity will be used as a substitute for oil. For example, diesel engines can be substituted with electric motors and electric stoves can replace LPG stoves. This would replace imported oil with domestic coal-generated electricity.

(3) China's TVP enterprises have been growing very rapidly. In the initial stage, TVP enterprises tend to use backward and labor intensive technologies which are not electricity intensive. With the modernization and electrification of the TVP industry, unit GDP electricity consumption of TVP enterprises is projected to increase.

Table 1.10. Electricity Consumption Per Unit of GDP by Province

	GDP (Billions of yuan)	Population (Millions of people)	Electricity Consump. (TWh)	Per Capita GDP (Yuan)	Per Capita Consump. (kWh)	Unit GDP* Consump. (kWh)
China	4501	1199	928	3755	774	206
Beijing	108	11	26	9636	2309	240
Tianjin	73	9	19	7755	1980	255
Hebei	215	64	53	3362	827	246
Shanxi	85	30	38	2804	1251	446
Inner Mongolia	68	23	18	3017	804	266
Liaoning	258	41	69	6354	1695	267
Jilin	97	26	28	3764	1105	294
Heilongjiang	162	37	44	4408	1204	273
Shanghai	197	14	39	14542	2912	200
Jiangsu	406	70	61	5779	875	151
Zhejiang	267	43	34	6211	800	129
Anhui	149	60	28	2500	465	186
Fujian	169	32	20	5295	640	121
Jiangxi	103	40	19	2570	474	184
Shandong	387	87	67	4466	772	173
Henan	220	90	50	2436	559	229
Hubei	188	57	42	3285	734	223
Hunan	169	64	34	2666	532	200
Guangdong	424	67	54	6340	800	126
Guangxi	124	45	19	2764	417	151
Hainan	33	7	2	4655	293	63
Sichuan	278	112	52	2477	466	188
Guizhou	52	35	15	1507	445	295
Yunnan	97	39	19	2473	472	191
Tibet	5	2	0	1941	157	81
Shaanxi	85	35	25	2432	730	300
Gansu	45	24	27	1899	1115	587
Qinghai	14	5	6	2916	1328	456
Ningxia	13	5	8	2659	1628	612
Xinjiang	67	16	10	4128	640	155

* Per 1000 yuan GDP.

Source: China Statistical Yearbook 1995.

Electricity Utilization Equipment by Province

China's regional electricity utilization capacities are listed in Table 1.11. Overall, industry accounted for 62 percent of total power utilization capacity, agriculture 16.3 percent, residential 9.5 percent, and others 12.2 percent.

Electricity Consumption by Province

Table 1.12 shows China's provincial electricity generation and consumption. The provinces that export the majority of electricity are Shanxi, Hubei, Inner Mongolia, and Qinghai; the provinces that import a large quantity of electricity are Beijing, Tianjin, Liaoning, Hunan, and Zhejiang.

Electricity Shortages and the Associated Economic Losses

China's nation-wide electricity shortage is estimated by the Ministry of Electric Power Industry (MEPI) to average 20 percent. However, due to concerns that the MEPI has a vested interest in overestimating electricity shortages, the State Planning Commission may assume a lower level of shortages, especially when a great deal of it is hidden shortages.

The hidden shortages are partially caused by under-investment in transmission and distribution systems. The share of investment in power transmission dropped from 24 percent in 1980 to 17 percent in 1993. Generally speaking, the share should amount to at least one-third for a power network to have enough capacity to handle the power generated.[1] In 1994, since most of the investments were used to build power plants, only 50 percent of the annual transmission and distribution targets were completed (Shi 1995). Due to the bottleneck of the transmission and distribution system, many potential electricity consumers cannot be hooked up to the power system. For example, many Chinese households that want to install room air-conditioners are refused by the utilities due to the limited distribution system capacity.

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[1] The share of investment in power transmission in China Light & Power in Hong Kong is about 50 percent, while KEPCO in South Korea spends about 40 percent on transmission and distribution systems (Peregrine 1995).

Table 1.11. Electricity Utilization Capacity by Province

	Generation Capacity 1990 (GW)	Electricity Utilization Capacity in 1990 (GW) Total (GW)	UG Ratio*	Industry (GW)	Residen. (GW)	Agricul. (GW)
China	137.89	347.41	2.52	215.51	33.06	56.64
Beijing	2.43	11.05	4.55	5.09	0.55	1.72
Tianjin	2.02	7.41	3.68	4.09	0.39	1.79
Hebei	6.67	17.49	2.62	8.50	1.28	5.76
Shanxi	5.89	13.69	2.32	8.45	0.68	2.68
Inner Mongolia	3.89	5.65	1.45	3.40	0.68	0.85
Liaoning	8.56	23.78	2.78	16.36	2.92	1.41
Jilin	4.78	10.05	2.10	6.17	1.81	0.74
Heilongjiang	6.13	13.72	2.24	9.55	1.60	1.13
Shanghai	5.80	16.99	2.93	11.68	1.15	1.55
Jiangsu	9.89	26.62	2.69	15.69	2.05	6.44
Zhejiang	6.12	14.67	2.40	8.84	1.69	2.75
Anhui	4.06	9.92	2.44	6.46	0.76	2.09
Fujian	3.88	3.88	1.00	2.40	0.43	0.44
Jiangxi	2.96	6.36	2.15	3.87	0.66	1.26
Shandong	8.63	23.68	2.74	14.31	1.71	5.66
Henan	6.17	21.40	3.47	12.51	2.61	4.03
Hubei	7.06	16.99	2.41	10.55	1.06	3.74
Hunan	5.44	20.24	3.72	16.15	1.03	2.06
Guangdong	8.28	20.55	2.48	11.07	3.99	2.11
Guangxi	3.43	7.63	2.22	4.88	1.36	0.78
Hainan	0.81	0.38	0.46	0.15	0.03	0.01
Sichuan	7.49	18.04	2.41	11.51	2.51	2.06
Guizhou	2.81	3.51	1.25	2.19	0.28	0.26
Yunnan	3.38	5.15	1.52	3.37	0.46	0.67
Shaanxi	2.86	9.41	3.29	5.27	0.58	1.78
Gansu	3.82	10.86	2.84	7.76	0.41	1.76
Qinghai	1.66	1.93	1.16	1.36	0.13	0.21
Ningxia	0.93	2.20	2.37	1.52	0.10	0.47
Xinjiang	1.90	3.86	2.03	2.38	0.16	0.49

* UG Ratio=Utilization Capacity/Generation Capacity.

Source: China Energy Statistical Yearbook 1991.

Table 1.12. Electricity Generation and Consumption by Province

	Generation			Consumption		Export
	(TWh) 1980	(TWh) 1990	(TWh) 1994	(TWh) 1985	(TWh) 1990	(TWh) 1990
China	300.5	620.9	928.1	410.9	622.3	-1.4
Beijing	10.7	12.5	13.0	12.6	17.4	-4.9
Tianjin	6.3	9.5	13.5	9.6	12.4	-2.9
Hebei	19.6	36.9	55.0	24.4	35.4	1.5
Shanxi	12.0	31.4	45.7	16.4	25.5	5.9
Inner Mongolia	4.9	17.0	26.1	7.0	12.2	4.8
Liaoning	29.9	43.6	50.4	34.8	46.2	-2.6
Jilin	11.2	17.5	26.0	14.0	19.1	-1.6
Heilongjiang	12.9	29.5	38.2	19.9	29.6	-0.1
Shanghai	20.6	28.4	39.9	20.5	26.5	1.9
Jiangsu	16.1	40.5	63.2	27.7	41.2	-0.7
Zhejiang	8.1	20.9	33.2	14.7	23.0	-2.2
Anhui	9.6	19.4	29.8	12.8	18.6	0.9
Fujian	5.0	13.7	22.9	7.7	13.7	0.0
Jiangxi	5.8	12.1	17.1	8.5	12.8	-0.6
Shandong	18.6	44.6	67.8	26.3	44.9	-0.2
Henan	16.0	31.9	48.5	22.8	33.8	-1.9
Hubei	13.1	34.0	42.6	19.3	28.1	5.9
Hunan	11.9	20.1	29.2	15.6	22.7	-2.5
Guangdong	11.3	34.4	77.1	18.4	35.9	-1.5
Guangxi	5.4	12.6	18.7	8.2	12.6	0.0
Hainan		1.4	2.9		1.4	0.0
Sichuan	16.4	34.3	52.5	23.2	35.0	-0.8
Guizhou	4.5	10.4	19.7	7.3	10.3	0.1
Yunnan	5.6	12.6	20.3	7.6	12.5	0.1
Shaanxi	7.9	15.0	22.2	11.2	17.0	-2.1
Gansu	12.0	17.1	24.9	12.6	17.8	-0.6
Qinghai	0.8	7.1	7.3	1.7	4.2	2.8
Ningxia	1.9	5.6	9.7	2.5	5.5	0.1
Xinjiang	2.4	7.0	10.6	3.8	7.0	0.0

Source: China Statistical Yearbook 1993; China Energy Statistical Yearbook 1991.

According to China Daily (March 24, 1995), power shortages in China have turned from a regional problem to a heavy burden beleaguering many areas. Due to power shortages, generating units have to be overloaded. This has made it impossible to undertake timely maintenance or repair, thus reducing the plant's service life and causing accidents. The negative effects of power shortages on existing generating units are felt more by the MEPI than the SPC.

Since electricity shortages are easier to feel than to measure, the recent policy change in electricity consumption priority may also have contributed to the different views of China's power shortage. Priority in electricity consumption was traditionally given to the production sectors but is now given to the residential sector. Therefore, the seriousness of electricity shortages is felt less by the general public as well as the SPC officials.

Reportedly about 240 billion yuan (US$29 billion) worth of industrial value added was lost due to electricity shortages in China in 1993 (*China Times Weekly* September 19, 1993). This translates to average economic costs of about US$0.17/Kwh to the consumer. Economic costs of power shortages in coastal areas are certainly higher than those in inland areas. According to the Asian Development Bank, the economic costs of each unserved Kwh is about US$0.35 in Asia. The economic costs of power shortages in Guangdong Province are estimated to be at least US$0.30/Kwh (Li and Johnson 1994b). Although the economic costs of electricity shortages are substantial, this type of costs are difficult to measure and subject to great measurement errors. To obtain an unbiased estimate of economic costs associated with electricity shortages, a research program hosted by a neutral institution and participated in by representatives of both the MEPI and the SPC will be very useful. The results of this research will be critical in power sector decision making.

The threat of power shortages is felt more by local governments. Since obtaining SPC approval to build large and medium sized power plants is difficult, many local governments (and foreign investors) turn to small projects to avoid central government regulations. As a result, the actual additional large- and medium-sized capacity to be commissioned during the Eighth Five Year Plan period (1991-1995) is estimated at 6 GW short of planned target, while the actual additional small-sized capacity is estimated at 7 GW above the planned target (MEPI 1995).

Electricity Tariffs

Electricity tariff is a fundamental factor underlying the conflict between the Chinese government and foreign investors in China's power sector. In this section, we will review the reforms of China's tariff system, tariffs for different customer groups, regional differences in tariff levels, and the factors affecting tariff levels.

Reforms of the Electricity Tariff System

Until the mid-1980s, China's electricity tariffs were set arbitrarily by the central government and were governed by the needs to supply cheap electricity for industrial and agricultural development. Increasing fuel prices appear to have been an important factor in the rapid decrease in profitability of the power industry in the 1980s.

In 1985, in response to the pressures of general economic reform, China adopted a multi-tiered tariff system. Under this system, older power plants heavily subsidized by the central government and with cheap "in-plan" coal supplies continued to hold down their electricity prices at state fixed levels, while power plants which had to purchase high-priced fuels were allowed to sell electricity at prices substantially above state fixed levels, and some power plants simply charged a processing fee to convert fuels to electricity for their customers, and the customers were responsible for the fuel supplies.

Currently, electricity tariffs throughout China consist of three components: (1) the state base prices; (2) a guidance price differential; and (3) additional fees and surcharges. These components are added to form the "administered" consumer tariff or the "guidance" tariff. Administered tariff refers to the state base prices plus various fees and surcharges, while the guidance tariff includes all three components. The amount of electricity sold under each tariff varies from place to place. In Jiangsu Province, for example, about one half of electricity sales are made using the administered tariff and the other half using the guidance tariff.

The state base prices are the prices charged for power plants financed by the central government and managed by provincial power corporations. This includes most power plants constructed before 1985 with grant funding and power plants constructed using central government loans since 1985. The structure and level of these prices was fully revised in 1993 for the first time since 1976, providing for an increase in the overall price levels and simplification. In principle, electricity prices can be adjusted to reflect fuel price changes, and the state base prices should include debt repayment to cover financing costs of plants built after 1985. Since government approval is still required before any tariff changes, the risk of being unable to obtain government approval for rational tariff changes is still very high (see Chapter 3 and 4 for further discussions of government interference on tariff controls). Unfortunately, the annual approval process conducted at the municipal, provincial, and state levels continues to ignore the true cost of building a power plant. The price as currently negotiated reflects the costs of operations in the previous year.

The guidance price differential accounts for the additional cost of out-of-plan electricity supply. Examples include additional costs of electricity from provincial and local government-financed power plants, electricity from independent power producers, including the Huaneng Group, and electricity provided by various power plants beyond their contracted production quotas. These plants often involves local government agreements to arrange for fuel supplies from other than the central fuel allocation process. These higher costs are averaged into a price markup which is added to the state base price.

Additional fees include (1) a 2.0 fen/kWh surcharge for provincial power construction funds, proposals has been made to increase the surcharge to 4.0 fen/kWh before the electricity tariff reaching a more rational level; (2) a 0.3 fen/kWh surcharge on all consumers in China to help finance the Three Gorges project, levied by the central government; and (3) surcharges for various local power construction funds, for example a 3.0 fen/kWh surcharge collected by the prefectural governments in Jiangsu Province.

In order to attract foreign investors and local investors, a new tariff system called "old electricity-old price, and new electricity-new price" has been adopted in China. Under this system, electricity tariffs are determined by the marginal cost of the additional generating plants plus a "reasonable" profit rate. The definition of reasonable, however, is still vaguely defined. In Shenzhen, China's largest special economic zone, electricity tariffs are based on total costs plus 15 percent "average social profit rate," which results in an average tariff of about 6.5 US cents/KWh. China's target of return on total capital in the power sector is 10-12 percent in constant terms.

Currently, about two-thirds of electricity distribution companies are separated from the vertical management system of the power industry. These companies, under the management of local governments, become local monopolists, and some of them charged very high electricity tariffs. According to field surveys of the author, some consumers have to pay 12-15 U.S. cents per kWh to obtain a power supply. Although the new tariff system allows utilities to charge high tariffs in some areas, the profits are not received by power plants.

The Chinese government acknowledges the chaotic nature of the current electricity tariff system and the need to continue reform. In the long run, China hopes to abolish the multi-tiered tariff system. For example, Jiangsu province plans to abolish the administered and guidance tariff system by 1997. In Nantong Prefecture, the tariff system has already been successfully collapsed into a single unified consumer tariff.

Tariff Levels and Regional Differences

Under the multi-tiered tariff system, China's consumer electricity tariffs vary substantially from consumer to consumer and from place to place. The overall picture is that tariffs are low in the poor, inland provinces and high in fast-developing coastal province. As shown in Table 1.13, in 1994 the average tariff was about 5.4 U.S. cents/kWh in Guangdong Province, while the national average tariff was only about 2.9 U.S. cents/kWh. Average electricity tariffs paid by consumers vary in the range of 1.6-5.6 U.S. cents/kWh, and consumers consuming electricity generated from diesel generators are charged 9.5 U.S. cents/kWh.

Table 1.13. China's Average Tariff by Power Networks in 1994

	Average Tariff in 1994		Increase over 1993
	Yuan/MWh	US$/MWh	%
Hainan	463.12	55.80	
Guangdong	446.17	53.76	
Shanghai	335.71	40.45	13.42
Jiangsu	305.97	36.86	49.38
East China	303.54	36.57	29.97
Zhejiang	282.89	34.08	28.65
Beijing-Tianjin-Tangshan	271.23	32.68	27.65
Anhui	270.04	32.53	31.21
Fujian	260.69	31.41	19.76
Hunan	259.90	31.31	25.19
Northeast China	255.49	30.78	23.36
North China	255.47	30.78	17.51
Hubei	251.18	30.26	33.24
Hebei	238.54	28.74	11.26
Central China	237.09	28.57	26.04
Shanxi	236.04	28.44	16.10
Shandong	220.41	26.56	20.35
Henan	216.75	26.11	21.27
Jiangxi	206.80	24.92	10.77
Xinjiang	203.21	24.48	21.62
Shaanxi	200.46	24.15	14.34
Yunnan	198.07	23.86	19.52
Sichuan	195.26	23.53	26.10
Northwest China	179.85	21.67	16.39
Ningxia	179.79	21.66	15.05
Guizhou	179.55	21.63	21.86
Guangxi	174.69	21.05	47.05
Gansu	163.80	19.73	23.40
Qinghai	136.09	16.40	21.67
Total Average*	244.50	29.46	24.33

*Average under the Ministry of Electric Power Industry system.

Source: Electric Power Industry in China 1995.

Table 1.14 shows the average electricity tariffs for typical customers. The average tariff for non-residential lighting was the highest in 1994 (4.2 US cents/kWh), followed by the non-industry & ordinary industry (3.6 US cents/kWh), large industry (2.9 US cents/kWh), residential (2.8 US cents/kWh), agriculture (2.7 US cents/kWh), and wholesale (2.3 US cents/kWh). The depressed electricity prices have two serious consequences: they provide no incentives for power conservation and make investing in new power projects unattractive.

Table 1.14. China's Average Tariff by Customer Category in 1994

	Average Tariff in 1994	
	Yuan/MWh	US$/MWh
Non-Residential Lighting	350.12	42.18
Non-Industry & Ordinary Industry	301.18	36.29
Large Industry	239.96	28.91
Residential	231.07	27.84
Agricultural	222.01	26.75
Wholesale	194.64	23.45
Total	244.50	29.46

Source: Electric Power Industry in China 1995.

Factors Affecting Tariff Levels

A rational electricity tariff is the key to attract private investors in China's power sector. There are many factors which affect the tariff levels paid by consumers. In this section we will only discuss the factors which affects the price charged by power plants, which include the fuel cost, the cost of debt service, returns on equity, the operating and maintenance (O&M) costs and taxes. We will also try to estimate the ranges for each components.

Coal is the predominate fuel consumed in China's power sector. Table 1.15 shows that coal prices vary dramatically from place to place. In some locations which are not included in this table, coal prices are even lower (for further discussion of coal prices see Chapter 5). Assume the unit coal consumption of new power plants can reached 330 grams of coal equivalent (gce) and the heat content of coal averages 6,300 kcal/kg, then the cost of fuel is in the range of 0.6-1.4 U.S. cents/kWh depending on the coal prices.

Table 1.15. Representative Bituminous Coal Prices at the End of 1995

		Price of Coal		Cost of Fuel	
City	Province	Yuan/ton	US$/ton*	Fen/kWh	Cents/kWh
Guangzhou	Guangdong	310	37	11.35	1.37
Hangzhou	Zhejiang	310	37	11.35	1.37
Xiamen	Fujian	305	37	11.16	1.34
Wuxi	Jiangsu	300	36	10.98	1.32
Nanjing	Jiangsu	280	34	10.25	1.23
Hefei	Anhui	275	33	10.07	1.21
Shanghai	Shanghai	275	33	10.07	1.21
Qingdao	Shandong	266	32	9.74	1.17
Shenyang	Liaoning	265	32	9.70	1.17
Dalian	Liaoning	260	31	9.52	1.15
Changsha	Hunan	260	31	9.52	1.15
Tianjin	Tianjin	241	29	8.82	1.06
Wuhan	Hubei	225	27	8.24	0.99
Qinhuangdao	Hebei	215	26	7.87	0.95
Chengdo	Sichuan	199	24	7.28	0.88
Beijing	Beijing	199	24	7.28	0.88
Taiyuan	Shanxi	195	23	7.14	0.86
Changchun	Heilongjiang	190	23	6.95	0.84
Harbin	Heilongjiang	188	23	6.88	0.83
Zhengzhou	Henan	180	22	6.59	0.79
Shijiazhuang	Hebei	170	20	6.22	0.75
Lanzhou	Gansu	167	20	6.11	0.74
Datong	Shanxi	140	17	5.12	0.62
Chongqing	Sichuan	140	17	5.12	0.62
Xian	Shaanxi	140	17	5.12	0.62
Kunming	Yunnan	138	17	5.05	0.61
Guiyang	Guizhou	125	15	4.58	0.55

* Current exchange rate 8.3 RMB yuan=1 US$.

The cost of debt service is obviously determined by the capital cost and the interest rate of loans. The capital cost of domestic coal-fired units is about $500/kW, while the capital cost of foreign joint venture coal-fired units is about $1,000/kW. Interest rates depend on the sources of loans, for commercial loans, however, the interest rate is at least 10 percent.

Another important factor which affects the levelized capital cost of per kWh of electricity is the capacity factor of the power plant. The relationships between capacity factors and the levelized capital costs for imported and domestic power plants are estimated in Table 1.16. In electricity price negotiations, it is assumed that annual operating hours will be 5,500 (a capacity factor of 63%) -- typical of Chinese coal-fired plants. However, foreign developers are accustomed to operating coal-fired plants at 7,000-7,500 hours (plant load factor of 80-86%) per year. Table 1.16 shows that at the capacity factor of 63 percent, the levelized capital cost is about 1.8 US cents/kWh for foreign joint venture projects and 0.8 US cents for domestic projects; at the capacity factor of 86 percent, the levelized capital costs are reduced to 1.3 US cents/kWh for foreign joint venture projects and 0.6 US cents for domestic projects.

The equity net return is determined by the internal rate of return (IRR) of the projects and is estimated at about 0.9-1.2 US cents/kWh for foreign joint venture projects and only 0.4-0.6 US cents for domestic projects (For further discussions of IRRs, see Chapter 3). The O&M cost and taxes are similar in domestic and foreign joint venture projects. O&M cost is about 0.7-0.9 US cents/kWh and total taxes is about 0.6-0.8 US cents/kWh.

Adding all components together, the levelized electricity price is in the range of 4.1-6.1 US cents/kWh for foreign joint venture power projects and in the 2.9-4.7 US cents/kWh for domestic power projects.

Table 1.16. The Effects of Capacity Factors on Levelized Capital Cost

Operation (Hours/Year)	Capacity Factor (%)	Capital Costs Mill/kWh		Capital Costs Fen/kWh	
		Imported	Domestic	Imported	Domestic
7500	86	13	6	11.07	4.90
7300	83	14	6	11.37	5.03
7100	81	14	6	11.69	5.17
6900	79	14	6	12.03	5.32
6700	76	15	7	12.39	5.48
6500	74	15	7	12.77	5.65
6300	72	16	7	13.17	5.83
6100	70	16	7	13.61	6.02
5900	67	17	7	14.07	6.22
5700	65	18	8	14.56	6.44
5500	63	18	8	15.09	6.68
5300	61	19	8	15.66	6.93
5100	58	20	9	16.27	7.20
4900	56	20	9	16.94	7.50
4700	54	21	9	17.66	7.81
4500	51	22	10	18.44	8.16
4300	49	23	10	19.30	8.54
4100	47	24	11	20.24	8.96
3900	45	26	11	21.28	9.42
3700	42	27	12	22.43	9.93
3500	40	29	13	23.71	10.49

Chapter 2

China's Power Sector Overview

Installed Generating Capacity and Energy Mix

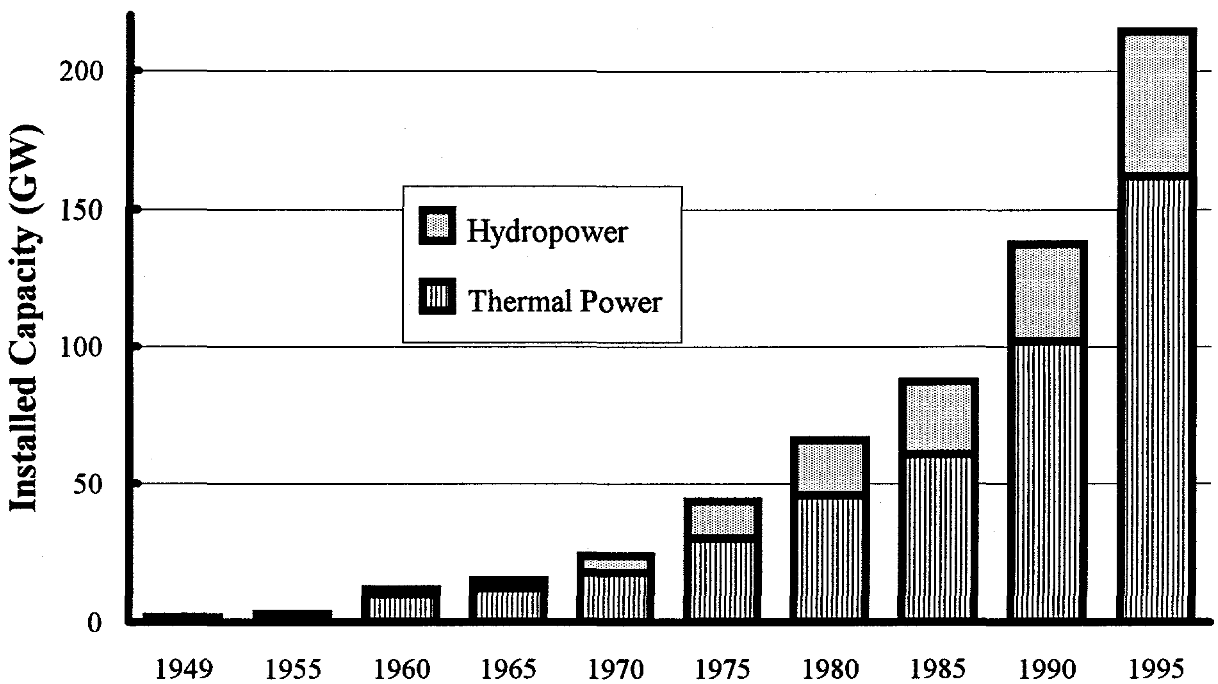


Figure 2.1. China's Installed Generating Capacity, 1949-1995

China's electric power industry has been growing rapidly since the founding of the People's Republic of China in 1949. As shown in Figure 2.1, between 1949 and 1995, China's installed generating capacity increased 116 times, from 1.85 GW of primarily thermal capacity to 214 GW. Since 1987, additional generation capacity has been exceeding 10 GW per year. However, China's per capita installed capacity was only 0.175 kW by the end of 1995, and the annual per capita electricity consumption was only 825 kWh, which is very low by international standards.

China's electricity is mostly generated from thermal power plants, which accounted for about three-quarters of total capacity and about 83 percent of total generation in 1995. China's thermal power plants are predominately coal-fired. The role of oil and natural gas in electricity generation is minimal. China is now capable of manufacturing 300 MW and 600 MW thermal generating units. Currently, about 80 percent of the power plant equipment is supplied by domestic manufacturers, and 20 percent is imported. By the end of 1994, China had 32 thermal power plants with a station capacity of over one GW and 24 GW-scale power plants partially completed or under construction.

Due to government priority on developing hydropower resources, the share of hydropower capacity increased from 9 percent in 1949 to about 30 percent in the late 1970s; however, the recent power sector investment mechanism reforms provided more incentives to develop thermal power projects. As a result, the share of hydropower capacity had declined by 1995 to about 24 percent, or 52 GW, which generated about 18 percent of China's electricity.

In 1993, the Qinshan and Daya Bay nuclear power stations were commissioned, which opened a new chapter in China's power industry. However, in the near future, nuclear power will still only be able to play a very limited role in China. The share of nuclear power capacity was only 1 percent in 1995.

China has been very slow in developing new and renewable sources of energy in addition to hydropower. Although the U.S. presidential mission on sustainable energy and trade to China, led by the U.S. Energy Secretary Hazel O'Leary in February, 1995, promoted the development of new energy sources in China, such as wind power and solar power, the effects will be very limited and only observed in the long run.

According to the Ministry of Electric Power Industry (MEPI 1995), China plans to increase its total generating capacity to 300 GW by the year 2000, including 231 GW of thermal power (77%), 66 GW of hydropower (22%), 2 GW of nuclear power (0.7%), and 1 GW of new energy (primarily wind and solar). As shown in Table 2.1, total generating capacity is projected to reach 530 GW in 2010 and 700 GW in 2015.[1] The share of coal-fired capacity is projected to remain at about the same level over the next two decades. The share of hydropower capacity is projected to declined to about 20 percent by 2015 due to the introduction of nuclear power and gas-fired power plants in southeast China.

Coal-Fired Capacity

China's thermal power plants are mainly coal-fired. During the past 15 years, as oil's share of total generating capacity decreased from 17 to 7 percent, and hydropower's share decreased from 31 to 24 percent, coal's share increased from 52 to 66 percent. Due to higher average capacity factors of coal-fired units, coal's share in total generation increased from 60.5 to about 76 percent.

The increased role of coal in China's power sector is largely due to the nature of its energy resources. As shown in Figure 2.2, coal accounts for about 93 percent of China's total primary energy resources; hydropower about 4 percent; and oil and gas 3 percent. It is estimated that about 4,500 billion tons of coal resources exist to a depth of 2,000 meters, and about 2,000 billion tons exist to a depth of 1,000 meters.[2]

The demonstrated coal reserves based on the Chinese definition (proved deposits) are 1,022.9 billion tons, and the remaining proved deposits are 1,001.8 billion tons by the end of 1994, of which mines in production and mines under construction contain 192.5 billion tons, the unused intensively explored deposits contain 85.5 billion tons; the deposits that need further exploration amount to 723.7 billion tons (1995 Energy Report of China). Among the proven reserves, bituminous coal accounts for 75 percent, anthracite 12 percent, and lignite 13 percent

[1] This is the East-West Center projection. The Chinese government has more ambitious plans. The government wants total installed capacity to jump to between 625 and 670 GW by 2010 and to between 970 and 1,100 GW by 2020 (*International Private Power Quarterly*, Second-Quarter 1996, 63).

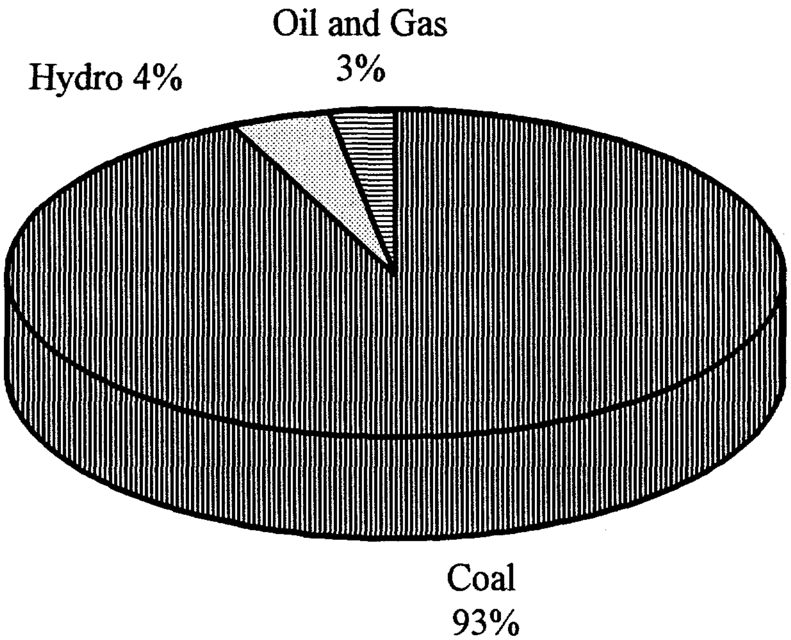
[2] Unless otherwise noted, "resources" here refers to the sum of Proved Amount in Place and Estimated Additional Amount in Place defined by the World Energy Conference.

(China Energy Annual Review 1994). Only 7 percent of China's coal reserves are suitable for open cast mining, of which about 70 percent is lignite.

Table 2.1. China's Installed Capacity by Energy Source

	Installed Capacity by Energy Type (GW)						
	Coal	Hydro	Oil	Gas	Nuclear	Others	Total
1980	34	20	11	0.1	0.0	0.0	66
1985	50	26	10	0.2	0.0	0.0	87
1990	89	36	11	1.2	0.0	0.2	138
1995	142	52	16	2.1	2.1	0.3	214
2000	203	66	24	4.0	2.1	1.0	300
2005	262	88	32	7.4	8.0	2.5	400
2010	345	110	38	12.0	20.0	5.0	530
2015	455	140	45	25.0	25.0	10.0	700
	Growth Rate of Installed Capacity (%/year)						
	Coal	Hydro	Oil	Gas	Nuclear	Others	Total
1981-1995	10.0	6.5	2.0	22.5			8.2
1981-1985	8.0	5.4	-1.9	14.9			5.7
1986-1990	12.2	6.4	2.0	43.1			9.6
1991-1995	9.8	7.6	6.3	11.8		8.4	9.2
1996-2000	7.4	4.9	9.0	13.8	0.0	27.2	7.0
2001-2015	5.5	5.1	4.3	13.0	18.0	16.6	5.8
	Share in Total Capacity (%)						
	Coal	Hydro	Oil	Gas	Nuclear	Others	Total
1980	52	31	17	0	0	0	100
1985	57	30	12	0	0	0	100
1990	65	26	8	1	0	0	100
1995	66	24	7	1	1	0	100
2000	68	22	8	1	1	0	100
2005	66	22	8	2	3	1	101
2010	65	21	7	2	4	1	100
2015	65	20	6	4	4	1	100

Figure 2.2. Shares of China's Primary Energy Resources



The economics of power generation are also in favor of coal-fired units. While the price of electricity generated by coal-fired units is around 30-40 fen (3.6-4.8 U.S. cents) per kWh, despite the need for more expensive imported equipment, the electricity from small-scale diesel-fired units is priced at 80 fen (9.6 U.S. cents) per kWh.

Through the introduction of manufacturing technology from companies mainly in the United States, such as Westinghouse, ABB, Combustion Engineering, and Foster Wheeler, Chinese power equipment manufacturers have already been able to produce 300 and 600 MW coal-fired generators. The first 600 MW coal-fired unit has been in operation for four years. Domestic manufacturers have already expanded the production capacity of their coal-fired units, with funding largely secured through the listing of Dongfang Electrical Machinery and Harbin Power Equipment in Hong Kong.

Of the 98 large thermal power plants (600 MW and larger) shown in Table 2.2 (which accounted for about half of China's total thermal capacity) only two of them are oil-fired and eight of them are duel-fired (coal and oil). All of the 29 GW of large thermal plants under construction or planned are coal-fired. Total coal-fired capacity is projected to reach 203 GW by 2000 and 455 GW by 2015.

The future development trends of coal-fired power plants is to increase the power plants built at the mine-mouth. A number of large coal-fired power plants near the coal mine areas such as Shanxi, Shaanxi, Inner Mongolia, Henan, Guizhou, and Yunnan will be built. In all, China has plans to add 37 GW mine-mouth coal-fired plants by 2000. The power produced there will be transmitted to North China, East China, and South China. A number of large coal-fired power plants will also be constructed in the load concentrated areas along the coast, near the sea ports and/or at the railway junctions.

Oil-Fired Capacity

The fate of oil in power generation has been affected by the changing perception of China's potential oil output. In 1950, China's crude oil production was only 0.44 million metric tons (Mt), and China remained an oil importer until the 1960s. With self-reliance as the foundation of China's economic and energy policy, the government saw little role for oil-fired plants. The opening of the Daqing and Shengli oil fields in the Northeast in the 1960s was the beginning of China's rise as a major oil producer. For over a decade and a half, the annual production growth of the Daqing field was over 20 percent. By the end of the 1960s, China became an oil exporter. In 1973, China produced 77 Mt of crude oil, and oil exports accounted for 12 percent of China's foreign exchange earnings.

The success of on-shore oil production, coupled with the discovery of some off-shore reserves, led to the over-optimistic estimation of China's oil reserves. Government plans even called for building 10 oil fields similar to Daqing in size by the year 2000. China was decided to shift gradually from a coal-based economy to an oil-based economy.

Table 2.2. China's Principal Thermal Power Plants

	Name	Location	Network	Capacity (MW)*			Fuel
				Design	Existing	Size	
Total				99958	71458		
1	Qinghe	Liaoning	NEPN	1300	1300	100, 200	coal, oil
2	Jinzhou	Liaoning	NEPN	1200	1200	200	coal
3	Liaoning	Liaoning	NEPN	1050	1050	50, 200	coal, oil
4	Dalian	Liaoning	NEPN	700	700	350	coal
5	Tieling	Liaoning	NEPN	1200	900	300	coal
6	Suizhong	Liaoning	NEPN	1600		800	coal
7	Yingkou	Liaoning	NEPN	600		300	coal
8	Changshan	Jilin	NEPN	693	693	200	coal
9	Jilin	Jilin	NEPN	850	850	100, 200	coal, oil
10	Shuangliao	Jilin	NEPN	1200	300	300	coal
11	Fularji No.2	Heilongjiang	NEPN	1200	1200	200	coal
12	Mudanjiang No.2	Heilongjiang	NEPN	1020	820	100, 210	coal
13	Shuangyashan	Heilongjiang	NEPN	820	820	200, 210	coal
14	Harbin No.3	Heilongjiang	NEPN	1600	400	200, 600	coal
15	Daqing	Heilongjiang	NEPN	600	400	200	coal
16	Hegang	Heilongjiang	NEPN	600		300	coal
17	Yuanbaoshan	Inner Mongolia	NCPN	2100	900	300, 600	coal
18	Tongliao	Inner Mongolia	NCPN	1200	800	200	coal
19	Fengzhen	Inner Mongolia	NCPN	1200	800	200	coal
20	Yimin	Inner Mongolia	NCPN	1000		500	coal
21	Dalate	Inner Mongolia	NCPN	660		330	coal
22	Gaojing	Beijing	NCPN	600	600	100	coal
23	Shijingshan	Beijing	NCPN	1766	1766	100, 200	coal
24	Dagang No.1	Tianjin	NCPN	640	640	320	oil
25	Dagang No.2	Tianjin	NCPN	640	640	320	coal
26	Junliangcheng	Tianjin	NCPN	1000	1000	200	coal, oil
27	Jixian (Panshan)	Tianjin	NCPN	1000		500	coal
28	Douhe	Hebei	NCPN	1550	1550	125,250	coal
29	Xingtai	Hebei	NCPN	1290	1290	200	coal
30	Matou	Hebei	NCPN	850	850	100,200	coal
31	Shang'an	Hebei	NCPN	1300	700	350	coal

* As of December 31, 1994.

Table 2.2. China's Principal Thermal Power Plants (continued)

	Name	Location	Network	Capacity (MW)			Fuel
				Design	Existing	Size	
32	Xibaipo	Hebei	NCPN	1200	600	300	coal
33	Zhangjiakou	Hebei	NCPN	1600	1300	100,300	coal
34	Shentou	Shanxi	NCPN	1300	1300	200	coal
35	Shentou No.2	Shanxi	NCPN	1000	1000	500	coal
36	Datong No.2	Shanxi	NCPN	1200	1200	200	coal
37	Zhangze	Shanxi	NCPN	1040	1040	100, 210	coal
38	Yangquan No.2	Shanxi	NCPN	1200		300	coal
39	Shidongko	Shanghai	ECPN	1200	1200	300	coal
40	Shidongko No.2	Shanghai	ECPN	1200	1200	600	coal
41	Wujing	Shanghai	ECPN	1000	1000	100, 300	coal
42	Minhang	Shanghai	ECPN	818	818	110, 125	coal
43	Baoshan	Shanghai	ECPN	700	700	350	coal, BFG
44	Waigaoqiao	Shanghai	ECPN	1200		300	coal
45	Jianbi	Jiangsu	ECPN	1625	1625	100, 300	coal
46	Xuzhou	Jiangsu	ECPN	1300	1300	125, 200	coal
47	Wangting	Jiangsu	ECPN	1100	1100	300	coal, oil
48	Nantong	Jiangsu	ECPN	700	700	350	coal
49	Ligang	Jiangsu	ECPN	700		350	coal
50	Nanjing	Jiangsu	ECPN	600		300	coal
51	Changshu	Jiangsu	ECPN	1200	1200	300	coal
52	Beilungang	Zhejiang	ECPN	1200	1200	600	coal
53	Zhenhai	Zhejiang	ECPN	1050	1050	125, 200	coal, oil
54	Taizhou	Zhejiang	ECPN	750	750	125	coal
55	Pingwei	Anhui	ECPN	1200	1200	600	coal
56	Huaibei	Anhui	ECPN	950	750	125, 200	coal
57	Huainan	Anhui	ECPN	600	600	120, 125	coal
58	Luohe	Anhui	ECPN	600	600	300	coal
59	Fuzhou	Fujian	FJPG	700	700	350	coal
60	Zouxian	Shandong	SDPG	2400	1200	300, 600	coal
61	Shiheng	Shandong	SDPG	1200	600	300	coal
62	Shiliquan	Shandong	SDPG	1225	625	125, 300	coal
63	Huangtai	Shandong	SDPG	925	925	100, 300	coal
64	Longkou	Shandong	SDPG	600	600	100, 200	coal
65	Xindian	Shandong	SDPG	600	600	100, 200	oil

Table 2.2. China's Principal Thermal Power Plants (continued)

	Name	Location	Network	Capacity (MW)			Fuel
				Design	Existing	Size	
66	Huangdao	Shandong	SDPG	670	670	125, 210	coal
67	Huaneng Dezhou	Shandong	SDPG	1200	1200	300	coal
68	Weifang	Shandong	SDPG	600		300	coal
69	Yaomeng	Henan	CCPN	1200	1200	300	coal
70	Jiaozuo	Henan	CCPN	1224	1224	200	coal
71	Sanmenxia	Henan	CCPN	600		300	coal
72	Luohe	Henan	CCPN	1200	600	300	coal
73	Hanchuan	Hubei	CCPN	1200	600	300	coal
74	Qingshan	Hubei	CCPN	674	674	100, 200	coal, oil
75	Jingmen	Hubei	CCPN	600	600	100, 200	coal
76	Yangluo	Hubei	CCPN	1200	600	300	coal
77	Yueyang	Hunan	CCPN	700	700	350	coal
78	Jinzhushan	Hunan	CCPN	600	600	125	coal
79	Shimen	Hunan	CCPN	600		300	coal
80	Jiujiang	Jiangxi	CCPN	650	650	125, 200	coal
81	Fengcheng	Jiangxi	CCPN	1200		300	coal
82	Qinling	Shaanxi	NWPN	1050	1050	125, 200	coal
83	Weihe	Shaanxi	NWPN	1300	700	300	coal
84	Puchen	Shaanxi	NWPN	660		330	coal
85	Jingyuan	Qinghai	NWPN	1400	800	200, 300	coal
86	Daba	Ningxia	NWPN	1200	600	300	coal
87	Luohuang	Sichuan	SCPG	700	700	350	coal
88	Chongqing	Sichuan	SCPG	696	696	200	coal
89	Jiangyou	Sichuan	SCPG	660	660	330	coal
90	Qingzhen	Guizhou	GZPG	658	658	200	coal
91	Huangpu	Guangdong	GDPG	1100	1100	125, 300	coal, oil
92	Shajiao A	Guangdong	GDPG	1200	1200	200, 300	coal
93	Shajiao B	Guangdong	GDPG	700	700	350	coal
94	Shajiao C	Guangdong	GDPG	1980		660	coal
95	Shaoguan	Guangdong	GDPG	624	624	200	coal
96	Zhujiang	Guangdong	GDPG	600		300	coal
97	Shenzhen	Guangdong	GDPG	600		300	coal
98	Daya Bay	Guangdong	GDPG	1800	1800	900	nuclear

With estimated oil reserves located in proximity to major load centers, planners saw oil as the answer to the fuel supply problems that plagued these centers. Not only were new oil-fired plants built, but also a large scale program of converting existing coal-fired plants to oil-fired was initiated. More than 6 GW of coal-fired capacity were converted to burn oil. Total oil-fired capacity exceeded 12 GW.

By the late 1970s, the Northeast oil base experienced a slowdown in the rate of oil extraction, and it became obvious that previous estimations of China's oil reserves was too optimistic. Skyrocketing domestic oil consumption began to erode China's position as an oil exporter. The central government took an abrupt policy change and initiated a second conversion process. Plants that had been converted to burn oil were retrofitted to burn coal. The Office of Substituting Coal for Oil under the SPC was established with the sole responsibility of promoting the conversion of existing oil-fired plants to burn coal (see Chapter 3 for further discussions).

China has become a net oil importer since 1993. The rapid expansion of ownership of cars, trucks, tractors, and diesel pumps has increased the demand for oil. The continually expanding use of oil as feedstock in the production of chemicals and plastics has also strained the oil supply. Depending on the level of domestic oil production, China will have to import around 1.0-1.3 million barrels per day of crude oil and products by 2000. The impact of such an imbalance is likely to be huge, as the country has never before encountered large energy deficits under the central-planning regime.

Substituting oil-fired units with coal-fired units is now one of China's basic energy policies. According to the government, most future fossil-fuel based power stations will be coal-fired. Existing oil-fired units will be converted to coal-fired whenever possible and no new oil-fired power stations will be built in general. However, for many provincial and local planners, local needs now take precedence over central government policy. Even as the central government has been promoting the conversion of oil-fired plants, oil-fired plants continue to be built. For example in Shenzhen, the largest special economic zone in China, oil-fired power plants using imported oil have been constructed in recent years. Reportedly, Community Energy

Alternatives (CEA) of the United States has signed an agreement to build, own, and operate a 350 MW oil-fired power plant known as the Jiangmen West River Power Plant in the city of Jiangmen in Guangdong Province. The first phase of 100 MW has been built by the city of Jiangmen at a cost of about $80 million. There is no date certain for development of the 250 MW second phase. Because it is relatively small, CEA did not need central government approval for the Jiangmen project. In Fujian Province, a 46 MW oil-fired power plant will be built in Xiamen, using $8 million loans from foreign banks.

The construction of modern hotels and office buildings in China's coastal cities has created an immediate demand for power. Many of these facilities service the international community, which is unaccustomed to power rationing. The most common answer to this new demand has been the construction of diesel plants. The strong advantage that diesel plants offer in terms of shorter construction time has made them irresistible to many local planners. As a result, sales of diesel generators have skyrocketed. While aggregate consumption of crude oil used in power generation has declined, the power sector's demand for diesel oil has sharply increased.

In the short term, oil's share in total generating capacity is projected to increase slightly due to the increased demand of diesel generators in power short areas. In the long term, however, oil's share is projected to decrease gradually. In the future, large scale oil-fired steam power plants are unlikely to be built in China, additional oil-fired capacity will mainly include diesel generators and some small oil-fired steam power plants installed in the rapidly growing areas.

Natural Gas-Fired Capacity

Until recently, natural gas has been overlooked as an important source of energy in China. Few provinces produce natural gas, and natural gas accounts for only 2 percent of total primary energy production and consumption. About 95 percent of natural gas is produced by China National Petroleum Corporation (CNPC). In 1995, China's annual natural gas consumption was only about 618 billion cubic feet (BCF), equivalent to about 16.5 million tons of oil.

Natural gas is mainly consumed as a feedstock and fuel in the production of fertilizers in China, and is increasingly being used in the residential sector. Between 1985 and 1994, the residential sector's share of natural gas consumption increased from 3 to 16.4 percent. In the future, the residential sector's share of gas consumption is projected to increase further. For example, the development of the giant Shaanxi-Gansu-Ningxia gas field, which has verified reserves of 340 billion cubic meters in Northwest China (China Daily 4/15/96), is targeted to provide gas to Beijing to replace 600,000 coal stoves and 40,000 communal public chimneys in the residential sector. More than 700 industrial enterprises and hundreds of thousands of city residents now use natural gas in the southwest, and it is projected that demand there will increase to 8 billion cubic meters (283 BCF) by the turn of the century. Consumption of natural gas in the power sector is still very limited at less than 5 percent of total natural gas consumption. Gas-fired capacity is currently less than 1 percent of total generating capacity.

China's resources of natural gas are among the largest in the world. According to the national oil and gas resource assessment completed by CNPC in 1993, there are 151 (Mesozoic, Cenozoic, and Paleozoic) sedimentary basins onshore and in the continental shelf of China, with a total area of 4.33 million square kilometers. The total estimated natural gas resources are about 1,377 trillion cubic feet (TCF). However, due to limited investment in natural gas exploitation, proven gas reserves is only about 60 TCF, about 4 percent of estimated resources, much less than the world average level (about 50 percent of the world natural gas resources are proven reserves). China's investment in natural gas exploitation accounts for only 10 percent of the total investment of oil and gas exploitations, compared to 30 percent in the former Soviet Union.

Growth in natural gas production is also behind the potential. Between 1980 and 1995, the annual growth rate of gas production averaged only 1.6 percent. During the same period, the annual growth rate of total energy production increased 4.2 percent. The main factor inhibiting the exploitation of China's gas reserves has been the continued governmental control on gas prices. Prices for gas are set at artificially low levels. Actual production costs often exceed state-set prices by 25 percent. This disincentive to producers has led to an unusually high percentage of gas to be consumed in less profitable oil field uses. However, this situation is improving. As shown in Table 2.3, although natural gas prices are still below the international level, they have increased rapidly in recent years.

Table 2.3. China's Natural Gas Prices by Customer Category

	Price in Sichuan		Price in Other Locations	
	Yuan/1000CM	US$/1000CF	Yuan/1000CM	US$/1000CF
Fertilizer	470	1.60	440	1.50
Residential	530	1.81	460	1.57
Industry	490	1.67	520	1.77
Commercial	670	2.29	670	2.29

Source: East-West Center, 1996.

China's proven gas fields are mostly small. There are 155 with reserves less than 180 BCF that account for 82.4 percent of the total number of gas fields, but their reserves account for only 26 percent of total gas reserves. China has only 18 gas fields with reserves greater than 350 BCF each. Because most are small fields, the profitability of exploring for gas is not as good as for oil. This is also an obstacle to the development of gas.

Approximately 60 percent of China's gas reserves are nonassociated, and 40 percent are oil-associated. Associated gas is produced in large volumes in major oil fields. Daqing has the highest production of associated gas, with production levels at about 82 BCF in 1994, followed by Liaohe at 62 BCF, Shengli at 46 BCF, Zhongyuan at 42 BCF, and Xinjiang at 29 BCF. The largest reserves of nonassociated gas are located in the Sichuan basin, which has an estimated 32 TCF of largely unexplored gas reserves. In 1994, Sichuan accounted for about 44 percent of China's total gas production, followed by Heilongjiang at 13 percent, Liaoning at 12 percent, Shandong at 8 percent, and Henan at 7 percent.

The geographic proximity of gas reserves to major load centers and the under-utilization of natural gas indicates that there is a significant potential in an expansion of gas based generating capacity in China. The Renqiu fields lie only about 100 miles south of Beijing, the

Dagang field is 60 miles south of Tianjin, and the Daqing field is 90 miles north of Harbin. When compared with construction of long distance transmission lines and new rail lines, the infrastructure requirements for increasing the share of gas-based plants seem insignificant. Gas-based plants also offer several advantages, including: (1) a shorter construction period; (2) a lower sulfur emissions; and (3) a higher energy efficiency and reduced CO_2 emissions. Government legislation can play a leading role in promoting the expansion of gas-based power generation. Changes in gas pricing policy could create incentives to develop gas fields. Recent changes in domestic oil prices suggest that changes in gas pricing are not far off. China's coal-bed methane is also an important potential energy source for power generation. Total coal-bed methane reserves are estimated to be over 140 TCF and are a yet-untapped source of fuel.

During the Ninth Five-Year Plan period (1996-2000), China's natural gas exploitation is expected to take off, as senior government officials and corporate executives acknowledge the urgent need to tap the plentiful resources. Ambitious natural gas development programs have been slated by CNPC and China National Offshore Oil Corporation (CNOOC).

In Sichuan Province, 1.8 billion yuan ($220 million) will be invested during the 1996-2000 period in developing gas facilities in Datianchi in the eastern part of Sichuan. According to CNPC, more than 12 TCF of natural gas are verified in this area (China Daily 4/15/96). Natural gas production in this field is projected to reach 106 BCF by 2000. So far, 24 gas wells have been drilled in Datianchi, and 15 of them have revealed commercially viable gas flows.

In April 1996, CNOOC announced the discovery of China's second largest offshore natural gas field, the Dongfang 1-1. This field, located in the western part of the South China Sea, is estimated to contain more than 3.5 TCF of natural gas. The natural gas produced in this field will mainly be used to produce chemical fertilizer in Hainan Province. In areas southeast of Dongfang, CNOOC has discovered several medium and small gas fields. In Ledong 22-1, an estimated reserve of 700 BCF has been discovered; and in Ledong 15-1, 635 BCF has been discovered.

The government realizes the advantage of using natural gas as the fuel to generate electricity. With policy changes in gas pricing, China is likely to move more quickly to gas-based plants. The share of gas based generating capacity is projected to increase to 2 percent by 2005 and 4 percent by 2015, with gas-based generating capacity reaching 7.4 GW by 2005 and 25 GW by 2015.

Reportedly, Zhejiang Province is now soliciting international private power developers to participate in a 2.4 GW gas-fired power project in Yuhuan County. The county is completing a feasibility study for the project which will be located at the seaport of Dameiyu. The project will be undertaken in 600 MW phases.

Although the LNG form of natural gas is still considered too expensive at this stage, foreign investors have started to pay attention in this area. Reportedly, the US-based Wing Group's current portfolio of power ventures in China includes three proposed LNG-fired power projects totaling 7.2 GW to be located in the coastal provinces of China, although the Wing Group is now more seriously considering the pipeline gas option for these plants. The Wing Group has signed memoranda of understanding with the Electric Power Bureaus in Jiangsu, Shanghai, and Zhejiang. The Wing Group also signed a letter of intent with the Shanghai Electric Power Bureau covering a proposed 650 MW LPG power plant near Shanghai.

Hydropower Capacity

China has very rich hydropower resources. The country's theoretical hydropower potential is estimated at 676 GW, of which the technically exploitable potential is 378 GW, which could generate 1980 TWh of electricity per year (average capacity factor of 58 percent). An estimate made in 1992 declared that the economically exploitable hydropower resources was 290 GW, with an average capacity factor of 49.6 percent. The total hydropower capacity installed at the end of 1995 was only 18 percent of the economically exploitable capacity. There is still plenty of room for further development.

Although the central government is keen to develop hydropower resources, local governments do not have much of an incentive to invest in it. The share of hydropower plants in total generating capacity has dropped continuously from over 31 percent in 1980 to only 24 percent in 1995. The decentralization of the power industry, the higher capital costs of hydropower plants, the long lead time to construct a hydropower plant, the high discount rate for investors, and the location of major resources far from load centers are the major factors that have impeded hydropower exploitation.

The effects of decentralization of the power industry are two-fold. In one hand, it increased the efficiency of hydropower development. On the other hand, it reduced the share of hydropower investment in total power investment. Before decentralization, the construction of hydropower projects was entirely conducted by the central government. There were a number of regional design institutes and construction bureaus, each responsible for a specific area, and there was no competition. This system did not encourage savings in construction cost and time. The construction bureaus were usually over-staffed. When a new project was started, they had to move from one project site to another carrying with them their families, schools, and hospitals, resulting in a big waste in management and overhead expenses. After decentralization, Western consulting firms were brought in to help the Chinese learn the whole process, from the preparation of bidding documents and bid evaluation, to contract management, following the general practice of the Western world. The bidding system was accepted for use on many other projects in China, including projects entirely financed by domestic funds. The government-run construction bureaus were reorganized into construction corporations which are financially independent. Through competition bidding, a reduction of 15-30 percent of project costs could be achieved.

Many of the large hydropower projects in China have comprehensive multi-purpose benefits, such as flood control, irrigation, and navigation in addition to power generation. This makes the development of hydropower more attractive for the central government than the local power developers. Before the reforms, funding from the central government budget was the only source of hydropower investment. Now most hydropower projects are jointly funded by local governments and the central government. Figure 2.3 shows that the share of hydropower investment in total power sector investment decreased significantly after the power sector decentralization in the 1980s.

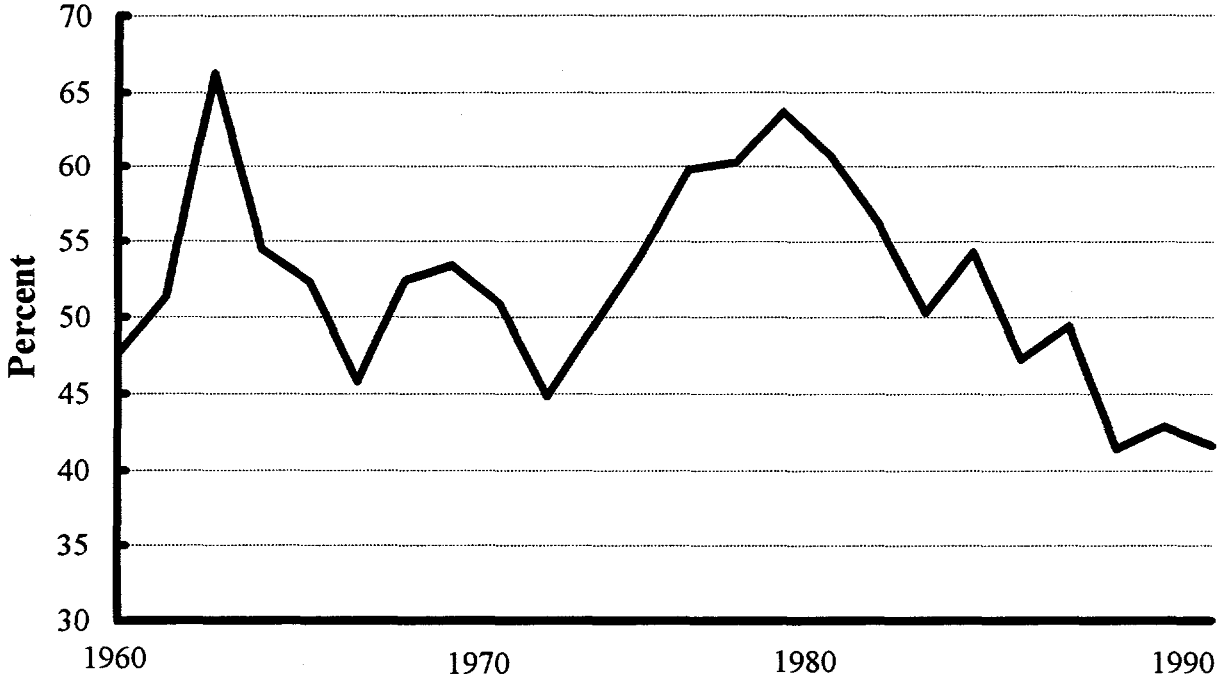


Figure 2.3. Share of Hydropower Investment in Total Power Sector Investment

Hydropower projects are normally much more expensive in capital costs than thermal projects. About half of the total investment in the power sector between 1953 and 1990 was in hydropower, yet hydropower accounts for only one quarter of Chinese power capacity and supplies only 19 percent of the electricity. Historically the capital cost per KW of hydropower capacity has averaged about 160 percent more than thermal plants. Even taking into account the potential costs of SO_2 emission controls on coal-fired plants and subtracting the costs of other benefits generated from the hydropower plants (such as irrigation and flood control), the capital cost of hydro plants is still over 100 percent higher than that of the coal-fired plants. Since the average capacity factor of hydropower plants is only about two-thirds of that of coal-fired plants in China, the equivalent capital costs to generate the same amount of electricity is even higher for hydropower plants.

Although the power sector reforms have improved the efficiency of hydropower development, the capital costs of hydropower plants are still substantially higher than thermal plants. For example, the capital costs of the six large hydropower plants (Yantan, Geheyan, Shuikou, Manwan, Guangzhou, and Wuqiangxi with total design capacity of 7.46 GW) constructed between 1986 and 1994 averaged $700 per KW (Cheng 1995), while the capital cost of coal-fired capacity (including associated power transformation and transmission equipment) is estimated at less than $400 per KW over the same period, assuming the use of domestically manufactured equipment. In a symposium held in 1994, it was concluded that the medium-sized hydropower plants (25-250 MW) can be built at a construction cost of about $600-850 per KW.

In contrast to thermal power plants, hydropower stations must be tailor-made to accommodate the different geographical and operational characteristics of specific hydropower projects. Every project involves a large amount of specific design work and can require years of preliminary design before actual construction can take place. Technology is not a major factor constraining Chinese manufacturers of medium-size projects under normal geographical conditions. However, technology imports are usually required in the following areas: (1) large turbine-generating units of over 300 MW; (2) bulb turbines required in low-head dams; and (3) generators for pump-storage projects.

Since the lead time of hydropower plants is longer than thermal plants, the discount rate for investors becomes very critical in determining the total present value of costs (including capital, fuel, and all other costs). In Figure 2.4, two curves are drawn, each assuming a different discount rate of project investors. Along the curves, the present value of total costs are the same for hydropower plants and coal-fired plants. Above the curves, coal-fired plants are cheaper than hydropower plants; while below the curves, hydropower plants are cheaper. In China, coal prices are typically in the $15-35 per ton range, and the capital cost of hydropower plants are typically in the $700-1000 per KW range. As shown in Figure 2.4, at a discount rate of 12 percent, coal-fired plants are cheaper than hydropower plants in most cases. But at a lower discount rate of 8 percent, substantial hydropower plants are cheaper than coal-fired plants. Since the typical discount rate adopted by power investors in China is likely to be at or higher than 12 percent, the economics is in favor of coal-fired plants in most cases.

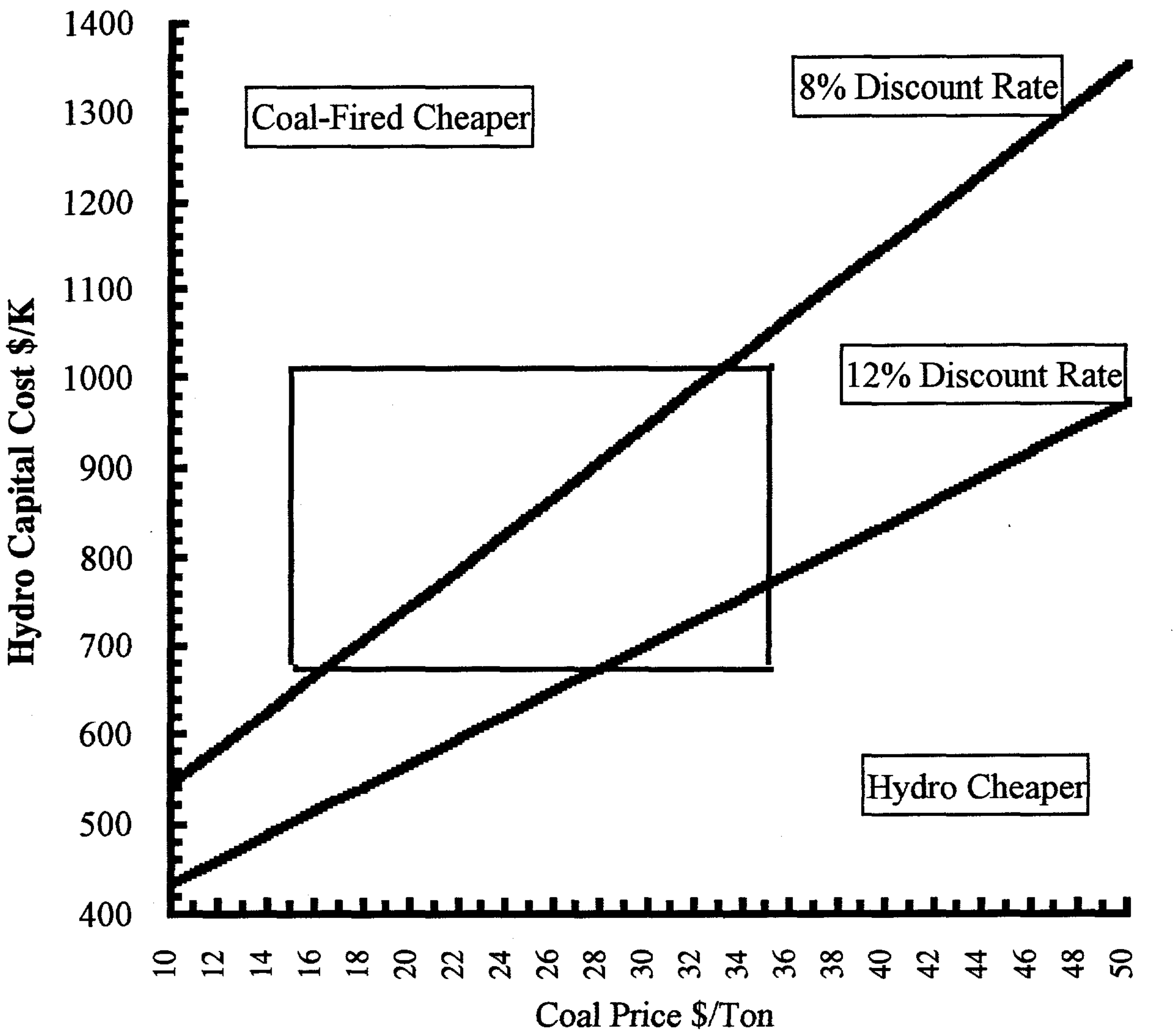


Figure 2.4. Hydro and Coal-Fired Power Plant Economics

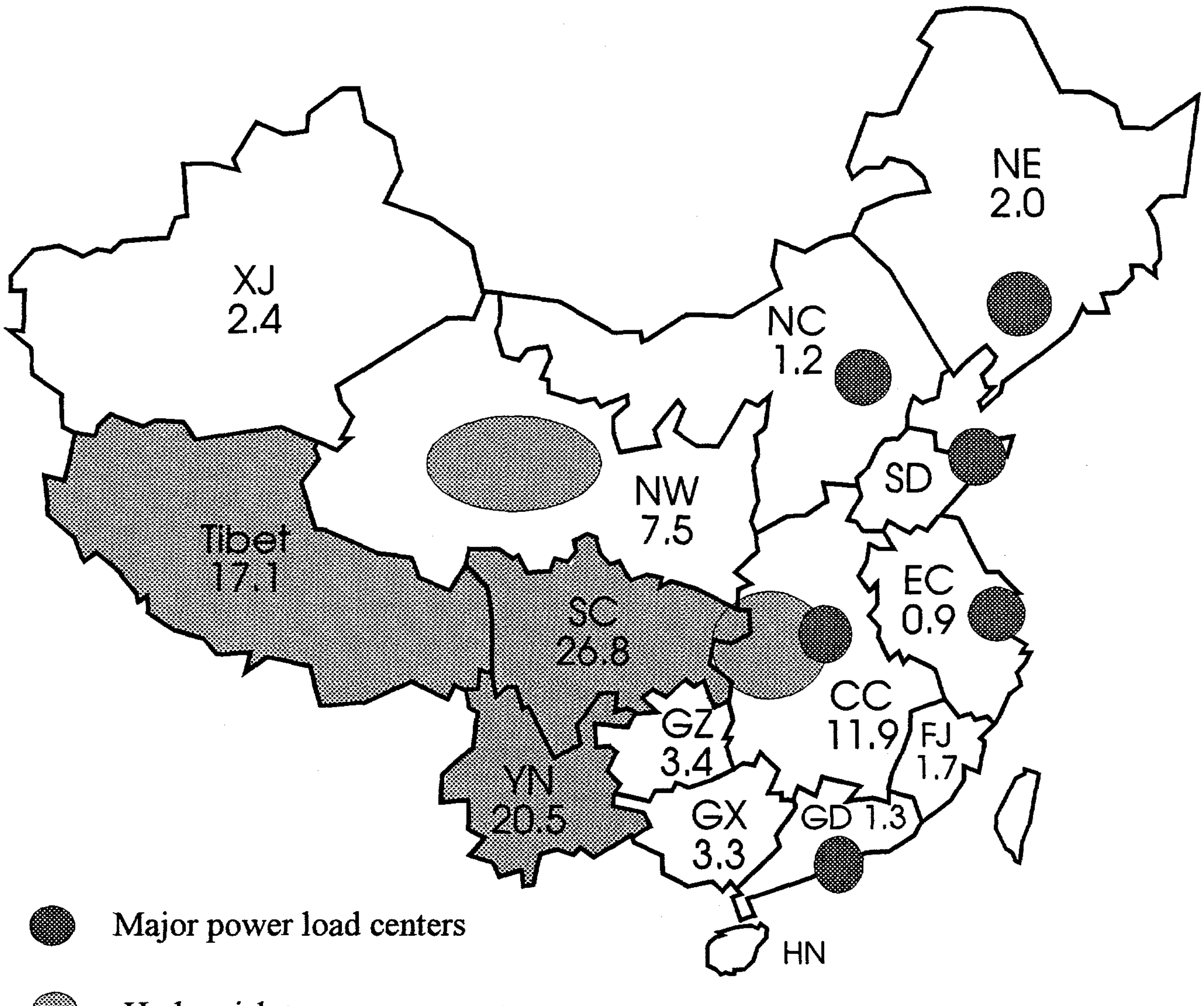
China's hydropower resources are remote, located mainly in the southwest, far away from electricity consumers in the east. Figure 2.5 shows that almost 70 percent of China's technically exploitable hydropower resources are located in the southwest (Sichuan, Yunnan, Tibet, and Guizhou, which are far away from major power load centers. Among the booming coastal provinces, only Fujian has some hydropower resources. Development of hydropower projects are focused on four major rivers and their tributaries, the Yangtze River, the Hongshui

River, the Yellow River, and the Minjiang River.

The Yangtze River originates in the Tibetan plateau and runs through north central China for a distance of 6,300 kilometers before reaching the sea. The Yangtze River and its tributaries (the Jinsha, Yalong, Daduhe, Wujiang, Hanjiang, Zishui, Yuanshui, and Lishui) account for more than half of China's hydropower resources. With a total fall of 5,400 meters, the Yangtze River has exploitable hydropower resources of almost 200 GW. Most of this potential lies on the upper portion of the river where the power market is very limited. Existing and planned hydropower projects on the Yangtze River include Gezhouba (2,715 MW), Ertan (3,300 MW), the Three Gorges (18,200 MW), Ankang (800 MW), Dongjieze (600 MW), Taipingyi (260 MW), Zhexi (448 MW), Baozhusi (700 MW), Wuqiangxi (1,200 MW), Geheyan (1,200 MW), Jinping (3,000 MW), and Beihetan (10,000 MW).

The Hongshui and Zhujiang river system located in south central China accounts for only 6 percent of China's exploitable hydropower potential. However, the system's proximity to Guangdong Province has made it one of the most active areas of hydropower development. Existing and planned hydropower projects on the Hongshui River include Yantan (1,100 MW), Dahua (1,200 MW), Longtan (4,000 MW), Datengxin (1,200 MW), Tianshengqiao I (1,200 MW), Tianshengqiao II (1,320 MW), and Lubuge (600 MW).

The Yellow River has a length of 5,464 kilometers and a total fall of 4,830 meters. The heavy silt load in the Yellow River's middle course necessitates the construction of massive costly reservoirs. The flooding problems created by the construction of the Sanmenxia project located in Henan Province caused a substantial scaling down of the project's original design. The relatively low silt load and deep gorge geography of the upper course have made that region the focus of recent development interest. On the Yellow River, some recent projects include: Liujiaxia (1,225 MW), Longyangxia (1,280 MW), Lijiaxia (2,000 MW), Laxiwa (3,000 MW) Yanguoxia (1,225 MW), Qingtongxia (272 MW), Sanmenxia (250 MW), Daxia, Wanjiazhai, and Xiaolangdi (1,800 MW).



Numbers represent the shares in total hydropower resources (%)

Figure 2.5. Regional Distribution of Hydropower Resources

The Minjiang and Ganjiang are located in southeast China. This system has less than 3 percent of China's exploitable potential. Proximity to major coastal load centers is the main advantage offered by projects in this region. Recent projects on the Minjiang and Ganjiang system include: Shuikou (1,400 MW) and Wanan (400 MW). In the coastal area, the Daguangba and Lianhua hydropower stations and a number of medium-sized and small hydropower stations are being built.

In order to promote hydropower development in the southwest and transmit electricity to the southeast, the South China Electric Power Joint Venture Corp (SCEP) was established. The four provincial power grids of Guangdong, Guangxi, Guizhou, and Yunnan were interconnected in July, 1993, to transmit electricity from the southwest to the southeast. Total installed capacity of the SCEP is planned to reach 40 GW by 2000 and 155 GW by 2015 (*International Private Power Quarterly*, Second-Quarter 1996). Reportedly, the SCEP has submitted a long-term plan to transmit electricity eastward from southwestern China, which requires an investment of around 100 billion yuan ($12 billion) to 2010. Much of the money will have to be sought from overseas. The funds will be used to build several hydropower and thermal power plants in Yunnan, Guizhou, and Guangxi. SCEP has contracts to send 3.43 GW from Yunnan and Guizhou to Guangdong and Guangxi before 2001. Power from SCEP is reportedly 40 percent cheaper than locally produced power in Guangdong (*China Daily* March 6, 1995).

In southwest China, 11 large-size hydropower plants (11 GW) have been built or are under construction. During the 1996-2000 period, 7 large hydropower plants, with a total capacity of 20 GW, will be build. More than ten joint venture power development agreements have been signed with foreign investors from the United States, Hong Kong, and Thailand in Yunnan, Sichuan, Guangxi, and Guizhou. A total of 65 large hydropower plants, with a combined capacity of 120 GW, are under planning in this region (*People's Daily Overseas Edition* March 26, 1994).

In July, 1993, China's State Council officially approved the Three Gorges Hydropower Project. The project will eventually add 18.2 GW (26X700 MW) of capacity, and average annual electricity generation will be 84.7 TWh. By the end of April, 1995, China had invested 9.5 billion yuan ($1.14 billion) in the Three Gorges project. The project is expected to cost a total of 146.8 billion yuan ($17.7 billion) by the time it is completed, or $973 per kW. Investment in 1995 will total 7 billion yuan ($843 million). Investment to date has come from two sources, the Three Gorges Construction Fund and domestic bank loans, each accounting for half the investment (*Asian Energy News* July 1995). China will also issue international bonds in 1995 to raise some of the $3 billion of foreign exchange needed to import the generators. The first unit in the Three Gorges project is scheduled to begin generation in 2003, and the whole project will be completed by 2009. Electricity generated from the Three Gorges will be transmitted to East China, Central China, North China, and Sichuan Province.

In Sichuan, the Sichuan Electric Power Administration (SEPA) has announced that it is now seeking international companies to take equity stakes and participate in the financing and construction of China's second largest hydropower project, the 3.3 GW Pubugou project in the counties of Hanyuan and Ganluo, both located in western Sichuan on the Dadu River. The project will install six 550 MW generating units.

In the northwest, a total of 25 large and medium-sized hydropower stations, with total capacity of 17 GW are planned between Longyangxia and Qingtongxia in the upper Yellow River. Presently 5 plants, with capacity of 3.3 GW and annual generation of 15.7 TWh, have been built, and two additional plants (2.3 GW) are under construction. Another 2.4 GW of capacity will be added by 2000, and 4.5 GW of new capacity will be added by 2010. Surplus hydroelectricity in the northwest will be sent to the North China Power Network.

It is uncertain whether this energy development, and electricity transmission strategy, will be successful, as it will increasingly be influenced by economic factors and not rigid central government plans. The main concern of the importing provinces is that exporting provinces will reduce their electricity export when local demand uses up the excess capacity.

In order to improve the operating conditions for power systems and reduce the environmental impacts of power generation, the central government is very ambitious to develop hydropower resources. China has introduced the method of cascade development, that is, to construct a series of plants along the same river. An early government plan had targeted a total of 75 GW of hydropower capacity to be built by 2000 (China Energy Annual Review 1994); however, due to difficulties in hydropower development, the government plan has been scaled down to install 66 GW of hydropower capacity by 2000, which will account for 22 percent of total generating capacity (MEPI 1995). The share of hydropower capacity is projected to decrease to about 20 percent by 2015.

As shown in Table 2.4, by the end of 1994, China had 41 hydropower stations with capacities of 250 MW and larger, with a total existing capacity of about 19 GW and an additional 16 GW under construction. The average capacity factor of these plants is estimated at around 46 percent.

With the soaring peak demand in many Chinese cities, the development of pumped storage stations become a necessity. Notable pumped storage projects include: (1) the 2,400 MW Guangzhou station in Guangdong Province, its first phase 1,200 MW was completed in 1994, and the second phase is expected to be commissioned in 1997; (2) the 1,800 MW Tianhuangping station near Shanghai, which started construction in 1994; (3) the 800 MW Shisanling station near Beijing, which is to be commissioned by 1995; (4) the 420 MW Panjiakou station near Tianjin, which was completed in 1992; and (5) the 112.5 MW Yangzhouyong Lake station in Tibet; which is expected to be commissioned in 1995. Table 2.5 shows the proposed pumped storage projects.

Table 2.4. China's Principal Hydropower Plants

	Name	River	Location	Capacity (MW)*		Generation	Operating
				Design	Existing	(TWh)	Hours
1	Shuifeng	Yalujiang	Liaoning	630	630	3.93	6238
2	Fengman	Songhuajiang	Jilin	639	639	1.96	3067
3	Yunfeng	Yalujiang	Jilin	400	400	1.75	4375
4	Baishan	Songhuajiang	Jilin	1500	1500	2.04	1360
5	Laohushao	Yalujiang	Jilin	390	390	1.20	3077
6	Panjiakou	Luanhe	Hebei	390	390	0.56	1446
7	Xin'anjiang	Xin'anjiang	Zhejiang	663	663	1.86	2808
8	Jinshuitan	Quijiang	Zhejiang	300	300	0.49	1633
9	Tianhuangping		Zhejiang	1800			
10	Wan'an	Ganjiang	Jiangxi	400	500	1.05	2625
11	Shaxikou	Shaxi	Fujian	300	300	0.96	3200
12	Shuikou	Mingjiang	Fujian	2000	800	4.95	2475
13	Zhaxi	Zishui	Hunan	448	448	2.20	4916
14	Fengtan	Youshui	Hunan	400	400	2.04	5100
15	Dongjiang	Laishui	Hunan	500	500	1.32	2640
16	Wuqiangxi	Yuanshui	Hunan	1200		5.37	4475
17	Danjiangkou	Hanjiang	Hubei	900	900	3.83	4256
18	Gezhouba	Changjiang	Hubei	2715	2715	14.10	5193
19	Geheyan	Qingjiang	Hubei	1200	1200	3.04	2533
20	Xiaolangdi	Huanghe	Henan	1800		5.10	2833
21	Guangzhou PS	Tributary of Liuxi	Guangdong	1200	1200	2.38	1983
22	Guangzhou PS II	Tributary of Liuxi	Guangdong	1200			
23	Dahua	Hongshuihe	Guangxi	400	400	2.05	5125
24	Yantan	Hongshuihe	Guangxi	1210	908	5.37	4438
25	Gongzui	Daduhe	Sichuan	1370	1370	7.33	5350
26	Baozhusi	Bailongjiang	Sichuan	700		2.28	3257
27	Tongjiezi	Daduhe	Sichuan	600		3.21	5350
28	Ertan	Yalongjiang	Sichuan	3300		17.00	5152
29	Wujiangdu	Wujiang	Guizhou	630	630	3.34	5302
30	Tianshengqiao-II	Nanpanjiang	Guizhou/Guangxi	1320	440	8.20	6212
31	Tianshengqiao-I	Nanpanjiang	Guizhou/Guangxi	1200		5.38	4483
32	Lubuge	Huangnihe	Yunnan/Guizhou	750	750	2.75	3667
33	Dongfeng	Wujiang	Guizhou	510		2.42	4745
34	Manwan	Lancangjiang	Yunnan	1250	1000	5.48	4384
35	Yanguoxia	Huanghe	Gansu	396	396	2.15	5429
36	Liujiaxia	Huanghe	Gansu	1225	1225	5.58	4555
37	Bikou	Bailongjiang	Gansu	300	300	1.46	4867
38	Ankang	Hanjiang	Shaanxi	800	800	2.86	3575
39	Longyangxia	Huanghe	Qinghai	1280	1280	5.98	4672
40	Lijiaxia	Huanghe	Qinghai	2000		5.90	2950
41	Shisanling PS	Wenyuhe	Beijing	800		1.2/1.65	1781

*Capacity as of December 31, 1994.

Table 2.5. Proposed Pumped-Storage Projects in China

Project	Province	Capacity (MW)	Head (M)
Total		12,194	
Pingjiang	Hunan	3,000	700
Huanggou	Heilongjiang	1,200	358
Pushihe	Liaoning	1,200	337
Banqiaoyu	Beijing	1,000	553
Zhanghewan	Hebei	1,000	349
Taohuashi	Tianjin	1,000	173
Xilongchi	Shanxi	1,000	819
Xianshuijian	Anhui	1,000	175
Taian (I)	Shandong	800	220
Tushan	Anhui	600	237
Xiwan	Jiangsu	150	57
Xianxongdian	Anhui	120	65
Xikou	Zhejiang	80	271
Langyaoshan	Anhui	44	135

Nuclear Power Capacity

Nuclear power development has progressed slowly in China. So far, only two nuclear power plants have been built in China, with 2.1 GW of capacity in operation. The domestically designed and constructed 300 MW Qinshan Nuclear Power Station (first phase) in Zhejiang Province was commissioned on December 15, 1991. The Qinshan project used a pressurized light water reactor. About 70 percent of the equipment in Qinshan was domestically manufactured. The second phase of the Qinshan station includes two 600 MW units which are now under construction. A larger share of domestic manufactured equipment will be used in the second phase of Qinshan. Commissioning of the second phase is expected after 2000.

The second nuclear plant is the 2X900 MW imported Daya Bay Nuclear Power Station in Guangdong Province--a joint venture with Hong Kong Light and Power Company. The first unit was commissioned in February, 1994, followed by the second unit in May, 1994. Construction of the $4 billion power plant was begun eight years ago. The plant is about 50 kilometers from Hong Kong, and 70 percent of the electricity will be sent to Hong Kong.

Imported nuclear power is an expensive option for China. The capital cost of Daya Bay is about $2200 per kW and the estimated capital cost of the planned Yangjiang Nuclear Power Plant (an imported plant in Guangdong) is $1727 per kW, while information from the listing prospectus of Huaneng Power International revealed that the estimated capital costs for domestic and imported coal-fired plants are about $427 and $750 per kW, respectively.

Although domestic nuclear power plants are cheaper than imported plants, domestic nuclear technology is still in the demonstration stage. In order to accelerate nuclear power development, China is focusing on the development of domestic 600 MW pressurized water reactors, anticipating mass production after 2000. Research and development are also underway on the advanced concentration technique of nuclear fuels, 1,000 MW pressurized water reactors, and 600 MW pressurized reactors with higher security characteristics. At this stage, the timing of available mature domestic nuclear technology is still subject to great uncertainty.

Nuclear power development has recently gained momentum in China due to environmental concerns and continued coal transportation bottlenecks. According to a recent announcement by Guangdong provincial officials, coal and oil-fired power plants will be banned from the Pearl River Delta in Guangdong Province in an attack on air pollution and acid rain (*Xinhua Daily Telegraph* May 31, 1995). The Pearl River delta contributes more than 70 percent of Guangdong's GDP. Nuclear power is seen as an increasingly attractive answer to meet electricity demand in this area. However, the implementation of the announcement appears questionable, because nuclear power plants will take many years to develop. Although electricity transmission from hydropower stations in southwest China may meet some of the growing electricity demand in this area, the continuing prosperity of the region is expected to require more electricity than the hydropower transmitted from the southwest could possibly to provide.

Most nuclear capacity is planned for Guangdong Province, which is located far from both coal fields and hydro sites. The rapid economic growth rates of this export-oriented province, and serious electricity shortages, increase the appeal of nuclear power. Although the large planned nuclear expansions may occur, it is the author's view that coal-fired plants (using both domestic and imported coal) are a lower cost, and more realistic alternative for the majority of the power requirements of Guangdong Province. The environmental impacts of coal-fired power plants can be reduced by introducing clean coal technologies.

China has ambitious plans for nuclear power development. According to the State Planning Commission, development of nuclear power will be among the top priorities of the Chinese government. A total of 10 GW of nuclear power plants will be under construction by the turn of the century. In the Ninth Five-Year Plan period (1996-2000), the government will allocate funds to standardize nuclear power plant construction (*China Daily Business Weekly* June 25, 1995). According to China's Nuclear Institute, under the low scenario, total unclear capacity will reach 20 GW by 2010 and 120 GW by 2050; under the high scenario, total unclear capacity will reach 40 GW by 2010 and 240 GW by 2050. It is important to note that China's large nuclear expansion plans appear overly ambitious. By the end of this decade, China can expect to have only two nuclear power plants. The recent aggressive push in nuclear power plant construction would only bear fruit after 2000.

Figure 2.6 shows the locations of the existing and planned nuclear power stations. According to China's Ninth Five-Year Plan, during the 1996-2000 period, China will start to construct the 2,000 MW Lingao project in Guangdong (eight kilometers from Daya Bay). Construction of the Lingao project was expected to begin in early 1996. The first unit is scheduled to be completed in 2002, and the second unit is scheduled for 2003 (*Power In Asia* August 21, 1995).

Meanwhile, China is to co-operate with Russia to construct a 4X1,000 MW nuclear power plant in Wafangdian, Liaoning Province. Reportedly, China has approved the construction of the Wafangdian project. The first phase of the plant will install two 1,000 MW units, with an estimated investment of 27 billion yuan ($3.25 billion). Apart from the Russian government loans, the China National Nuclear Corp., the Liaoning provincial government, and the Northeast Power Group will also provide investment for the project (*China Daily* May 6, 1995).

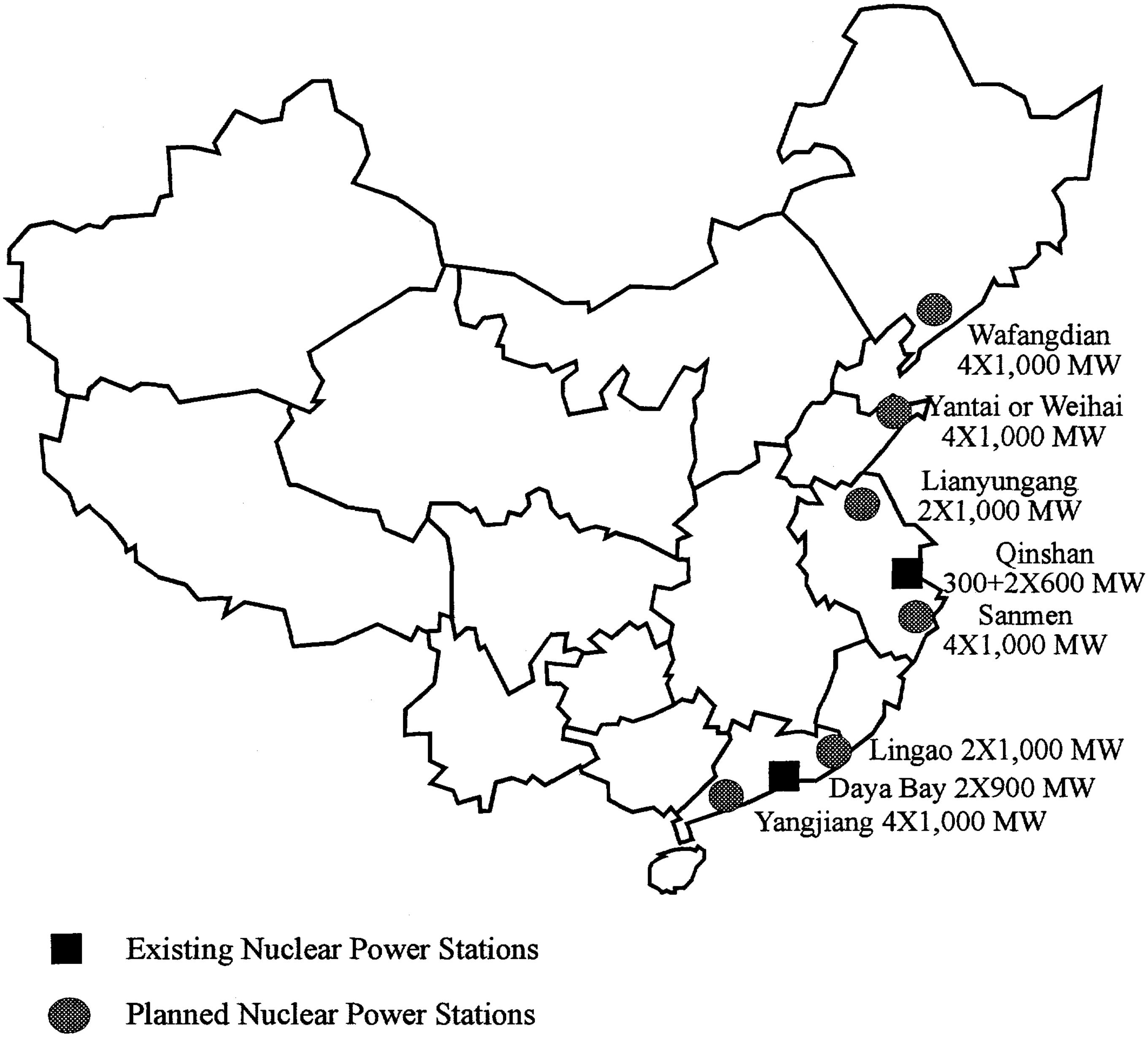


Figure 2.6. China's Existing and Planned Nuclear Power Stations

According to the Ministry of Electric Power Industry, Shandong Province has obtained approval to build a 4X1,000 MW nuclear power plant. The plant will be located either in Yantai or in Weihai. The first two units are scheduled to start construction in 1998. Initial investment in the first phase will be 40 billion yuan ($4.8 billion). The proposed Shandong project is not included in the nuclear power development plans of the China National Nuclear Power Corporation (*Power in Asia* September 4, 1995).

The preparatory works will also be conducted for the 4,000 MW Yangjiang project (may be extended to 6,000 MW later) in Guangdong and the 4,000 MW Sanmen project in Zhejiang (MEPI 1995; *China Daily* April 6, 1995). Local authorities in Fujian, Jiangsu, and Hainan are also keen to build nuclear power stations to meet booming power demand. Total nuclear capacity is projected to reach 20 GW by 2010 and 25 GW by 2015.

Currently, China's existing and planned nuclear reactors are mainly imported from French. The French had hoped China would standardize its nuclear power industry using French technology. However, some Chinese officials are in favor of diversification of nuclear technology, especially after a faulty guide-tube system caused the unit one reactor at Daya Bay to be shut down from March, 1995, until the end of June. The strained relationship between China and France has slowed Sino-French talks on building the Lingao project. China has announced that nuclear power equipment that has not been operationally tested by its foreign supplier will not be imported anymore. The anti-vibration control-rod-guide-tube system installed in Daya Bay was never operationally tested in any of France's nuclear power plants.

Deterioration of the Sino-French relationship could be good news for the U.S. nuclear power industry. Westinghouse, General Electric, ABB, and other companies are also interested in obtaining a share in the world's largest potential market for nuclear power. So far, however, U.S. companies have been frustrated by U.S. government restrictions on nuclear power hardware sales to China. Before any US sales can go ahead, the U.S. president must certify that China is not proliferating nuclear technology. China's agreement in the mid-1980s to sell a nuclear reactor to Pakistan kept U.S. suppliers out of the bidding for the first phase of Daya Bay. With China on the verge of selling a similar reactor to Iran, such certification would be difficult. Nonetheless, some U.S. executives are hopeful the barriers may soon disappear. Since Energy Secretary Hazel O'Leary's visit to China in 1995, the U.S. embassy has been collecting information on how much business U.S. companies are losing because of the restrictions.

China has already signed letters of intent to buy nuclear equipment from Russia and Canada. And Chinese officials have privately told several U.S. executives that they would prefer U.S. reactors over any others if Washington would allow the sales (*Wall Street Journal* April 25, 1995). Reportedly, Korea Electric Power Corp (KEPCO) has signed a memorandum of understanding with the Chinese National Nuclear Corp. which could lead to construction of a Korean designed reactor in China. Under the agreement, the two companies will undertake a feasibility study to determine the technical and economic viability of building a Korean standard nuclear power plant in China. The nuclear reactor to be imported will be the same as the 1,000 MW KEPCO units now under construction as units 3 and 4 at Uljin, North Kyongsang Province. If the project proceeds beyond the feasibility study stage, KEPCO expects to arrange loans and financial assistance for constructing the plant.

Fuel Consumption of Thermal Power Plants

China's thermal power is mainly generated using coal. As shown in Table 2.6, the share of coal in total fuel consumption of thermal power generation increased from 76 percent in 1980 to 94 percent in 1994, while the share of oil decreased from 24 to 5 percent. The role of gas in thermal power generation is very limited at less than 1 percent. In 1994, 393 million metric tons (Mt) of coal, 12 Mt of oil, and 30 BCF of gas were consumed in thermal power plants of 6 MW and above to generate electricity. In addition, about 40 Mt of coal, 3 Mt of oil, and 25 BCF of gas were consumed in power plants to produce steam and hot water.

Between 1980 and 1995, total coal consumption (including coal consumption in steam and hot water production) in the power sector more than tripled, increasing from 123 Mt in 1980 to 478 Mt in 1995. During the same period the growth of coal consumption in China's power sector accounted for about three-quarters of China's total coal consumption growth.

Table 2.6. Fuel Consumption of Thermal Power Generation

	Coal (Mt)	Oil (Mt)	Gas (BCF)	Total (MTCE)	Share of Fuel (%) Coal	Oil	Gas
1980	110	16	7	97	75.7	24.0	0.3
1981	110	16	6	96	76.4	23.4	0.2
1982	117	15	8	100	77.9	21.8	0.3
1983	126	15	7	104	79.7	20.0	0.3
1984	141	14	10	113	82.2	17.5	0.3
1985	157	13	13	124	84.1	15.6	0.4
1986	193	14	19	137	85.4	14.0	0.5
1987	196	13	20	152	86.9	12.6	0.5
1988	224	14	15	168	87.5	12.2	0.3
1989	274	17	33	201	87.2	12.2	0.6
1990	291	15	34	212	89.0	10.4	0.6
1991	326	15	37	237	90.4	9.1	0.6
1992	327	12	23	233	92.3	7.3	0.4
1993	362	12	29	288	93.7	6.0	0.4
1994	393	12	30	309	94.2	5.4	0.4

Sources: 1995 Energy Report of China

In contrast to other sectors, coal consumption in China's power sector is relatively price inelastic. Between 1988 and 1993, due to coal price increases, coal consumption in most other sectors stagnated or even declined, while consumption in the power sector increased by more than 60 percent. During this period, increases in coal consumption within China's power sector (154 Mt) exceeded China's total coal consumption growth in the same period (127 Mt). In order to determine the fuel demand of China's power sector, giving the projection of generating capacity and energy mix, the following factors will have to be considered: (1) the average capacity factors for each type of power plants; (2) the thermal efficiencies of each type of plants; and (3) the demand of fuels for cogeneration of steam and hot water.

Table 2.7. China's Gross Generation by Energy Source

	Gross Generation by Energy Type (TWh)						
	Coal	Hydro	Oil	Gas	Nuclear	Others	Total
1980	183	58	59	1	0	0	301
1985	265	92	52	1	0	0	411
1990	437	125	55	4	0	1	621
1995	760	175	48	4	12	1	1000
2000	1062	230	78	12	15	3	1400
2005	1354	320	103	27	57	8	1869
2010	1783	405	111	45	140	15	2500
2015	2352	515	135	120	177	31	3330
Growth Rate							
1981-1995	10.0	7.6	-1.3	12.5			8.3
1981-1985	7.7	9.7	-2.5	12.0			6.4
1986-1990	10.5	6.2	1.2	27.2			8.6
1991-1995	11.7	7.0	-2.7	0.0		7.4	10.0
1996-2000	6.9	5.6	10.1	25.1	5.2	23.7	7.0
2001-2015	5.4	5.5	3.7	16.5	17.7	17.0	5.9
	Share in Gross Generation (%)						
	Coal	Hydro	Oil	Gas	Nuclear	Others	Total
1980	60.9	19.4	19.5	0.2	0.0	0.0	100
1985	64.6	22.5	12.6	0.3	0.0	0.0	100
1990	70.3	20.1	8.9	0.6	0.0	0.1	100
1995	76.0	17.5	4.8	0.4	1.2	0.1	100
2000	75.8	16.4	5.5	0.9	1.1	0.2	100
2005	72.5	17.1	5.5	1.5	3.0	0.4	100
2010	71.3	16.2	4.5	1.8	5.6	0.6	100
2015	70.6	15.5	4.0	3.6	5.3	0.9	100
	Average Capacity Factors (%)						
	Coal	Hydro	Oil	Gas	Nuclear	Others	Total
1980	61	33	59	78			52
1985	61	40	57	68			54
1990	56	39	55	38		40	51
1995	61	38	35	22	65	38	53
2000	60	40	37	35	84	33	53
2005	59	42	37	42	81	35	53
2010	59	42	33	43	80	35	54
2015	59	42	34	55	81	35	54

As shown in Table 2.7, over the past 15 years, China's overall average capacity factor has been in the 51-54 percent range.[1] The average capacity factor of coal-fired plants remained at about 61 percent, the average capacity factor of hydropower plants increased from 33 to 38 percent due to the commissioning of a number of large hydropower plants which have better seasonal adjustability. The average capacity factor of oil-fired plants decreased substantially from 59 to 35 percent due to the government policy of substituting coal for oil in power generation.

In the future, although the commissioning of new large traditional hydropower stations will tend to increase the average capacity factor of hydropower plants, the new pumped storage stations required to meet peak demand will tend to reduce the average capacity factor of hydropower plants. The combined effects are expected to leave the average capacity factor of hydropower plants increasing only slightly in the short run and remain at about 42 percent in the long run.

Since nuclear power plants are used to serve the base load, their capacity factors are typically the highest in the power system, while oil-fired capacity, especially diesel generators, will mainly be used to serve the peak load. Therefore, the load factor of oil-fired plants is expected to remain low. Most of China's gas-fired plants are expected to use pipe-line gas instead of LNG, the capacity factor of gas-fired plants is expected to be below average in the short run but gradually exceed average in the long run because of the requirement of stable gas supplies. The capacity factor of coal-fired plant is expected to remain at about the current level, due to the constraints of China's load patterns. China's overall capacity factor is expected to stay at about the current level over the next two decades.

Under the above expectations, it is projected that China's coal-fired electricity will reach 1,026 TWh by 2000 and 2,352 TWh by 2015; oil-fired electricity will reach 78 TWh by 2000 and 135 TWh by 2015; gas-fired electricity will reach 12 TWh by 2000 and 120 TWh by 2015;

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[1] The average capacity factor is calculated using the year-end installed capacity and annual gross generation, which is slightly lower than the reported capacity factor for power plants of 6 MW and above.

and unclear power will reach 177 TWh by 2015.

The thermal efficiency of China's power sector is very low according to international standards, and it has been improving very slowly. As shown in Table 2.8, gross energy consumption per kWh of electricity decreased from 407 grams of coal equivalent (gce) in 1980 to 381 gce in 1994, representing an improvement of thermal efficiency of about 2 percentage points from 30.2 to 32.3 percent.

Table 2.8. China's Thermal Efficiency in Power Generation, 1980-2015

	Fuel Consumption (gce/kWh)*				Thermal Efficiency (%)			
	Total	Coal	Oil	Gas	Total	Coal	Oil	Gas
1980	407				30.2			
1981	404				30.4			
1982	400				30.7			
1983	398				30.9			
1984	398				30.9			
1985	398				30.9			
1986	397				30.9			
1987	397				30.9			
1988	397				31.0			
1989	392				31.3			
1990	390				31.5			
1991	390				31.5			
1992	386				31.8			
1993	384				32.0			
1994	381				32.2			
1995	380	380	380	377	32.3	32.3	32.3	32.6
2000	372	372	375	354	33.0	33.0	32.8	34.7
2005	362	362	370	330	33.9	33.9	33.2	37.2
2010	350	350	360	310	35.1	35.1	34.1	39.6
2015	339	340	350	290	36.3	36.1	35.1	42.4

* Gross fuel consumption.

Such a low thermal efficiency of power generation is due mainly to electricity shortages and a pronounced lack of capital. Owing to the severe power shortages, some of the world's oldest generating units are still in operation within China. China currently has 30 GW small, and low-efficient coal-fired generators, with the average thermal efficiency of less than half the high-efficient generators.

China's MEPI is very ambitious to improve the thermal efficiency of the power sector through the introduction of high-efficient generators and by retrofitting low-efficient generators. As a matter of MEPI policy, newly-installed coal-fired generators in the inter-provincial power networks will seek to have coal consumption not higher than 330 gce per kWh, or 37 percent in thermal efficiency. Newly-installed power plants will use mainly 300 MW and 600 MW units for domestic manufactured generators, and 350 MW and 660 MW units for imported generators. During the 1990s, China plans to retrofit or eliminate 18.5 GW of the small, low-efficient power plants. However, past experience has shown that when electricity shortages are serious, small and medium-sized low-efficiency power plants will proliferate, while old power plants will continue in service even though they should have been retired.

Given the success of China's economic development, the country is not likely to allow power shortages to curb future economic growth. If sufficient foreign investment and high-efficiency generators are not available, the high economic costs of electricity shortages will lead to increased utilization of low-efficient generators, and much higher energy consumption in the long run. This scenario has been observed in recent Chinese history, and the 30 GW low-efficient power plants are in part the result of insufficient foreign-invested and/or high-efficiency domestic generating capacity.

Within the present environment of decentralization, government regulations are decreasing. For example, despite the MEPI policy that newly-commissioned power plants should have thermal efficiency over 37 percent, low-efficiency power plants increased substantially in recent years. As the share of central government investment in the power sector decreases, the ability to implement government policy through regulations also decreased. Given serious power shortages, local consumers will build inefficient, small power plants due to their limited ability to raise funds and lack of experience in constructing large power plants. Some local consumers even import outdated or retired foreign generators because of their low capital costs.

For these reasons, we project that the thermal efficiency of China's coal-fired power plants will not improve substantially in the short term (see Table 2.8). The thermal efficiency of gas-based plants are, however, projected to increase much faster than that of coal-fired plants, because combined-cycle gas generators, which have much higher thermal efficiency, will increasingly be used in China. The thermal efficiency of oil-fired plants is projected slightly below that of coal-fired capacity, because most oil-fired plants are either very old or very small.

In addition to the fuels used to generate electricity, the power sector also consumes substantial fuels to produce steam and hot water. Since the combined efficiency of co-generation is generally above 80 percent, developing co-generation is adopted as one of China's basic energy policies. Currently, China has more than 400,000 industrial boilers with a total capacity of around 800,000 tons of steam per hour. These boilers annually consume more than 300 Mt of coal. The Residential sector also consumes substantial coal for space heating. The potential to develop co-generation is very great. Future development of co-generation is more likely through coal-fired plants for economic reasons. Therefore, the share of coal used in producing steam and hot water in the power sector is projected to remain at least at the current level, while the shares of oil and gas used in co-generation are expected to decline.

Table 2.9 shows that China's total coal consumption in the power sector is projected to reach 811 Mt by 2005 and 1,323 Mt by 2015; total oil consumption is projected to reach 32 Mt by 2005 and 37 Mt by 2015; and gas consumption is projected to reach 277 BCF in 2005 and 969 BCF by 2015.

Table 2.9. Projection of Fuel Consumption in the Power Sector

	Fuel Consumption in Power Generatiion						
	Coal (Mt)	Oil (Mt)	Gas (BCF)	Total (MTCE)	Share of Fuel (%) Coal	Oil	Gas
1995	426	13	40	309	93.6	5.9	0.5
2000	583	20	113	429	92.2	6.8	1.0
2005	724	27	237	537	91.2	7.1	1.7
2010	922	28	370	678	92.0	5.9	2.1
2015	1181	33	924	882	90.7	5.4	3.9
	Fuel Consumption in Steam and Hot Water Production						
	Coal (Mt)	Oil (Mt)	Gas (BCF)	Total (MTCE)	Share of Fuel (%) Coal	Oil	Gas
1995	51	3.0	30	40	86.5	10.7	2.8
2000	70	3.5	35	54	88.2	9.3	2.5
2005	87	3.7	40	66	89.6	8.1	2.3
2010	111	4.0	45	82	91.0	6.9	2.1
2015	142	4.0	45	103	92.8	5.5	1.6
	Total Fuel Consumption in the Power Sector						
	Coal (Mt)	Oil (Mt)	Gas (BCF)	Total (MTCE)	Share of fuel (%) Coal	Oil	Gas
1995	478	16	70	349	92.8	6.5	0.8
2000	653	24	148	482	91.7	7.1	1.2
2005	811	30	277	603	91.1	7.2	1.7
2010	1032	32	415	760	91.9	6.0	2.1
2015	1323	37	969	985	90.9	5.4	3.7

* Heat content: Coal 4,740 Kcal/kg, Oil 10,000 Kcal/kg, Gas 263.6 Kcal/CF.

The Manufacturing Capacity of Generating Equipment

China's power equipment manufacturing industry has now reached the ability to produce 10 GW large and medium-sized power generating equipment. Domestic manufacturers can produce 8.6 GW of generators with unit capacity of 100 MW and larger, and 2 GW generators with unit capacity of 50 MW and smaller. China now has nine major bases to manufacture thermal power equipment in Harbin, Shanghai, Sichuan (Dongfang), Beijing, Wuhan, Jiangsu, Shandong, Hangzhou, and Guangzhou. The Xian Power Machinery Manufacturing Co. and Northeast Electric Power Transmission and Transformation Co. are major manufacturers of electricity transmission and transformation equipment. Domestically manufactured generators are mainly 600 MW, 300 MW, 200 MW, 125 MW, 100 MW, 75 MW, 50 MW, 25 MW, 12 MW, 6 MW, 3 MW, and 1.5 MW units.

The manufacturing industry of China's hydropower equipment consists of nearly 100 enterprises. Large hydropower generators are mostly manufactured in Harbin and Dongfang, while medium and small hydropower equipment can also be manufactured in Tianjin, Chongqing, Hangzhou, Shaoguan, Fujian, Nanning, Lingling, and Kunming. Total annual manufacturing capacity is about 2 GW. The most commonly adopted hydropower units are the Francis generators, of which China has manufactured several hundreds.

Domestic manufacturers usually join up with foreign manufacturers to bid for large hydropower projects. For example, Harbin Power Plant Equipment Corporation has teamed up with Hitachi to bid for the generators in the 7X200 MW Shuikou Power Plant in Fujian. Similarly, Dongfang Electric Machinery Corporation is working with Canada GE on a bid to supply equipment for the 6X550 MW Ertan Power Station in Sichuan. Equipment supply for the Three Gorges Project will follow a similar pattern: foreign partners will supply the first few sets of equipment, the equipment will then be jointly manufactured by the domestic and foreign manufacturers, and the final sets will be made by the domestic manufacturer alone.

Currently, domestically manufactured power generating equipment can only meet 70-75 percent of China's needs. China plans to add an average of 17 GW per year of installed capacity between 1996 and 2000. The Ministry of Machinery Industry (MMI) will have difficulty meeting this target for power generators. This imbalance has created a large market for foreign manufacturers of power generation equipment. Importing the required equipment will have a significant impact on China's trade balance.

Domestic Power Plant Builder

The 62 power construction companies in China are divided into three classes according to government guidelines. Only a few of these enterprises are integrated companies that can do all phases of power plant construction. As a rough guideline, the first-class enterprise can serve as primary contractor to install 600 MW units; the second-class enterprise can serve as primary contractor to install 300 MW units; and the third-class can serve as primary contractor to install 100 MW units.

China has only 4 first-class power plant constructors: (1) the Anhui No.2 Electric Power Construction & Engineering Corp. (EPCEC); (2) the Northeast EPCEC; (3) the Shanghai EPCEC; and (4) the Zhejiang EPCEC. Of there four enterprises, only the Anhui No.2 EPCEC and the Northeast EPCEC are integrated builders and do all phases of plant construction. The Shanghai EPCEC and the Zhejiang EPCEC only install the plant equipment, and use other power constructors as their subcontractors. There are about 20 second-class power plant constructors in China. Most of these companies are not integrated and use many subcontractors to get the work done.

Technology Sophistication

About 80 percent of China's power plants use domestic equipment, and the other 20 percent use imported equipment. Table 2.10 shows that about 55 percent of China's thermal power capacity was composed of units above 100 MW each in 1994, and 44 percent of hydropower capacity was composed of units above 40 MW each. The most common thermal generator sizes were 200 MW, 100 MW, 125 MW, and 300 MW. Between 1987 and 1994, the capacity share of "principal units" (200 MW and above) increased from 24 to 36 percent.

Table 2.10. Indicators of China's Major Generating Units in 1994

Fossil-Fired Units (100 MW and above)

Rating (MW)	No.of units	Capacity Total (MW)	Capacity Share (%)	Generation Average (MWH)	Generation Total (TWh)	Generation Share (%)	Annual Operating Hours	Weighted Average EAF (%)	Weighted Average EFOR (%)
100	115	11500	14	584997	67	14	5850	88.40	2.52
110	6	660	1	745022	4	1	6773	89.41	0.59
120	2	240	0	750674	2	0	6256	85.64	3.67
125	86	10750	13	771618	66	14	6173	87.54	3.21
200	143	28600	34	1198941	171	36	5995	85.02	4.42
210	10	2100	3	1163878	12	2	5542	87.48	3.96
250	2	500	1	1829816	4	1	7319	92.77	0.07
300	55	16500	20	1695151	93	19	5651	77.60	9.97
320	4	1280	2	1058588	4	1	3308	81.29	11.52
330	2	660	1	1955761	4	1	5927	79.47	6.18
350	12	4200	5	2123153	25	5	6066	87.71	2.34
362	4	1446.7	2	1820847	7	2	5035	76.27	2.43
500	2	1000	1	1852082	4	1	3704	67.21	15.31
600	6	3600	4	3057580	18	4	5096	73.64	6.89
Sub-total	449	83037	100		483	100			
Share of thermal			55			63			

Hydropower Units (40MW and above)

Type	No.of units	Capacity Total (MW)	Capacity Share (%)	Generation Average (MWH)	Generation Total (TWh)	Generation Share (%)	Annual Operating Hours	Weighted Average EAF (%)	Weighted Average EFOR (%)
Axial	57	5198	24	424557	24	33	4656	90.17	0.46
Francis	149	16000	75	333766	50	67	3108	91.70	0.21
P.S.	3	270	1	155490	0	1	1728	89.39	0.91
Sub-total	209	21467	100		74	100	3466		
Share of hydro			44			45			

EAF: Equivalent availability factor. EFOR: Equivalent forced outage rate.

Source: Electric Power Industry in China, 1995.

Chapter 3

Government Organizations and Policies

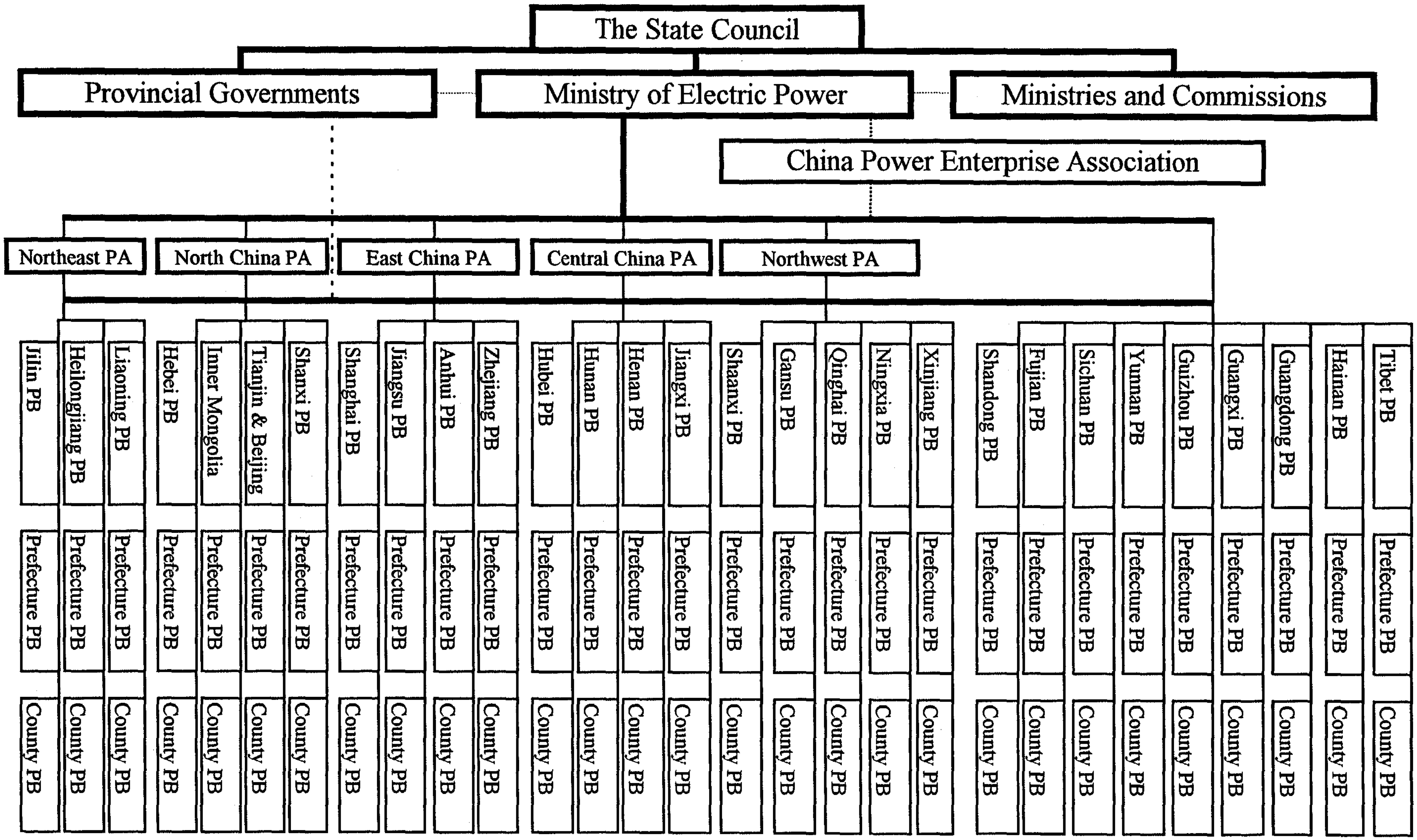
The Administrative and Business Management Systems

Figure 3.1 shows that the administrative system of China's power sector resembles a six-layered pyramid, which includes the State Council, the central government authorities, the regional power administrations, the provincial power bureaus, the prefectural power bureaus, and the county power bureaus. In addition to the vertical authorities, provincial governments also have powerful influences on provincial power bureaus.

In 1993, the State Council dissolved the former Ministry of Energy and formed the Ministry of Electric Power Industry. As a move to separate government functions from those of the enterprises and grant more decision-making power to enterprises, five regional power groups were established on the basis of the regional power administrations in 1993, and China established thirty provincial power companies on the basis of provincial power bureaus. In order to promote hydropower development in the southwest and transmit electricity to the east, the Southern China Electric Power Joint Venture Corporation (SCEPJVC) was established which covers Guizhou, Yunnan, Guangxi, and Guangdong. The four provincial power grids were interconnected in July 1993, when electricity was transmitted from the west to the east. Unlike the five regional power groups, the SCEPJVC is in fact a joint venture of the four provinces. Figure 3.2 shows the business management system of China's power industry.

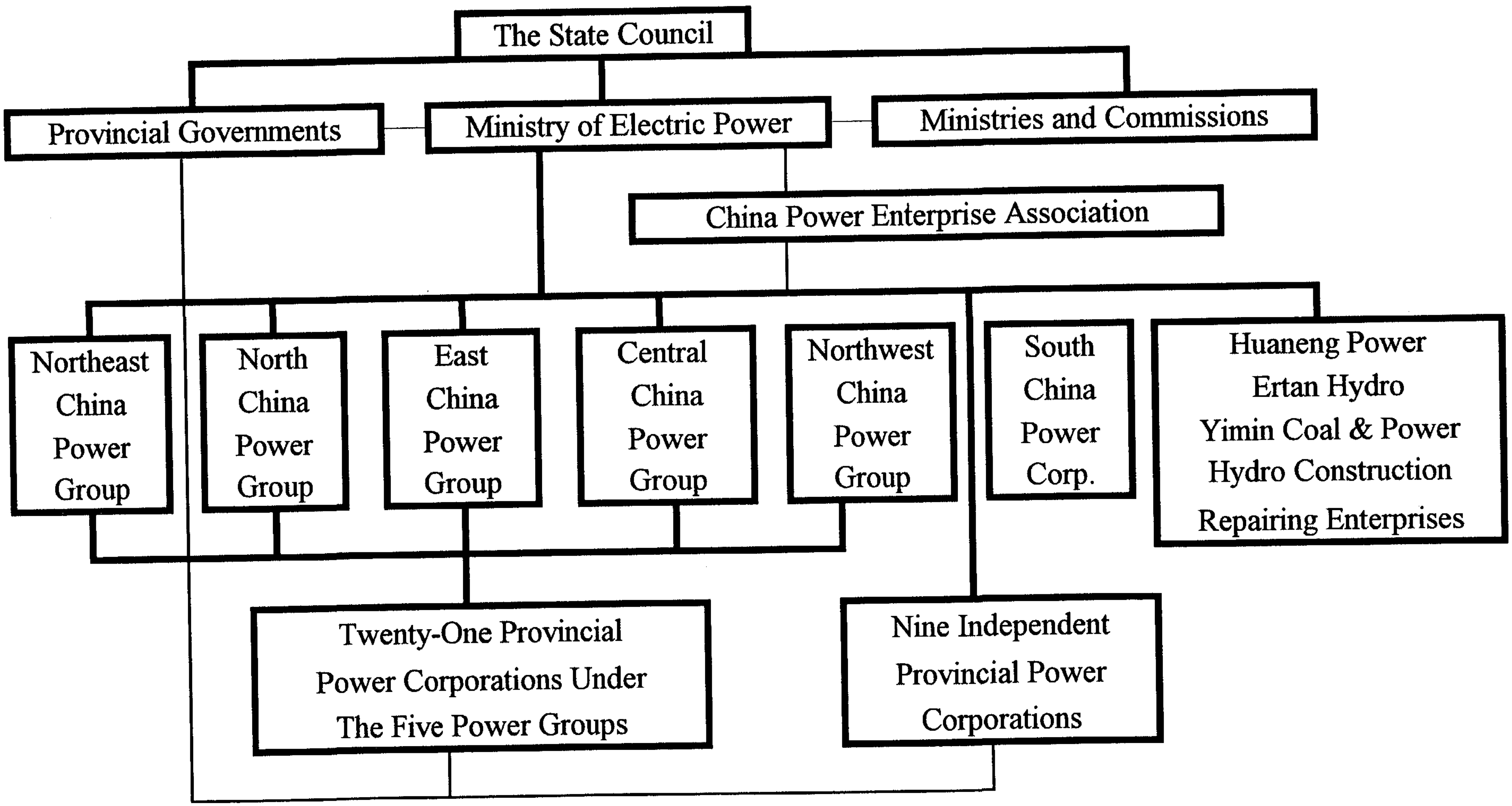
In principle, the regional power administrations and provincial power bureaus are representing the government and the regional power groups and provincial power companies are commercial companies. However, since regional power groups and the provincial power companies are spun off from the regional power administrations and provincial power bureaus, respectively, and most staff members hold positions in both organizations, the bureau and the company have not been completely separated yet. They are owning and regulating themselves.

Figure 3.1. Administrative System of China's Electric Power Industry



Note: PA refers to Power Administration, and PB refers to Power Bureau

Figure 3.2. Business Management System of China's Electric Power Industry



Central Government Organizations and Functions

A small group of individuals compose China's topmost leadership. These leaders have invariably overlapped with the Communist Party leadership, which retains political control over China despite the move toward a market economy. The "constituencies" of senior leaders are their supporters within the party and government, and the policies and decisions they make are therefore tied to this group. China's topmost leaders are generally involved in the energy and environmental policy to a great extent. Many senior officials, including Premier Li Peng, have worked their way up the leadership ladder through positions at the power and energy ministries. However, the almost limitless power of senior leaders is changing in China. Now greater initiative and policy formation occur at lower strata of government. In addition, there is a long-term trend toward a more professionalized bureaucracy. This trend is extremely important in terms of the senior leaders' impact on energy policy in China. In the past, the will and ideas of senior leaders could become policy without any debate. Now the ideas of senior leaders face much more debate. It may take considerable time before China's senior leadership is accountable directly to the people it governs; however, it is becoming clear to these leaders that greater power should be granted to professionals and dedicated bureaucrats so that China can enjoy the benefits of a stable, efficiently-managed system independent of the health of a single politician.

Relative to the senior leadership, China's National People's Congress (NPC) has only recently emerged as an important player in energy and environment decision making. While formally recognized as China's legislative branch and highest authority in the land, the NPC has in the past played little role in determining national policy and has been referred to as a "rubber stamp" body--simply approving what was presented to it by senior officials. In a recent debate over the Three Gorges project, however, the NPC was given much greater freedom to consider whether the controversial project should be launched. After relatively open sessions, the project was approved by a margin more narrow than is typical for the NPC. The NPC will attempt to expand its role and influence in future national decisions. Its chairman, Qiao Shi, is among the very small group of leaders positioned to assume greater power in the transitional post-Deng era.

Thus, the authority and effectiveness of the NPC will increase over time.

Sitting atop China's policy, planning, and implementing bureaucracy is the State Council. As China's institutional executive branch, the State Council is much stronger than the NPC in practical terms and plays a pivotal role in shaping policy. The State Council coordinates the goals of senior leaders with the input of research entities and the interests of competing ministries and administrations below it. In line with the shift toward professionalized bureaucracy, the State Council and its subsidiaries have moved from simply enforcing the will of paramount authorities toward a more deliberative role.

Under the State Council, the State Planning Commission (SPC) and the Ministry of Electric Power Industry (MEPI) are two of the most important organizations. At the national level, the following organizations are also involved in power development and the approval process of major power projects: the State Development Bank of China (SDBC), the Ministry of Finance (MOF), the Ministry of Foreign Trade and Economic Cooperation (MOFTEC), the People's Bank, the State Economic and Trade Commission (SETC), the National Environmental Protection Agency (NEPA), the State Science and Technology Commission (SSTC), the Ministry of Machinery Industry (MMI), the Ministry of Coal Industry (MCI), State Administration of Exchange Control (SAEC), China International Engineering and Consulting Corporation (CIECC), the China Huaneng Group (CHNG), and the Ministry of Railroads.

In early 1996, the State Council approved the establishment of the National Power Corporation (NPC), which will consolidate the country's power sector and operate at an arm's length from other government functions. NPC will control all existing national electrical power assets now under the authority of the State Council. The establishment of NPC, which had initial funding of $300 million, is intended to advance the transition from a centrally planned to a market economy, speed up development of the power industry and improve overall efficiency and planning. Current plans also call for the MEPI to be dissolved with its functions transferred to several state commissions, NPC, and the China Electricity Council. The MEPI will focus on governmental affairs. Following the completion of the national changes, the same structure could be adopted for regional and power administrations.

The State Planning Commission

The State Planning Commission (SPC) is primarily an administrative authority. It is the highest level planning organization in China. It is responsible for making national energy strategies, policies, and the developmental plans. It coordinates the input and interests of the research institutes, ministries, and provincial governments in order to produce coherent national economic development plans for approval by the State Council. Along with the general climate of decentralization, the function of the SPC has changed from directly allocating funds for projects included in the state development plan to allocating permits to such projects. The responsibility of allocating funds is passed to the newly-formed State Development Bank of China (SDBC). While the funds allocated by the SPC were grants, without requirement of repayment, the funds allocated by the SDBC are loans with repayment expected.

Although the SPC is supposed to further change its function from direct control of the economy to indirect policy guidance and the areas directly controlled by the SPC have been reduced substantially, the power sector is still under the firm control of the SPC. Presently, all large and medium-scale energy projects must obtain approval from the SPC. The size of the power projects which need the SPC approval is $50 million or 50 MW.[1] To reduce inflation rate and runaway fixed assets expansion, China has adopted macro-regulation measures since the summer of 1993, and the SPC played a critical role in strengthening central government oversight over the economy.

Besides Minister Chen Jinhua, Vice Minister Ye Qing is responsible for energy and transportation within the SPC. Ye's background is oil and petrochemicals; he used to be the president of Sinochem and the head of the Economic Reform Committee of the State Council. There are two departments in the SPC which are particularly important for the power sector. The first is the Department of Transportation and Energy, heated by Director Wu Youwen, who was Chief Engineer at the former Ministry of Energy and has a strong oil background. His two

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[1] Medium-sized power projects are defined as 50 to 250 MW, and large power projects are over 250 MW. Projects over 800 MW require State Council approval as well (Lawson 1994).

deputy directors are Cao Zhengyan, in charge of electricity, and Li Hunxun, in charge of coal. The second department of interest is the Department of Foreign Capital Utilization. In addition, an office specializing in substitute coal for oil is also set up within the SPC.

In order to ease the change of function of the SPC from a direct controller to a policy guider, the SPC expanded its Economic Research Center into the Academy of Macro-Economic Research (AMR). The MAR engages mainly in the research of applied policies. Its main functions are organizing comprehensive researches on the issues concerning reforms and economic development. The research results of the AMR are submitted directly to the SPC or the State Council to help the government make policy decisions. The AMR has an authorized staff of 750 and maintains close relations with the provincial planning commissions. Mr. She Jianming, vice minister of SPC, is the president of AMR. The AMR consists of 9 research institutes which include: (1) the Energy Research Institute; (2) the Institute of Comprehensive Transport; (3) the Institute of Economics; (4) the institute of Investment; (5) the Institute of Industrial and Technical Economics; (6) the Institute of Land Development and Regional Economics; (7) the Institute of Market and Prices; (8) the Institute of Social Development; and (9) the Institute of Foreign Economics. The Energy Research Institute (ERI), headed by Director Zhou Fengqi, is an energy consultant for the SPC and is conducting policy studies which feeds into the decision-making process of the SPC. The following journals are published by the AMR: (1) *Energy of China*; (2) *China Price*; (3) *Comprehensive Transport*; (4) *China Investment and Construction*; (5) *Economic Reform and Development*; (6) *China Techno-economic Science*; (7) *Price Theory and Practice*; and (8) *China Human Resources Development.*

The Ministry of Electric Power Industry

The Ministry of Electric Power Industry (MEPI) is both an administrative authority and the top business management organization of the nation's power industry. It is responsible for formulating, in coordination with the SPC, electricity policies and development plans and then overseeing the implementation of such plans. It also responsible for examining the key construction projects, monitoring the performance of state-owned power plants and utilities.

Any large and medium-sized power projects must obtain the MEPI approval or be initiated by the MEPI before it is sent to SPC for final approval.

Compared with the SPC, the MEPI is more like a combination of state enterprises and government authority, while the SPC is more of a regulatory authority. The MEPI is under intense pressure to close the wide gap between China's power needs and its current capacity. Since the MEPI owns many of China's power enterprises and holds direct responsibility for meeting China's electricity demand, it has a vested interest in seeing a fast-growing and profitable power industry. While the SPC has less of a vested interest in the rapid growth and profitability of the power industry, it also has much less knowledge with respect to the electricity demand and supply situations. Recently, China's electricity shortages appear to have been alleviated, which is an important reason for the reluctance of the SPC to approve power projects, although the MEP has warned the SPC that any attempt to curb inflation by suspending new power projects will set back China's economic growth (*Power in Asia* April 17, 1995).

MEPI is headed by Minister Shi Dazhen, who has been very active in inviting foreign investors to experiment with various forms of independent power projects in China. MEPI's Planning Department works closely with the SPC's Department of Transportation and Energy and the Energy Research Institute under the SPC. The planning department is developing recommendations which will be submitted to the State Council regarding the types of projects that can incorporate foreign funding. The China Power Enterprise Association serves as a bridge between government and power enterprises.

As shown in Figure 3.3, under the direct jurisdiction of the MEPI there are five regional power groups (each covering 3-5 provincial power companies), six independent provincial power companies (including that of Shandong, Fujian, Sichuan, Guangxi, Yunnan, and Guizhou), the Southern China Electric Power Joint Venture Corporation, the Ertan Hydropower Development Corporation, the Hydropower Construction Corporation which includes 17 construction bureaus, the Yimin Coal and Power Corporation, and 14 repairing enterprises. In addition, three provincial power companies are listed as under "professional administration" of the MEPI, each for apparently different reasons. The Guangdong Power Company is subject to MEPI's macrocontrol on issues of natural resource use, but has autonomy to make its own decisions regarding financing, personnel, and power project planning up to 250 MW. For power project above 250 MW, central government approval is still required. The other two provincial power companies listed as "non-directly" under MEPI are Hainan Power Company and Tibet Industry and Power Administration. The three provincial power companies are primarily under the management of their respective provincial governments. As the largest domestic independent power developer, the Huaneng International Power Development Corporation (HIPDC) is only under professional administration of the MEPI.

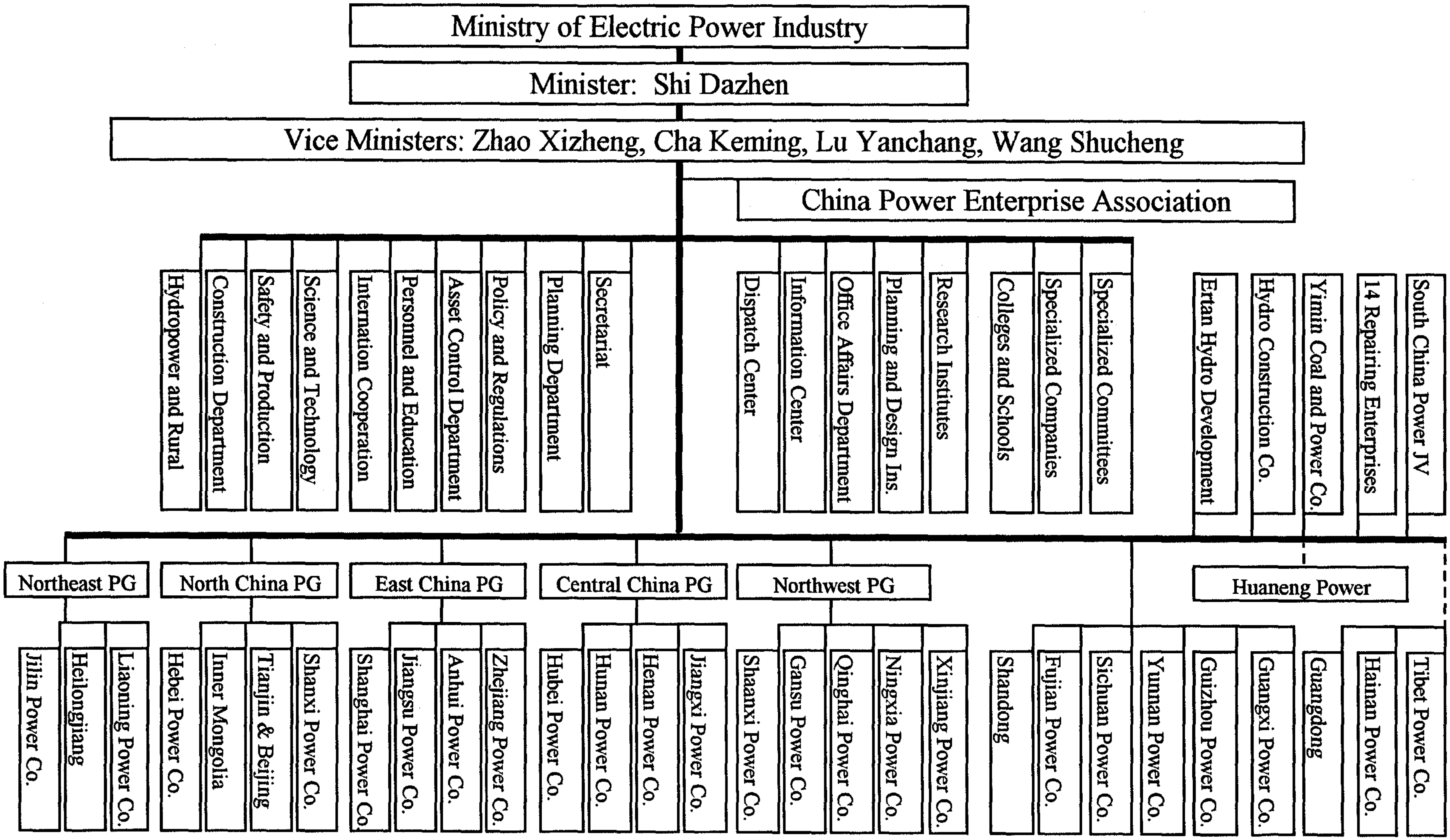
The State Development Bank of China

In April 1994, six state investment corporations specializing in energy, transportation, and agriculture were transformed into the State Development Bank of China (SDBC). As a policy bank, SDBC is responsible for providing capital to key state development projects. The formation of the SDBC is part of a far-reaching banking system reform in which China's largest state banks will become commercial entities.

As government lending is now being performed by three new policy banks--the SDBC, the Import and Export Credit Bank, and the Agricultural Development Bank--China's new accounting system will distinguish between policy and commercial loans. Policy loans are credits extended by the government for public or key development projects judged incapable of making profits. Commercial loans are extended to profit-making enterprises. China is to be divided into two regions for the purposes of access to power project financing. In the developed areas, including Guangdong, Shandong, Jiangsu, Zhejiang, and Hainan, all thermal power projects must apply for commercial loans, but hydropower or other complex, multi-provincial projects may apply for policy loans. For the other parts of China, all projects may apply for policy loans, but must apply on a case-by-case basis.

Until the establishment of the SDBC, the SPC had full control over fixed-asset investment through the six state investment corporations, including the State Energy Investment Corporation(SEIC), which reported directly to the SPC. Credit-worthiness often came in second

Figure 3.3. Organization of the Ministry of Electric Power Industry



Note: PG refers to Power Group.

to political importance, causing excessive over-investment in some projects and lack of funding for some key projects. The State Council established the SDBC in order to eliminate this problem. However, the bank may create a new layer of bureaucracy at the top of the planning system, although the original motive was to marketize the process.

As an entity for the investment of state funds, the SDBC may affect BOT projects in three different ways. First, a part of the SDBC can take an equity position in a joint venture project. The bank will then become both an investor and an approval authority. As an investor, the bank will be called the State Development Investment Corporation (SDIC). Second, for projects in which the SDBC is not an investor but a lender of state funds, it will also have approval authority. The Chinese partner of a foreign-invested joint venture project may apply for a loan from the SDBC in support of the Chinese side's participation in the projects. In this case, the SDBC will become an approval authority. Third, in cases where projects are financed by foreign investments and non-state funds, the bank will play a very limited role, and the SPC would be the ultimate authority.

The formal State Energy Investment Corporation has been involved in over 70 percent of the power projects built in China, including almost all of the hydropower projects. It has provided investment for the energy sector from four sources: (1) state funding; (2) provincial and municipal government funding; (3) funds from industrial groups and industrial ministries; and (4) funds from external sources, including direct investment by cooperative joint ventures and indirect investment from international financial institutions.

The president of the SDBC, Mr. Yao Zhenyuan, is a former vice minister of the SPC who has a rank of minister. The SDBC has four vice presidents, Mr. Tu Yourui is a former vice minister of the Ministry of Railways who also has minister rank. The staff of 1,000 comes mainly from the six investment corporations. Initial capitalization of the bank is 50 billion yuan ($6 billion), to be disbursed in five installments over five years. The bank will begin issuing bonds to raise 660 million yuan ($80 million), first domestically and then internationally, and hopes to reach the 80-90 billion yuan ($9.6-10.8 billion) capital level in five years.

The Financial and Economic Ministries

China's financial and economic ministries are responsible for ensuring that the nation's economic development proceeds in a sound and steady fashion. These ministries, especially the Ministry of Finance (MOF), Ministry of Foreign Trade and Economic Cooperation (MOFTEC), People's Bank, and Ministry of Domestic Trade, are particularly concerned that booming expenditures on energy infrastructure could weaken China financially. Currently, their greatest worry is the spiraling inflation rate. There are additional concerns as well, including provisions for foreign exchange, fears of over-dependence on and overpayment to foreign companies, uneven regional growth, and harm to China's credit rating due to overextension of sovereign project guarantees.

Meeting growing energy needs is the objective of these ministries only to the extent that doing so does not further aggravate China's macroeconomic stability. In particular, the financial ministries would like to keep the incremental costs of power plant construction down. Attempts to accomplish this by setting a fixed cap on rates of return to foreign companies participating in China's power sector have met with little success. Getting China's financial ministries to support an increase of 5-20 percent in project costs in order to include environmental controls in future power projects will be difficult unless the external costs of environmental damages from uncontrolled power plant emissions are more clearly figured into a national calculus of well-being.

The Industrial Ministries

China's industrial ministries also hold a strong interest in shaping the energy sector. This group includes the ministries of Chemical Industry, Construction, Electronics, Machine-Building, and Metallurgical Industry. This set of interests is concerned with ensuring sufficient energy supplies to maintain production levels. However, unlike the MEPI, these industries represent the debt-ridden state sector enterprises least able to embrace market forces which would force price reforms on them. Historically concerned that energy price reforms might drive unemployment in the state sector, national planners have in the past deferred the energy price reforms to their ministries, causing further inefficiency.

The National Environmental Protection Agency

At present, NEPA is poorly positioned to protect China's environment. An independent agency only since 1988, NEPA lacks ministerial status and has a staff of only 300 people. Its mandate, to assess environmental needs and formulate policy in conjunction with relevant departments is itself a serious limitation, requiring that a consensus must be reached with the energy ministries before NEPA can set emission standards. NEPA must then submit its proposed regulations to the NPC for approval and implementation subject to overall balancing by the State Council, which make sure the regulations do not conflict with planned growth targets.

The State Environmental Protection Commission (SEPC) is responsible to coordinate divergent economic and environmental interests. In addition to NEPA, which serves as the SEPC's secretariat, the SEPC includes members from the SPC, SSTC, SETC, and Ministries of Construction, Forestry, Agriculture, Water Resources, Chemical, Coal, and Electric Power. The SEPC, however, only meets four times a year.

In general, environmental initiatives seem to fall victim to economic development priorities. For example, on several occasions power plants which were blocked by NEPA for failing to meet environmental standards have been reinstated by the SPC. Prioritization of energy interests at the expense of environmental considerations has become a hallmark of Chinese government decision making.

Other National Level Authorities

The Department of Resource Conservation and Comprehensive Utilization, subordinated to the State Economic and Trade Commission (SETC), mainly deals with the administration of application of energy and raw materials, integrated utilization of resources, planning and approval of key technical retrofitting projects, and prevention and control of industrial pollution.

The Industrial Science and Technology Department of the State Science and Technology Commission (SSTC), together with the SPC and the SETC, makes the national energy science and technology development strategies and policies. SSTC represents the State Council in the implementation of bilateral and multilateral agreements in technological cooperation among governments including clean coal technology (CCT) cooperations. It is responsible for the development and small-scale tests of domestic CCTs. The SSTC has taken a key role in national development planning as coordinator of China's ambitious Agenda 21 program.

The Ministry of Coal Industry (MCI), headed by Minister Wang Senhao, is an organization administrating the coal industry, its role in the coal industry is more or less the same as that of the MEPI in the power industry. The MCI has traditionally been seen as a very conservative bureaucracy which moves slowly.

The Ministry of Machinery Industry (MMI) is responsible for the manufacturing of domestic power plant equipment. The National Environmental Protection Agency (NEPA) is responsible for China's environmental control; however, its political power is weaker than other major government authorities involved in the power sector.

The China International Engineering and Consulting Corporation (CIECC) has emerged as a key player in the decision-making process for large infrastructure projects. CIECC does engineering consulting for the central government and regional and provincial enterprises. All medium-sized and large capital construction projects in energy, transportation, machinery, and electronics which require SPC approval are funneled to the CIECC for project appraisals and feasibility studies, as well as engineering design.

The China Huaneng Group

The China Huaneng Group (CHNG) is a large state-owned comprehensive group ratified by the State Council that includes ten member corporations and one Power Business Unit. Its electric power activities are centralized under the Power Business Unit and the Huaneng International Power Development Corporation (HIPDC). The CHNG is a national power plant development corporation with strong ties to Premier Li Peng and operates directly under the State Council.

Huaneng's initial goal was to substitute China's oil-fired power plants with coal-fired power plants. The central government provided a start-up budget, but the company has now become the largest domestic independent power producer. By the end of 1994, CHNG had already raised and utilized $4.5 billion of foreign funds and built a group of large thermal power plants with advanced technology. It has constructed 30 power plants with a total capacity of 12.5 GW. Huaneng plans to add, by the end of 2000, 15 GW of installed capacity of which thermal power comprises 14 GW and hydropower 1 GW. In order to meet the large demand for capital, in addition to raising money from domestic sources, Huaneng will also tap some foreign capital markets by different means with the support of the Chinese government.

Huaneng's methods and means used to develop its power projects with foreign funds are as follows:

(1) Using foreign government loans, seller's loans, and commercial loans to import advanced power equipment. So far, Huaneng has signed contracts worth $3.4 billion with the United States, Japan, France, Great Britain, German, Italy, Canada, and Switzerland. About 8 GW of power plant equipment was imported. In this way, nine power plants have been installed and most of their units are 350 or 600 MW. In addition, 2.4 GW power units are under construction. These power plants operate well and are earning Huaneng a solid financial regard in foreign countries.

(2) Huaneng also imported power equipment from Russia and other countries of the former Soviet Union through deferred term barter. In these trades, foreign parties offered power equipment while Huaneng mainly offered labor in ship repairing or light industry products. In this way, Huaneng has constructed five power plants with a total capacity of 3.4 GW by mainly deploying 300 or 500 MW units. Some of these plants have already been put into operation.

(3) Several power plants invested in by Huaneng were restructured as publicly traded companies with shares issued through initial public offering on overseas stock markets. The $958 million raised on the NYSE by issuing the stocks of Shandong Huaneng Power Development Co. Ltd and Huaneng International Power Development Co. were spent on extending oil power plants and constructing new ones with an installed capacity of 8.4 GW.

(4) Huaneng has established 30 Sino-foreign joint ventures, the largest of which is Sino-Japanese Dalian Huaneng-Onoda Cement Co. Ltd, with a total output of high quality cement of 1.37 Mt and an investment of $188 million. The 350 MW Shenzhen Nanshan Cogeneration Power Plant now in operation is a Sino-foreign joint venture power project. Another two joint

venture power plants, the 2.4 GW Sino-American Nanjing Jingling Power Plant and the 2.5 GW Sino-Israeli Shandong Rizhao Power Plant have signed cooperation agreements and will start construction soon.

Huaneng enjoys preferential policies in foreign exchange procurement and tax treatment. The electricity prices charged by Huaneng are based on the marginal costs plus a profit margin and are substantially higher than prices charged by other domestic power plants. Huaneng not only utilizes foreign funds to construct domestic power plants, but also cooperates with foreign firms to invest in and construct overseas projects, although this kind of activity is only in its early stage.

Contacts

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Regional and Local Power Organizations

At the second level of the administrative system of China's power industry are the regional power administrations. China has five regional power networks each covering 3 to 5 provinces. Each regional power administration, representing the MEPI, is responsible for regulating one regional power network.

The business management at the regional level is now conducted by the regional power groups which were established in 1993. Before 1993, the business management was also the responsibility of the power administrations. The idea of the reform is to make the power groups and the provincial power companies independent legal entities, and have them assume responsibility for their profits and losses. The regional power groups were also granted greater autonomy to conduct external business. They have the authority to conduct direct negotiations for equipment importation, to sign contracts and send labor for construction overseas, to send delegations abroad, and to invite foreign experts.

The regional power groups have varying degrees of control over four different categories of power enterprises in their respective power networks. The so-called core enterprises are under the groups' direct administration, including some key power plants, power transmission and distribution stations, dispatching bureaus, material supply companies and research institutes. The so called closely-linked enterprises are under the groups' direct control for dispatch but accounting and management are handled independently, this category includes some power plants, design institutes, and construction companies. The semi-closely-linked and loosely-linked enterprises include service companies for the power networks and power companies in remote areas. For example, the North China Power Group claims 152 enterprises under its jurisdiction. Among these enterprises, there are 21 core enterprises, 47 closely-linked enterprises (including the power companies of Shanxi and Hebei as well as some design institutes, construction companies, and others), 55 semi-closely-linked enterprises (including power companies in Inner Mongolia), and 29 loosely-linked enterprises.

The third level of China's electric power pyramid is the provincial power bureaus. At the provincial level, everything becomes more complicated because of the dual leadership from the "strip" (the MEPI-Regional Power Administration/Groups system) and the "square" (the provincial government). Behind the conflicts between the "strip" and the "square" are the interests of central and local governments. For example, the applications to increase electricity prices by the central government-owned power enterprises are very often denied by the provincial governments, but on the other hand local governments (provincial, prefectural, and county) add various fees and additional charges on top of the electricity tariffs paid by consumers. As a result, the profitability of central government-owned power plants are decreasing rapidly, and the actual electricity tariffs (including all fees and charges) are becoming chaotic, and are very high in some localities. The attempt of the central government to grant more autonomy to enterprises was also undermined by the local governments when they increased the interference on the power companies. At this stage, the provincial governments are still very powerful administrative authorities at the local level. Under each provincial government, there is a provincial power investment (development) company. The company collects 2 fens (0.24 U.S. cent) per kWh on top of the electricity tariffs to invest in local power projects. The company is under the leadership of the provincial planning commission.

The business management at the provincial level is conducted by the provincial power companies. Twenty-one of the thirty provincial power companies have joined the five regional power groups. Before 1988, the regional power administrations were more important than the provincial power bureaus; however, with the implementation of the policy to make provinces the real entity, there has been a swing of importance toward the provincial power companies. The regional groups coordinate the power networks, while the provincial power companies are in charge of project development. Provinces in the power networks decide power plant locations but must receive approval from regional power groups. Local authorities at the provincial level very often pay limited attention to regional power groups for power project negotiations.

Most of China's large and medium-sized (greater than 250 MW) power plants are operated by the provincial power companies. Some hydropower plants and thermal power plants are operated by the Ministry of Agriculture and the Huaneng Power Company. The Qinshan Nuclear Power Plant is operated by the Ministry of Nuclear Industry. Together with foreign joint venture power plants, all these plants sell the electricity generated to the power networks and grids.

The provincial power companies will maintain their importance in China's power industry. The scope of their activities will be obviously restricted by the need to out-source their generation to either the carved-out generating companies or new independent power projects. Their dominant position is ensured by maintaining their own generation plus having a complete monopoly over transmission and distribution to ultimate customers. There appears to be no intent to permit any access to final consumers by either the joint-venture generating companies or the new independent power projects. The provincial power companies will be the sole customer of all privatized power plants and thus in a position to dictate the terms of how new power plants are developed.

The prefectural (city) power bureaus are responsible for administration and business management at the prefectural level. They report to both the provincial power bureaus and the provincial power companies.

China has 2,300 county level power enterprises. Among them only 711 are directly managed and operated by provincial power companies. There are 650 county level power bureaus supplied primarily by small hydropower plants.

Government Policies and Power Sector Reforms

For a number of reasons, including artificially low electricity tariffs, insufficient investment in the power sector, and insufficient capacity to produce generating equipment, China's electricity supply falls short of demand. Serious power shortages have led to the rapid growth of small, inefficient power plants and the environmental pollution which accompanies them. To solve these problems, the Chinese government conducted a series of reforms in the power sector to implement the following policies: (1) encourage foreign and local investment in the power sector; (2) rationalize energy prices (i.e. move toward market prices); (3) introduce improved technologies to increase the efficiency of energy production and utilization; (4) substitute coal for oil in electricity generation and develop cogeneration; (5) give priority to coal-fired electricity in the development of energy industries; (6) enhance the development of extra-high voltage (EHV) transmission and mine-mouth power plants in north China; (7) accelerate hydropower exploitation to increase its share to 20 percent of total electricity generation; (8) develop the manufacturing and construction technology for nuclear power as soon as possible; (9) reduce coal generated environmental pollution in urban areas; and (10) place balanced emphasis on energy resource exploitation and conservation. It should be mentioned that although these policies have been accepted in principle, their actual implementation is subject to varying degrees of flexibility.

To improve the legal system of the power sector, China's first Electric Power Law went into effect on April 1, 1996, after approval by the National People's Congress. According to the new law, China's power industry should grow faster than other industries, investment in the power sector should be encouraged, the environment should be protected, and priority should be given to development in remote and poor areas. To protect the environment, China will increase its use of clean coal, natural gas, and liquefied petroleum gas. Article 15 of the law says that environmental protection facilities should be designed and installed together with power generating projects. In addition, model projects for reducing sulfur dioxide emissions are under way. Technology and experience gathered in that field will be spread in the Ninth Five-Year Plan period (1996-2000).

The new law also specifies the principles related to foreign investment in the power sector. In general, direct foreign investment is allowed in power projects, either those wholly owned by foreign investors or those developed under a build-operate-transfer (BOT) scheme. The restrictions of foreign invested projects include the following:

(1) All foreign investment in the power sector must conform with China's industrial policy, must be accepted as part of the country's Ninth Five-Year Plan (1996-2000) and be included in the government's 15-year development plan.

(2) Foreign investment is allowed in power projects using coal, clean coal, natural gas and liquefied petroleum gas, hydropower, and nuclear energy. However, the government prefers foreign investors to emphasize hydropower and nuclear power projects, and new, non-polluting

technologies.

(3) China will offer no sovereign guarantees, but will offer limited guarantees to BOT projects "under some special circumstances." For example, if BOT developers face economic losses due to a major policy change after a project is in commercial operation, tariffs may be raised or the term of the power-purchase agreement may be extended to make up the projected differences.

(4) During the current five-year plan, a number of supplementary regulations on power supply and consumption, as well as the regulation of electricity prices will be crafted, issued and implemented. The regulation on power consumption is expected to go into effect in September 1996 and the pricing regulation in the beginning of 1997.

(5) Transmission and distribution projects are reserved for domestic investment.

Attitude Towards Foreign Investment

In January 1993, the Chinese government announced that China welcomes foreign investors to develop joint venture, cooperative, and solely foreign owned power projects in China. In July 1994, the State Council approved four share-holding power companies to sell their stocks in foreign countries, they are the Huaneng International Electric Power Corporation, Shandong Huaneng Power Development Corporation, Shandong International Electricity Corporation, and Beijing Datang Corporation.

With respect to foreign investment in China's power sector, both the MEPI and the SPC have two schools of thinking. The school against foreign investment emphasizes the higher prices of foreign invested power projects, while the school in favor of foreign investment emphasizes the economic losses of electricity shortages due to the limited ability for domestic sources to meet demand, and the higher quality of foreign invested power projects in terms of reliability of supply. Reportedly about one-third of the necessary funds to achieve the planned capacity target by 2000 has not been available so far (*China Daily* March 24, 1995). To cover this gap, the MEPI hopes to raise $25 billion abroad in the 1995-2000 period (Peregrine, 1995); therefore the MEPI are more active in inviting foreign companies to develop power projects in

China.

The high prices of foreign invested projects are caused by two factors. One is that most of them tend to use imported equipment which is more expensive than domestic equipment.[1] The second reason is that foreign investors require higher returns on their investment than the state-owned power plants.[2] There are several ways to reduce the costs of foreign invested power projects through the efforts of both parties, although it is difficult to do so. For foreign investors, trying to use more domestic equipment will have the obvious effect of reducing costs. Since Chinese consumers are used to lower-quality electricity supplies, improvement in supply reliability is valued much less than in developed countries. With respect to the required returns on investment, there is less room to make concessions with foreign investors, given the huge demand for international capital and better terms offered by other Asian countries. However, policy reforms in China's power sector may reduce the risk premium required by foreign investors.

A survey conducted by the East-West Center of the United States among international power, coal, and engineering companies indicates that the target internal rate of return (IRR) required of China by international power, coal, and engineering companies is the highest among the 13 major Asian-Pacific economies (Table 3.1), reflecting the fact that foreign companies require the highest risk premium in China.

The results of the survey also suggest the following directions of policy changes to reduce the required risk premium in China:

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[1] In the listing prospectus of Huaneng Power International (HPI), the estimated construction cost of the Shangan Phase II is budgeted at only 2.23 billion yuan, while the Dalian Phase II is estimated 4.57 billion yuan. The plants are roughly the same size, the only difference being that Shangan will use domestic equipment while Dalian will use imported equipment. Information from the listing prospectus of HPI revealed that the estimated investment for domestic and imported coal-fired power plants are about $427 and $750 per kW, respectively (Peregrine, 1995, p.5, p.15).

[2] Reportedly, the profit rate of capital for China's domestic power sector as a whole is only 2.5 percent (*Energy Research Bulletin*, April 24, 1994).

Table 3.1. Target IRR on Investments of International Power and Coal Companies

	Mean IRR on Investment (Percent/Year)				Average Ranking (1=Lowest)
	Equity Current	Equity Constant	Total Funds Current	Total Funds Constant	
China	22.5	20.0	19.2	16.6	13
Vietnam	22.1	20.0	18.8	15.0	12
Pakistan	21.6	20.5	18.5	15.0	11
India	21.9	21.2	17.3	15.0	10
Indonesia	20.7	19.8	18.3	16.3	9
Thailand	20.1	19.0	17.4	15.3	8
Hong Kong	21.0	17.0	18.3	15.0	7
Philippines	19.9	19.6	17.4	15.0	6
South Korea	19.7	17.0	16.7	15.7	5
Malaysia	19.7	18.5	17.3	15.0	4
Taiwan	19.0	17.8	16.7	14.7	3
Australia	18.2	15.6	15.7	14.4	2
Japan	17.6	13.5	16.0	13.3	1

Source: Charles J. Johnson and Binsheng Li, 1995.

(1) Improving the creditability of the regulatory authority. Figure 3.4 shows that government policy is the most important criteria in selecting countries for investment. If the government retreats from its promises for political reasons, it will force foreign companies to demand a higher political risk premium. In 1995, as an anti-inflation measure, price administration authorities throughout China have implemented price control measures. For example, the Shandong Huaneng Power Development Corporation indicated that its application to raise tariffs according to the agreed tariff formula had been turned down by the local authorities. The tariffs of the company for 1995 were maintained at the 1994 level. As a result the market value of the stock decreased to about half of its initial price by July 1995 (SH Annual Report 1994). The impact of this event is not limited to one company, it has seriously undermined the credibility of China's regulatory framework.

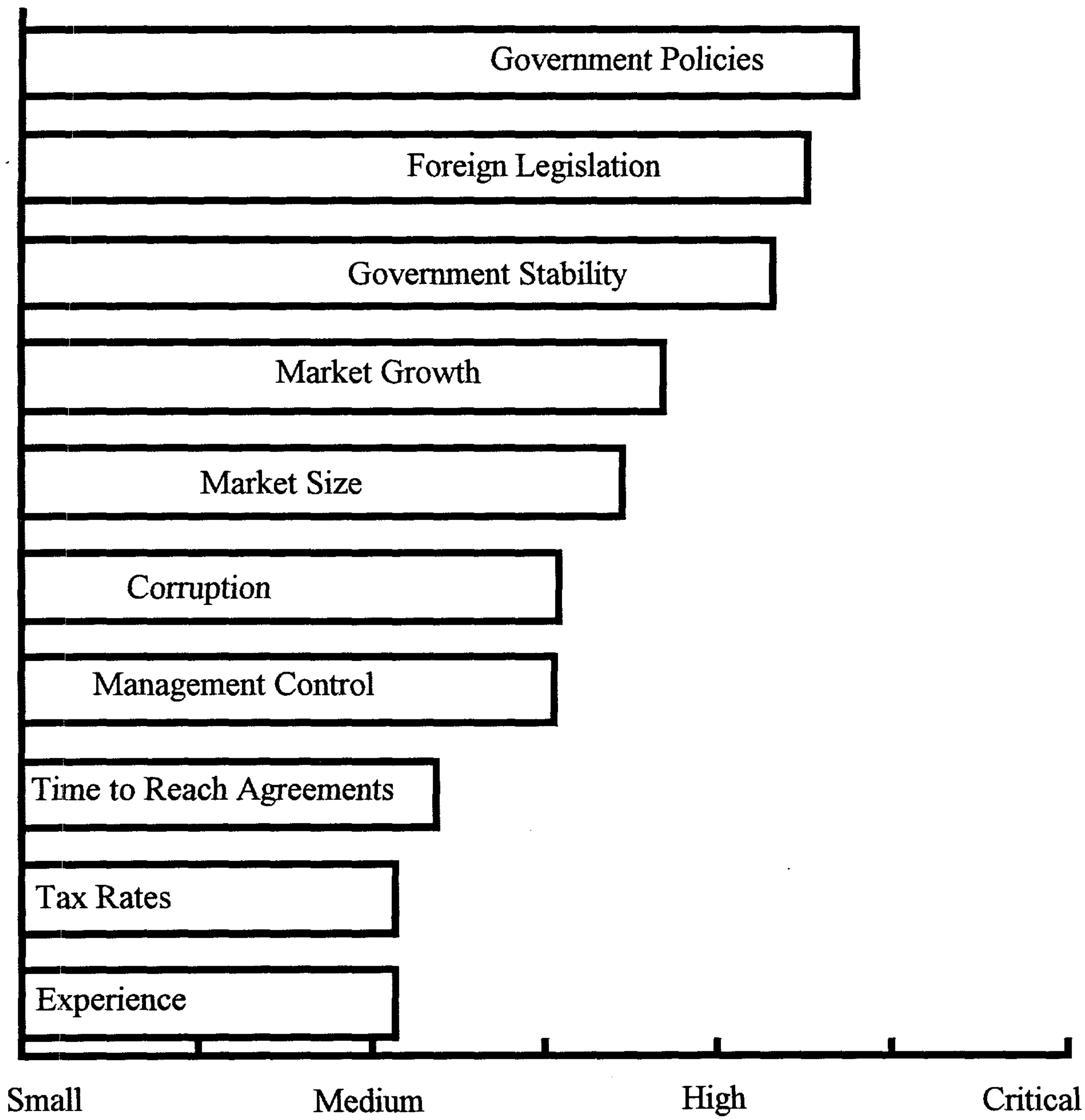

Figure 3.4. Importance of Investment Criteria in Selecting Countries for Investment.

(2) Regulating on electricity prices instead of on rates of return. Figure 3.5 indicates that according to the Euromoney country risk ranking China has a lower risk than Pakistan, Vietnam, the Philippines, and India; however, international power companies are requiring a higher risk premium in China than the aforementioned countries. One possible explanation is that while China is regulating on the rate of returns, Pakistan, Indonesia, and the Philippines are fixing the electricity prices (only fuel cost is allowed to fluctuate). Under a fixed price contract, power companies bear the major risks of operation and obtain the marginal benefit of improved operational efficiency. The potential disputes between the power companies and the utilities over the actual costs under the fixed rate of return system can be avoided under the fixed price system, therefore reducing the required risk premium.

(3) Improving the transparency of government policy. Foreign power investors face similar regulations in China and India; however, they charge a lower risk premium in India than in China. One of the most important reasons is that India has a clear policy with well-defined financial terms, while foreign investors complain that China lacks a similarly clear policy. When the Chinese government attempted to cap the rate of return on power projects at 12-15 percent, it did not clarify the actual meaning of rate of return. As indicated in Table 3.1, the required IRRs on different bases are substantially different.

(4) Providing incentives to increase the share of debt financing. If China insists on regulating the rate of return, it is better to cap IRRs based on total funds rather than on equity. In addition to providing a stable electricity supply, the government's main objective is to minimize the tariffs paid to foreign investors. The investors' objective is to maximize the return on equity. By regulating the return on total funds the government can directly control tariffs while the investors can achieve a higher return on equity through the increased share of debt financing and/or acquiring lower interest loans.

Although the measures discussed above may narrow the price difference between domestic and foreign invested power projects, the gap is unlikely to be closed in the foreseeable future. Therefore, the government's attitude toward foreign invested power projects is critically determined by power shortages and their associated economic costs.

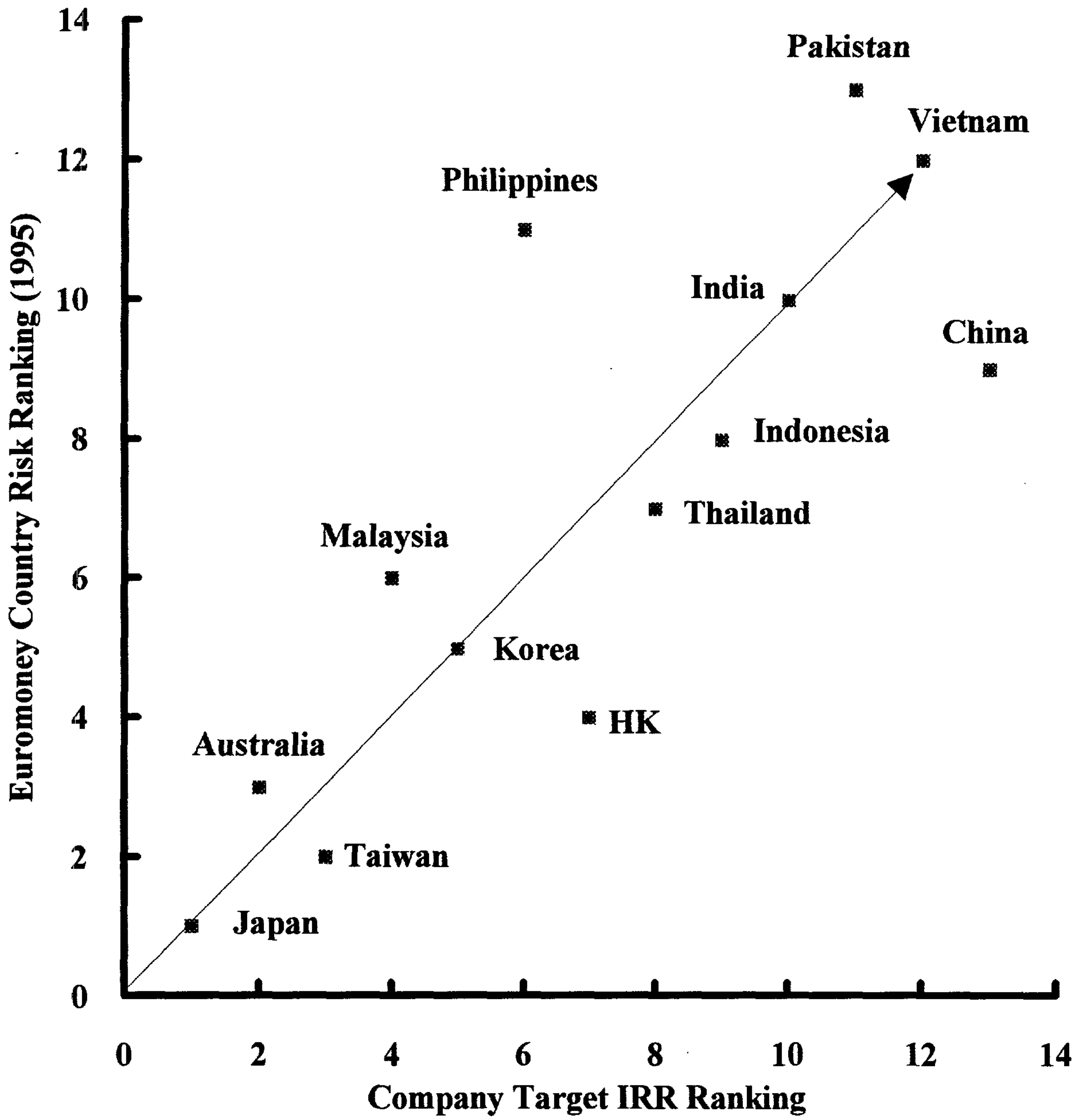

Figure 3.5. Comparison of Investor Target IRR with Euromoney Country Risk Rankings

As mentioned in Chapter One, China's nation-wide electricity shortage is estimated to average 20 percent. However, due to concerns that the MEPI may have a vested interest in over-estimating electricity shortages, the SPC may assume a lower level of shortages, especially when a great deal of the shortages are hidden. Although the economic costs of such shortages are substantial, this type of costs are difficult to measure and are subject to large measurement errors, especially the opportunity costs of potential electricity consumers. To obtain an unbiased estimate of economic costs associated with electricity shortages, a research program hosted by a neutral institution and participated in by representatives of both the MEPI and the SPC will be very useful. The results of this research will be critical in power sector decision-making.

The threat of power shortages is felt more strongly by local governments. Since obtaining SPC approval to build large and medium-sized power plants is very difficult, many local governments (and foreign investors) turned to small projects to avoid central government regulations. As a result, the actual additional large and medium-sized capacity to be commissioned during the Eighth Five Year Plan period (1991-1995) was estimated at 6 GW short of the planned target, while the actual additional small capacity plants is estimated at 7 GW above the planned target (MEPI 1995).

With increased foreign interest in China's power sector,[1] the Chinese government has tried to lower the IRRs of the joint venture projects. Recently, power sector officials from the center and provinces have been discussing the development of guidelines to control foreign investment and cooperation, with the ultimate aim of keeping as much profit and control as possible in their own hands. Since the profit rate of capital for China's power sector as a whole is only 2.5 percent, even a 14 percent IRR is considered high.

Chinese officials refuse to admit that there is a limitation on the IRRs of joint venture power projects and insist on negotiating on a project by project basis; however, currently if a

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[1] According to Peregrine (1995), China now has a total of 60 foreign-financed power projects (24,720 MW in hydropower, 45,670 MW in thermal power, and 2,000 MW in nuclear power) and one transmission project either under construction or negotiation. We believe most of the projects are under negotiation.

project has an IRR above 14 percent it is very difficult to obtain approval from the MEPI as well as the SPC. In fact, the North China Power Group (NCPG) currently uses 14 percent as a ceiling and aims for 13 percent. The East China Power Group (ECPG) also has similar targets. On the other hand, most foreign investors want IRRs above 17 percent.

In addition to the misleading belief that China's power shortage has been substantially alleviated, China's recent tough attitude towards foreign investors is also caused by two assumptions. The first assumption held by some Chinese authorities is that power business is risk-free in China. The second assumption is that "there is a large amount of floating money in the world" (Dai 1995).

The first assumption is apparently not shared by foreign investors. As indicated by the aforementioned survey conducted by the East-West Center, China's investment climate is ranked barely ahead of last-placed Vietnam among 13 Asian economies that are significant users of coal in their power sectors (Figure 3.6).

The second assumption is wishful thinking. The fact is that China's power sector now faces severe competition from other Asian countries vying for limited international capital. It is estimated that between 1995 and 2000, Asian economies will add about 200 GW of new power-generating capacity, other Asian economies will account for 55 percent (Figure 3.7). Given that most other developing Asian economies have not the ability to manufacture large-scale power generating equipment, most of their equipment will have to be imported resulting in much higher average prices per unit than those of China. Accordingly, the total investment requirement for the above expansion plan may surpass $200 billion. With such strong demand for capital, foreign investors will be selective and choose those countries that offer the most attractive investment environment.

Another reason for the reluctance of the SPC to approve foreign invested power projects is their sensitivity toward being exploited and the fear that China may not have the foreign currency to pay the investors later. In China, officials will not be personally responsible if they fail to grant approval to a good project; however, if they grant approval to a bad project, they will be held accountable. Therefore, SPC officials are traditionally very conservative.

Reduced foreign interests in developing power projects in China, caused by the tough attitude of the Chinese government toward foreign investors, and the development of power shortages will force China to adjust its attitude towards foreign investors in the near further.

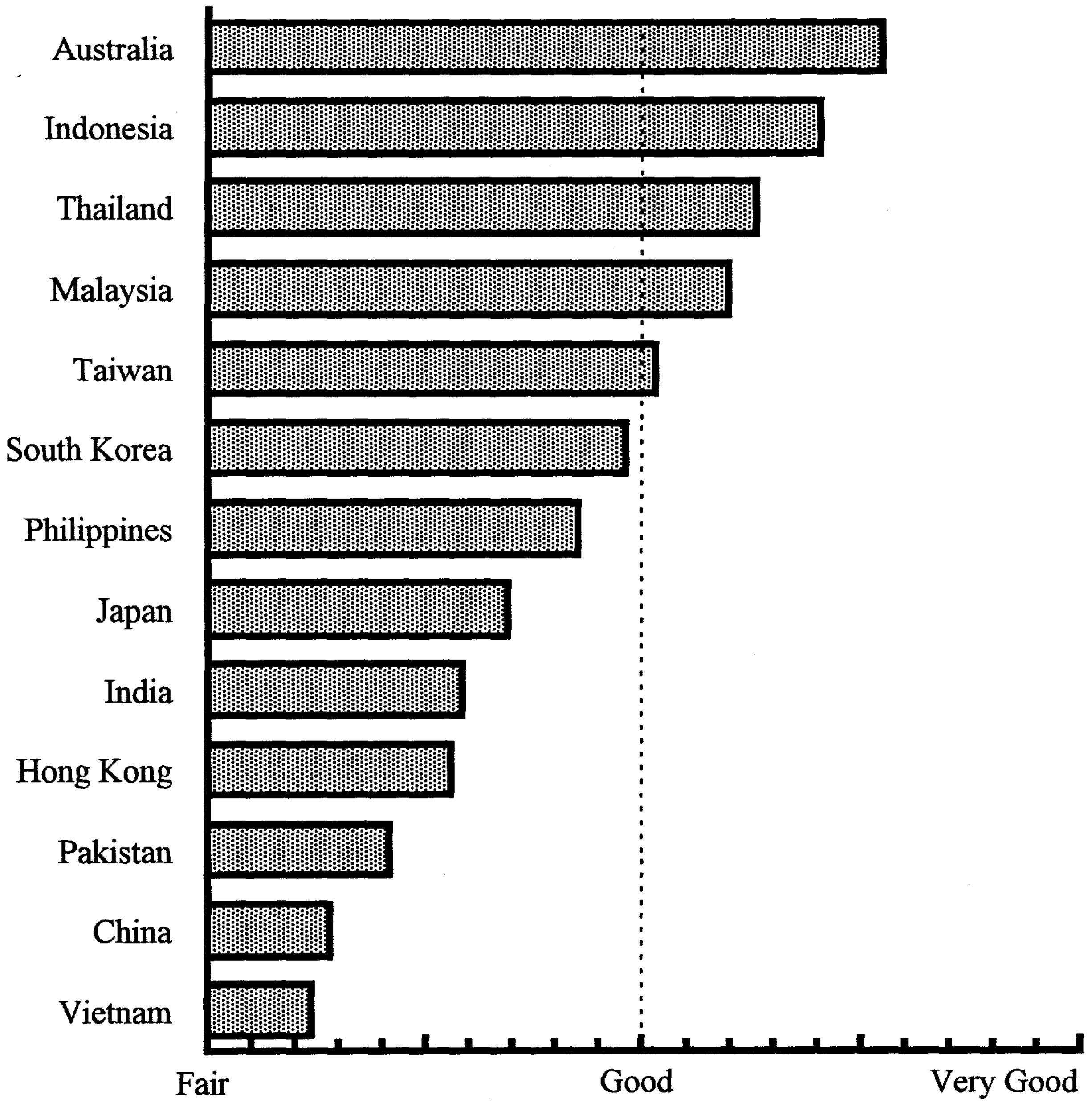
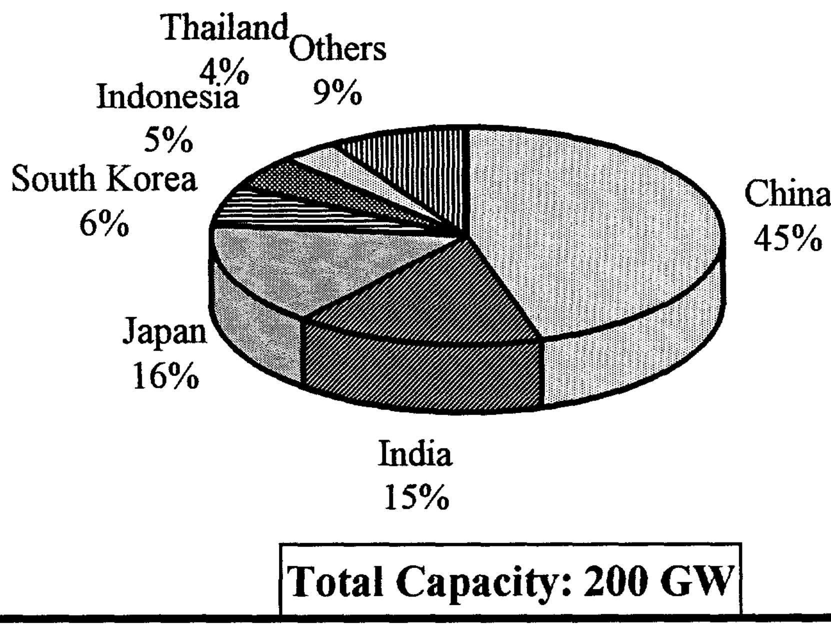


Figure 3.6. Ranking of Investment Climates for Asian Economies

Figure 3.7. Shares of Additional Generating Capacity in the 1995-2000 Period in Asia



In mid-1995, China relaxed its unofficial 12 percent limitation on rates of return in power-purchase agreements, if projects achieve certain performance standards. China's project availability benchmark is generally 5,500 hours per year. According to the recent Chinese agreements approved by central planning authorities, rates of return are increased following a review once the 5,500 hours benchmark is posted. It is likely that over the next few years, the initial performance benchmark will be raised as power plant standards improve. But right now the standards are relatively low.

After learning that the Chinese government had eased its cap on rates of return in first-quarter 1995, the chairman of Consolidated Electric Power Asia (CEPA), Gordon Wu, said he would return to the Chinese market after pulling out in favor of other Asian markets. CEPA has agreements for about 20 power projects in several Chinese provinces. Each agreement is for a minimum 660 MW, coal-fired project, for a total of about 13,200 MW.

Introducing Build-Operate-Transfer Projects

The concept of the Build-Operate-Transfer (BOT) system of building power plants was first introduced to China by Hopewell Holdings of Hong Kong. In 1983, Hopewell approached Mayor Liang Xiang of the Shenzhen Special Economic Zone on the BOT concept of building a 700 MW coal-fired power station (Shajiao' B) in Shenzhen. Hopewell would carry out the design, construction, operation, and financing of the plant. Shenzhen would purchase at least 3,679 GWh (60%) of electricity generated from the plant at the price of $0.0526/kWh. After 10 years of operation, the plant will be the property of Shenzhen. Half of the purchase money is paid for in foreign exchange and the other half paid for in Renminbi. Hopewell would use the Renminbi to buy coal in China. A 33 month construction period from July 1, 1985, to April 1, 1988, was contracted, but actual construction was 11 months ahead of schedule.

Although the Shajiao' B project was viewed as a great success by Hopewell, Chinese officials hold different views of this project. As indicated by Dai Riyong, Executive Director and President of the BOT Investment and Development Corporation (BOTIDC), "Shajiao' B was built at the initial stage of China's opening up to the world, during which time, the conditions of China's market economy was not yet mature (Dai 1995)."

Due to shortages of funds and infrastructure capacities, the BOT investment method was considered by the SPC when formulating China's Foreign Capital Utilization Program of the Eighth Five-Year Plan (1991-1995). However, the introduction of BOT projects was conducted cautiously. At present, China's policy on BOT projects is as follows: (1) to gain experience through experimentation first; (2) to standardize the BOT method based on the experiences gained, and (3) to popularize the standardized BOT method gradually under government guidance. The 1995-1996 period is at the stage of experimentation. It is planned that the BOT method will become one of the main investment methods in infrastructure construction after 1996.

In November, 1993, China established the BOTIDC which is the first professional commercial entity specializing in BOT investment. As a non-government agency, but under the support and business guidance of the SPC, BOTIDC intends to serve as a commercialized intermediary to link the Chinese government with foreign investors. It provides investment services, such as bidding invitations, prequalifications of investors, feasibility studies, and financial, engineering, and legal consultations.

Rationalization of Energy Prices

After many years of debate, consensus was reached within the Chinese government that energy prices should be subject to market forces. In April 1993, reform measures were adopted in China's six power networks and grids, where electricity prices of newly established power plants would to be based on operating costs and debt services, thus readjusting the electricity price level and structure. However, government efforts to control high inflation has slowed the process of electricity price adjustment.

In order to solve the financial difficulties of the state coal mines, the Chinese government decided to release controls on coal prices in 1994. It also reduced its subsidy to the state mines by 2 billion yuan ($240 million) each year and intends to eliminate all subsidies to the state mines by 1996. Production costs of the state mines increased by 3.6 billion yuan ($434 million) in 1994 due to price increases of raw materials. Although the state mines have attempted to balance their budgets, including 100,000 laid off from the current work force of 3.21 million miners, coal prices will have to increase at least 10 yuan ($1.2) per ton on average to cover the reduced subsidy and increased production costs.

However, the power sector has resisted coal price increases. Reportedly, when the Datong Coal Administration (DCA) in Shanxi Province increased the price of coal supplied to the power plants of the North China Power Group (NCPG) by 10 yuan ($1.2) per ton in late 1993, the NCPG refused to accept the price. On December 30, 1993, DCA informed the NCPG that if the new coal price was not accepted, it would stop supplying coal. NCPG replied that because the electricity price was not allowed to increase accordingly, NCPG could not accept coal price increases. In the New Year of 1994, DCA stopped supplying coal to NCPG. NCPG reported the situation to the central government and stopped part of the electricity supply to DCA on January 3, 1994. On January 4, 1994, vice premier Zhou Jiahua ordered NCPG to resume normal power supply to DCA after receiving an emergency report from the Shanxi Provincial Government. Although both power and coal supplies were resumed on January 4, 1994, after government intervention, the underlying problem was not resolved. Two options were suggested--to keep the previous coal price and resume the subsidies on coal supplied to the power sector, and to increase the electricity price accordingly. In Northeast China, coal companies required a price increase of 32 yuan ($3.9) per ton, which also was resisted by the power sector.

Even though coal producers did not increase their prices substantially after the release of coal price controls, the prices paid by coal consumers, especially non-utility consumers did rise substantially. The difference between these new price levels is attributed in large part to the increased transaction costs of middlemen. For example, coal prices are about 100 yuan ($12) per ton in Datong, Shanxi Province, and about 200 yuan ($24) per ton in Qinhuangdao. The distance by rail between Datong and Qinhuangdao is 653 km, and the railway freight rate is 5.35 fen (0.64 US cents) per ton-km. Using these figures, the railway transportation cost should add only 35 yuan ($4.2) per ton to the Datong price. The transaction costs of middlemen account for the remainder of 65 yuan (US$7.8) per ton.

A two-tiered pricing system for crude oil was introduced in 1983 when the government established a 2 million b/d quota for the national oil industry. Output above the quota was sold at much higher "out-plan" prices which are close to international market prices. A similar two-tiered pricing system was also introduced in the country's oil refining industry. In 1993, price controls on 14 small-and-medium-sized oil fields were ended. This measure reduced the quota of crude oil to 1.6 million b/d, which accounted for 55 percent of the country's total output.

In early 1994, the government planned to phase in a reform package in order to increase control over the volatile oil market. The package was scheduled to take effect on May 1, but was postponed to June 1, 1994. According to the plan, the two-tiered pricing system for crude oil would remain, but both the in-plan and out-plan prices would be fixed, and the ex-refinery prices for oil products would be unified and fixed. Clearly, the plan represents an attempt to return the oil industry to government's control after the chaos of 1993 following what many saw as a too-rapid attempt to deregulate prices.

Foreign Exchange System Reforms

On December 28, 1993, the People's Bank of China issued "Public Announcement on Further Reforming of the Foreign Currency Management System." In January 1994 China eliminated the official exchange rate of 5.7 yuan to the U.S. dollar because it was far below the swap market exchange rate of 8.7 yuan to the U.S. dollar. The current exchange rate of about 8.3 yuan to the U.S. dollar more closely reflects the open market exchange rates.

In addition to a currency devaluation, a national inter-bank foreign exchange trading system was established in China. Joint venture projects approved by the SPC will be reviewed for approval of foreign currency debt service and equity returns by the State Administration of Exchange Control (SAEC). Once approved, the SAEC will issue an annual approval to the joint venture company for the conversion of Renminbi into foreign currency at designated foreign exchange banks. This system has officially replaced the former swap center system and direct payment in foreign currency.

As a milestone in China's economic reform, effective July 1, 1996, foreign-invested enterprises are able to buy and sell foreign exchange in banks, just as Chinese firms have been able to do since April 1994. Since most foreign companies have not had trouble obtaining foreign exchange before this new reform, the move does not have a major immediate impact on them, but the move is significant because it assures foreign companies investing in China that they can reliably send their profits back home. By the end of 1996, China will have completed all steps needed to meet the International Monetary Fund's definition of current-account convertibility, four years ahead of the 2000 target date set by Vice Premier Zhu Rongji. This does not mean China's currency will be convertible for all purposes. China has not even set a target date for achieving convertibility in its capital account. Capital account transactions, including direct and equity investments, still require government approval.

Reforms on Accounting and Taxation System

In July 1993, all energy enterprises adopted the "Corporate Financial Guideline" and the "Corporate Accounting Guideline." In January 1994, the transition tax system (which mainly composes a 17 percent value added tax) was put into effect. Meantime, the "Provisional Regulations on Resource Tax" were also put into effect. According to the regulations, crude oil producers must pay 8-30 yuan ($0.96-3.6) per ton of resource taxes, natural gas, 2-15 yuan ($0.24-1.8) per 1,000 cubic meters, and coal, 0.3-5 yuan ($0.036-0.6) per ton based on the sum of the total sales and own consumption.

In April 1994, the "Regulation on Fees for Mineral Resources Utilization" was adopted. The Fees for utilizing mineral resources are calculated as total sales revenue times a coefficient inversely related to the recovery rate. The revenue from the fee is equally shared between central and local governments.

Introduction of Advanced Technologies

Between 1985 and 1993, China's net coal consumption per kWh of electricity decreased from 431 to 417 grams of coal equivalent (GCE), averaging a 1.75 GCE/kWh decrease per year. This is much lower than the targeted 6 GCE/kWh per year. The low thermal efficiency of power generation is caused mainly by electricity shortages and a pronounced lack of capital. Due to the severe capacity shortages, some of the world's oldest power plants remain in operation in China. China currently has 30 GW of small and low-efficiency coal-fired generators, with an average thermal efficiency of less than half of the high-efficient generators.

To improve the thermal efficiency of China's power plant, the MEPI has introduced several measures, including introducing high-efficiency generators and retrofitting low-efficiency generators. As a matter of MEPI policy, the net coal consumption for newly-installed generators in the inter-provincial power networks should not exceed 330 GCE/kWh. Newly-installed power plants will use mainly 300 MW and 600 MW units for domestically manufactured generators, and 350 MW and 660 MW units for imported generators. During the 1990s, China plans to retrofit or eliminate 18.5 GW of the small, low-efficiency power plants. However, past experience has shown that when electricity shortages are serious, small and medium-sized, low-efficiency power plants will proliferate, while old power plants will continue in service even though they should be retired.

Given the success of China's economic development policies, the country is not likely to allow power shortages to curb future economic growth. If sufficient foreign investment and high-efficiency generators are not available, the high economic costs of electricity shortages will lead to increased utilization of low-efficiency generators and much higher energy consumption in the long run. This scenario has been observed in the recent Chinese history, and the 30 GW low-efficiency power plants are in part the result of insufficient foreign-invested and/or high-efficiency domestic generating capacity.

Within the present environment of decentralization, the authority of the MEPI is decreasing. Given serious power shortages, local consumers will build inefficient, small power plants due to their limited ability to raise funds and lack of experience in constructing large power plants. Some local consumers even import outdated or retired foreign generators because of their low capital costs.

Substituting Oil-Fired Units with Coal-Fired Units

China's coal resource is much more abundant than oil resource; therefore, using coal as the primary fuel in thermal power plants was adopted as a basic energy policy in China. During the 1970s, however, China installed a batch of new oil-fired power plants and converted some coal-fired units to oil-fired units due to an overestimation of China's potential oil resources. Into the 1980s, China's crude oil production staggered at the 100 million metric ton (Mt) level. Excluding exports, only around 80 Mt was available for domestic consumption, and half of them were burned by power plants, industrial boilers and kilns as fuel. Compared with burn coal and based on international oil prices, about $5 billion were wasted annually.

To solve this problem, the SPC adopted three measures: (1) convert the oil-fired units which were previously converted from coal-fired units back to coal-fired starting from the late 1970s; (2) build a batch of new coal-fired units to substitute oil-fired units starting from 1980;

(3) convert oil-fired units into coal-fired units starting from 1986. Presently, China still has 6 GW oil-fired units which are designed to burn crude oil. By the end of 1993, the amount of crude oil directly burned has been reduced by about 18 Mt per year; however, China now still burns about 29 Mt of crude oil per year (Wang and Liu 1995). As a basic energy policy, existing oil-fired units will be converted to coal-fired whenever possible and no new oil-fired power stations will be built in general. However, in southern China, especially in Guangdong Province, tight transportation capacity prevents the coal supply from meeting demand, so substantial oil-fired capacity may be installed regardless of the government policy, but the new oil-fired units are unlikely to burn crude oil.

Developing Mine-Mouth Power Plants

In an effort to ease the pressure on the overloaded railway system and to bring faster development to the lagging inland provinces, a policy to encourage the construction of mine-mouth power plants in the north was recommended by the SPC and touted by the MEPI. Mine-mouth power plants are scheduled to be build in Shanxi, Shaanxi, the eastern part of Heilongjiang, the eastern part of Inner Mongolia, northern and southern Anhui, and part of Yunnan. In all, China has plans for the addition of 37 GW of mine-mouth power plants by 2000. Shanxi Province alone has plans to build 18 GW of new mine-mouth power plants. Most of the electricity generated will be transmitted to other provinces.

Mine-month plants are uncharted territory for China. The central and local governments are at the beginning of the process of dealing with the range of issues to be faced. At the top of the list is the question of who should build them. Both the MEPI and the Ministry of Coal Industry have indicated their interests in controlling the mine-mouth power plants, and each has its own list of planned projects.

Environmental Regulations and Policies

In 1993, the Environmental Protection Committee was established under the National People's Congress. At the Second National Industrial Pollution Protection Conference, the following basic principles were issued: (1) The traditional development strategy should change to actively promote clean production while maintaining continued growth. (2) In order to adapt to the market-oriented economy, the functions of the government in environmental management should be strengthened. (3) Industrial pollution control should include both terminal points and the whole production process, both pollutant emission concentrations and the total amount of pollutants, and both concentrated pollutant sources and scattered sources. According to these principles, a series of environmental policies have been formulated. An air pollutant permit system for trial implementation was introduced in 16 cities in 1993. In two provinces (Guangdong and Guizhou) and nine cities (Chongqing, Yibin, Nanning, Guilin, Liuzhou, Changsha, Hangzhou, Qingdao, and Yichang) a pilot practice of imposing levies on SO_2 emissions is being conducted. In March 1994, the government approved China Agenda 21, and is using it as a guiding document to formulate the national plan for medium and long term economic and social development.

Coal production and utilization are the most important factors contributing to regional environmental problems such as air pollution and acid rain, as well as global climate change. Coal related environmental problems have become a barrier affecting China's economic and social development, especially in major cities and areas consuming high-sulfur coals. Environmental factors have become important in selecting the location and size of power plants.

China's coal related environmental impacts have become an international concern. SO_2 and NOx emissions caused by coal combustion have caused concern in neighboring countries; CO_2 emissions, which contribute to global warming, have caused even more international concerns. However, in the foreseeable future China cannot reduce its coal consumption. The only feasible choice is developing clean coal technologies (CCTs) and increasing coal utilization efficiency. Therefore, clean coal is the future of China's energy. Developing CCTs which are suitable for the Chinese situation is an important medium- to long-term Chinese strategy.

Chapter 4

Investment in the Power Sector

The Transformation of the Investment Mechanism

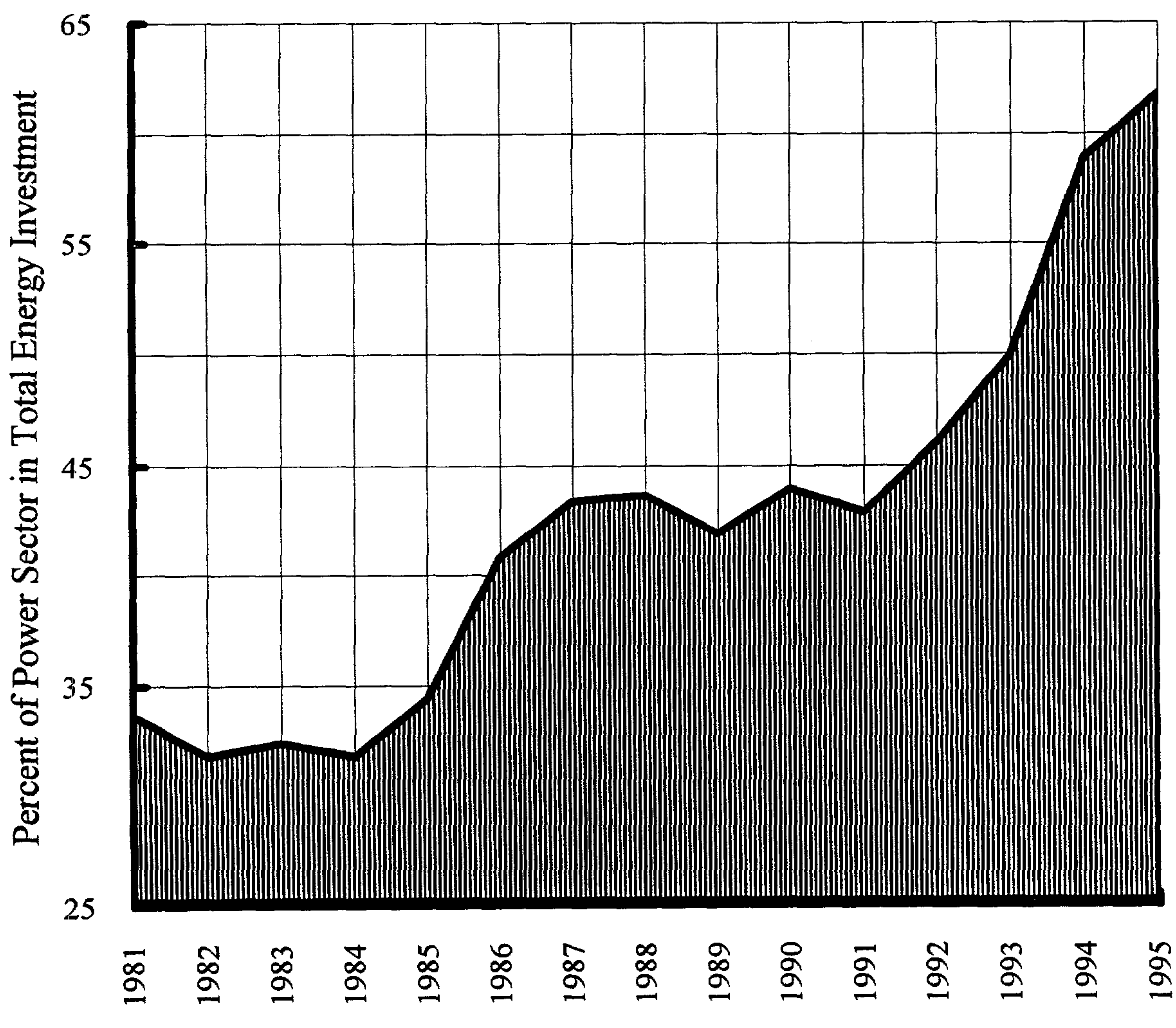


Figure 4.1. The Growing Share of Power Sector in Total Energy Investment (State-Owned Units)

China's rapid economic growth has led to increased needs for electricity, creating huge requirements for capital investment. As shown in Figure 4.1, the share of power sector investments of state-owned units in total energy investment increased from 33 percent in 1981 to 62 percent in 1995. The government is already busy trying to find ways to manage the inflated debt burdens, and it has little capacity for funding the capital needed to expand electricity generation. In the power sector, as almost the whole world is beginning to embrace the principles of free market capitalism and private ownership, China also recognized the significant benefits to be realized, through decentralization and privatization, which include reduced national deficits, increased efficiency, access to foreign investment capital, greater internal capital generation, and most importantly, more electricity to fuel economic growth. This recognition has resulted in a strategic transformation of the power sector investment mechanism; however, the transformation process is conducted slowly and cautiously.

New Channels of Domestic Financing Sources

Before China's economic reforms (1949-1979), investment in China's power industry basically came from central government allocations, and all profits generated by the power sector were turned over to the central and local governments. Since 1979, China has changed the financing of its power industry from government allocations to loans. Figure 4.2 shows that in 1981, when economic reform had just started, budgetary allocations accounted for 66 percent of total investment in the energy sector, including power generation, oil and gas exploration, and coal mining; however, the share had dropped to 7 percent by 1992. During the same period, the share of self-raised funds increased from 13 to 58 percent; the share of domestic loans increased from 14 to 24 percent; and the share of foreign investment increased from 7 to 11 percent.

China also adopted the following measures to create new channels of domestic financing sources:

(1) In 1980, China switched most of its budgetary allocations to loans. The fifteen-year government loans were offered at a very low 3.6 percent annual interest rate.

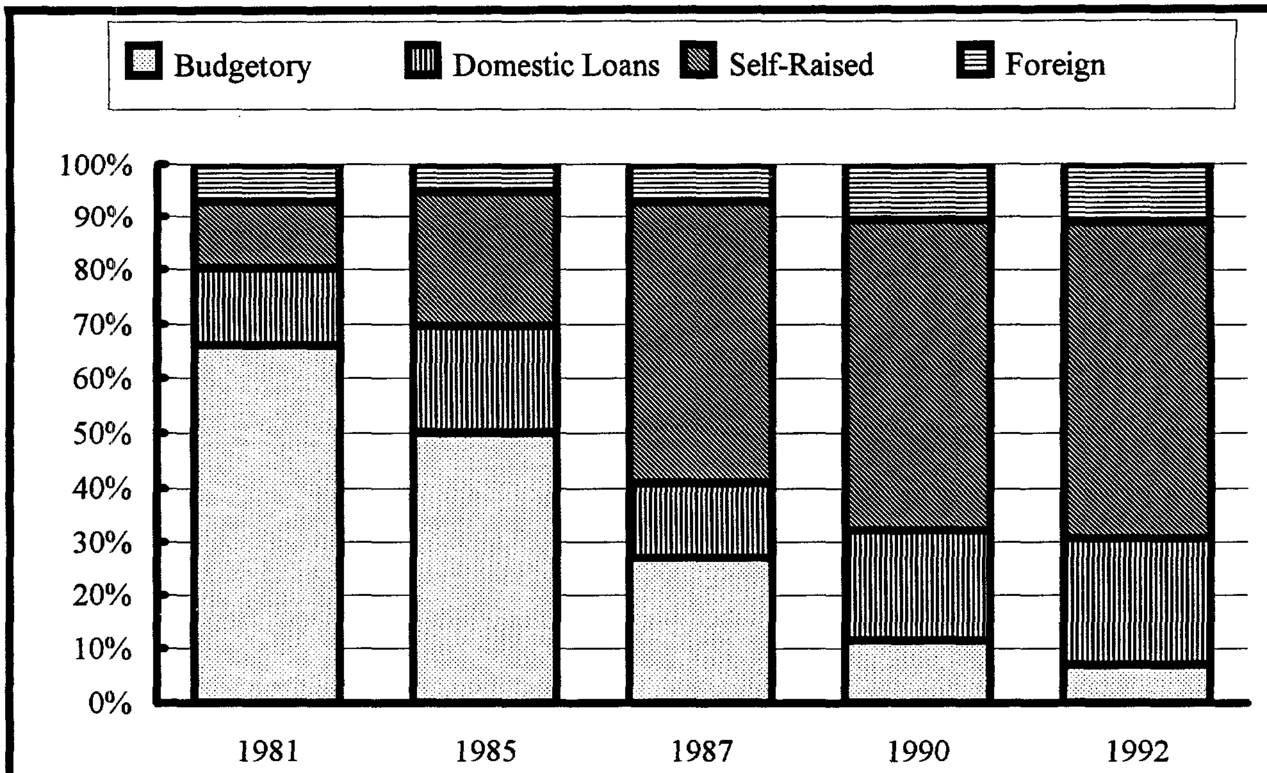


Figure 4.2. Source of Energy Sector Investment

(2) In 1981, China started to promote the policy of substituting oil with coal. The money saved through promoting this policy was used to establish a special fund, most of which were used in the power sector to convert oil-fired power plants to coal-fired plants or to build new hydropower plants to replace oil-fired plants.

(3) In 1983, China started to collect the "energy and transportation construction fund," which equals 10 percent of the non-budgetary capital of all enterprises (the rate was increased to 15 percent later). This fund was turned over to the Ministry of Finance, and part of it was used in the power sector.

(4) In 1985, China started to encourage local governments and electricity consumers participating in the investment of power plants either through direct investment or through purchasing the rights to use electricity.

(5) In 1987, China started to issue electric power bonds. In the same year China started

to collect 2 fen per kWh for all electricity consumers, except agricultural and residential consumers. The money was used by local governments in power projects.

(6) In 1991, China started to test the shareholding system in power enterprises. A few power plants issued stocks to employees and a few power stocks were sold to the public.

(7) China also established a specialized "energy conservation fund," which provides low interest loans to the retrofitting power projects that may achieve substantial energy conservation.

Channels of Direct Foreign Investment

In addition to the reforms of domestic investment mechanism, bans on utilizing foreign investment in the power sector are being gradually lifted. China began introducing foreign investment in its power sector in 1979. By the end of 1994, China had contracted $14.5 billion of foreign investment in its power sector for 64 large and medium-sized projects with a total capacity of 40.7 GW. Of the contracted foreign investments, $12.1 billion has been put in use. The commissioned installed capacity reached 19.57 GW (*The China Energy Report* October 1995). The foreign funds included loans from the World Bank, the Asian Development Bank, Japan, Russia, France, Italy, and many other countries. Foreign investment in joint venture projects has reached $5.77 billion, with a total of 6.475 GW of capacity completed or under construction (*China Daily* December 28, 30, 1994).

Utilizing foreign capital is divided into direct investment and indirect investment. Direct investment, including equity joint venture projects, cooperative joint venture projects, and wholly foreign-funded projects.

Equity joint venture projects have a limited live span of 10-20 years. Profits are shared by both sides according to the respective percentage of equity. Foreign investors are required to hold at least 25 percent of the equity. Registered capital of joint venture companies cannot be below one-third of total investment (Ohyang 1994).

One example of an equity joint venture project is the 1,320 MW coal-fired Taishan Power Plant, a joint venture including Entergy Power Group of the U.S., Japan's Marubeni Corp., the Guangdong Power Company, and China Union of Hong Kong. Entergy will invest

$40 million for a 10 percent equity share. The Guangdong Power Company will hold 53 percent. The rest will be shared by other foreign investors involved in this project. The Taishan project is the first of some 50 power projects involving foreign investment awaiting government approval. Entergy's rate of return on this project is estimated at 16-17 percent, significantly in excess of the 12 percent cap associated with China's investment policy. The Taishan Power Plant is scheduled to install 6 GW of capacity by 2006, the first unit will start operation in 1997, total investment needs is estimated at $3.6 billion.

Existing power plants can also be converted to equity joint venture company. The process of converting existing power plant to equity joint venture company is as follows: (1) calculate the market value of the existing power plant; (2) sell up to 49 percent of the stocks of the existing plant to foreign investors, (3) use the proceeds to build new power projects; and (4) the old power plant become a new equity joint venture company. Examples of equity joint venture power projects include Daya Bay (Guangdong Province) Nuclear Power Plant, Zhengzhou (Henan Province) Thermal Power Plant, Ligang (Jiangsu Province) Power Plant, Xinxiang (Henan Province) Power Plant, Huanghai (Shandong Province) Thermal Power Plant, Zhuhai (Guangdong Province) Power Plant, Mawan (Guangdong Province) Power Plant, and some oil-fired and gas turbine power stations in Guangdong Province. Table 4.1 lists some other joint venture power projects which are scheduled to start construction before 2000.

Another type of equity foreign investment is selling stocks in the overseas stock exchange. The first two issues were completed in 1994 with the New York Stock Exchange listings of Shandong Huaneng Power Development Co. Ltd. (SHP) in July for approximately $312 million and Huaneng Power International (HPI) in October for $583 million. Another two power companies, Shandong International Power Source Development and Datong Power Plant, are scheduled to be listed in Hong Kong. Before the listing of the stocks, MEPI's spokesman said that investors will get a return of 15 percent from the four power companies. Returns above 15 percent may be obtained if the companies are efficiently managed. However, the performance of the two stocks in the United States was discouraging.

Table 4.1. China's Major Ongoing and Proposed Power Projects with External Financing

Project Name	Location Province	Capacity (MW)	Construction Period	Source of Finance
Total		71120		
Hydropower:		22560		
Mianhuatan	Fujian	600	1995-2002	ADB
Shisanling PS	Beijing	800	1990-1996	OECF, Japan
Zhanghewan PS	Hebei	1000	1996-2001	ADB
Geheyan	Hubei	1200	1988-1995	Canada
Wuqianxi	Hunan	1200	1988-1996	OECF, Japan
Lingjintan	Hunan	240	1994-1999	ADB
Tianshengqiao II	Guizhou	1320	1988-1996	OECF, Japan
Tianshengqiao I	Guizhou	1200	1991-2002	OECF, Japan
Hongjiadu	Guizhou	540	1995-2001	ADB
Guangzhou PS II	Guangdong	1200	1994-1998	ADB
Pushihe PS	Liaoning	1200	1998-2003	WB
Shuikou	Fujian	1400	1987-1997	WB
Ertan	Sichuan	3300	1991-2000	WB
Longtan	Guanxi	4200	1995-2003	WB
Huanggou	Heilongjiang	1200	1999-2004	OECF, Japan
Gongboxia	Qinghai	1500	1997-2005	OECF, Japan
Jilintai	Xinjiang	460	1997-2002	OECF, Japan
Thermal Power		46560		
Beilungang	Zhejiang	2400	1986-1998	WB
Yangzhou	Jiangsu	1200	1994-1998	WB
Tuoketuo No.1	Inner Mongolia	1200	1996-2000	WB
Zouxian	Shandong	1200	1992-1996	WB
Qinbei	Henan	1200	1997-2000	WB
Ezhou	Hubei	600	1992-1997	OECF, Japan
Jiujiang	Jiangxi	700	1994-1998	OECF, Japan
Hejin	Shanxi	700	1994-1998	OECF, Japan
Sanhe	Hebei	700	1994-1998	OECF, Japan
Waigaoqiao II	Shanghai	2000	1997-2002	
Jiaxing II	Zhejiang	2400	1996-2002	
Ligang II	Jiangsu	700	1989-1993	
Ligang III	Jiangsu	1200	1995-1998	

Table 4.1. China's Major Ongoing and Proposed Power Projects with External Financing (continued)

Project Name	Location Province	Capacity (MW)	Construction Period	Source of Finance
Shidongkou II	Shanghai	1200	1988-1993	
Yangcheng	Shanxi	2100	1995-2001	
Tuoketuo II	Inner Mongolia	2400	1999-2005	
Daihai	Inner Mongolia	2400	1997-2001	
Datong No.2	Shanxi	1200	1998-2002	
Shuangyashan	Heilongjiang	1200	1997-2001	
Hanfeng	Hebei	1200	1996-2000	
Zhuhai	Guangdong	1200	1995-2000	
Shenzhen East	Guangdong	2400	1997-2003	
Beihai	Guangxi	700	1996-2000	
Rizhao	Shandong	700	1995-1998	
Shiliquan	Shandong	600	1997-2000	
Laicheng	Shandong	1200	1995-1998	
Shiheng II	Shandong	600	1996-1999	
Meizhouwan	Fujian	1200	1993-1997	
Songyu	Fujian	700	1993-1997	
Hanchuan II	Hubei	700	1998-2003	
Dalian II	Liaoning	700	1995-1998	
Dandong	Liaoning	700	1995-1998	
Nantong II	Jiangsu	700	1996-1998	
Fuzhou II	Fujian	700	1995-1998	
Yueyang II	Hunan	700	1996-1999	
Luohuang II	Sichuan	700	1996-1999	
Shantou II	Guangdong	700	1997-2001	
Yingkou II	Liaoning	1200	1997-2000	
Gaobeidian	Beijing	660	1995-1999	
Yahekou	Henan	700	1994-1997	
Huanggang	Hubei	1200	1997-2001	
Nuclear Power:		2000		
GD Nuclear No.2	Guangdong	2000	1998-2005	

CASE STUDIES

Shandong Huaneng Power Development Co. Ltd.

Shandong Huaneng Power Development Co. Ltd. (SHP) was incorporated on June 27, 1994, and was the first Chinese enterprise listed on the New York Stack Exchange (NYSE). On August 4, 1994, the company offered 23,274,000 American Depositary Shares (ADS), representing 26 percent of the total stocks of SHP, to the public at a price of $14.25 per ADS. The ADSs were fully subscribed and listed on the NYSE on the same day. Out of the net proceeds of $312.5 million from the public offering, approximately $80 million were used to repay the principal and interest on loans. The remaining proceeds will be used to finance the future expansion of existing power plants and the construction of new power plant.

By the end of 1994, SHP's proportional share of the aggregate installed capacity of the three existing power plants at Dezhou (100 percent stack in four 300 MW coal-fired units), Jining (75 percent stack in 300 MW capacity) and Weihai (60 percent stack in 250 MW capacity) increased to 1,575 MW. Due to electricity shortages in Shandong Province, SHP's generating units are operating at very high capacity factors. For example, the Weihai Power Plant was reported to have a capacity factor of 93 percent in 1994. During the first half of 1995, electricity generation from the three existing plants increased by 23 percent compared to the same period in 1994, principally due to the start of commercial operation of both Dezhou Unit 4 and Weihai Unit 2 during this period. The 125 MW Weihai Unit 2 commenced trial operation in July 1994 and commercial operations in January 1995. In addition to these new generators, the company was granted permission to increase its on-grid output at all three plants beginning in the second half of 1995. As a result of this increase, total planned on-grid electricity output of the three plants in 1995 will be increased from 8,231 to 9007 GWh. The Board of Directors has decided to pay an interim dividend of $0.24 per ADS, while earnings per ADS were $0.47 for the six months ended June 30, 1995. The consolidated net income for the six months increased by 32 percent.

SHP has ambitious development and expansion plans to construct a total of 2,200 MW generating capacity including: (1) two 600 MW in Phase III of the Dezhou Power Plant; (2) two

300 MW units in Phase II of the Weihai Power Plant; and (3) an aggregate capacity of 2,500 MW in Rizhao Power Plant in phases, with phase I consisting of two 350 MW units. The company's expected investment in the Rizhao Power Plant has been reduced from a 45 percent interest to 25.5 percent. Reportedly, the approval for the construction of Weihai Phase II project has already been given by the Government and SHP expects to receive official approval soon. However, all these development projects, some of them having been approved by the SPC in 1994, are delayed by anti-inflation measures adopted by the Government. Due to the delays of these projects, a significant portion of the net proceeds from the public offering was put in bank accounts at interest rates much lower than the targeted 15 percent of return on investment.

Under the Tariff Agreement, the SHP is entitled to charge tariffs for the company's proportionate share of the planned on-grid output of each of the three operating plants designed to allow the company to recover, at planned output levels, its proportionate share of all operating costs, including depreciation of fixed assets, financial expenses and taxes on the three operating plants, and to earn a return on the company's proportionate share of the average net book value of fixed assets, including construction-in-progress, of 15 percent (SHP Annual Report 1994). However, price administration authorities throughout China, including Shandong Province, have implemented price control measures in compliance with the anti-inflation policy announced by the State Council in the second half of 1994. As a result, the on-grid tariffs for the three operating power plants for 1995 approved by the Shandong Province Price Administration Bureau were maintained at the same levels as 1994. The company is considering making application to the Price Administration Bureau for a tariff increase in the second half of 1995; however, there can be no assurance that the company will make such application or that such application will be approved. Accordingly, the rate of return on net fixed assets and net income for 1995 will be affected. As a result the market price of SHP's stock dropped from $14.25 per ADS in August 1994 to below $7 per ADS in July 1995, before rising to about $8.5 in June 1996. For further information, contact: Zhou Yongliang or Gao Ding of Shandong Huaneng Power Development Co. Ltd., Tel (86-531) 295-3743.

Huaneng Power International

Huaneng Power International (HPI) is a subsidiary of Huaneng International Power Development Corp (HIPDC). HIPDC was established by the central government to promote financing sources for developing the power industry. HIPDC uses international financing to develop, build, own, and operate new power plants using primarily imported equipment. HIPDC is the largest user of foreign debt financing for power plant development in China.

HPI was listed in October 1994 on the NYSE. The offering in the United States was not entirely successful. Due to the lukewarm response from investors, the company had to reduce its offering price to $20 per ADS from its initial target of $22.5-27.5 per ADS. About $583 million in net proceeds came from the issue.

To help HPI's listing overseas, the MEPI announced a pricing policy specifically applicable to HPI. The policy extends the principles of State Council Document 72 to HPI but improves on them by replacing the fixed return per kWh with the allowed rate of return on net fixed assets. HPI's net fixed assets are the annual average of the book value of the company's fixed assets less accumulated depreciation and construction work in progress. The pricing policy allows HPI to recover all operating expenses and debt service costs through the tariff charged to customers. In principle, the rate will be adjusted once a year, and the company's rates will vary with changes in fuel prices, transportation costs, foreign exchange rate fluctuations and other variables. In addition, the allowed rate of return on the net fixed assets of the company's power plants under construction will be realized through the revenues collected for electricity generated by the company's operating power plant. Since the beginning of 1994, HPI's electricity tariff has been increased to 0.335 yuan ($0.04) per kWh from 0.283 yuan ($0.034) per kWh in 1993 (China Daily November 1, 1994).

According to the HPI plan, through the annual rate-setting process with the local power bureaus for 1995, the company will gain an annual rate of return equal to 11 percent on equity-financed net fixed assets and an annual return of 15 percent less actual interest costs (up to 8%) on debt-financed net fixed assets. An authorized 15 percent rate of return on equity-financed net fixed assets will be phased in over four years from 1995 to 1998. However, investors also worry *about difficulties the company may have trying to raise electricity tariffs given the high rate of inflation in China.*

Apart from raising foreign funds through equity offerings and debt issues, HPI has also prepared to form a joint venture with Southern Electric International of the United States to develop the 2X600 MW Jinling Power Plant in Jiangsu Province, with total investment estimated to be around $1.1 billion. Other HPI projects under development include: (1) the 1,200 MW coal-fired Shangan phase 3 expansion; (2) the 1,200 MW coal-fired Dandong phase 2 expansion; (3) the 1,200 MW coal-fired Nantong phase 3 expansion; (4) the 1,200 MW coal-fired Jinling phase 2 expansion; (5) the 1,200 MW coal-fired Jinling plant; (6) the 700 MW coal-fired Dalian phase 2 expansion; (7) the 700 MW coal-fired Dandong plant; (8) the 700 MW coal-fired Nantong phase 2 expansion; (9) the 700 MW coal-fired Fuzhou phase 2 expansion; (10) the 700 MW coal-fired Shantou phase 2 expansion; (11) the 700 MW coal-fired Fuzhou phase 3 expansion; (12) the 600 MW coal-fired Shangan phase 2 expansion; and (13) the 600 MW coal-fired Dalian phase 3 expansion. The company plans to finance 70 percent of the investment through debt service. If HPI can achieve its grand plan for power plant development, the company's installed capacity will increase from 2,900 MW upon listing to 14,900 MW by the early 21th century. Despite such excellent fundamentals, investors still worry about the uncertainty of China's policy. The market price of HPI's stock dropped from $20 per ADS in October 1994 to below $13 per ADS in June 1995, before rising to $20 per ADS in August 1995.

In May 1995, the Chinese government created another entity, the State Development & Investment Corporation (SDIC), to seek joint venture partners from international investors to develop power plants on a build-own-operate (BOO) basis. SDIC has registered capital of nearly $700 million and is charged with attracting equity investment in projects not undertaken by the state shareholding companies or the state's central enterprises. SDIC describes itself as a state-owned, policy oriented investment institution supervised by the State Development Bank (SDB) and a board of supervisors. The board consists of members from SDB, the State Planning Commission, the State Economic and Trade Commission, the Ministry of Finance, and the People's Bank of China. When SDIC was formed, it took over initial plant development of two hydropower stations and one pumped-storage plant totaling 5,850 MW and is seeking equity participants in the ventures. The projects include the 3,300 MW Ertan hydropower station in Sichuan, the 1,200 MW Guangzhou pumped-storage project, and the 1,350 MW Dachaoshan hydropower station in Yunnan.

Reportedly, SDIC and Community Energy Alternatives (CEA) of the United States has signed a joint venture agreement for the 600 MW, coal-fired Jingyuan power plant in Gansu Province, to be developed on a build-own-operate basis. CEA will hold 30 percent equity, SDIC 50 percent, Gansu Electric Power Construction Investment & Development Corp., 15 percent, and Gansu Electric Power Corp., 5 percent. Development is contingent upon approval from the Ministry of Foreign Trade & Economic Cooperation, which is expected in September 1995. The State Development Bank, China's largest policy-oriented bank designed to fund key infrastructure projects, will provide 50 percent of the project's debt funding requirements.

Late in 1995, the Ministry of Electric Power Industry created China Power Investment Corp (CPIC) to raise international capital for power projects. The capital-raising function will be carried out by CPIC's subsidiary China Power International Holding Ltd. (CPIH), which began operations in August 1995 from its Hong Kong office. CPIH will float public power plant assets, issue corporate bonds, establish power development funds, and channel foreign investment for build-operate-transfer (BOT) projects. A number of Chinese provinces have asked CHIH to raise funds from overseas for local power projects.

In addition to equity joint venture projects, cooperative joint venture projects are also common in China. Cooperative joint venture is also called "contract" joint venture project. The main difference between a cooperative joint venture project and a equity joint venture project is that the profits and risks are not shared according to equity shares of the two sides in the case of the cooperative joint venture project, but according to the provisions determined in the contract. Equity joint venture is preferred to cooperative joint venture in China. The Shajiao' B and Shajiao' C projects in Shenzhen are examples of cooperative joint venture projects.

CASE STUDY

Hopewell Holdings' Shajiao' C Project

Following its success with Shajiao' B project, Hopewell Holdings of Hong Kong has gone on to develop a second and larger BOT project in China called Shajiao' C (3X600 MW). Located on the same site just to the east of the Shajiao' B station, the project is a cooperative joint venture company called Guanghope Power Co. Ltd., organized under the framework of China's joint venture law, 60 percent owned by Party A and 40 percent by Party B. Party A is a Chinese registered company established for the project and owned by Guangdong General Power Company, a PRC state-owned corporation dealing with foreign parties in connection with the management of electricity in Guangdong Province. Party B is a Hong Kong registered company wholly owned by Hopewell Holdings Ltd.

Pursuant to the joint venture contract, Party A and Party B have entered into a power plant development contract under which Party B will be responsible for appointing contractors to complete the project on a turnkey basis for a fixed price by or before a contract completion date. Party B is also responsible for procuring bank facilities to fund the construction and operation of the project. Party B will then on-lend the proceeds from the bank facilities to the joint venture company under an on-lending agreement.

Under the project's turnkey contract, the project contractor is itself a joint venture comprising of three companies: GEC Alstrom, Combustion Engineering, and Slipform Engineer (a subsidiary of Hopewell). Under the project's operation and offtake agreement, Party A and its shareholder are to operate the plant jointly and purchase its electricity. The operator/purchaser is responsible to ensure that electricity is generated in a steady pattern to enable the payment obligations of the joint venture company to be met. In return for the operation services performed by the operator/purchaser, the joint venture company will pay a fee calculated on the basis of electricity generated by the Shajiao' C station and available to be taken. Payment of the operation fee is conditional upon payment of the electricity price by the operator/purchaser.

The operator/purchaser is obliged to purchase a minimum offtake quantity of electricity *per year from the joint venture company. The electricity price payable by the operator/purchaser to the joint venture company is also calculated on the basis of electricity generated by the station and available to be taken.*

The portion of payment obligations in U.S. dollars is guaranteed by the Guangdong International Trust and Investment Corporation. The shareholders of the joint venture company have undertaken to provide a shortfall guarantee up to $250 million. Party A's shortfall obligations are guaranteed by Guangdong General Power Company. In addition, the Guangdong Provincial People's Government has pledged its support of the project by way of a comfort letter.

The total project cost up to completion date is estimated to be $1,966 million, financed as follows: (1) shareholders equity $375 million (19%), (2) shareholders loans and capitalized interest $444 million (23%), shareholders shortfall finance and capitalized interest $214 million (11%), EGB loans and accrued interest $183 million (9%), and bank loans $750 million (38%). The debt/equity ratio of the project was conservatively set at 1:1. Hopewell elected to contribute a substantial amount of funds directly and by shareholders loans to the project's equity. The consensus among Hong Kong bankers was that Hopewell could have achieved financing with 25 percent equity.

Solely foreign-funded projects are 100 percent owned and managed by foreign investors. China only has a few small solely foreign-funded projects in the coastal areas of Guangdong Province, for example, the 6X10 MW diesel engine plant in Shunde, the 2X25 MW Songshan Power Plant, the 2X50 MW Haishan Power Plant, and the 2X25 MW Haimenzheng Power Plant. Reportedly, bidding has been completed for the country's first large scale solely foreign-funded power project, the Meizhen Bay Thermal Power Plant in Fujian Province. Total investment in the project is expected to exceed $500 million.

Hong Kong firms are presently the largest investors in China's power sector followed by US firms. Singapore, Malaysia, and Thailand are also involved as shown in Table 4.2. As most private sector investments in China's power sector are still in the discussion/negotiation stages, the actual mix of foreign investment could be quite different from present expectations.

Table 4.2. Power Projects with Foreign Private Investments*

Name	Capacity (MW)	Schedule Status	Investment ($million)	Foreign ($million)	Foreign Firms	Location
Total Contract	**29690**		**26390**	**13006**		
Zhuhai	3720	Contract	3180	*1590*	Three HK firms	Guangdong
Daya Bay	1800	87--93	4000	1000	China Light&Power HK	Guangdong
Taishan	4920	93--97	2240	*1120*	Entergy US	Guangdong
Shajiao C	1980	93--95	1875	750	Hopewell HK	Guangdong
Shajiao B	700	85-87	513	513	Hopewell HK	Guangdong
Nansha	1200	88-94	380	190	New World HK	Guangdong
Wushashan	1200	Contract	1030	422	Orient HK	Zhejiang
Yinglongshan	1200	Contract	1200	600	Sembawang Singapore	Zhejiang
Jiangsu	2400	Contract	2400	1680	Wing Merrill US	Jiangsu
Anhui	600	94-97	600	600	United Engineers US	Anhui
Qinzhou	1320	Contract	1250	750	Hopewell HK	Guangxi
Beihai	600	Contract	692	346	New World HK	Guangxi
Mixian	1400	94--97	500	*250*	Wing Merrill US	Henan
Dengfeng	1400	94--97	500	*250*	Wing Merrill US	Henan
Meizhouwan	1200	93--97	1000	1000	HK, US, Singapore	Fujian
Shengli	600	Contract	500	250	Cathay HK	Shandong
Zouxian	1200	Contract	600	180	Goldman Sachs US	Shandong
Other Shandong	na	Contract	2000	*1000*	China Light&Power HK	Shandong
Lianyuan	250	Contract	230	115	Time Berhad Malaysia	Hunan
Yangcheng I	2000	Contract	1700	400	Strategic US	Shanxi
Negotiation	**37230**		**30950**			
Yangcheng II	*2000*	Negotiation	1700	na	na	Shanxi
Changzhi	*2000*	Contacting	1700	na	US or HK	Shanxi
Yangquan	*2000*	Contacting	1700	na	US or HK	Shanxi
Hequ	*2000*	Open	1700	na	na	Shanxi
Seven Others	*14000*	Open	11900	na	na	Shanxi
Jinghong	1350	Contract	na	na	Thailand	Yunnan
Other Hopewell	6680	Approached	6250	na	Hopewell HK	5 Provinces
Huhhot	7200	Approached	6000	na	na	Inner Mongo.
Sichuan 3 Plants	na	Contract	na	na	HK	Sichuan
Guizhou 2 Plants	na	Intent	na	na	HK and US	Guizhou

* Not necessarily a complete list and numbers in italics are estimates only.

In recent years, intention contracts between China and the United States in the power sector have reached $12 billion, with an installed capacity of 30 GW. So far the actual contracted value has reached $4 billion, with a total capacity of 7 GW.

Chinese officials have received several hundred private power project proposals from power developers, far more than can be included in the government's national power development plan. China has plans to adopt a competitive bidding system for its power project development, virtually ending the current system of negotiated deals between private developers and utilities. When the competitive bidding system is implemented, power developers with a signed letter of intent will be allowed to proceed with their projects if already approved by the State Planning Commission, otherwise the developers will have to participate in the competitive system.

Channels of Indirect Foreign Investment

Indirect foreign investments adopted in China include international loans, export credit, international renting, trade through bartering, and international bonds. Sources of international loans include international banking institutions, such as the World Bank (WB) and the Asian Development Bank (ADB), foreign governments, and commercial banks (see Appendix 4.1).

China started to use international loans to develop hydropower resources in southwest China (Sichuan, Yunnan, Guizhou, and Guangxi) in 1984. As shown in Table 4.3, several billion dollars from the WB, the ADB, and foreign governments have been used to finance large hydropower projects in the region. The projects include the 3,300 MW ($3.45 billion) Ertan hydropower plant in western Sichuan. Reportedly, the government has approved the use of a $1.3 billion loan from the WB for the 4,200 MW Longtan hydropower station in Guangxi (phase I will use a WB loan of $350 million). According to the newly issued Electric Power Law, loans from the WB and ADB will be more widely used to finance the state projects. Table 4.4 lists the thermal power and electricity transmission projects which have used or are scheduled to use foreign loans.

Table 4.3. Hydropower Projects Which Have Used Foreign Loans

Project	Capacity (MW)	Construction Schedule	Loan ($million)	Source of Loans	Project Location
Total Hydropower	24730		3821		
Lubuge	600	84--90	141	World Bank	Yunnan
Shuikou	1400	87--97	240	World Bank	Fujian
Yantan	1210	84--93	52	World Bank	Guangxi
Ertan (Phase I)	3300	91--2000	380	World Bank	Sichuan
Tianhuangping	1800	93--97	300	World Bank	Zhejiang
Longtan (Phase I)	4200	94--2002	350	World Bank	Guangxi
Hongjiadu	540	95--2001	200	World Bank	Guizhou
Wuqiangxi	1200	88--96	200	OECF (Japan)	Hunan
TSQ-II	880	84--93	478	OECF (Japan)	Guizhou
Shisanling PS	800	90--95	100	OECF (Japan)	Beijing
TSQ-I	1200	92--2000	160	OECF (Japan)	Guizhou
Guangzhou PS (P-I)	1200	88--94	200	France	Guangdong
Geheyan	1200	88--93	108	Canada	Hubei
Guangzhou PS (P-II)	1200	93--97	361	ADB, Others	Guangdong
Lingjintan	240	94--99	100	ADB	Hunan
Mianhua tan	600	95--2002	200	ADB	Fujian
Zhangjiawang PS	600	95--2001	250	ADB	Hebei

Source: Electric Power Industry in China, 1993; 1992.

Table 4.4. Thermal Power Projects Which Have Used or Are Scheduled to Use Foreign Loans

Project	Capacity (MW)	Construction Schedule	Loan ($million)	Source of Loans	Project Location
Total Thermal Power	15300		4799		
Beilungang	1200	86--93	390	World Bank	Zhejiang
Wujing	600	88--92	190	World Bank	Shanghai
Zouxian	1200	92--96	310	World Bank	Shandong
Yanshi	600	92--95	200	World Bank	Henan
Yangzhou	1200	93--97	300	World Bank	Jiangsu
Ligang	700	88-92	245	Spain & Italy	Jiangsu
Ezhou	600	92--95	250	OECF (Japan)	Hubei
Sanhe	600	93--96	250	OECF (Japan)	Beijing
Jiujiang	600	93--96	250	OECF (Japan)	Jiangxi
Hejin	600	94--97	250	OECF (Japan)	Shanxi
Nanjing	600	89--92	241	Former USSR	Jiangsu
Jixian	1000	89--93	430	Former USSR	Tianjin
Suizhong	1600	90--95	650	Former USSR	Liaoning
Yimin	1000	90--95	430	Former USSR	Neimongol
Wentuozi	2000	Agreed	na	Former USSR	Liaoning
Shidongkou No.2	1200	88--92	413	EDC, USA	Shanghai
Power Transmission	**500 KV (KM)**	**Construction Schedule**	**Loan ($million)**	**Source of Loans**	
Total	4935		460		
TSQ-II-Guangzhou	1050	88--93	116	OECF (Japan)	
TSQ-II-Guiyang	285	88--92	24	OECF (Japan)	
TSQ-I-Guangzhou	1100	94--98	140	OECF (Japan)	
Outgoing Lines for Ertan Hydro	2500	94--98	180	World Bank	

Source: Electric Power Industry in China, 1993; 1992.

Loans from the WB, ADB, and foreign governments are mostly on concessional terms that provide lower interest rates and longer repayment periods than the commercial banks could offer. For example, the $300 million WB loan for the 1,800 MW Tianhuangping pumped-storage power plant is for a term of twenty years including a five-year grace period, with an interest rate calculated at the bank's standard variable rate, 7.34 percent as of May 1993. However, such loans are usually accompanied by other special requirements imposed by the lender, and the total volume of these loans is limited.

Generally, the WB loans may vary from several years to 30 years, averaging about 17 years, with a grace period of about 4 years. Interest rates are related to the market rates, but are normally below the market rates. The WB loans are linked to specific projects and under strict supervision of the WB. The loans are based on U.S. dollars, and must be returned without any delays. With complicated formalities, from providing application to obtaining the loans, normally need one and a half to two years.

The ADB loans are divided into ordinary loans and favorable loans. Ordinary loans are for a term of 10 to 30 years plus a four-year grace period. Interest rates are calculated according to the costs to obtain the funds plus 1 percent per year. Favorable loans are for a term of 40 years plus a ten-year grace period with a very low interest rate of 1 percent per year.

Reportedly, the ADB is expected to grant a $500 million loan to support construction of the Fuyang Power Plant in Anhui Province. The loan will be used to purchase power generating and controlling equipment from overseas through international bidding. After the bidding for equipment is completed in the latter part of 1997, the $500 million loan will be granted to help kick off the construction of the 1.2 GW coal-fired power plant. Total investment for the power plant will be 9.9 billion yuan ($1.18 billion) in 1994 price, including 1 billion yuan ($119 million) for a transmission project. Domestic investment will come from the East China Power Group, the Anhui Power Development Corp, Anhui Provincial Power Corp, and Fuyang Power Development Corp (*China Daily* May 1, 1995).

Government loans are favorable loans which are guaranteed by the Chinese government. Generally, government loans have the following features: (1) the loans are on concessional terms with low interest rates and very limited additional fees; (2) the loans have rather long repayment periods, normally 10, 20, or even 30 years; and (3) the loans are associated with additional conditions which include: (i) the loans must be used to purchase commodities, technologies, and services from the lending country or from "qualified source countries" defined by lending countries; and (ii) China must use a certain percentage of export credit from the lending countries.

From 1979 to the end of June 1994, China obtained $31.4 billion in government loan commitments from 22 countries. The actual amount of loans used was $18.5 billion. Around $3.5 billion have been used in the construction of 44 power projects (*China Daily* November 28, 1994).

The interest rates of commercial loans are higher than those of government loans, and their repayment periods are shorter. However, commercial loans are more abundant in sources, and relatively easier to borrow. Commercial loans take two forms. In one case, a Chinese bank or an international trust and investment corporation acts as the borrower and then lends the funds to the Chinese power company. In the other, the foreign bank lends the money directly to the power company, provided an approved Chinese financial institution acts as guarantor. Currently most loans are of the latter type. China's Huaneng Group is the primary user of commercial loans in China's power sector.

Export credit is provided by foreign governments to promote exports of commodities from their own countries. Export credit is a favorable loan, and the risk of the loan is borne by the exporting country. In China's power sector, the use of export credit is also limited to the Huaneng Group.

International renting is very limited in China's power sector. So far, only the Liuzhou Gas Turbine Power Plant in Guangxi Province and the Shantou Diesel Power Plant in Guangdong Province adopted the international renting method.

China also uses bartering to import equipment, technology, and service into its power sector. Although bartering may solve the problem of insufficient foreign exchange, the use of bartering is limited by the following factors: (1) the exporters of generating equipment and technologies may not willing to accept the commodities offered by the Chinese side; (2) it is difficult to introduce advanced equipment and technologies using this method; and (3) the sales of the bartered commodity are subject to uncertainty and risk. Bartering in the power sector is also limited in the Huaneng Group. So far the Nanking Thermal Power plant in Jiangsu Province, the Yingkou Power Plant in Liaoning Province, and the Hougang Power Plant in Guangdong Province have used this method.

International bonds have not been used to finance China's power development yet, but are considered seriously. Recently the MEPI created a new Hong Kong registered subsidiary, China Power Investment Corp (CPI), to raise international capital, then invest those funds in power projects through several units, including MEPI's major subsidiary, China Power International Holding Ltd. (CPIH). CPIH began operations in July 1995 from an office in Hong Kong following approval from China's State Council. CPIH will float public power plant assets, issue corporate bonds, establish power development funds and channel foreign investment for build-operate-transfer projects. The central government transferred a total of 6.6 GW of existing capacity to CPIH in the form of eight plants, with CPIH owning equity stakes of between 7.5 and 100 percent. The transferred facilities include minority stakes in the Daya Bay Nuclear Power Plant and the 2.1 GW coal-fired Yuanbaoshan Power Plant in Inner Mongolia. CPIH was also given 5 percent of Huaneng International Power Development Corp (HIPDC) which holds a 40 percent equity stake in Huaneng Power International.

Targets of Power Sector Financing System Reforms

Most of China's power enterprises are owned by the state. In the past, these enterprises put social and political objectives on top of business objectives. With the development of the market economy, the conflicts between business objectives and social objectives become more and more serious. The following problems have become very obvious: (1) because electricity tariffs are maintained at a very low level, investments in the power sector are unable to generate a rational return. (2) Most investments in the power sector have to rely on sources from the central and local governments, and enterprises have no decision-making power. As a result, available capital is substantially below the investment requirement to meet the rapid growth of electricity demand. (3) The approval process takes too much time, which has contributed to the development of power shortages. (4) The allocation of insufficient electric power to consumers is not based on their economic efficiency or marginal profitability. Therefore, China's power sector must be reformed.

The final target of China's power sector financing system reform is to shift the responsibility of power sector financing from the government to the power enterprises, and the financing of power projects should be based on market forces. To achieve this target, the following measures are considered by the Chinese: (1) separating the function of government and business and promoting the commercialization and corporatization of power enterprises; (2) establishing, as soon as possible, the Electric Power Investment Law to protect the investment in power development; (3) establishing a rational electricity tariff system; (4) relieving the tax burden on power enterprises and increasing their profitability; (5) defining the property rights of power enterprises, separating the ownership and management authority of state power enterprises, and transfering the operating authority of state power assets to power companies; and (6) re-evaluating the assets of power enterprises and increasing depreciation rates.

China is considering separation of its power sector reforms into two stages. The first stage is commercialization, and the second stage in corporatization. With commercialization, the state-owned enterprises will operate based on business objectives instead of on social and political objectives. This means a shift from a government bureaucracy to an efficient, profit-driven enterprise where the social responsibilities are transferred back to the government. These new conditions hold the prospect that the national power companies will become increasingly commercially focused, similar to their private-sector counterparts.

The corporatization is the process that establishes the state-owned enterprises as independent operating entities that will be self-funding enterprise, no longer receiving government subsidies, or the subsidies will be phased out. This includes establishing a corporate charter, appointing a board of directors, and transferring assets and liabilities to the new enterprise.

Although commercialization and corporatization are closely related to each other, commercialization must lead corporatization. Specifically, the commercialization of China's power enterprises at the current stage includes the following:

(1) Giving enterprises the autonomy to operate and manage their own business. The first step is separate power enterprises from the government organizations and reducing the interference of government in the business activities of the enterprises. There should be a clear-cut contract between the government and enterprises that identifies the targets and responsibility of the enterprises.

(2) Rationalizing electricity tariffs. The current electricity tariff system is unsuitable for the development of market economy; therefore, tariff reforms are urgent. China's tariff reforms is targeting a cost-plus type system which will cover all costs, interest payments, taxes, and a rational return to investors. Currently, only newly built power plants adopted the cost-plus tariff system.

(3) Introducing international accounting principles. Introducing international accounting principles is a very important factor in commercialization. The assets of the enterprises should be re-evaluated.

(4) Giving enterprise the authority to make financing decisions. The government should clarify the rights of the enterprise to raise money through various channels, including international financing sources.

(5) Reducing the tax burden of power enterprises.

China is reluctant to talk about privatization at this stage; however, the concept of privatization is penetrating into the power sector. Privatization requires the transfer of ownership, as well as operational and administrative control, to the private sector. By exposing the power companies to the discipline of the capital markets and by allowing owners and management to reap the financial rewards of improved levels of performance, it is presumed that they will be more effectively directed and will be motivated to reduce costs and increase efficiency. The techniques of privatization are numerous and include the following: sale of the company to private investors, sale of the assets, capitalization of the company's shares in the international stock market, or maintaining state ownership of the utilities while creating a market for new entrants to add generating capacity.

The financial operating targets of China's power industry are: (1) the capital profit rate should be 10-12 percent after adjusting for inflation; (2) investment from retained profits of power enterprises should account for 35 percent of total power sector investment; (3) the ratio between annual gross income (before interest payments and taxes) and debt payable (including principal and interest) of the same year should be greater that 1.5:1; and (4) equity finance should account for 35-40 percent of total investment, while debt finance account for less than 60-65 percent (MEPI).

The Gap of Capital Availability

The amount of investment required to achieve China's power development target will be huge, especially as a significant portion of the equipment will need to be imported. China's official estimate indicated that in order to increase China's total generating capacity to 300 GW by 2000, a total of 600 billion yuan ($72 billion in 1993 price) will be needed during the last eight years of the 1990s, about 75 billion ($9 billion) per year on average. Even taking into account all current and forthcoming money raising methods, there will still be a gap of 200 billion yuan ($24 billion) or about one-third of the total capital requirement. The official estimate appears conservative for the following reasons:

(1) The share of imported equipment will increase. To increase China's generating capacity to 300 GW by 2000, China needs to add 87 GW of capacity during the 1996-2000 period, averaging more than 17 GW per year. However, the Ministry of Machinery Industry (MMI) has a severe problem in meeting the demand for power generators, as its current capacity is only about 9 GW per year. Even taking into account the manufacturing capacity of small-sized generators, China's domestic manufacturers can only produce around 12 GW of power generating units per year. Almost one-third of generating capacity must be imported. In addition, domestically manufactured generators are mostly 200 and 300 MW units, the manufacture of 600 MW units has just started. In order to improve the overall technological

level of the power industry, advanced equipment and manufacturing technologies should be imported. As mentioned in Chapter 3, imported equipment is much more expensive than domestic equipment. For example, the aforementioned Fuyang coal-fired power plant which is scheduled to use ADB loans to purchase imported equipment is estimated to cost around $1,000 per kW, while coal-fired power plants using domestic equipment normally below $500 per kW.

(2) The share of investment on transmission systems will increase. Due to limited fund availability, China's transmission and distribution facilities are underinvested. The share of investment in power transmission dropped to only 16 percent in 1991 from 24 percent of total investment in 1980, before rising to 17 percent in 1993. This is a very low level by any standard. For example, the total capital expenditure of China Light & Power in Hong Kong is equally divided between power generation and transmission, while KEPCO in South Korea spends around 40 percent of capital expenditure on transmission facilities. Generally speaking, investment in power transmission and distribution should amount to at least one-third of total investment for a power network to have enough capacity to handle the power generated.

The major reason for underinvestment in power transmission and distribution systems is local governments' perception of transmission and distribution as being peripheral to power generation. This phenomenon is quite common in various areas in China where production has long been emphasized over distribution and sales. Until relatively recently local bureaucrats were judged by their ability to generate electricity. Increases in generating capacity can be observed and praised much easier than an improvement in the network from a local government official's point of view. Therefore, with limited resources, generation has always had priority over transmission and distribution. In 1994, only 50 percent of the annual transmission and distribution targets were completed (Shi 1995). Due to the bottle-neck of the transmission and distribution system, many potential electricity consumers cannot be hooked up to the power system. For example, many Chinese households that want to install room air-conditioners are refused permission by the utilities due to the limited distribution system capacity.

(3) Environmental costs will increase. China's power sector is a major contributor of SO_2 emissions. In 1991, total SO_2 emissions in the power sector reached 5.3 Mt. It is estimated

that SO_2 emissions in China's power sector may exceed 10 Mt by 2000 if substantial desulfurization equipment are not installed. To reduce SO_2 emissions from the power sector, the State Environmental Protection Agency issued the "Air Pollutant Emission Standards for Coal-Fired Power Plants" in 1992. However, capital availability is the major factor preventing widespread installation of desulfurization equipment in coal-fired power plants. Desulfurization equipment will typically add 10-15 percent of power plant capital investment in China, widespread installation of desulfurization equipment is a heavy burden for the Chinese power sector. So far, China's sulfur control is mainly through high stacks which, although reducing local SO_2 concentration, cause longer distance transmission of SO_2. Although newly constructed power plants have left spaces for future installation of desulfurization equipment, actual installation in the near future is restrained by capital availability. To protect local industries, many local governments have relaxed the official standards. However, this attitude of local governments may not apply to independent power developers, especially in the high pollution areas. Environmental requirements will likely be higher in the future. According to a recent announcement from Guangdong Province, coal and oil-fired power plants have been banned from the Pearl River Delta in Guangdong Province in an attack on air pollution and acid rain (*Xinhua Daily Telegraph* May 31, 1995). The Pearl River Delta region contributes more than 70 percent of Guangdong's GDP. Regulations were in the works to force existing power stations to install desulfurization systems. Although the announcement should be interpreted carefully and may not be actually implemented, it does indicate that as income level increases there will be dramatic policy changes with respect to pollution controls and higher environmental control investments.

For these reasons, international analysts typically assume higher investment needs in China's power sector than the Chinese official estimates mentioned above. For example, Peregrine (1995) estimated that investment in China's power sector between 1994-2000 will be $89 billion, averaging $12.7 billion per year. A recent paper from the Planning Department of MEPI estimated that total power sector investment during the 1996-2000 period will be $770 billion yuan ($93 billion), averaging $18.6 billion per year (MEPI 1995).

Table 4.5. China's Investment Needs for Power Development, 1996-2015

Installed Capacity (GW)

	Total	Coal-fired	Hydro	Nuclear	Other
1995	213	138	54	2	19
2000	300	200	66	2	32
2010	530	340	110	20	60
2015	700	450	135	25	90

New Capacity (GW)

	Total	Coal-fired	Hydro	Nuclear	Other
1996-2000	87	62	12	0	13
2001-2010	230	140	44	18	28
2011-2015	170	110	25	5	30

Capital Cost of New Capacity and T&D System($billion)

	Total	Coal-fired	Hydro	Nuclear	Other	T&D
1996-2000	67	37	11	0	5	13
2001-2010	208	84	40	31	11	42
2011-2015	137	66	23	9	12	27
Average						
1996-2000	13	7	2	0	1	3
2001-2010	21	8	4	3	1	4
2011-2015	27	13	5	2	2	5

Capital Cost Assumptions

	$Million/GW
Hydropower	900
Nuclear	1750
Coal-fired	600
Other	400
Share of investment in transmission and distribution equals 20% total investment	
Exchange rate: 8.3 RMB=1 U.S. dollar	

Note: Capital costs are the weighted average of domestic and imported units.

Table 4.5 shows that China's total capital investment requirements for electricity development are conservatively estimated at about $72 billion (at the 1995-constant prices) between 1996 and 2000 (averaging about $14 billion per year), about $204 billion between 2001 and 2010 (averaging $20 billion per year), and about $138 billion between 2011 and 2015 (averaging $28 billion per year). The estimation is based on the assumptions listed in table 4.5. The capital costs of generating capacity are weighted average costs of domestic and imported equipment. For example, the capital cost of coal-fired capacity is calculated by assuming that using domestic equipment costs $500 per kW, using imported equipment costs $900 per kW, and that domesticly manufactured equipment could only satisfy 75 percent of the demand.

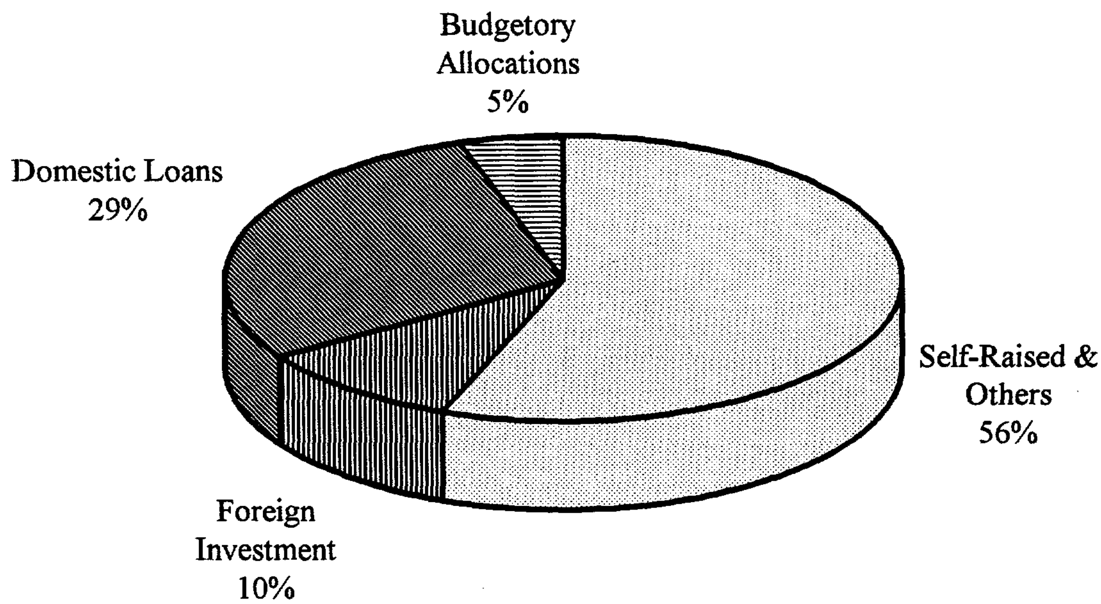
Due to the transformation of China's investment mechanism, the central government is no longer the major sources of investment in the power sector and should not be relied on for future funding. Between 1980 and 1992, the share of central government investment (including domestic loans and budgetary allocation) in total power sector investment decreased from 91 to 34 percent. At present, the share of central government investment in any new power project is normally less than 30 percent of total project investment, in many cases, less than 20 percent.

Most funding today comes from local governments in the form of specialized tariffs charged to electricity users, and stocks and bonds issued to the public, among other methods. In some cities, local governments have raised funds for power sector investment through soliciting funds from enterprises with a promise of electricity quota allocation after the power generating units commence operations. Figure 4.3 shows that the share of self-raised funds accounts for 56 percent of total power sector investment in 1992.

Raising money from local sources is not an easy job given the present unfavorable investment climate in China's power sector. According to the State Development Bank of China, the delay of fund allocation from local authorities and the heavy burden of debt repayment on power projects have become the major hurdles hindering development of many power projects. Local authorities are expected to raise 20.2 billion yuan ($2.4 billion) for power projects in 1995. However, by the end of March, only 1.3 billion yuan ($154.8 million) from local governments had gone to the projects. That means the local governments only fulfilled 6.6

percent of their planned investment to power projects in the first quarter of this year (*China Daily* May 1, 1995).

Figure 4.3. China's Power Sector Investment Mix in 1992



In addition to insufficient investment from local sources, the financial struggles of many power projects were especially difficult in 1995, because together these projects will have to repay about 5.2 billion yuan ($619 million) in principals and interest on loans. This includes 3.27 billion yuan ($389.3 million) in construction bonds sold to financial institutions, about 500 million yuan ($59.5 million) in loans from the State Development Bank of China, and 1.4 billion yuan ($166.7 million) in other bank loans and interest. However, by the end of March, only 280 million yuan ($33.3 million) worth of bonds had been redeemed (*China Daily* May 1, 1995).

Determinants of a Successful Power Project

The gap between investment requirements and capital availability in the power sector calls for increased use of international sources. Recent movement in a number of key areas, particularly foreign currency exchange and an increased transparency in the project approval process, have helped to move China closer to obtaining project capital from these markets. Legal and regulatory issues concerning power project documentation and electricity pricing have also become more clear. However, some gaps still exist in assessing project risk as it pertains to achieving reasonable and fair return of capital from foreign-funded project.

For a project to succeed, it must meet international standards of acceptable risks and rewards and requirements for project equity and debt financing. Documentation, power purchase agreements, fuel supply agreements, and operating and maintenance agreements will be largely similar to international standards and tailored to accommodate Chinese practice and law.

Certain characteristics of Chinese projects provide rewards and risks which differ from projects elsewhere in the world. Attention to these determinants of success will not only speed up negotiation of joint venture agreements and project contracts, but also ensure a solid basis for international financing.

Given the complexity of the approval process and the important role of the Chinese counterparts in the process--structuring of preliminary feasibility studies, negotiating with appropriate ministries, formulating pricing approvals and price levels, determining interconnection capacities, assessing local demand and dispatch provisions--a joint venture structure with Chinese partners is recommended. In a new and developing market like China, there are numerous advantages of having an experienced local partner and few advantages to structuring a wholly foreign-owned enterprise.

The great majority of joint venture contracts currently under discussion in China follow an equity joint venture structure. While both cooperative joint venture and wholly foreign-owned enterprises are possible, equity joint venture structures have been favored by the Chinese side over cooperative structures, largely because of the desire to ensure the long-term participation of the foreign party in the project. Although early repatriation of capital is a clear benefit of a cooperative joint venture, it may forego much of a project's inherent value over the full contract period as well as limit the foreign investor's longer-term "foothold" in China.

The coastal provinces have historically been the focus of much of China's power development, both domestic and foreign-sponsored. In addition to the high demand for power in these provinces due to rapid economic growth, these provinces have been the most credible providers of foreign currency protection for debt and equity returns. Coastal locations will continue to play an important role in the future for these reasons. One disadvantage of coastal locations can be the long distance from high quality and inexpensive sources of domestic coal. limited transportation infrastructure from inland provinces to the coasts have caused coastal power plants to rely heavily on world market pricing for coal, with associated incremental electricity costs.

Strong projects are not limited to coastal provinces. Other areas of China offer different advantages, despite lower economic growth rates and foreign exchange earnings. Inland provinces of Shanxi, Shaanxi, Inner Mongolia, and to a lesser extent Hebei and Anhui all have abundant, high-quality coal reserves. Northeast China, in particular Liaoning and Heibei, have relatively extensive transportation networks.

One of the priorities of the Chinese government is the increased establishment of several large mine-mouth power plants in inner China which will transmit electricity through existing or new transmission lines to the coastal provinces several hundred or thousands of kilometers away. Environmental issues in already crowded coastal regions have provided further impetus to moving plants inland and away from major metropolitan centers.

Pricing to end-users varies by province but often entails multi-tiered pricing based on set offtake amounts. Increased demand results in incrementally higher pricing. In some provinces, higher priced electricity generated in foreign-funded plants is blended into the overall rate charged by the provincial utilities. Figure 4.4 shows the components of electricity prices of new Chinese plants and foreign joint venture plant. Pricing differences are primarily a result of lower domestic capital costs and lower equity return requirements of the Chinese investors. Reduced equity return requirements result in higher levels of equity and limited required annual dividends. RMB debt had also historically been extended on terms which were slightly more favorable than bank market debt to China projects. Current bank markets and the increased use of public and private market bonds will lessen the price burden for foreign-funded projects.

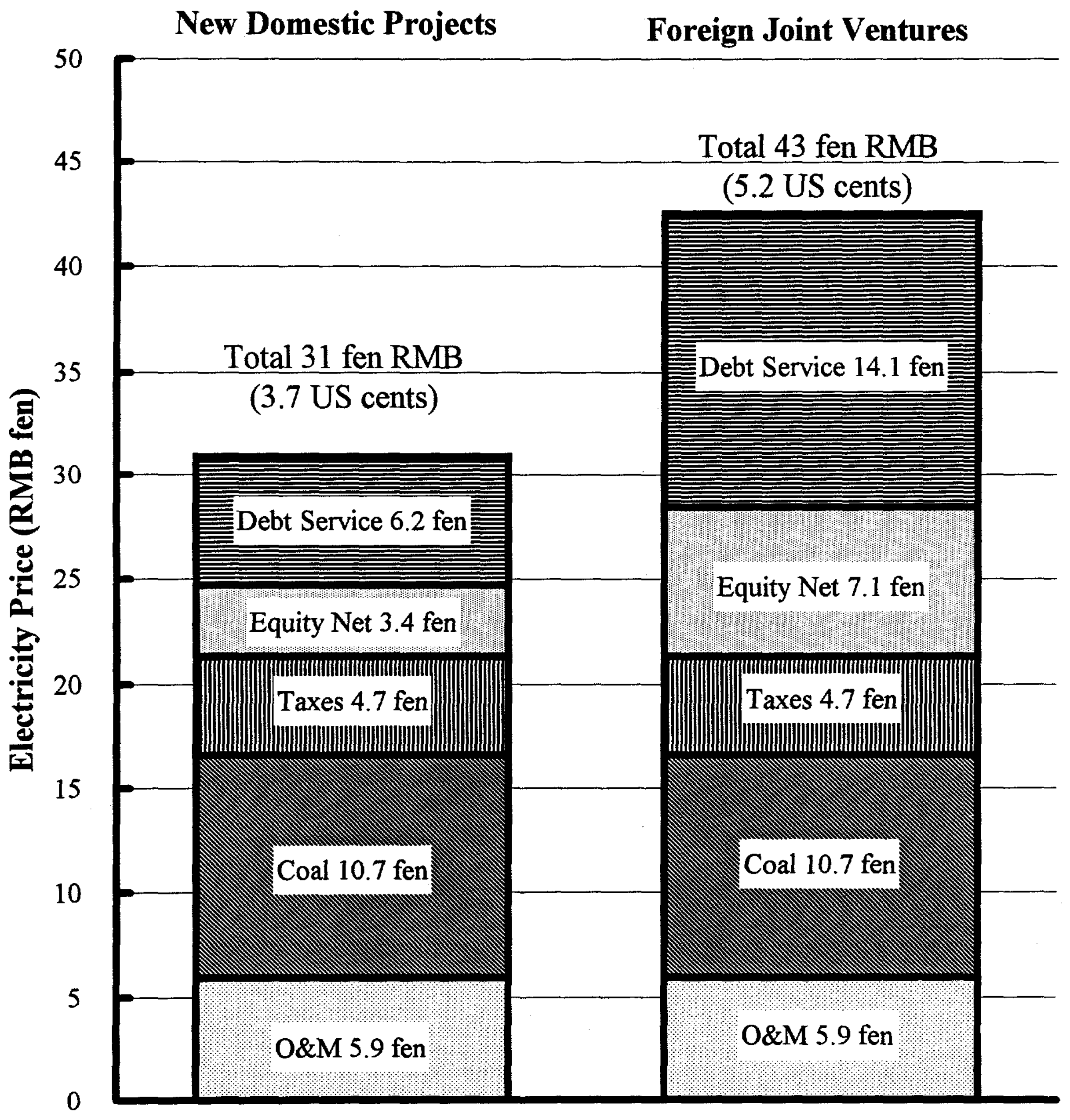


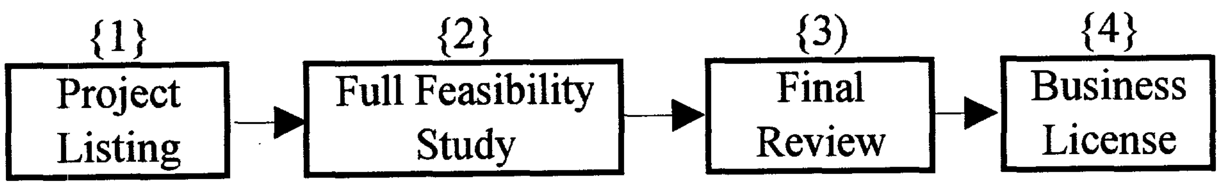
Figure 4.4. Components of China's Electricity Price

New regulations on power pricing require that the electricity price must be denominated in RMB, although certain components of foreign exchange may be incorporated into the power price, particularly in the case of repayment of principal and interest on foreign-denominated debt. The addition of foreign currency protection to project debt or equity will naturally introduce more price risk to a foreign-funded project.

Approval Process of Foreign-Funded Power Projects

Project approval of foreign invested power projects has become more transparent in recent years. Although the approval process will vary for each project, it will always involve the local power authority, the Ministry of Electric Power Industry (MEPI), various other related central government authorities depending on the project location and fuel choice, and ultimately the approval of the State Planning Commission (SPC) for large and medium sized projects. As shown in Figure 4.5, from initial conception to obtaining a business license, four phases are normally included: (1) project listing, (2) full feasibility study, (3) final review, and (4) approval of a business license for operations.

Figure 4.5. Steps in the Approval Process



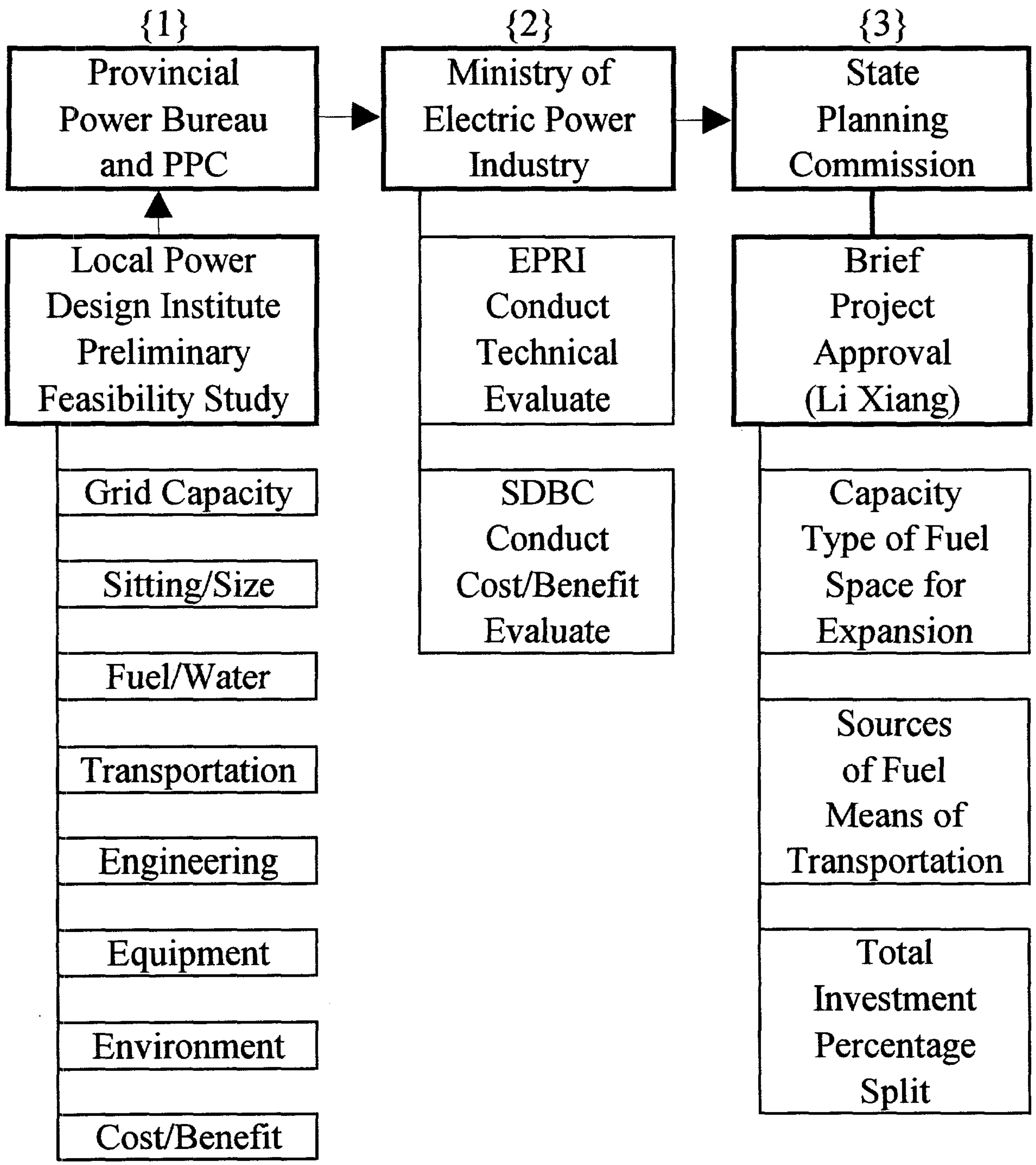
Project Listing

Figure 4.6 shows the whole process of project listing. Major authorities involved in this phase are the local authorities (mainly the provincial power bureau and the provincial planning commission), the MEPI, and the SPC. The MEPI and the SPC depend on the provinces and regions to provide proposals for projects which are going to be built in their jurisdictions. Projects may be proposed by municipalities or by the province itself. Very often a provincial design institute will carry out a preliminary feasibility study including a review of grid generating capacity, site selection and land acquisition, size of project, sources of fuel supply and transportation, water sources, engineering and construction conditions, equipment needed, environmental considerations, and a brief cost benefit analysis.

If approved by the provincial power bureau and provincial planning commission, the preliminary feasibility study will be submitted to the MEPI, where it will be reviewed by EEPI's Electric Power Research Institute (EPRI) for technical considerations and by the State Development Bank of China (SDBC) for financial considerations. The EPRI will check the technical review done at the provincial level, while the SDBC with check the cost benefit analysis of the preliminary feasibility study. The SDBC will evaluate whether or not the local sponsors have the ability to repay the loans needed, and whether or not the project fits the government's policies and long-term plan. Both the SDBC and the EPRI will provide a written statement, and both statements and the preliminary feasibility study will be submitted to the SPC.

The SPC must decide among a long list of competing projects for inclusion in the state plan. Using the materials submitted by the MEPI, it will decide whether or not to issue a brief project approval. This approval is usually a one-page document which will be forwarded to the ministries and the province concerned. The document generally approves three areas: (1) capacity of the project, type of fuel, and the space for further expansion; (2) the sources of fuel in the current phase and the means of fuel transportation; and (3) the amount of total investment, including the percentage split among the proposed investors.

Figure 4.6. The Process of Project Listing



This project listing approval, called lixiang, allows the provincial government and power bureau either to begin a domestic project or to start negotiations with foreign investors on the establishment of a joint venture. Foreign investors may enter the process before the conclusion of the project listing because the Chinese entity may already have signed a letter of intent with a foreign partner, but this entire first phase is most often an internal Chinese procedure.

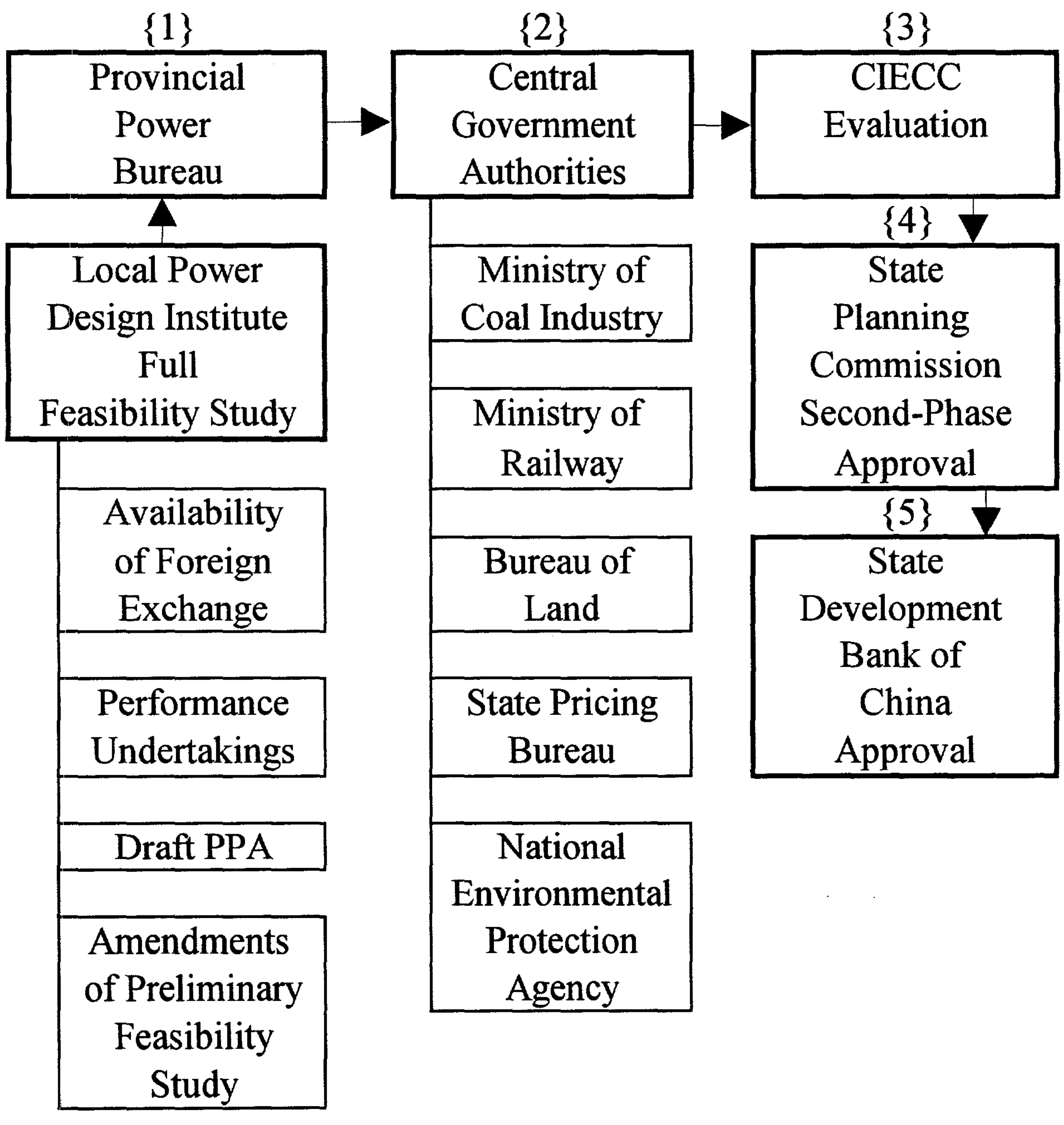
Full Feasibility Study

Figure 4.7 shows the process of the full feasibility study. The approved project is sent back through the MEPI to the provincial level, where the provincial design institute will carry out a full feasibility study. This study expands substantially on the same areas of the preliminary study. If a foreign partner has been brought into the project with the signing of a letter of intent, consideration must be made regarding availability of foreign exchange and performance undertakings. The power purchase agreement (PPA) must be drafted. Typical amendments will include changes in equipment, operating responsibilities, capital cost estimates, ownership structure, and equity return issues.

A joint venture agreement between the foreign partner and the Chinese entity must be submitted back to the central government as part of this phase. At this stage, agreements must be reached with other central government authorities on fuel supply, railway transportation, water sources, land acquisition, environmental impacts, and investment needs. In the case of coal-fired power plants, their authorities include the Ministry of Coal Industry (MCI), the Ministry of Railway (MOR), the National Environmental Protection Agency (NEPA), the Bureau of Land (BOL), the State Pricing Bureau (SPB).

The feasibility study will go back to MEPI's EPRI, and from there, back to the SPC's Department of Transportation and Energy (DTE). The DTE will forward it to China International Engineering and Consulting Corporation (CIECC), which evaluates the proposal from a broad economic perspective, including potential sources of funding, appropriate use of funding and repatriation of funds. Subsequently, DTE utilizes MEPI's analysis and CIECC's appraisal to come to a second-phase decision on approval of the feasibility study.

Figure 4.7. The Process of Full Feasibility Study



Following the SPC approval of the feasibility study, the whole investment plan will be submitted to the SDBC for final approval. While the SPC's criteria for approval concern the need for the project and its ability to assist in achieving key economic objectives, SDBC's criteria will be entirely financial. A credit analysis will be performed on each proposal, not all of which will necessarily gain approval. SDBC acts as a final break on the state's investment plan and on the allocation of central government investment funds.

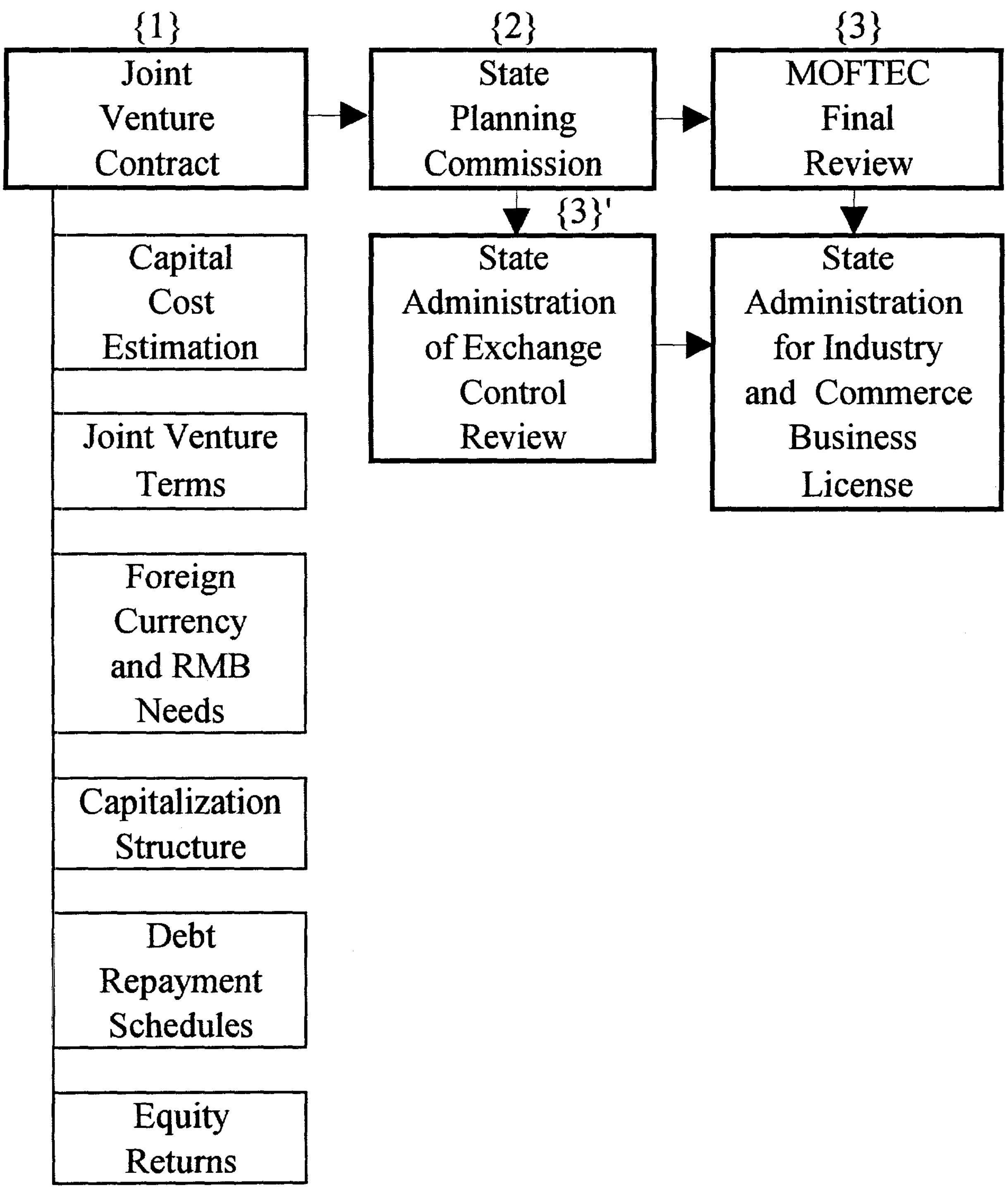
Despite the addition of another bureaucratic layer, the SDBC might be welcomed by foreign investors because it also adds another layer of money. With SDBC acting as an investor and likely taking some risks that foreign investors might be afraid to, the extra time involved at this point could be very favorable. The SDBC approval will be inserted prior to the final negotiation and signing of the joint venture documents.

Final Review

Figure 4.8 shows the process of final review. For projects with foreign participation, a joint venture contract and associated contracts may now be negotiated and signed. At this stage, the feasibility study should be completed and capital cost estimated, usually through the attachment of a completed turnkey construction contract, should be final. Foreign currency and RMB needs should be firmly established. Amendments will be allowed in the future based on necessary changes as a result of financing or otherwise, but substantial changes to the project's structure or capitalization should be avoided. The final review results in an approval of the actual project contracts and the joint venture contract.

The SPC sends the contracts to the Ministry of Foreign Trade and Economic Cooperation (MOFTEC) for final review of the joint venture terms, capitalization structure, debt repayment schedules, and provisions for equity returns. Projects approved by the SPC will also be reviewed by the State Administration of Exchange Control (SAEC), a unit of the People's Bank of China (PBOC), China's Central Bank, for approval of foreign currency debt service and equity returns.

Figure 4.8. The Process of Final Review



Once approved, the project will become part of the State's five-year plan for infrastructure development, and necessary allocations will be made for both RMB funding and foreign currency allocation. The SAEC will issue an approval to the joint venture company for the conversion of RMB into foreign currency at designated foreign exchange banks. This system has officially replaced the former "swap" center system and direct payment in foreign currency. These organizations are seen as being very bureaucratic and very slow.

At all stages of approval, the local power bureau and all Chinese partners to the joint venture contract can be expected to play an important role. The power bureau will be responsible for ensuring that documents forwarded for approval adhere to government requirements and guidelines for such submissions.

Approval of Business License for Operation

The contract must be submitted to the State Administration for Industry and Commerce (SAIC) for a business license. Assuming appropriate approvals are granted to this point, an approval for a business license granting permission to operate as a newly-formed company will be forthcoming. Capital contributions of at least 15 percent of total equity must begin within three months of approval, after which a formal business license will be issued. Provisions for further capital contributions may be scheduled over time, depending on the actual construction schedule of the project.

Key Players of Private Power Projects

Private power investors are very active in China. A total of about 137 GW project proposals which involve foreign private sector investment have been identified in China so far, although some of the proposals are still very preliminary and might be collapsed in the future. About 80 percent of the proposed projects are coal-fired; the remaining projects are mostly natural gas fired (17%), although some gas-fired plants may also use oil; hydropower projects account for 2.6 percent; and all others account for only 0.4 percent. Proposals from the U.S. firms and Hong Kong firms account for about 43 and 25 percent respectively. The remaining projects come mainly from the UK (5.3%), Singapore (5.3%), Australia (5%), Israel (2.9%), Germany (2.4%), Thailand (2.3%), Japan (1.9%), and Canada (1%). It should be noted that because the proposals are at different stages, from preliminary discussion to final approval, the country share of proposals may change substantially over time.

Hong Kong

Hong Kong is the pioneer for private investment in China's power sector. Table 4.6 shows that, so far, about 35 GW of project proposals have been provided by Hong Kong's private power investors; these project will need about $30 billion of capital investment (foreign investors will only provide part of the capital). Major Hong Kong companies involved in China's private power development include: (1) Consolidated Electric Power Asia (CEPA), a subsidiary of Hopewell Holdings; (2) Henderson China Investment, a subsidiary of Henderson Land; (3) China Light and Power (CL&P); (4) Hutchison Whampoa; (5) New World Development; and (6) China Strategic Investment.

Consolidated Electric Power Asia. CEPA is the first private power developer in China. It has a 50 percent interest in the operating 700 MW Shajiao' B project and a 27 percent stake in the 1980 MW Shajiao' C project. In the fourth quarter of 1994, CEPA received central government approval to build the 4X660 MW Shenzhen East plant (first phase). As shown in Table 4.6, CEPA has agreements to build a total of 13,200 MW coal-fired plants in Guangdong, Jiangsu, Shandong, Henan, Fujian, and Guangxi. CEPA will install standardized 660 MW units on a BOT basis. Capital cost of CEPA's projects is estimated about $950/kW. In the first quarter of 1995, CEPA's chairman Gordon Wu said he would return to the Chinese market, after learning that the Chinese government had eased its cap on rates of return. CEPA is negotiating a return on investment higher than 12 percent.

Henderson China Investment. Henderson is involved in projects which may eventually install 7,800 MW of coal-fired capacity. In Shandong, it will form a 50-50 joint venture with the power bureau of Yantai to develop the 600 MW Moushan plant. The project could expand to 1,800 MW later. Henderson is also negotiating the possibility of developing up to 4,800 MW of other coal-fired projects in Shandong, including a 1,600 MW plant to supply electricity to Laicheng, Liaocheng, and Weifang. Henderson will hold 30 percent of the equity. In Hubei, Henderson will take a 55 percent equity on a 2X300 MW coal-fired project. In Guangxi, Henderson and New World are developing the $346 million, 600 MW Beihai plant. New World and Henderson will jointly own a total of 50 percent of the equity.

China Light and Power. China Light & Power (CL&P) is a net exporter of electricity to China. It currently owns 25 percent of the Daya Bay nuclear power plant. Reportedly, CL&P and Electricity de France International (EdF) are nearing the end of a detailed feasibility study for a joint development of three 1,200 MW coal-fired projects in Heze, Shiheng, and Liaocheng, all in Shandong Province. CL&P will take a 29 percent, and EdF a 20 percent equity stake in these BOO projects. Chinese partners of this joint venture will take 51 percent of the equity. CL&P is also considering future investment in other regions such as Guangxi, Fujian, Shanghai, Jiangsu, Zhejiang, and Inner Mongolia. EdF has also signed contracts totaling nearly $3 billion to provide equipment and service for two nuclear power plants. In January 1995, EdF signed an agreement to expand Daya Bay by another 1,800 MW.

Hutchison Whampoa. Three Hong Kong companies controlled by Hutchison Whampoa have formed a joint venture with Guangdong Power Bureau and the Zhuhai Municipal Government to develop the 3,960 MW coal-fired Zhuhai project. The first phase will consist of two 660 MW units and will cost about $1.3 billion. This project is being developed on a 25-year BOT basis. Hutchison will hold a 45 percent equity. Hutchison and Cheung Kong are developing a 50 MW ($26 million) coal-fired project in Shantou, also in Guangdong.

New World Development. New World Development, through its subsidiary of Guangzhou Pearl River Power, plans to build a $360 million, 600 MW, coal-fired plant in Guangdong. The second phase of this plant will add another 600 MW. Guangzhou Pearl will borrow $140 million to partly finance the project. The loan was arranged by China Development Finance of Hong Kong. The five-year loan, which could be extended to eight years, carries interest at 1 percentage point over London Interbank Offered Rates and will be fully guaranteed by New World. The ADB has also agreed to lend Guangzhou Pearl $50 million for 14 years at a concessional rate. The plant will buy 1.2 Mt of coal annually from northern China at market prices.

New World is also targeting China's renewable energy development. It has reached joint venture agreements for five hydropower projects totaling 246 MW in Fujian. New World will purchase at least 40 percent of equity in the five plants which are currently under construction. New World has signed letters of intent to build a 50 MW wind farm on Nanao Island and a 25 MW wind farm in Shenzhen both in Guangdong Province. New World and its partners could develop another 200 MW wind farms if PPA can be secured. While tariffs of the proposed power projects have not yet been finalized, a ceiling of 7 U.S. cents per kWh has been set.

China Strategic Investment. China Strategic has signed a letter of intent with the Shanxi Electric Power Corp. to jointly develop a 2,000 MW, coal-fired plant in Yangcheng. The $1 billion project will be built on a 20-year BOT basis. China Strategic will hold 51 percent equity.

Other Hong Kong Firms. The Cathay International Group has reached a joint venture agreement with Shengli Petroleum Administration to build, own, and operate a $500 million, 2X300 MW, coal-fired plant. Construction of the project is scheduled to be completed by mid-1997. The joint venture also agreed to rehabilitate, own, and operate two existing 200 MW coal-fired plants now owned by the Dongying government.

Hong Kong Macau International Investment has signed an agreement to invest $58 million for a 25 percent equity stake in the 600 MW Hengshui plant in Hebei.

The China Merchants China Direct Investment Ltd. (CMCDI) in Hong Kong will invest $10 million in the 2X200 MW coal-fired Longkou Power Plant in Yantai, Shandong Province. CMCDI has set up a co-operative joint venture with the Electric Power Development Corp. of Yantai to acquire 27 percent of the Longkou Power Plant Phase II. The joint venture, named the Yantai Hua Shang Power Co. Ltd., will also receive an investment of $30 million from the cities of Yantai and Weihai, and the MEPI.

China Overseas Land & Investment and Well Pool Development will build a 240 MW coal-fired plant in Shaoguan, Guangdong Province. China Overseas will take a 52.5 percent equity, and Well Pool will take 22.5 percent. The project, to be completed by year-end 1995, will receive 0.9 Mt of coal annually at a fixed price from Hunan.

Sung Foo Kee Holdings will take a 50 percent equity in a 60 MW coal-fired plant in Wuhu and a 49 percent equity in a 120 MW coal-fired plant in Dalian.

Wharf Ningbo has acquired a 25 percent equity in the 80 MW Yangluo plant in Wuhan, Hubei Province.

Pacpo Investment will take a 90 percent equity in the 60 MW coal-fired Raoping plant in Chaozhou, Guangdong Province.

Paliburg International, Chang Jiang Power Development, and Chang Jiang Energy will jointly develop the Changfu project in Wuhan. The Changfu project is the first of a series of joint venture projects between Paliburg and Chang Jiang Power. The joint venture plans to build 10 to 20 power plants in China and Southeast Asia.

The United States

Private power investors from the United States have become very active in China. Table 4.6 shows that so far a total of 58 GW of private power projects have been proposed by the U.S. private power developers in China. Major U.S. companies involved in China's private power sector include: (1) AES China Generating Co (AES Chigen), a subsidiary of AES Corporation; (2) the Wing Group; (3) Entergy Enterprises; (4) Tong Tech Investment; (5) Sithe Energies; (6) Bechtel Enterprises; (7) American Electric Power Resources International (AEPRI); (8) Cogen Technologies; (9) Southern Electric International (SEI); (10) First Washington Asia; and (11) CEA Asia, a subsidiary of Community Energy Alternatives.

AES China Generating Corporation. As shown in Table 4.6, AES has preliminary agreements to build a total of 6,200 MW coal-fired large and medium-sized power projects in Shanxi, Jiangxi, Hubei, Fujian, Heilongjiang, Henan, Shandong, and Guangdong. Capital Cost of these projects are estimated in the $850-1000/kW range. In December 1994, a joint venture agreement was signed for the Yangcheng (2,100 MW) project in Shanxi Province. AES will take a 25 percent stake. The project includes a 440 mile transmission line to Husiyin in Jiangsu Province. Construction began in the first quarter of 1996. In June 1993, a preliminary agreement was reached for the 1,200 MW Fencheng project in Jiangxi Province. AES will also take a 25 percent equity share in this project. In July 1993, AES reached a preliminary agreement to participate in the 1,200 MW Wuhan project in Hubei Province. In May 1994, AES signed a joint venture agreement to invest in the 600 MW Quanzhou project in Fujian Province. Other AES projects include the 400 MW Harbin project in Heilongjiang, the 250 MW Wanfang project in Henan, and the 250 MW Weihai project in Shandong.

Due to the slow pace of approval for large power projects, AES decided to also pursue smaller projects that do not need central government approval. AES has completed two small diesel plants (20 MW) and may expand the two plants by an additional 71 MW. AES also has under construction a 63 MW gas-fired project in Wuxi, Jiangsu, to be completed in 1996.AES has also formed a joint venture company with Guangdong International Trust & Investment, called AES-GITIC Power Development Corporation, to develop and acquire small power plants in Guangdong. The joint venture will purchase three existing power plants (200 MW) in Guangdong. AES has signed a memorandum of understanding (MOU) for the joint development of IMC's natural gas reserves contained within coalbed methane reservoirs in China. AES will purchase 50 percent of IMC wholly owned subsidiary, Sino-American Energy Inc. (SAEI). SAEI is involved in two natural gas and coalbed methane development projects.

The Wing Group. The Wing Group has a MOU with Henan Province to develop two 1,400 MW coal-fired projects on a BOO basis. One project is planned for Mixian, and the other one is for Dengfeng. A third 1,400 MW coal-fired project is planned for Qinbei but is not part of the MOU. Capacity of this plant may be expanded in the future. The Wing Group partners include Bechtel, Westinghouse, Riley Stoker, and TransAlta Utilities (Canada).

The Wing Group is also seeking to develop 10,000 MW gas-fired projects along China's east coast. The proposed plants are planned to use imported pipeline gas. However, these proposals are still in very preliminary stage. In the first quarter of 1995, the Wing Group signed a strategic alliance with Mobile to develop private power projects together. Mobile now holds a 30 percent equity stake in Wing's current and future LNG and LPG projects in China.

Entergy Enterprises. Entergy has agreements to develop a total of 6,240 MW coal-fired capacity in Shanxi and Guangdong. The Taishan project has received central government approval in the fourth quarter of 1994, the first such approval since 1992. Capital cost of this project is estimated $910/kW. Entergy will hold 10 percent equity; the Guangdong Power Bureau will hold 53 percent; and the remaining equity will be divided between Marubeni and China Union International Enterprises. Two 660 MW units will be installed on a 20-year BOT basis. The project is expected to be completed before 2000. There is provision for a 1,320 MW second phase, but plans are incomplete.

In September 1994, Entergy signed an agreement to form an equity joint venture with Lippo Group of Hong Kong, called the Lippo Entergy Power Holdings, to acquire a 40 percent equity in the 1,200 MW Datong No. 2 plant. The remaining equity will be held by the North China Power Group. There is provision to expand the project to up to 3,600 MW.

Tong Tech Investment Group. The California based Tong Tech Investment Group has launched up to 4,500 MW coal-fired independent power project in China. Initially, a 2,100 MW plant will be built in Xinjiang, Shanxi Province. The central government will buy the electricity generated from this plant for 5 US cents per kWh, followed by annual increases of 2.6 percent. This plant is being developed on a BOT basis under a 30-year term. A 1,200 MW project will follow the 2,100 MW project after it is under construction for about one year. A third project, also 1,200 MW, is in the early stages of development. A consortium of Swiss banks has agreed to provide financing of $2 billion for the project.

Sithe Energies. Sithe and its joint venture partner China National Offshore Oil Corp (CNOOC) received formal government approval to conduct a feasibility study for a 4,000 MW gas-fired independent power plant on Donghai Island in Guangdong Province. The project is part of a larger development effort by Sithe and CNOOC, signed in May 1994, to develop between 9,600 and 10,000 MW of private power. The proposed project with CNOOC will be built as a series of 300 MW, gas-fired units with the first unit to be completed by 2000. The remaining units are expected to phase in over the following three to six years. Plants built under the joint venture agreement are likely to be fueled by either gas or oil supplied by CNOOC.

Sithe will take a 70 percent equity stake in the 300 MW Meishan project in Sanya City of Hainan Province, which will cost $250-300 million to develop. The plant will use either oil or gas supplied by CNOOC.

Sithe has been involved in a number of medium-sized coal-fired projects. In most of the cases, Sithe will acquire existing or under-construction plants, expand, and then operate them. These projects include: (1) expanding the 200 MW mine-mouth Liancheng plant in Gansu to 600 MW, phased in over a two-year period beginning in 1996; (2) expanding a 100 MW in Shanxi to 300 MW; (3) expanding the 100 MW Tangshan plant in Hebei to 300 MW; (4) expanding the 100 MW Zunhua plant also in Hebei to 300 MW, and (5) investing in the 250 MW Shuangqiao project in Guangdong. Sithe has also signed a joint investment agreement with the Guangdong International Trust & Investment Corp. (GITIC) to acquire, expand, and operate power plants in Guangdong. Sithe will hold a majority interest in the joint venture and be in charge of the selection, development, operation, and potential expansion of the projects.

In fourth-quarter 1995, Sithe signed a power-purchase agreement with the Beijing Power Bureau for a 100 MW, coal-fired plant in Shunyi on a BOO basis. Sithe will have a majority interest and will be responsible for the development and operation of the plant. Sithe also signed an agreement with Zhejiang Province to develop a 70 MW ($63 million), coal-fired plant.

Sithe has acquired a majority interest in the 66 MW, oil-fired Houjie plant in Guangdong. The project is now under construction and is expected to be completed by year-end 1995. Capital cost of this project is estimated at $820/kW.

Bechtel Enterprises. Bechtel is very ambitious in China's private power development. Although declining to provide details, Bechtel officials have confirmed that the company is involved in at least 10,000 MW of power projects in some stage of development. In Jiangsu Province, Bechtel has formed a joint venture with Singapore based Sembawang Resources to develop the 2,400 MW coal-fired Suzhou plant. The joint venture is seeking equity participation from third parties. Funding of this project will likely come from Singapore and Hong Kong sources. Development of an identical 2,400 MW project with Sembawang is underway in Jiangsu.

American Electric Power Resources International. AEPRI has signed a letter of intent to build two 1,300 MW coal-fired plants in Suizhong, Liaoning Province. AEPRI will be involved in the engineering, design, construction, and training for operation. It has not yet been determined whether AEPRI will take equity in this project. Project construction is expected to begin within two years, with startup sometime after 2000. The plant will burn low-sulfur coal from Shanxi Province near Inner Mongolia.

Southern Electric International. SEI has reached an agreement with China's Huaneng Power International (HPI) in 1994 to jointly develop a 1,200 MW, coal-fired, plant in Jiangsu Province. SEI will take 30 percent of the plant's equity. Construction of the project is scheduled to begin in 1996, with commercial operation in 1999.

First Washington Asia. An international consortium led by First Washington Asia has signed agreements to build five power plants, representing about 1,000 MW at a total cost of $1.17 billion. Two of the five plants will be built in Guangdong.

Community Energy Alternatives. CEA plans to install two 300 MW coal-fired units in the Jingyuan power plant in Gansu. The 20-year BOT project is scheduled to be operational by 1997. CEA is taking a 30 percent equity. Reportedly, the project will generate an IRR of 15.5 percent, and CEA believes that higher IRR is possible by exceeding the specifications of the PPA. Recently, CEA has formed a 50-50 joint venture with the Asian Infrastructure Fund. The new company, called Meiya Power Co. Ltd. (MPC), will be based in Hong Kong. MPC will take over CEA's 30 percent stake in the Jingyuan project.

CEA Asia, an affiliate of CEA has signed a BOO agreement to develop a 350 MW oil-fired plant in Jiangmen City, Guangdong Province. CEA Asia will hold a 75 percent equity stake. The two 50 MW units ($80 million) in the first phase is scheduled for operation in August 1995. No date is yet set for the 250 MW second phase.

Other U.S. Firms. Cogen Technologies is also developing four projects in China, including the 1,200 MW Wujing project in Shanghai, two 100 MW projects near Beijing, and a 100 MW project at a port. Cogen, with its partner AIG Asian Infrastructure Fund, has a 45 percent stake in the Wujing project.

A joint venture of Mission Energy, Bechtel, Sembawang, and Lippo is negotiating a PPA with the Fujian Power Bureau for the 2X350 MW coal-fired Meizhou Bay plant. Construction of the plant is expected to begin in 1995.

General Electric will participate as both an investor and vendor in the retrofit of the 400 MW residual oil-fired Zhabei project in Shanghai. A feasibility study for the $200 million project has been finalized. GE has applied to the U.S. Export-Import Bank for debt financing of about $120 million.

Bio Development Corp. and ICT Corp. are developing three 200 MW coal-fired power projects in Guizhou. One project is located in Guiyang, the other two near Duyan.

Energy Initiatives has begun preliminary discussions concerning development of two 125 MW coal-fired plants in Sichuan. Energy Initiatives would develop both Ming Jiang Power and EI power through limited partnerships that will control up to 75 percent equity stake. Intesol International Ltd. of Hawaii will own 20 percent of the Ming Jiang plant.

Dominion Bridge has signed a joint venture agreement to build a 200 MW ($80 million) pumped-storage project in Chengdu, Sichuan Province. Dominion will retain about 70 percent of the equity stake. Dominion is involved in the construction of the Three Gorges project.

Enron Development is building a 150 MW gas-fired plant in Hainan Province. Project finance is expected to come from a $100 million debt issue using the Rule 144a private placement market allowed under U.S. Securities & Exchange Commission rules. The plant will first use distilled oil then switch to gas supplied from nearby gas fields developed by Enron. In February 1996, Enron sold 50 percent of its 150 MW Hainan project to Singapore Power PTE Ltd. Enron Solar, an affiliate of Enron Development, agreed to jointly conduct a feasibility study for a 150 MW solar power project.

New Age International Investment Group of the US and Hebei Province have agreed to jointly develop a $97 million, 150 MW coal-fired plant on a BOO basis. New Age International will hold a 70 percent equity stake in this project.

Coastal Power Production has completed a 40 MW diesel power plant in Wuxi City, Jiangsu Province. Coastal is considering a second phase that would extend the capacity of the current plant to 120 MW, beginning construction in 1996. Coastal has also signed a joint venture agreement to build, own, and operate a $29 million, 58 MW, gas-fired, simple-cycle plant in Suzhou, Jiangsu Province. Commercial operation is scheduled for July 1996. Coastal will cover 60 percent of the project cost.

Westinghouse Electric is planning a joint venture with Longyuan Power Technology Exploitation to renovate China's existing outdated generators. Most details of the agreement are not yet worked out.

FloWind Capital and Inner Mongolia Power Co. have signed an agreement to develop an $85 million, 110 MW wind farm. The project could begin construction this year.

The Institute of Gas Technology and Shanghai Coking & Chemical General Plant have established a 50-50 joint venture to develop a 60-70 MW trigeneration project. A feasibility study of the second phase is underway.

During the 5-day trip of US Energy Secretary Hazel O'Leary to China, China and the US signed 26 energy deals worth $4 billion. The deals included a contract to explore natural gas in the South China Sea, sales of US wind turbines, hydropower, and coal-washing equipment, components for a nuclear power plant, and joint venture power plants. The largest deal is a letter of intent to set up a joint venture to build and operate a 1.2 GW power plant in western Sichuan Province. The Plant requires a capital investment of more than $1.2 billion. More than $1 billion will come from the US (*Asian Energy News*, March 1995).

Singapore

Singapore investors are involved in 7,280 MW coal-fired power projects in China. In addition to the two 2,400 MW projects to be jointly developed with Bechtel, Sembawang Resources is going to take a 50 percent equity in the 2,400 MW coal-fired Yinglongshan project in Zhejiang. Capital cost of this project is estimated at $1,000/kW. The first phase will install two 600 MW units. International capital, both in the form of equity and debt, will be used to finance the project. Sembawang has short listed four financial institutions and will soon select one to package a loan for the project. Sembawang has also formed a separate joint venture with China

International Engineering Consulting Corp. (CIECC) to undertake plant processing, construction of power plants and offshore platforms in China and other parts of Asia.

Singapore-based Amcol Holdings will buy an 80 percent equity in a $39.5 million, 80 MW, coal-fired plant in Qingyuan.

Temasek Holdings and the Singapore Public Utilities Board (PUB) are considering to development of coal-fired projects in Shanxi as wholly foreign owned or BOT plants. Current negotiations are preliminary. The Singapore PUB is also studying possible power projects in Ningbo, Wuxi, and Suzhou.

The first power supply company with foreign equity participation in China will be established in Suzhou, Jiangsu Province. The joint venture between Singapore and Suzhou will secure and distribute electricity to Suzhou and also provide related services. It will collect connecting fees and tariffs and maintain the distribution network. This consortium, Singapore Suzhou Township Development Pte Ltd, has an authorized capital of $300 million. It is expected to start operation by the first half of 1995 (*The Straits Times* December 3, 1994).

Australia

Three major companies in Australia are considering development of up to 6,840 MW generating capacity in Sichuan, Shanxi, Inner Mongolia, and Beijing. In Sichuan, BHP Power has begun prefeasibility studies for an integrated power project near Chengdu. This project will build a combined-cycle power plant and a gas pipeline to use energy resources from nearby coal and gas developments. The project will use coal and methane gas from coal mines in Chongqing, Shanxi, and Lanzhou. BHP and possible partners may spend up to $3 billion in this project. In Inner Mongolia, BHP is studying the feasibility of building a 2,000 MW mine-mouth plant at the open-cut coal mine of Zhungeer.

Atlas Developments and Guangdong's Jilida are considering development of the 2,640 MW coal-fired Shentou No.2 project in Shanxi. The Shanxi Electric Power Co. will procure Chinese government guarantees needed for project funding, while Altas and Jilida would act as developers, arrange international finance and participate in project equity. The final agreement is expected within several months.

Kaiser Engineers has signed a letter of intent to build, own, and operate a 200 MW coal-fired plant in Beijing on a joint venture basis. If the feasibility and financial studies are positive as expected, construction will begin next year and project completion is expected in two years.

United Kingdom

Three United Kingdom companies are involved in 7,300 MW coal-fired power projects in China. PowerGen PLC of the U.K. has signed a memorandum of understanding with Jiangsu Province for a joint venture to develop a 2,400 MW coal-fired independent power plant in Xiangshui County. The $1.5 billion project is PowerGen's first one in China. The first phase of the project will consist of two 600 MW units. Coal to fuel the project will be transported by rail from Shanxi to Qinhuangdao and Huanghuagang and then to Yancheng by ship. It is possible the plant could be developed on a BOT basis. PowerGen is also selling three outdated coal-fired power plants totaling 1,214 MW to an unnamed Chinese bidder. The plants will be dismantled, shipped to China, and reassembled.

British Energy International Ltd. and Jiangsu Province agreed to develop the 2,400 MW coal-fired Chengang project. The first phase of the project will install two 600 MW units. The two units will begin construction in 1998, with the initial stage of commercial operation set for 2002 and 2003. There is not yet a timetable for the second phase.

The National Power PLC of the U.K. and GEC Alsthom of the France will build, own, and operate a 2,500 MW, coal-fired plant in Jiaxing, Zhejiang Province. National Power and GEC will invest 40 percent of the $1.5 billion development costs.

Israel

The United Development Inc. of Israel and Jiangsu Power Co. agreed to develop a total of 4,000 MW coal-fired plants in phases on a BOO basis. The first phase will consist of two 1,000 MW units in the Lusigang power plant at an estimated cost of $2.15 billion. United Development will hold 35 percent of project equity.

Germany

The Power Generation Group of Siemens has signed three private power development agreements with a total coal-fired capacity of 3,340 MW in China, including the 1,320 MW Shuangyashan project in Heilongjiang, a 1,320 MW project at Hanfeng in Hebei, and the 700 MW Rizhou project in Shandong. The capital cost of these projects is estimated at $760-860/kW. Siemens, together with United Development Inc. of Israel, will take a 40 percent stake in the Hanfeng project, which is scheduled to be completed by 2000. The Hanfeng project will install two 660 MW units supplied by Siemens at a cost of about $1 billion. Financing for the export portion of the project, about half the total cost, will be arranged through export financing channels. In the first quarter of 1996, Chinese officials told the developers to change the Shuangyashan project from a BOT project to a BOO project. The 2X350 MW Rizhao project is expected to cost $600 million. The first unit of the plant is scheduled to become operational by end-1998 and the second unit in early 1999. Siemens and United Development will each hold a 12.5 percent stake in the project. The plant will be equipped by an international consortium led by Siemens which will supply the turbines, generators, boilers, and all the electrical equipment and control equipment. Rizhao is the first of several BOT power projects for Siemens in China. All these projects will be developed on a BOT basis for 20 years.

Thailand

The Chai Tai Group has formed a joint venture in Hebei Province to develop a 1,200 MW coal-fired project in Xibaipo. The BOT project is based on a 20 year contract, and Chai Tai will hold 45 percent of the equity.

MDX Power has reached agreements to build, own, and operate three hydropower projects with total capacity of 2,000 MW in Yunnan. About half of the electricity generation is scheduled to be exported to Thailand. The projects will cost approximately $2 billion. MDX will take a 45 percent equity stake. The first unit is scheduled to begin operation in 2001, with the others to be completed in stages through 2004. However, the Electricity Generating Authority of Thailand (EGAT) has not yet agreed to buy the electricity. There are also questions on the cost of power because of the high expense of building transmission lines to Thailand.

Japan

Japanese firms are newcomers in China's private power sector. Reportedly, Marubeni will take a 20 percent equity in a 2X660 MW coal-fired project in Guangdong. The capital cost of this project is estimated at $1,135/kW.

Kanematsu, a Tokyo-based trading company, plans to develop a $850 million, 1050 MW, gas-fired plant on Dachan Island in Guangdong. Kanematsu hopes to have the plant operational by 1998. The plant will use natural gas from offshore fields near Hainan Island.

The Japanese Maeda and Hong Kong-based Kumagai Gumi and Ringo Trading are developing a 173 MW project at Yangpu, Hainan Province. About 36 MW of the project are diesel units and have entered service in 1994, another 137 MW gas-fired units will be ready for commercial operation several years later.

Twelve unidentified Japanese firms from various sectors have agreed to combine with the Tokyo based Institute of Energy Economics (IEE) to build joint venture, coal-fired plants in Guangdong. The plants are likely to be built on a BOT basis, and IEE will act as the negotiator representing the Japanese firms.

Canada

In November 1994, B.C. Hydro International of Canada signed enabling agreements with the Ministry of Water Resources for eight hydropower projects totaling 1,140 MW in Guangxi, Yunnan and Hunan. Equity splits in all the projects will be 50-50. Four units (total 285 MW) in Guangxi are already under construction by B.C. Hydro's Chinese partners. These units will cost about $528 million ($1853/kW). Power purchase agreements are under negotiation. In Yunan, B.C. Hydro will invest a 450 MW hydropower project on the Panlong River. This project is estimated to be completed in 1999. Also under development is the 250 MW ($300 million) hunan project on the Yuanshui River to be completed in 1999, and two 72 MW hydropower projects on the Jongjiang and Guijiang rivers in Guangxi at an estimated cost of $170 million.

TransAlta Energy of Canada has signed joint venture agreement to construct a 250 MW coal-fired plant in Shaowu, Fujian Province. TransAlta and Hong Kong-based Great China International will take a 60 percent equity stake. Construction of the project will begin in 1995 and to be completed in the third and fourth quarters of 1997.

Malaysia

Malaysia's Asiavest Consolidated is developing a 250 MW ($288 million) coal-fired independent power project in Hiuchow. The project is based on a 30 year BOT contract. All capital and interest will be repaid during the first 10 years of operation. For the next 20 years, the domestic and foreign partners will share all profits on a 50-50 basis.

Time Engineering has reached a BOT joint venture agreement to develop the 250 MW coal-fired Lianyuan project in Hunan. Time will take a 70 percent equity.

A consortium of Malaysian firms, including Kanzen Energy Ventures, Tan Chong Trading, and Shanghai Chong Kee Construction are jointly developing a 60 MW cogeneration plant in Jiangyin. The second phase will add another 20 MW.

Others

Babcock Energies-und Umwelttechnik, a subsidiary of Deutsche Babcock AG, plans to build a 250 MW coal-fired plant near Beijing.

In Hohhot City, a 7,200 MW coal-fired project is planned which will involve international private power developers, but no deals are yet signed. Talks are underway with three Korean companies, including the Hyundai Group, the Samsung Group, and the Daewoo Group, plus at least one Japanese firm. The project will include three phases, with the first being to install 1,200 MW.

Table 4.6. Project Proposals of Foreign Investors

Name	Capacity (MW)	Investment ($million)	Foreign Firms	Location	Fuel
China Total	**136462**	**119661**			
Hong Kong	**34466**	**29751**			
CEPA Total	13200	12540			
Shenzhen East	2640	2500	CEPA, HK	Guangdong	Coal
Qidong	2640	2500	CEPA, HK	Jiangsu	Coal
Liaocheng	2640	2500	CEPA, HK	Shandong	Coal
Shouyangshan	1320	1260	CEPA, HK	Henan	Coal
Tanfang	1320	1260	CEPA, HK	Shandong	Coal
Fujian	1320	1260	CEPA, HK	Fujian	Coal
Guangxi	1320	1260	CEPA, HK	Guangxi	Coal
Henderson Total	7800	5746			
Moushan I	600	*450*	Henderson, HK	Shandong	Coal
Moushan Exp.	1200	*900*	Henderson, HK	Shandong	Coal
Other Shandong	4800	*3600*	Henderson, HK	Shandong	Coal
Hubei	600	*450*	Henderson, HK	Hubei	Coal
Beihai	600	346	Henderson&New World	Guangxi	Coal
CL&P Total	3600	3603			
Heze	1200	*1200*	China Light & Power, HK	Shandong	Coal
Shiheng	1200	*1201*	China Light & Power, HK	Shandong	Coal
Liaocheng	1200	*1202*	China Light & Power, HK	Shandong	Coal
Hutchison Total	4010	3926			
Zhuhai phase 1	1320	1300	Hutchison Whampoa, HK	Guangdong	Coal
Zhuhai Exp.	2640	2600	Hutchison Whampoa, HK	Guangdong	Coal
Shanton	50	26	Hutchison, Cheung Kong	Guangdong	Coal
New World	1696	1440			
Guangdong	1200	720	New World Power, HK	Guangdong	Coal
Fujian	246	*320*	New World Power, HK	Fujian	Hydro
Nanao Island	50	*80*	New World Power, HK	Guangdong	Wind
Inner Mongolia	200	*320*	New World Power, HK	Inner Mongolia	Wind
Other Hong Kong	4160	2412			
Yangcheng	2000	1000	China Strategic Investment	Shanxi	Coal
Hengshui	600	232	HK Macau International	Hebei	Coal
Shengli	600	500	Cathay International, HK	Shandong	Coal
Longkou	400	*200*	CMCDI, HK		Coal
Shaoguan	240	*240*	China Overseas Land, HK	Guangdong	Coal
Sung Foo Kee	180	*150*	Sung Foo Kee, HK	Hubei, Liaoning	Coal
Yangluo	80	*40*	Wharf Ningbo	Hubei	Coal
Raoping	60	*50*	Pacpo	Guangdong	Coal

Note: Numbers in italics are estimated by the East-West Center.

Table 4.6. Project Proposals of Foreign Investors (continued)

Name	Capacity (MW)	Investment ($million)	Foreign Firms	Location	Fuel
United States	**58084**	**49089**			
AES Total	6373	5680	AES Chigen, U.S.		
Yangcheng	2100	1800	AES Chigen, U.S.	Shanxi	Coal
Fencheng	1200	*1050*	AES Chigen, U.S.	Shanxi	Coal
Wuhan	1200	*1050*	AES Chigen, U.S.	Hubei	Coal
Quanzhou	600	*550*	AES Chigen, U.S.	Fujian	Coal
Harbin	400	*400*	AES Chigen, U.S.	Heilongjiang	Coal
Wanfang	250	*250*	AES Chigen, U.S.	Henan	Coal
Weihai	250	*250*	AES Chigen, U.S.	Shandong	Coal
AES Guangdong	200	*200*	AES Chigen, U.S.	Guangdong	Coal
AES Diesel	110	*80*	AES Chigen, U.S.		Diesel
Wuxi	63	*50*	AES Chigen, U.S.	Jiangsu	Gas
Wing Group Toral	14200	10100	Wing Group, US		
Gas Plants	10000	*6500*	Wing Group, US	East seaboard	Gas
Mixian	1400	*1200*	Wing Group, US	Henan	Coal
Dengfeng	1400	*1200*	Wing Group, US	Henan	Coal
Qinbei	1400	*1200*	Wing Group, US	Henan	Coal
Entergy Total	6240	5250	Entergy, US		
Taishan	1320	1200	Entergy, US	Guangdong	Coal
Taishan, Exp.	1320	*1000*	Entergy, US	Guangdong	Coal
Datong No.2	1200	*1050*	Entergy, Lippo (HK)	Shanxi	Coal
Datong Expansion	2400	*2000*	Entergy, Lippo (HK)	Shanxi	Coal
Tong Tech Total	4500	4200	Tong Tech Investment		
Xinjiang	2100	2000	Tong Tech Investment	Shanxi	Coal
Xinjiang, Exp.	1200	*1000*	Tong Tech Investment	Shanxi	Coal
Other Tong Tech	1200	*1200*	Tong Tech Investment		Coal
Sithe Total	11486	10252	Sithe Energies, US		
Donghai Island	4000	3600	Sithe Energies, US	Guangdong	Gas, Oil
Other CNOOC	5700	*5130*	Sithe Energies, US		Gas, Oil
Liancheng Exp.	400	*350*	Sithe Energies, US	Gansu	Coal
Meishan	300	275	Sithe Energies, US	Hainan	Gas, Oil
Shuangqiao	250	*200*	Sithe Energies, US	Guangdong	Coal
Shanxi Exp.	200	*160*	Sithe Energies, US	Shanxi	Coal
Tangshan Exp.	200	*160*	Sithe Energies, US	Hebei	Coal
Zunhua Exp.	200	*160*	Sithe Energies, US	Hebei	Coal
Shunyi	100	*100*	Sithe Energies, US	Beijing	Coal
Zhejiang	70	63	Sithe Energies, US	Zhejiang	Coal
Houjie	66	*54*	Sithe Energies, US	Guangdong	Oil

Note: Numbers in italics are estimated by the East-West Center.

Table 4.6. Project Proposals of Foreign Investors (continued)

Name	Capacity (MW)	Investment ($million)	Foreign Firms	Location	Fuel
Cogen	1500	1350	Cogen Technologies		
Wujing	1200	1050	Cogen Technologies	Shanghai	Coal
Two Beijing Plants	200	200	Cogen Technologies	Beijing	Coal
Port	100	100	Cogen Technologies	Shanghai	Coal
Other US	13785	12257			
Bechtel	5200	*4500*	Bechtel Enterprises, US		
Suizhong	2600	*2200*	American Electric Power Re.	Liaoning	Coal
Southern Electric	1200	*1050*	Southern Electric Intern.	Jiangsu	Coal
First Washington	1000	1170	First Washington Asia, US	Guangdong	Coal
Meizhou Bay	700	*700*	Mission, Bechtel, Sembaw.	Fujian	Coal
Bio Development	600	*600*	Bio Development, US	Guizhou	Coal
Jingyuan II	600	*600*	CEA Asia, US	Gansu	Coal
Zhabei retrofit	400	200	General Electric, US	Shanghai	Oil, Coal
Jiangmen West	350	*280*	CEA Asia, US	Guangdong	Oil
Energy Initiatives	250	*250*	Energy Initiatives, US	Sichuan	Coal
Chengdu PS	200	*80*	Dominion Bridge, US	Sichuan	Pumped-S
Enron	155	*100*	Enron Development, US	Hainan	Oil, gas
Enron Solar	150	*270*	Enron Development, US		Solar
Handan	150	*97*	New Age International	Hebei	Coal
Wuxi	120	*75*	Coastal Power Production	Jiangsu	Diesel
Flowind	110	85	Flowind Capital, US	Inner Mongolia	Wind
Singapore	**7280**	**7240**			
Ying Long Shan	2400	2400	Sembawang, Singapore	Zhejiang	Coal
Suzhou	2400	*2400*	Sembawang & Bechtel	Jiangsu	Coal
Jiangsu	2400	*2400*	Sembawang & Bechtel	Jiangsu	Coal
Qingyuan	80	40	Amcal Holdings		Coal
Australia	**6840**	**7400**			
Chengdu	*2000*	3000	BHP Power, Australia	Sichuan	Gas, Coal
Zhungeer	2000	*1800*	BHP Power, Australia	Inner Mongo.	Coal
Shentou No.2	2640	*2400*	Atlas, Australia	Shanxi	Coal
Beijing	200	*200*	Kaiser Engineers, Australia	Beijing	Coal
U.K.	**7300**	**5400**			
Xiangshui	2400	1500	PowerGen	Jiangsu	Coal
Chengang	2400	*2400*	British Energy	Jiangsu	Coal
Jiaxing	2500	*1500*	National Power PLC, UK	Zhejiang	Coal
Israel	**4000**	***3950***			
Lusigang	2000	2150	United Development	Jiangsu	Coal
Lusigang, Exp.	2000	*1800*	United Development	Jiangsu	Coal

Table 4.6. Project Proposals of Foreign Investors (continued)

Name	Capacity (MW)	Investment ($million)	Foreign Firms	Location	Fuel
Germany	**3340**	**2600**			
Shuangyashan	1320	*1000*	Siemens, German	Heilongjiang	Coal
Hanfeng	1320	1000	Siemens, German	Hebei	Coal
Rizhao	700	*600*	Siemens, German	Shandong	Coal
Thailand	**3200**	**3050**			
MDX	2000	2000	MDX Power, Thailand	Yunnan	Hydro
Xibaipo	1200	*1050*	Chia Tai Group, Thailand	Hebei	Coal
Japan	**2543**	**2075**			
Swatow	1320	1135	Marubeni, Japan	Guangdong	Coal
Dachan	1050	850	Kanematsu, Japan	Guangdong	Gas
Yangpu	173	90	Maeda, Japan	Hainan	Gas, Diesel
Canada	**1379**	**1788**			
Guangxi	285	528	B.C. Hydro International	Guangxi	Hydro
Yunnan	450	540	B.C. Hydro International	Yunnan	Hydro
Hunan	250	*300*	B.C. Hydro International	Hunan	Hydro
Guangxi	144	*170*	B.C. Hydro International	Guangxi	Hydro
TransAlta	250	*250*	TransAlta Energy	Fujian	Coal
Others	**8030**	**7318**			
Huhhot (Korea)	7200	*6500*	Hyundai, Samsung, Daewoo	Inner Mongolia	Coal
Babcock	250	*220*	Deutsche Babcock AG	Beijing	Coal
Asiavest	250	288	Asiavest, Malaysia	Hiuchow	Coal
Lianyuan	250	*240*	Time Engineering, Malaysia	Hunan	Coal
Jiangyin	80	*70*	Kanzen Energy, Malaysia	Jiangsu	Coal

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Appendix 4.1. International Financing Institutions and Bilateral Assistance

The multilateral development banks, notably the World Bank (WB) and the Asian Development Bank (ADB), have played a major role in funding China's power projects. Working primarily with the government, these institutions bring capital, expertise, and policy prestige to China. In addition to the multilateral institutions, many countries provide bilateral development assistance to China.

The World Bank

The World Bank is one of the Bretton Woods institutions designed after World War II to help manage the international economic system and development process. It works alongside the International Monetary Fund and the trade regime to foster productive national development conductive to peaceful international relations.

The WB currently lends more to China than to any other country. During the 1978-1993 period, it had committed $16.5 billion to China, although only $9.6 billion had been dispersed by the end of 1993. WB lending to China will continue to be significant given the nation's recognized development needs, the importance to the international economic system of stable development in China, and the country's good repayment record. The low interest "soft loans" on concessional terms may, however, be reduced in the future, reflecting China's strong economic performance and growing ability to borrow on commercial terms. China also receives funding from the WB's private sector branch, the International Finance Corporation (IFC).

Power projects have been a staple of WB lending for many years. Power sector related activity in China amounted to $2.157 billion in 1994. Recently, the WB has approved more than

$1 billion in loans to finance China's two energy projects and one clean coal technology project. The Zhejiang power development project will use $400 million WB loan to finance 22 percent of the total costs. The project will install three 600 MW coal-fired units and strengthen the distribution network. The Sichuan power transmission project will receive $270 million loan which will be used for improving the operation of the provincial power company, building a large transmission network, and adding substations to improve power distribution. The clean coal technology loan of $200 million will be used to develop new industrial technologies aimed at improving productivity and curbing pollution.

However, the WB's power sector track record has recently come under attack from environmental groups which criticized the WB's focus on increasing energy supply rather than improving energy efficiency and failure to meet the requirements of its own energy policy. Other criticisms point to the WB's preference for large-scale power projects rather than small-scale alternatives and its insufficient attention towards the social and environmental impacts of hydropower projects. More broadly, it has been encouraged to participate in the power sector more through its private sector arm and to concentrate efforts on social and environmental programs less able to attract market investors. The WB has shown sensitivity to these criticisms and has decided not to become involved with the Three Gorges Project due largely to social and environmental considerations.

Reportedly, the WB will issue revised environmental standards within the next several months that are expected to have a significant impact on thermal power projects in China. The new requirements will update and strengthen two types of standards set by the WB back in 1988, including industry-wide performance standards and standards for specific pollutants and control technologies. The revised standards will limit SOx emissions to 0.2 tons per day per MW for the first 1,000 MW and 0.1 ton per day for each additional MW, while the 1988 guidelines allowed SOx emissions to go as high as 500 tons per day. NOx emissions will be limited to 230 ng/J for coal-fired plants, 100 ng/J for oil-fired, and 65 ng/J for gas-fired plants. This is a reduction from 300 ng/J, 130 ng/J, and 86 ng/J for coal, oil, and gas based plants respectively. Revisions will also be made for particulate, liquid effluent discharges and ash disposal (*The*

China Energy Report October 1995).

Power developers will be impacted in a number of ways by the new environmental requirements. The new standards potentially put more pressure on the site selection process of power projects. Under the power plant guidelines, new thermal power plants will face tougher pre-construction review requirements. This could confront developers with longer project lead times. Delays could also result from the need to install monitoring equipment and collect meteorological data. It will be difficult for coal-fired power plants to obtain World Bank funding without sulfur scrubbers. Specific technologies recommened include the installation of evaporative recirculating cooling systems, low-NOx burners, and dry sulfur scrubber systems over wet scrubber systems.

The impact of the new WB standards is likely to reach beyond projects financed by the WB, given the WB's role as a baseline for other lending institutions. The new standards are likely to become the minimum requirements for the International Finance Corporation, ADB, Japan's Overseas Economic Cooperation Fund, and other international lending agencies. The date when the new requirements will go into effect has not been announced. However, if the WB's internal review process moves forward as expected, the new standards could be issued as early as the end of 1995 or early 1996. The preliminary version of the new environmental standards are available in the Industrial Pollution Prevention and Abatement Handbook, which can be obtained from the WB's office of external affairs: World Bank, 1818 H Street, NW, Washington, DC 20433, Tel (202) 458-0358; Fax (202) 522-3405.

The WB has become increasingly aware that its project-lending role is quickly changing. According to a WB policy paper, the World Bank's Role in the Electric Power Sector, the principles for improving the WB's lending include mitigating investment risks through greater use of the IFC and Multilateral Investment Guarantee Agency (MIGA). The WB recently extended "risk guarantees" to commercial lenders in power projects. It has also discussed with Chinese officials the creation of a Chinese National Power and Development Fund to float WB backed bonds to private investors. Thus, the WB is gradually changing its role from project financier to project guarantor.

The Asian Development Bank

The Asian Development Bank (ADB) was created by Asian nations to increase resource availability regionally. Like the WB, the ADB provides both hard and soft loan facilities. A total of 30 projects, with a cumulative value of nearly $3 billion, have been approved in China since it joined the ADB in March 1986, and the ADB plans to increase lending and technical assistance to China in the future.

China is expected to receive $1.2 billion in loans from the ADB in 1995. The loans will mainly flow to power, transportation, agricultural, and telecommunication industries. Projects to be supported in 1995 include the Pinghu natural gas project in Shanghai, which is expected to borrow $130 million. The ADB will also help arrange financing for equipment imports for a natural gas project in Shanghai's Pudong New Area. China will continue to put the majority of ADB loans into infrastructure construction and the power industry. Reportedly, the ADB is expected to grant a $500 million loan to support construction of a 1.2 GW coal-fired power plant in Fuyang, Anhui Province. The loan will be used to purchase power-generating equipment from overseas through international bidding. Construction of this plant will start in late 1997, and at least one of the two 600 MW units will be put into operation by 2000.

The ADB has also become acutely aware of the environmental impacts associated with its energy sector projects in China and has given more attention to these issues in recent years. The ADB has approved a loan of $157 million and two technical assistance grants of $1 million to China for an environmental improvement project in Beijing. The project will support policy reforms conductive to environmental management in the city. The reforms are aimed at saving energy and promoting the use of cleaner energy sources through cost-effective and self-financing environmental improvement measures to ease pollution.

The ADB's technical assistance has also helped to identify alternative development paths for China's power sector. It sponsored a major assessment of global warming issues related to China's development. The analysis concluded that China should have a strong interest in taking steps to address climate change issues in the power sector, with considerable investment in improved thermal efficiency and fuel switching. In parallel with its studies, ADB's future lending portfolio to China will include, in addition to financing for power plants, improvements in supply and demand side energy efficiency and in integrating environmental considerations into energy development plans.

The Japanese Government Aid Programs

Due to the increasing concern with the transboundary effects of Chinese air pollution, Japan has the largest and most comprehensive environmental assistance program in China, involving the exchange of personnel, studies, loans, and cooperative research and demonstration projects. The Japanese are also interested in the market opportunities to export energy and environmental technologies and equipment.

The most important Japanese national effort influencing China's development path is its multi-billion dollar program of Yen loans, dispersed in three-year periods. During the 1996-1998 period, a total of 580 billion yen ($5.8 billion) in low-interest loans will be provided to finance 40 projects, a large share of which are directed towards improving energy efficiency. While a number of planned projects are aimed at reducing air pollution, especially from cities close to Japan, Japan's focus is also on establishing closer commercial relationships in the power and environmental equipment fields.

Japan's $1.6 billion Green Aid Plan, administered by the Ministry of International Trade and Industry (MITI), provides China will additional power sector assistance. With its grants subsidizing the transfer of pollution control equipment to China, the Green Aid Plan supports joint demonstration projects with redesigned Japanese technology that is simplified and cheaper to purchase and maintain. Two large-scale flue gas desulfurization systems, totaling 7.3 billion yen ($73 million), are being supported through this program. The first, constructed at the Huangdao power plant in Shandong Province, was completed in August 1994. The second project at a power plant near Taiyuan, Shanxi Province, is scheduled to be completed in 1996.

There are conflicting views on the motivations behind Japan's increasing environmental assistance. Some observers view the aid as fundamentally export promotion, pointing to the fact that the Green Aid Plan has given Japanese firms a dominant position in the clean coal projects.

Others, however, see Japan's China aid as a response to a more complex set of political, economic, environmental, and security concerns.

The United States Government Aid Programs

Compared to Japan, the U.S. government assistance to China has been limited. In the wake of the Tiananmen Square incident, Congress cut off all U.S. aid to China. Some restrictions, such as those placed on the Trade and Development Agency (TDA) which provides trade promotion, the Overseas Private Sector Investment Corporation (OPIC) which provides risk insurance, and the Agency for International Development (AID) which provides market support, have not yet been lifted.

However, some China assistance has been available through the Department of Energy (DOE), the Department of Commerce (DOC), and the Environmental Protection Agency (EPA). Other U.S. assistance to China has been trade-oriented. A more ambitious China assistance plan, put forward by DOE along the lines of Japan's Green Aid Plan, was rejected by Congress in 1994. Specifically, in its 1995 budget request, DOE proposed redirecting $50 million from its domestic clean coal technology (CCT) program to support a showcase CCT project in China. The Chinese government, which had included the project as one of the 62 priority projects under its Agenda 21 plan, was disappointed by this rejection. DOE has since broadened its scope from CCT to what it views as a window for energy efficiency and renewable energy technologies in China. In February 1995, DOE secretary Hazel O'Leary led a mission to China specifically designed to increase market opportunities for U.S. sustainable energy technologies in China's power sector.

The U.S. Export-Import Bank has significantly increased its export-backing in China. In 1994, the bank created a project finance division and will now match other countries' soft loans and lend to credit-worthy projects which lack the host government's guarantee (*Journal of Commerce* October 28, 1994). In fiscal year (FY) 1994, the U.S. Export-Import Bank played a minor role in China with only $150 million in loans. In FY 1995, funding for the energy sector jumped to $600 million, exceeding 50 percent of the anticipated $1.1 billion authorized for China. Funds were used to finance components for the Dandong ($278 million) and Dalian ($237 million) power projects in May 1995. The loans from the Bank offer a grace period of 5 years, and the Bank is attempting to be competitive with soft loans offered by other Export Credit Agencies. To date, the U.S. Export-Import Bank has not completed any project financing in China despite the setting up of a project finance office more than a year ago. However, the Bank believes that project finance regarding the power sector may be coming soon. The Bank also plans to increase non-recource lending to China and to work with the State Development Bank on power projects (*Journal of Commerce* October 21, 1994). It is now facilitating a $2.1 billion joint venture between American Electric Power Company and Northeast China Electric Power Company (*Journal of Commerce* November 30, 1994).

Loans from the U.S. Export-Import Bank are more sensitive to political concerns. In mid-October 1995, the Clinton administration announced that it opposes credit from the U.S. Export-Import Bank for companies seeking to take part in China's Three Gorges project. The National Security Council concluded that the U.S. government should not aid the project directly because of environmental concerns, although the U.S. government will not prohibit private-sector involvement in the project.

The Department of State (DOS) and other agencies have launched a joint implementation initiative under which the U.S. private sector would work with developing countries to reduce greenhouse gas emissions and receive credit for the reductions. Under the joint implementation, a country may, by financing a project in another country, credit reductions towards its own domestic commitments, thus achieving reductions cost-effectively. While this concept is accepted between developed countries, several countries would like to have it extended to include all countries. China's position, like most developing countries, has traditionally been to oppose this concept out of concern that this would provide developed countries a route to avoid taking more drastic measures domestically. Although China released a paper supporting the concept following the visit by representatives of the U.S. initiative on joint implementation, it withdrew the paper after debate with other members of the "Group of 77" developing countries. China is facing a trade-off between its urgent need for cost-effective solutions to reduce its potential emissions and its desire to be seen as a developing country for the purposes of the treaty, and thus to remain among and adhere to the consensus of these countries.

Other Bilateral Government Aid Programs

Several other countries have also provided bilateral assistance relating to China's power sector and often reflecting commercial interests more than China's specific energy needs. Germany's energy and environmental aid to China, totaling over $385 million, supports projects in thermal power plant upgrades, CCT projects, coke and town gas, and wind power.

France's bilateral program in China focuses on nuclear technologies. Canada has also negotiated a $2.5 billion contract for two "Candu" nuclear reactors (*Journal of Commerce* November 20, 1994). Denmark has provided China with $16.4 million in financing for wind power projects, as well as $5.6 million for district heating in Beijing, as part of a $45.3 million energy and environmental loan package to China. Great Britain's environmental assistance program in China provided $12.5 million during the 1990-1993 period, and is budgeted at $16.3 million for the 1994-1998 period. Australia is making a serious effort to expand environmental loans to China and has identified 13 projects for the 1995-1996 period. Australia's Development Import Finance Facility (DIFF) provided $26.4 million to China for a coal gasification project in Henan.

Chapter 5

Energy Availability and Transportation

Energy Production and Consumption

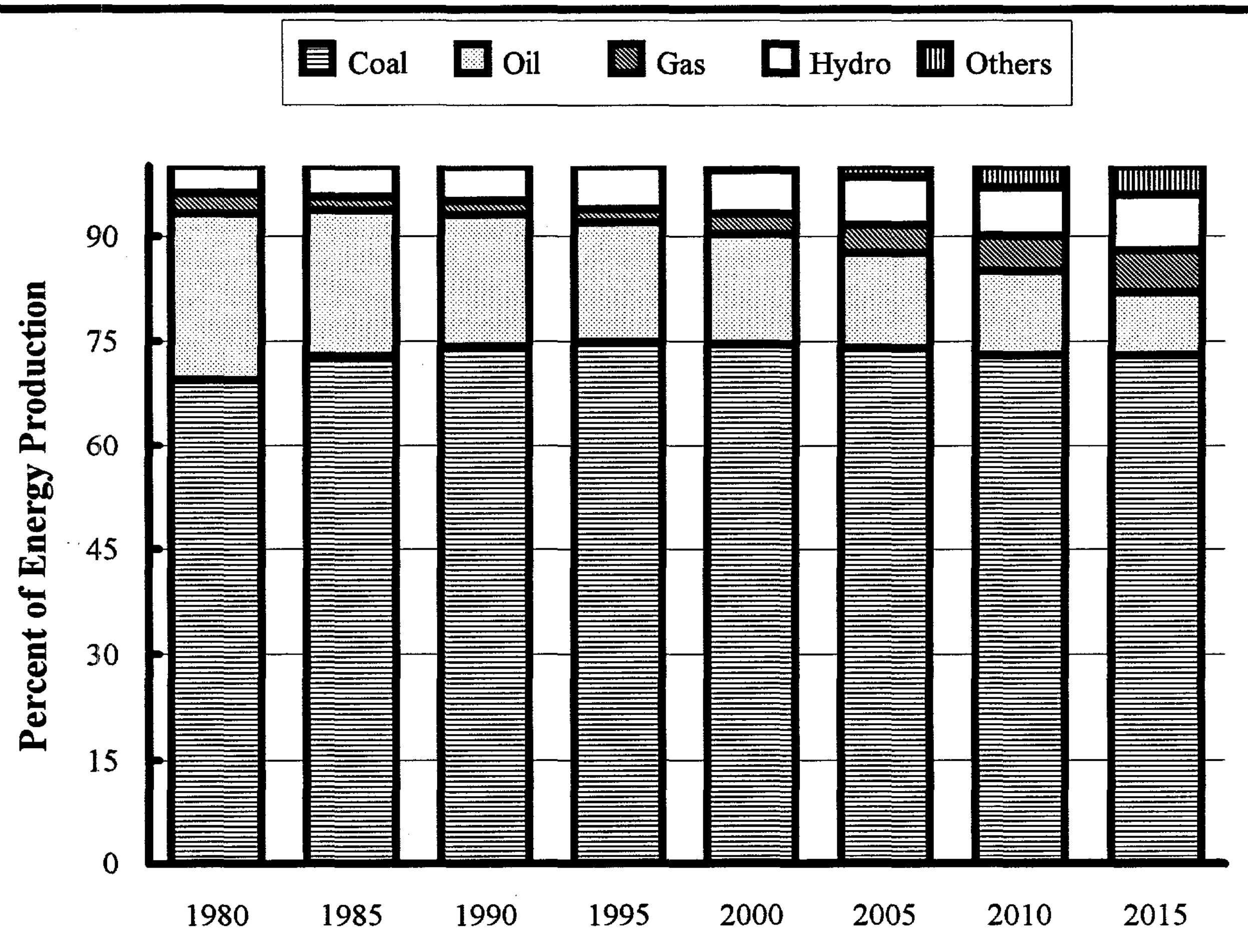

Figure 5.1. China's Energy Production Mix, 1980-2015

During the past 15 years, China's annual commercial energy production growth rate averaged 4.5 percent, with total energy production increasing from 638 to 1239 million tons of coal equivalent (MTCE). As shown in Figure 5.1, during this period, coal's share in total energy production increased from 69 to 75 percent; oil's share decreased from 24 to 17 percent; hydropower's share increased from 4 to 6 percent; and the share of natural gas decreased from 3 to 2 percent.

Over the next two decades, China's annual commercial energy production is projected to grow at about 3 percent per year, increasing from 1230 to 2213 MTCE. Coal's share is projected to decrease slightly from 75 to 73 percent, oil's share is projected to decrease to about 9 percent, while the shares of natural gas, hydropower, and others are projected to increase to 6, 8, and 4 percent respectively.

Most of the coal produced in China is consumed domestically. Currently China's net coal exports are about 27 Mt per year. Although China has ambitious plans to expand its coal exports, the increased demand for imported coal in the southeast region will offset the increases in coal exports in the north. Therefore net coal export is unlikely to increase substantially over the next two decades. Currently, provinces are free to import as much coal as desired, as long as they have the foreign exchange to pay for it. In the long run, coal imports will be determined by an economic comparison with domestic coal. Railway system congestion will likely prevent most interior cities from importing coal. Coal will be imported mainly to power plants and other big coal users with ship berths along the coast that can receive coal from self-unloading foreign vessels. Imports could be extended up the inland waterway system using oceangoing barges.

Due to slow production growth and rapid consumption growth, the surge of crude oil and oil product imports in December 1993 made China a net oil importer for the first time since the mid 1960s. In the future, China will increasingly depend on imported oil to meet its demand.

As discussed in Chapter 2, China's thermal power plants are basically coal-fired, and this situation is not expected to change over the foreseeable future. Therefore we will focus our attention on the coal sector in this Chapter. Since China's coal production is determined, to a large degree, by coal demand, we first take a look of China's coal demand before turning our attention to coal production.

The History of China's Coal Consumption

Before China's economic reforms started in 1978, China's development priority was heavy industry which was typically energy intensive. Energy prices, especially coal prices, were fixed below their market values. As a result, the average growth rate of coal consumption was higher than the economic growth rate. Between 1953 and 1978, China's national income growth rate averaged 5.7 percent per year, while the coal consumption growth rate averaged 8.6 percent per year respectively, the elasticities of coal consumption with respect to national income was 1.52.

The situation has changed completely since 1978. Although the growth rate of coal consumption was still following the same trend of economic growth, the growth rate of coal consumption was below the economic growth rate. Between 1978 and 1995, China's GDP growth rate averaged 9.5 percent per year, while coal consumption growth rate averaged only 4.8 percent per year, the elasticity of coal consumption with respect to the GDP was only 0.5.

The slower growth rate of coal consumption during the 1980s was mainly caused by supply shortages. Due to low or negative profitability and insufficient investment in the state owned coal mines, coal shortages became a common phenomenon in China during the early 1980s. The year of 1988 was the "golden" year for Chinese coal producers, when coal shortages became extremely serious. Table 5.1 shows that China's coal stocks decreased 31 Mt during 1988 from 138 Mt to 107 Mt, and the share of coal stocks in annual coal production declined to 11 percent. Chinese experience shows that the share of coal stocks should be kept in the range of 14-16 percent under normal situations. When the share declined to 12 percent there would be serious supply shortages (Wu 1993).

Since 1989, however, coal stocks started to increase. In 1992, the share of coal stocks in coal production increased to more than 19 percent, and the coal market slumped. Between 1988 and 1993, GDP growth rate averaged 8.5 percent, while the coal production growth rate averaged only 3.2 percent per year. The elasticity of coal production with respect to GDP was only 0.38. Coal stocks increased from 107 Mt in 1988 to 213 Mt in 1993. About 33 percent of the coal stocks are in coal mines, 46 percent in coal consuming enterprises, and 21 percent in the markets. Chinese experts estimated that the coal stocks in coal mines should be reduced by 40 percent, the stocks in consuming enterprises should be reduced by 30 percent; and the stocks in the markets should be reduced by 20 percent (Zhang 1994).

Table 5.1. China's Share of Coal Stocks in Coal Production

	Coal Production Mt	Net Export Mt	Stock Decrease* Mt	Stock at Year End Mt	Share of Stock %
1980	620	4	10	76	12.3
1981	622	5	7	69	11.1
1982	666	4	-3	72	10.8
1983	715	4	-13	85	11.9
1984	789	4	-17	102	12.9
1985	872	5	-39	141	16.2
1986	894	7	-13	154	17.3
1987	928	12	16	138	14.9
1988	980	14	31	107	11.0
1989	1054	13	-28	145	13.7
1990	1080	15	-42	184	17.0
1991	1087	19	-16	200	18.4
1992	1116	18	-13	213	19.1
1993	1150	17	0	213	18.6

* a negative sign means that stock increased during the year.
Source: China Energy Statistical Yearbook 1991; Energy of China No.2 1994; and China Daily, various issues, 1993, 1994.

Major reasons for the recent slump in coal consumption are: (1) transportation capacity shortages and the resulting high consumer coal prices; (2) energy conservation measures; (3) rapid growth of the less energy-intensive service sector and manufacturing; and (4) increases in imports of energy intensive products.

In China, coal prices paid by consumers vary widely from region to region because of differences in transportation costs, transaction costs, and producer prices. For example, at the end of 1995, coal prices were 140 yuan ($17) per ton in Datong, Shanxi Province, 265 yuan ($32) per ton in Shenyang, Liaoning Province, 275 yuan ($33) per ton in Shanghai, and 310 yuan ($37) per ton in Guangzhou, Guangdong Province.

Since the late 1980s, the share of coal obtained from the market has increased sharply. Not only were producer prices higher in the market, but also transportation costs and transaction costs were higher for the coals obtained from the market, causing the consumer price to increase dramatically. The high consumer coal market price in the late 1980s was due not only to higher producer prices and transportation costs; to a larger degree it was due to the high transaction cost caused by the involvement of middlemen. For example, in 1989, the railway freight rate from Datong, Shanxi Province, to Qinhuangdao was only 10 yuan per ton; the coastal waterway freight from Qinhuangdao to Shanghai was only 7.26 yuan per ton; while the intermediate charges were 95-104 yuan per ton (*Energy Policy Research Communication* No.2, 1992).

Due to transportation capacity shortage and high consumer coal prices, coal demand in the south has been depressed. It is estimated that Guangdong and Guangxi Provinces alone would add another 100 Mt of coal consumption per year if there would be enough transportation capacity (*People's Daily Overseas Addition* April 28, 1994).

Energy conservation has also resulted in slower growth in coal consumption in China. Energy conservation measures in China were formally launched in 1980 when conservation projects were officially included in the national economic and social development plans. Low coal prices and the lack of a market system resulted in low efficiencies in energy use until reforms in the 1980s. During the 1980s, the government invested 17.2 billion yuan ($2 billion) in energy conservation basic construction projects, which led to the installation of 35 MTCE energy conservation capacity. During the same period the government invested 10 billion yuan ($1.2 billion) in energy conservation retrofitting projects, which added another 31 MTCE energy conservation capacity. As a result of energy conservation efforts, the specific energy consumption for about two-thirds of China's total products were decreased during the 1980s (Shen 1992).

During the 1980s, consumers were able to rapidly increase efficiencies in energy use in response to higher energy prices. However, since domestic coal prices in the south are already close to the international level, coal prices in the south are not expected to increase in the near future, and the extraordinarily low elasticity of coal consumption during the 1990-1995 period is not expected to last.

In addition to direct energy conservation, energy conservation through structural changes and switching to high value added products are even more important. A simple example is switching from producing $1 tennis shoes to $20 sneakers with little impact on energy consumption but a substantial impact on the growth of GDP. The achievements in energy conservation over the past 15 years are expected to slow over the next two decades as China completes its shift from low to intermediate quality products. Most of China's recent growth has occurred in the non-state sectors which focus on down-stream processing industries. In the long run, sustainable economic growth will have to rely on a balanced sectoral development.

In recent years, the imports of energy-intensive products have been increasing, which has reduced domestic energy consumption. For example, between 1980 and 1993, China's net steel imports increased 16 percent per year on average from 5 Mt to 35 Mt, since the energy consumption of producing one ton of steel in China is about 1.52 ton of coal equivalent (TCE), and one ton of Chinese coal consumed in the iron and steel industry equals 0.82 TCE on average. The 35 Mt of steel imported in 1993 would have consumed 65 Mt of coal if produced in China. Between 1982 and 1992, China's net chemical fertilizer imports increased 12 percent per year from 6 Mt to 18.6 Mt. Energy consumption of chemical fertilizers averaged 3.38 TCE per ton of fertilizer in 1990. If the 18.6 Mt of chemical fertilizer were produced in China using coal, coal consumption would have increased by 88 Mt (assume average calorific value of 5,000 Kcal/kg). In the long run, China plans to reduce its dependency on imports of steel and chemical fertilizer, which will lead to higher domestic coal consumption in these sectors.

After scrutinizing the reasons behind the recent slump in the coal demand, it appears that the major factors that contributed to it are only short lived. In 1995, China's coal consumption increased about 6 percent.

Projections of China's Coal Demand, 1996-2015

Most Chinese experts believe that the elasticity of coal consumption with respect to GDP is going to average 0.5 in the long run. If we adopt this elasticity as an assumption, then to achieve an 8.5 percent GDP growth rate in the rest of the decade and a more modest 6.5 percent in the 2001-2015 period, coal demand will reach 1,570 Mt by 2000 and 2,538 Mt by 2015.

Using average elasticity to project coal demand is, however, a risky methodology in China. In this section we project coal demand by looking at the historical performance of each sector and their energy conservation potential. The results are summarized in Table 5.2.

Table 5.2. Projection of China's Coal Demand by Sector

	Coal Demand (Mt)				
	1995	2000	2005	2010	2015
Total	1276	1556	1820	2132	2500
Power	478	653	811	1032	1323
Industrial Boilers*	235	265	295	324	350
Construction Materials	182	245	310	374	428
Residential	135	120	110	95	85
Iron and Steel	119	130	140	151	160
Chemical Fertilizer	72	90	106	111	110
Others	55	53	48	45	44
	Share in Total Demand (%)				
	1995	2000	2005	2010	2015
Total	100	100	100	100	100
Power	37	42	45	48	53
Industrial Boilers*	18	17	16	15	14
Construction Materials	14	16	17	18	17
Residential	11	8	6	4	3
Iron and Steel	9	8	8	7	6
Chemical Fertilizer	6	6	6	5	4
Others	4	3	3	2	2

* Excluding the chemical, iron and steel, and construction material industry.

China's coal demand is projected to increase to 1,820 Mt by 2005 and 2,500 Mt by 2015. The share of the power sector (including steam and hot water production) is projected to increase from the current 37 percent to 45 percent by 2005 and 53 percent by 2015. It should be noted that actual coal consumption may be lower than the projected demand, due to supply side restrictions and transportation difficulties, which will negatively affect the nation's economic growth. Actual consumption may be below the projected demand if abnormal improvements in energy efficiency, industrial structure, and technology breakthroughs can be achieved. The following sector by sector analysis is meant to provide a clear picture of the rationales behind the assumptions of the projections. The coal demand in the power sector has been discussed in Chapter 2. In this section we focus on other coal consuming sectors.

The Iron and Steel Industry. The analysis of coal consumption in the iron and steel industry is provided in Table 5.3. Between 1980 and 1995, China's steel production increased from 37 Mt to 93 Mt, and net imports of steel and semi-finished steel products decreased from 5 to 4 Mt (it increased to 35 Mt in 1993, then decreased to 4 Mt in 1995). Total equivalent consumption of steel increased from around 42 Mt to 97 Mt, and the equivalent steel consumption growth rate averaged 5.8 percent per year. China's annual growth rate of equivalent steel consumption is projected to average 4.3 percent during the 1996-2000 period, and reduce to about 3.1 percent in the 2001-2015 period, and equivalent steel demand is projected to reach 140 Mt by 2005 and 190 Mt by 2015.

Assuming that China can keep net steel imports at approximately 10 Mt per year in the long run, although China does have plans to reduce its dependency on steel imports, then domestic steel production will have to increase to 130 Mt by 2005 and 180 Mt by 2015.

The coal consumption to produce the projected amount of steel depends on the following factors: (1) the total energy consumed in producing one ton of steel, or the specific energy consumption of steel; (2) the share of coal in energy consumption of the iron and steel industry; and (3) the average calorific value of the coal used in the iron and steel industry. Between 1980 and 1991, China's specific energy consumption of steel decreased 1.8 percent per year on average, from 1.91 to 1.57 TCE. However, the potential for energy conservation in the iron and steel industry is still very large. In developed countries, for example, specific energy consumption of steel is only about 0.7 TCE, less than half of China's average level (Wang 1993). If China can reduce its specific energy consumption of steel at the current speed, then it will be reduced to 1.22 TCE in 2005 and 1.01 TCE in 2015, and total energy consumption of the iron and steel industry will reach 160 MTCE by 2005 and 182 MTCE by 2015.

Currently, coal accounts for about 72 percent of energy consumption in China's iron and steel industry, the average calorific value of coal used in the iron and steel industry is 5,740 Kcal/kg. If we assume the two figures will remain the same over the next two decades, then total coal demand in the iron and steel industry will reach 140 Mt by 2005 and 160 Mt by 2015.

Table 5.3. Projection of Coal Demand in China's Iron and Steel Industry

	Steel Produc. (Mt)	Net Imports (Mt)	Net Demand (Mt)	Energy Needs Total (MTCE)	Energy Needs Specific (TCE/t.s)	Share of Coal (%)	Coal Demand (MTCE)	Coal Demand (Mt)
1980	37	5	42	71	1.91	71	51	60
1985	47	19	66	76	1.63	72	55	67
1990	66	2	69	106	1.59	72	76	92
1991	71	1	72	112	1.57	72	80	98
1992	81	5	86	125	1.54	72	90	109
1993	88	35	123	133	1.52	72	96	117
1994	93	22	115	138	1.49	73	101	123
1995	93	4	97	136	1.46	72	98	119
2000	111	9	120	149	1.34	72	107	130
2005	130	10	140	160	1.22	72	115	140
2010	154	10	164	172	1.12	72	124	151
2015	180	10	190	182	1.01	72	131	160
Growth Rate								
1980-1995	6.3	-0.9	5.8	4.4	-1.8	0.1	4.5	4.7
1996-2000	3.6	0.0	4.3	1.8	-1.8	0.0	1.8	1.8
2001-2005	3.3	0.0	3.2	1.4	-1.8	0.0	1.4	1.4
2006-2010	3.4	0.0	3.2	1.6	-1.8	0.0	1.6	1.6
2011-2015	3.2	0.0	3.0	1.1	-2.0	0.0	1.1	1.1

The Construction Materials Industry. China's construction materials industry has undergone tremendous growth over the past 15 years due to a robust modernization drive in the country. Between 1980 and 1995, cement production increased from 80 Mt to 446 Mt, or at an average annual growth rate of about 12.1 percent. Table 5.4 shows that even at a much slower growth rate, cement production is projected to reach 940 Mt by 2005 and 1,605 Mt by 2015. The demand for bricks is correlated to the demand for cement, and is projected to reach 1075 billion pieces in 2005 and 1,670 billion pieces in 2015.

Table 5.4. Projection of Coal Demand in China's Construction Materials Industry

	Cement			Bricks			Total Coal Demand (Mt)
	Cement Production (Mt)	Coal Demand		Brick Production (Billion)	Coal Demand		
		Total (Mt)	Average (Kg/t.cem.)		Total (Mt)	Average (Kg/brick)	
1980	80	23	291	130	21	0.16	44
1992	308	77	250	408	57	0.14	134
1995	446	107	240	573	76	0.13	182
2000	670	150	223	804	96	0.12	245
2005	940	195	207	1075	116	0.11	310
2010	1258	240	191	1373	134	0.10	374
2015	1605	281	175	1670	147	0.09	428
Growth Rate (%/Year)							
1980-1995	12.1	10.7	-1.3	10.4	9.0	-1.3	9.9
1996-2000	8.5	7.0	-1.4	7.0	4.9	-2.0	6.1
2001-2005	7.0	5.4	-1.5	6.0	3.9	-2.0	4.8
2006-2010	6.0	4.3	-1.6	5.0	2.9	-2.0	3.8
2011-2015	5.0	3.2	-1.7	4.0	1.9	-2.0	2.8

Source: East-West Center 1996.

China has about 65 large and medium-sized state-owned cement plants that account for only 17 percent of cement production. About 40 percent of these plants use dry processes. Most local and township cement plants use small vertical kilns. Between 1980 and 1992, the average coal consumption of cement decreased about 1.3 percent per year on average; however, China's average coal consumption in cement production is still about 70 percent higher than that of the developed countries. If China can continuously reduce its average coal consumption of cement slightly above the historical speed, coal demand in cement production will reach 195 Mt by 2005 and 281 Mt by 2015.

In 1990 China produced 356.2 billion pieces of brick, which consumed about 53 Mt of coal (Guo 1992). Currently around 90 percent of bricks are produced in small township, village, and private (TVP) brick plants, and their energy conservation potential is very large. The average coal consumption in China's brick production is about 47 percent higher than that of the new building materials. Assume that the specific energy consumption of brick can be reduced at 2 percent per year over the next two decades, then coal demand in brick production will reach 116 Mt by 2005 and 147 Mt by 2015. Total coal demand of the construction materials industry is projected to reach 310 Mt by 2005 and 428 Mt by 2015.

<u>The Chemical Fertilizer Industry</u>. As shown in Table 5.5, between 1982 and 1995, China's chemical fertilizer production increased 5.6 percent per year, net imports of fertilizer increased 9.7 percent per year. As a result, the total consumption of fertilizer increased 7.1 percent per year. Even if we assume a much lower annual growth rate of fertilizer consumption over the next two decades, China's total fertilizer demand would still reach 69 Mt by 2005 and 89 Mt by 2015.

Considering imported fertilizer is more expensive, China plans to reduce its dependency on fertilizer imports over the long run. If China can limit its fertilizer imports to around 20 Mt in the long run, domestic production would have to rise to about 49 Mt by 2005 and 69 Mt by 2015 to meet projected increases in demand.

In 1990, around 63.5 MTCE of energy was consumed to produce 18.8 Mt of chemical fertilizer, whereby the average amount of energy consumed to produce one ton of fertilizer was

3.38 TCE. During the 1980s, the specific energy consumption of fertilizer decreased 2.6 percent per year, and China plans to reduce it at the same speed in the 1990s. If we assume that specific energy consumption of fertilizer can be reduced at about the same speed over the next two decades, then total energy demand of fertilizer production will reach 114 MTCE by 2005 and 118 MTCE by 2015. Currently, about two-thirds of China's chemical fertilizers are produced by coal. If we assume the same share, total coal demand in fertilizer production will reach 106 Mt by 2005 and 110 Mt by 2015.

Table 5.5. Projection of Coal Demand in China's Chemical Fertilizer Production

	Fertilizer Production (Mt)	Net Imports (Mt)	Total Demand (Mt)	Energy Demand		Coal Demand (Mt)
				Total (MTCE)	Average* (TCE/t.fer.)	
1982	13	6	19	54	4.18	50
1992	21	19	39	66	3.22	62
1995	26	20	46	78	3.00	72
2000	37	20	57	96	2.60	90
2005	49	20	69	114	2.30	106
2010	59	20	79	119	2.00	111
2015	69	20	89	118	1.70	110
Growth Rate (%/Year)						
1982-1995	5.6	9.7	7.1	2.9	-2.5	2.9
1996-2000	7.4	0.1	4.5	4.4	-2.8	4.4
2001-2005	5.9	0.0	4.0	3.4	-2.4	3.4
2006-2010	3.7	0.0	2.7	0.9	-2.8	0.9
2011-2015	3.2	0.0	2.4	-0.1	-3.2	-0.1

* Average energy consumption per ton of fertilizer production.

Industrial Boilers. In 1990, China had about 400,000 industrial boilers with a total capacity of around 800,000 tons of steam per hour (t/h). These boilers consume about 300 Mt of coal and emit about 150 Mt of CO_2, 6 Mt of SO_2, and 8 Mt of particulate a year (SIBRI 1992). Currently, China has about 500 industrial boiler manufacturing factories with an annual manufacturing capacity of 56,000 t/h. It is projected that the demand for industrial boilers will increase at about 4 percent a year in the 1990s and 2-3 percent a year during the 2001-2015 period. Table 5.6 shows that China's total boiler capacity is projected to reach 1.37 Mt/h by 2005 and 1.72 Mt/h by 2015.

Table 5.6. Projection of Coal Demand in China's Industrial Boilers

	Capacity of Boilers (1,000 t/h)	Average* Coal Demand. (Ton/t.h)	Average Efficiency (%)	Coal Demand	
				Total (Mt)	Exclude** (Mt)
1990	800	375	58	300	210
1995	973	345	63	336	235
2000	1184	320	68	379	265
2005	1373	306	71	421	295
2010	1553	298	73	463	324
2015	1715	290	75	497	350
Growth Rate					
1990-2000	4.0	-1.6	1.6	2.4	2.4
2001-2005	3.0	-0.9	0.9	2.1	2.2
2006-2010	2.5	-0.6	0.6	1.9	1.9
2011-2015	2.0	-0.5	0.5	1.5	1.6

* Average annual coal consumption per ton-hour steam capacity.

** Excluding boilers in the chemical fertilizer, the iron and steel, and the construction material industries.

Most of China's industrial boilers burn raw coal, and due to unreliable coal supplies and low quality of coals, coals consumed in industrial boilers very often do not match the requirements of the boiler design, leading to very low thermal efficiency. Poor operating skills at industrial boiler plants also contribute to low thermal efficiencies. Average thermal efficiency of China's industrial boilers is in the range of 55-60 percent, while efficiencies of industrial boilers in developed countries are typically more than 80 percent.

Two major energy conservation measures have been implemented in China to solve the coal quality problem. One is developing fluidized-bed combustion (FBC) boilers; another involves the use of coal preparation. Through the use of FBC boilers, thermal efficiency can be increased to above 80 percent, and pollution can be reduced substantially. However, currently, FBC boilers account for only 2.5 percent of the total capacity of industrial boilers, and the annual FBC boiler manufacturing capacity is only 2,000 t/h.

If we assume that thermal efficiency of China's industrial boilers can be increased to 71 percent by 2005 and 75 percent by 2015, total coal demand of industrial boilers will reach 421 Mt by 2005 and 497 Mt by 2015. Since about 30 percent of the industrial boilers are in the chemical fertilizer, iron and steel, and construction materials industries, the coal demand of industrial boilers excluding the above three industries will be 295 Mt by 2005 and 350 Mt by 2015.

The Residential Sector. Between 1987 and 1995, coal consumption in China's residential sector decreased from its peak 208 Mt to about 135 Mt. Coal consumption in the residential sector is a major source of air pollution in China, and thermal efficiency in the domestic sector is very low. Currently about 75 percent of coal consumption in the domestic sector is raw coal, and the efficiency is only about 15 percent. Coal demand in the domestic sector is projected to decrease to 110 Mt in 2005 and 85 Mt in 2015.

China's Coal Production

China is the largest coal producer in the world, with total raw coal production of 1,292 Mt in 1995. During the past 15 years, annual coal production growth averaged 5 percent, substantially below the growth rate over the 1949-1980 period, which averaged 10 percent. The slower production growth in recent years is not due to any lack of coal reserves. As mentioned in Chapter 2, China has about 1,000 billion tons of coal reserves, approximately one-third of the world's total.

The majority of China's coal reserves are high-quality bituminous coal (75%), with a carbon content of about 60 percent. China also has sizable anthracite reserves (12%), with a carbon content generally over 80 percent, used mainly for residential purposes and the chemical industry. Lignite reserves (13%), with a carbon content of around 30-40 percent, are located mostly in the northeast and Inner Mongolia, and is mainly burned in mine-mouth power plants. Currently, thermal coal accounts for about 55 percent of total production; however, about 70 percent of China's metallurgical coal is burned as thermal coal. The average sulfur content of China's thermal coal is 1.1 percent; the average ash content is 20 percent; the average total moisture is 10 percent; and the average calorific value is 25.2 MJ/kg (6010 Kcal/kg). According to the coal quality data base, the average sulfur content of China's thermal coal reserves is 1.15 percent, and the average ash content is 17 percent.

China's coal mines are divided into three categories: state mines are primarily large mines managed by the Ministry of Coal Industry; local state mines are mostly medium-sized mines managed by provincial, prefectural, and county governments; and TVP mines are mostly small mines owned by townships, villages, and private individuals. Since China's economic reform started in the late 1970s, the three types of mining enterprises have increased production at very different rates. Between 1980 and 1995, China's coal production grew at an average of 5 percent per year, increasing from 620 to 1292 Mt. More than 70 percent of coal production increase was due to the growth of TVP mines. As shown in Figure 5.2, during this period, the share of TVP mines in total production increased from 18 percent to 46 percent, the share of state mines declined from 56 percent to 38 percent, and the share of local state mines declined from 26 percent to 16 percent.

The key factors behind the rapid growth in small TVP mines are that they require little capital investment, were able to avoid many of the safety and environmental constraints required of large mines, were able to use large numbers of cheap miners, and had higher efficiency because they are managed like private enterprises. TVP mines provide peasants the opportunity to earn more income and therefore are supported by local governments. Currently more than 2 million miners are working in China's TVP mines.

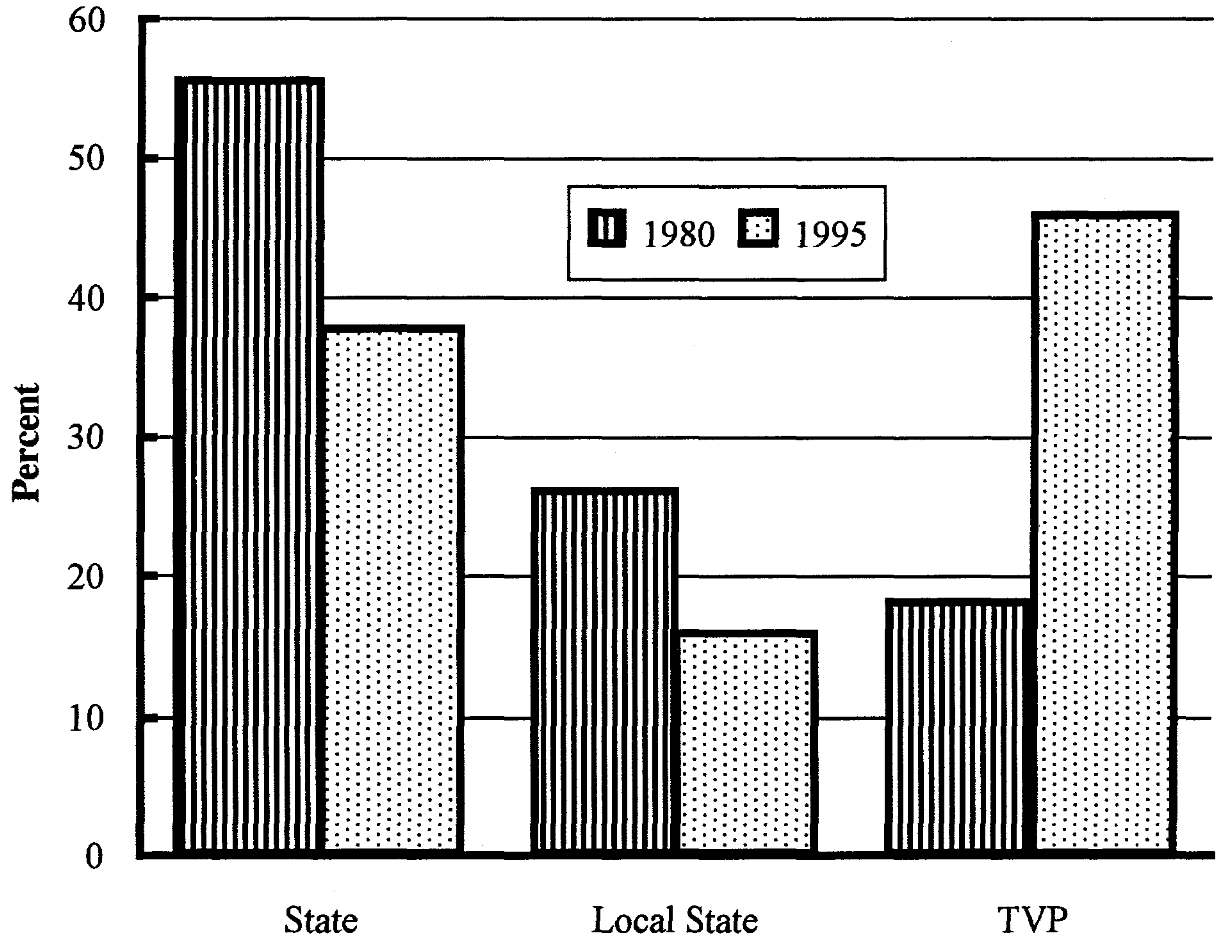

Figure 5.2. Changing Shares of China's Coal Production by Types of Mines

As shown in Table 5.7, the capital cost and operating cost of TVP mines are only about half of the respective costs in the state mines. It should be noted that the cost data were based on 1989 constant price. The current value is much higher due to China's high inflation rates. However, the relative production costs are still relevant. In addition, production costs in coastal regions are generally higher than in the Coal Base.

Table 5.7. China's Coal Production Costs

	Coal Base (yuan/ton)	Coal Base ($/ton)*	Coastal (yuan/ton)	Coastal ($/ton)
Operating Cost				
TVP	12--46	1.4--5.5	40--60	4.8--7.2
Local State	20--50	2.4--6.0	40--70	4.8--8.4
State	35--58	4.2--7.0	50--120	6.0--14.5
Capital Cost				
TVP	100--140	12.0--16.9	125--150	15.1--18.1
Local State	160--200	19.3--24.1	200--240	24.1--28.9
State	200--250	24.1--30.1	250--300	30.1--36.1

Note: the cost date are based on 1989 constant price.
* Based on current exchange rate of 8.3 RMB yuan = 1 US$.

The major problems of the TVP mines are resource waste, the high death rate of miners, and interference on the production of state mines. As shown in Figure 5.3, the average recovery rate is around 15 percent for TVP mines, 55 percent for state mines, and 35 percent for local state mines. In 1993, the death rate at TVP mines was 8.5 people per Mt of coal production, 6-7 times higher than that of the state mines. Currently China has more than 80,000 TVP mines, and half of these mines are illegal. There are 25,000 TVP mines within the territory of the state mines, of which 70 percent are illegal. During the past 15 years, around 3,000 TVP mines dig into the state mines, which caused more than 3,000 deaths and direct economic losses of 2 billion yuan.

A major policy issue in the coal sector is the regulation of TVP mines. In the 1980s, the Chinese government lifted or ignored most regulations in order to promote more coal production from TVP mines. This led to a rapid development of TVP mines. However, the negative impacts of nearly uncontrolled TVP mining resulted in government action to control these mines. In 1993, the government started to shut down unsafe TVP mines. By 2000, China plans to reduce the total number of TVP mines by 50 percent. The degree to which China can actually strengthen its regulations on TVP mines in the long run will be determined by the balance of short-term versus long-term interests, as well as local versus national interests.

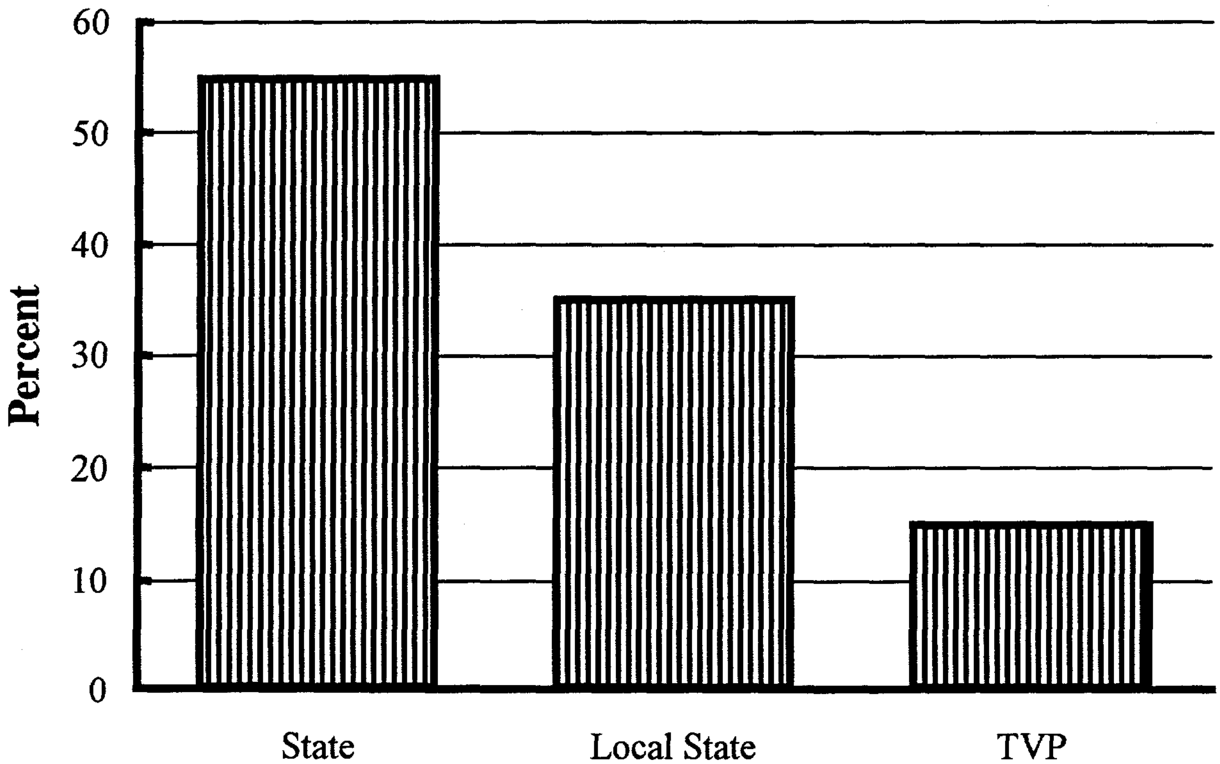

Figure 5.3. The Recovery Rate of China's Coal Mines by Type.

The Chinese government hopes to rely more on large and medium-sized coal mines to meet its coal demand in the long run. However, the current conditions at state mines are not ideal. Major problems plaguing state mines include: (1) serious financial problems and insufficient investment in coal development; (2) low production efficiency and excess labor; and (3) insufficient capacity to transport coal to the demand areas.

China's state coal mines include 104 coal mining administrations (614 coal mines). Traditionally, the Chinese central government invested in state coal mines, and the state-set coal prices were far below market clearing levels. As a result, more than 90 percent of the state coal mining administrations are losing money. Annual losses of the state mines increased from 500 million yuan ($57 million) in 1985 to 12.4 billion yuan ($1.5 billion) in 1991. The cumulative losses of the state mines during 1985-91 were 42 billion yuan ($5 billion), while the total government subsidy during the same period was only 19 billion yuan ($2.3 billion). The remaining 55 percent of the losses was covered by cutting expenditures such as maintenance and exploration. This damaged the future productivity of existing mines and limited the ability to develop new mines.

The financial difficulties of the state mines are also attributable to delays in payments for coal sales. Reportedly, by the end of October 1994, defaulted debts of all state mines amounted to 29.3 billion yuan ($3.5 billion), among which unpaid debts for coal sales totalled about 20 billion yuan ($2.4 billion), roughly half of the total annual sales. Excluding the debts owed by the state coal mines, the customers still owe the coal mines 13.4 billion yuan ($1.6 billion). Due to a lack of funds, major state coal mines ordered only eight sets of comprehensive mining equipment in 1994, while at least 50 sets were needed to replace the old ones, and 15 sets should be added to keep a reasonable development (*China Daily* April 7, 1995). In the first nine months of 1994, the state mines owed more than 2 billion yuan ($240 million) in salaries to workers. By the end of 1994, unpaid pensions amounted to nearly 300 million yuan ($35.6 million).

To reduce the negative impact of delayed coal payment, a delivery-on-payment policy was introduced by the Ministry of Coal Industry. Coal enterprises now are able to get back more than 90 percent the value of coal sold, compared with last year when nearly half of the coal was sold without being paid for. By the end of February 1995, the total amount of default debts had been reduced to 28 billion yuan ($3.32 billion).

The first obstacle to the delivery-on-payment policy came from local governments, many local governments urged coal mines to continue their supply to locally crucial enterprises (gashouses, power plants, and metallurgical companies) without timely payments. The transportation system has its own plans, which are usually made one or two months ahead. Many mines can neither send coal to those who paid on time nor stop coal from going to those who did not pay due to the restrictions of the transportation system. The policy is also threatened by gloomy prospects for the coal market.

In order to solve the financial difficulties of the state coal mines, the Chinese government decided to release controls on coal prices. The Chinese government also reduced its subsidy to the state mines by 2 billion yuan each year and intends to eliminate all subsidies to the state mines by 1996. Production costs of the state mines are projected to increase by 3.6 billion yuan in 1994 due to price increases of raw materials. Although the state mines have attempted to balance their budgets, including 100,000 laid off from the current work force of 3.21 million miners, coal prices will have to increase to cover the reduced subsidy and increased production costs. However, coal price increases have faced severe resistance from the power sector which is also politically powerful.

Coal productions are limited by China's serious railway capacity constraints. Coal producers are normally responsible for coal transportation. When coal price controls were removed, China also reduced the railway transportation quota previously allocated to state mines. Since local coal mines have greater flexibility in spending their money than state mines, they have a comparative advantage over the state mines in gaining access to rail transportation. In fact, even before the complete release of coal price controls in 1994, the transportation quota was decreasing. As a result, coal production at the state mines in 1993 decreased by about 10 Mt, while coal production at the local mines increased by about 35 Mt.

Coal production in China is currently planned by the government to reach 1.4 billion tons in 2000. However, even under conservative estimations, coal demand in 2000 is likely to exceed 1.5 billion tons. The 100 Mt gap between coal demand and the current coal development plan for 2000 could cause three possible scenarios: (1) a coal shortage will slow down economic growth; (2) the increased marginal return of coal will force the country to import coal; or (3) China will speed up its domestic coal development to meet the increased energy demand.

The first scenario is unlikely, because as stated earlier, the driving forces of China's rapid economic growth are dramatic increases in the effective labor supply and effective capital stock brought about by economic reforms. China is unlikely to let an energy shortage curb its economic growth as it did under the planned economic system in the 1970s and early 1980s.

Whether China can close the gap between coal demand and supply through increases in domestic production depends on China's future development policies in the energy and transportation sectors. Based on current policy directions, we believe that China will meet most of its energy demand through more rapid development of domestic coal resources. In South and East China, substantial coal imports are likely, due to limitations of domestic transportation capacity.

In the short term, there are limited investment opportunities in China's coal sector. Foreign firms will have difficulty achieving acceptable returns on investments in the short term if they must rely entirely on the Chinese market. Domestic suppliers are unlikely to meet demand by the late 1990s and shortages will push prices to acceptable levels in some areas of China. Therefore, regional price differences and transportation capacity are critical in selecting mine sites.

In the medium term, there will probably be substantial mining opportunities for foreign companies. Foreign firms will be able to achieve acceptable profits from sales to the domestic market. In developing coal mines, secure transportation is most important. Improving coal quality through washing will be greatly expanded, and future legislation and enforcement are likely to result in a premium for high quality, low sulfur coals.

In the long term, there will be substantial opportunities in exploration for coal. Although China has abundant estimated coal resources, proven reserves based on the international standards are not very high, and about 70 percent of the proven reserves are occupied by existing coal mines; therefore, only about 40 billion tons of reserves are available to develop new large and medium-size coal mines. Current low exploration activities cannot meet China's demand for quality reserves in the long term; therefore, China is likely to invite foreign companies to participate in exploration on favorable terms in the long run..

Facing the possibility of long-term coal shortages, China is pushing forward with several initiatives to get foreign investors involved in mining, processing, and transportation projects. In September 1995, the Ministry of Coal Industry offered 247 projects for foreign investors, including 16 large open-cast mines in a trade fair at Xiamen.

China's Petroleum and Natural Gas Development

According to the national oil and gas resources assessment completed by CNPC in 1993, China has 151 Mesozoic, Cenozoic, and Palaeozoic sedimentary basins onshore and in the continental shelf of China, with a total area of 4.33 million square kilometers; the total estimated petroleum resources are 88.8 billion tons (648 billion barrels), and the total estimated gas resources are 39,000 billion cubic meters (1377 TCF). Proven oil and gas reserves account for 20 and 3 percent of estimated resources respectively. However, China's oil and gas reserves based on western standards are only about 70 billion barrels and 300 TCF respectively, while proven oil and gas reserves are only 24 billion barrels and 60 TCF respectively.

The regional distribution of oil and gas in China is also uneven. About 80 percent of the proven oil reserves and 88 percent of oil production are concentrated in the eastern portion of China, north of the Yangtze River. Natural gas reserves are mainly located in the central Sichuan Basin, the Shaanxi-Gansu-Ningxia Basin, and the Talimu Basin in west China. Offshore natural gas is mainly located in the South China Sea and East China Sea. The oil and gas resources in Northwestern China is just second to the eastern region, and is the main potential area. China's future oil and gas development strategy is "stabilizing eastern production, developing the western region, and speeding up the exploration for natural gas."

Growth in domestic crude oil production has been limited since the mid-1980s due to the increasing difficulty of recovery from older fields in eastern China. Only limited exploration and development of potential reserves was undertaken in this period, reflecting official preference to concentrate investment in existing fields. However, China has increased its oil exploration activities since the fourth quarter of 1993, because it has become increasingly difficult to maintain current production levels at the decades-old oil fields of East China.

China is now the fifth largest oil producer in the world. In 1995, China produced 149 Mt (2.98 million barrels per day) of crude oil and 17.6 billion cubic meters (BCM) of natural gas. Table 5.8 shows China's major oil and gas production bases. By the end of 1994, China had developed 323 oil fields and built 18,000 km of pipelines for the transportation of oil and gas. Two-thirds of China's oil is transported by pipelines.

Table 5.8. China's Major Oil and Natural Gas Production Bases

Name	Production in 1994		Percent in Total Production	
	Crude Oil Mt	Natural Gas BCM	Crude Oil %	Natural Gas %
China Total	146.08	17.00	100.0	100.0
Daqing	56.01	2.32	38.3	13.6
Shengli	30.90	1.31	21.2	7.7
Liaohe	15.02	1.75	10.3	10.3
Xinjiang	7.90	0.83	5.4	4.9
Zhongyuan	4.83	1.20	3.3	7.1
Huahei	4.64	0.30	3.2	1.8
Dagang	4.25	0.40	2.9	2.4
Jilin	3.30	0.19	2.3	1.1
Henan	2.05	0.04	1.4	0.2
Changqing	1.96	0.08	1.3	0.5
Qinhai	1.13	0.07	0.8	0.4
Jiangsu	0.92	0.02	0.6	0.1
Jianghan	0.87	0.08	0.6	0.5
Yumen	1.85	0.09	1.3	0.5
Yanchang	0.63	0.00	0.4	0.0
Sichuan	0.16	7.07	0.1	41.6
South Sea & Bohai Sea	4.63	0.00	3.2	0.0

Source: 1995 Energy Report of China.

Xinjiang is the most important potential area for future oil development. The Tarim Basin, Jungger Basin, and Turpan-Hami Basin (covering a total area of 720,000 square kilometers), are estimated to contain 28 percent of China's total oil reserves and 33 percent of total gas reserves. To date, 38 oilfields with oil reserves of 1,781 Mt (13 billion barrels) and gas reserves of 161 BCM (5.7 TCF) have been discovered in this region. Chinese geologists indicate that reserves in the Tarim Basin in southern Xinjiang are on the order of 60 billion barrels of oil and 88 TCF of natural gas. The government claims that recoverable oil reserves in western China are at least 220 billion barrels, but this number may be overestimated. The claim has not yet been confirmed independently or recognized internationally.

To promote the oil development in Xinjiang Province, in the third round of onshore bidding in 1995, China opened 12 blocks covering 112,739 square kilometers in the Tarim Basin and the Junggar Basin. All proposals must be received by October 31, 1995. CNPC and Japan's Marubeni may jointly bid for oil exploration rights. Marubeni and CNPC also intend to launch a feasibility study for an oil refinery near the prospective Tarim Basin exploration site (*China Daily* June 30, 1995). The oil production in the Tarim Basin reached 39,000 b/d in 1994, and oil production of the Cainan oil field in Jungger Basin has reached 30,000 b/d in mid-1995.

A transportation bottleneck may limit the crude oil produced in Xinjiang to be shipped out. Oil production in Xinjiang is expected to reach 5 Mt per year (100,000 b/d) by the end of 1996, but the annual rail capacity for the transportation of crude oil to the central area is only 3 Mt. Railway transport will be saturated when Tazhong, the Tarim's fifth oilfield, with an annual capacity of 2.5 Mt (50,000 b/d), goes into full production at the end of 1996. To ease the transport bottleneck, China plans to turn Korla, a town close to Tarim, into a major petrochemical base. Reportedly, the Tarim Petrochemical Exploration and Development Bureau will raise 25 billion yuan ($3 billion) to build an oil refinery, a power plant, and some factories to manufacture chemical fertilizer, ethylene and methane in Korla. The refinery will be designed for an annual production capacity of 1 Mt (20,000 b/d). A project to double the tracks of the rail line from Urumqi to Lanzhou in Gansu Province is expected to begin operation later in 1995. A 219-km desert highway will be extended to another 250-km to cover Xinjiang from north to south. China is also considering construction of a 2,200-km pipeline linking Xinjiang to eastern China. The multi-billion dollar pipeline will be feasible only if the Tarim, Karamay, and Turpan-Hami oil fields have a combined annual oil production of over 10 Mt. Currently CNPC is building a 310 km pipeline to carry 22 million barrels of oil and 14 BCF of gas out of the Tarim Basin. The pipeline is scheduled to be completed by July, 1996 and will stretch from Tazhong 4, Tarim's largest oil field, to Lunnan at the northern fringe of the basin.

China's off-shore exploration has identified 7.8 billion barrels of oil and 4.7 TCF of gas. Offshore oil production is expected to reach 65.7 million barrels in 1995, increasing 30 percent from 1994. By now, all 13 operational offshore oil and gas fields are making profits, with a profit rate of about 40 percent. China expects to drill 11 new oil wells in the East China Sea in the next few years (*China Daily* June 20, 1995)

In 1993 China became a net oil importer. This position reflects a market reversal of China's emphasis on exporting petroleum to earn foreign exchange. During the early 1980s, oil and petroleum products accounted for 20-25 percent of gross export earnings, but rapid economic growth and expansion in the stock of motor vehicles has quickly eroded the possibility of continued growth in exports. In 1995, China exported 18.85 Mt (377 thousand b/d) of crude oil and 4.15 Mt (83 thousand b/d) of petroleum products; it imported 17.09 Mt (342 thousand b/d) of crude oil and 14.39 Mt (288 thousand b/d) of petroleum products. Net imports of crude oil and oil products was 8.48 Mt (170 thousand b/d).

After two years of rapid growth in oil consumption in 1992 and 1993, China's annual oil consumption growth dropped to 4.5 percent in 1994 and 1995 as a result of the government's macro-adjustment policy aimed at controlling inflation. Since China's oil production is unlikely to increase sharply unless new oil fields can be developed quickly, current policy emphasizes that oil should be used only where it is difficult to be substituted by other fuels, such as in the transportation sector, in petrochemical feedstocks, and for agricultural mechanization.

According to China's Foreign Trade Administration, China's oil demand will increase from the current 3 mmb/d to 4 mmb/d by 2000, while its oil production will remain at about 3 mmb/d. Oil demand is increasing both from the industrial sector and other sectors in the country. For example, China is expected to become the world's third largest automobile market after the United States and Japan by 2010 when its annual demand could reach 6.5 million cars. High-sulfur crude oil from the Middle East is predicted to occupy 85 percent of China's crude oil imports in 2000. Total Chinese crude imports is expected to reach 1 mmb/d in 2000, 1.6 mmb/d in 2005, and 2 mmb/d in 2010 (*The Business Daily* June 1, 1995). Meanwhile, China's consumption of LPG used for cooking increased from 2.56 Mt in 1980 to 5.43 Mt in 1994. A quarter of the LPG consumption was met by imports. By 2005, cooking gas demand is projected to rise to 17 Mt, leaving potential shortages of 8 Mt to be met by imports.

At present, natural gas provides only a small contribution to China's overall energy structure: about 2 percent of total primary energy consumption. Limited domestic production and constraints on gas imports are largely responsible for the low share of gas in current energy use. Chinese natural gas production expanded rapidly from a very limited base in the 1960s and 1970s with the discovery of large gas fields in Sichuan. In the 1980s, however, gas production fell as the increased output of associated gas from oil fields failed to offset declining production from major gas fields. About half of the natural gas output is used in the oil fields, such as in heating oil pipelines and for reinjection for oil recovery. Most of the remaining gas is used in chemical and fertilizer industry. Official policy since 1980 has encouraged the residential use of gas in heating and cooking. Natural gas is available in over one-half of China's cities, but less than 20 percent of these urban populations actually have access to gas (Agenda 21 1994). Very little gas is burned in power plants. Currently, China is expanding its gas distribution infrastructure in Sichuan and Guangdong. Plans for constructing a national gas transport grid, as well as a pipeline to transport gas from the Shaanxi-Gansu-Ningxia gas field in Northwest China to Beijing are also under consideration.

New gas fields have been discovered and geological formations suggest the potential of sizeable resources. In addition to the Tarim Basin, promising fields exist in the Ordos Basin, the East China Sea, and Sichuan. However, domestic exploration to determine the magnitude of gas resources remains an outstanding issue, since development and exploration have, until recently, been virtually ignored. This reflects not only the Chinese government's underpricing of natural gas, but also the lack of political clout of Chinese natural gas interests among state petroleum companies and the perception of very limited opportunities for regional exports of gas. Foreign assistance could support more aggressive exploration and development in the Tarim and Sichuan basins, as well as in the development of a distribution infrastructure.

China's onshore natural gas production was 16 BCM (565 BCF) in 1994, of which 7 BCM was produced in Sichuan Province. In an effort to narrow the gap between gas demand and supply, CNPC has decided to further push its onshore gas production. By 2000, gas production is projected to reach 883 BCF (*China OGP* December 15, 1994). CNPC is trying to step up gas exploration and development in the western fields where the Shaanxi-Gansu-Ningxia basin has a proven reserve of more than 3.5 TCF.

China is also speeding up its offshore gas development. Reportedly, construction of a natural gas project in Hainan Province is almost finished. The gas field is 91 meters underwater and occupies 53 square kilometers. With total reserves of 3.5 TCF, the field is expected to produce steadily for 20 years. The gas field will begin trial production in December 1995. Its annual production will be about 120 BCF. Natural gas produced in this field will be delivered to Hong Kong and the Nanshan terminal in Sanya (*China Daily Business Weekly* May 28, 1995).

China's current policy in encouraging the residential use of natural gas is sound given the opportunity to achieve sizable reductions in indoor air pollution. This use of natural gas is likely to absorb virtually all available domestic supplies in the near future. Unless additional sizable reserves are found that could yield supplies above the demand in household and commercial sectors, natural gas is likely to play a limited role in power generation. However, in some local and urban areas, the use of natural gas in small gas turbines and combined-cycle systems may prove cost-competitive.

Coalbed methane is an important undeveloped energy source in China. The most recent estimates of China's coalbed methane resources to a depth of 2,000 meters range from 1,060-1,240 TCF. Other estimates place the upper limit of this resource at 2,825 TCF. By all accounts, the resource base of coalbed methane in China is among the largest in the world, and most importantly, much of this large resource lies in the eastern part of China, where most of the population and industrial base is located.

Total methane emitted from China's coal mines is estimated in the range of 425-635 BCF per year, while the 110 state coal mines that employ methane recovery systems recovered only 15 BCF in 1990, they accounted for 2.4-3.5 percent of total methane emissions. This enormous volume of wasted and polluting energy is about equal to the annual production of the coalbed methane fields in the United States, which was 550 BCF in 1994. Currently, the Chinese government is actively seeking international technology and investment to assist in alleviating the serious problems of coalbed methane utilization in coal mining operations. However, the role of coalbed methane is likely to account for only a small share of total energy consumption over the next two decades.

Renewable Energy Development

Renewable energy sources represent a major component of future energy supply. Over the next several decades some of the renewable technologies, including wind, solar, and biomass are expected to become cost-competitive with conventional energy sources. At present, however, renewable energy plays a very limited role in China's power generation. Current energy economics suggest renewables are best suited for specific applications such as residential and commercial water heating and space heating, and in remote areas poorly served by existing power systems. China's already sizable programs to develop rural energy supplies and considerable success in promoting the adoption of improved biomass stoves indicate recognition of the potential and need to locally produce renewable energy suited for rural areas.

The Chinese government has invested sizable funds in the development of passive solar houses, solar cookers and water heaters, solar dryers, and photovoltaic technologies. It has been reported that 2 million solar water heaters are used residentially, with annual sales of 500,000 domestically produced units. The government plans for solar energy facilities to provide 2-3 MTCE of energy by 2000, concentrated in remote areas. The installation of water and space heating units for residential and commercial sectors and for industrial process heat will likely require backup energy sources. Advances in western photovoltaic and solar power generation technologies have brought operating costs down to an estimated 2-4 times that of conventional power generation. At this price the technology is likely to have cost-effective applications only in special situations, such as remote areas off regional grids. To date China has shown only limited interest in pursuing these technologies for integration into the power generation systems.

China's total wind power resources are estimated at 1,600 GW, about 10 percent of the estimated resources that are believed to be exploitable. The most promising areas to develop wind power are in Shandong, Liaoning, and Inner Mongolia. By the end of 1994, China had only 30 MW wind power capacity in Guangdong, Xinjiang, and Inner Mongolia. Of these facilities, the biggest unit has a capacity of 0.5 MW. The current annual wind power generation is about 80 GWh (*Science and Technology Daily* May 11, 1995). Eleven additional wind farms are projected to be established in the next five years, bringing total wind capacity to a projected 1 GW by 2000. Although the wind turbines has achieved significant reductions in cost in recent years, it is still an expensive option to provide electric power in China. Chinese experts estimate wind power capacity would cost 7,000-10,000 yuan ($840-1200) per kW in China, compared with domestically manufactured coal-fired capacity normally below $500/kW. Therefore wind power may be competitive in cost with new coal-fired plants only in special cases. To gain continuous power supply, the combined system of wind power and pumped-storage hydropower has been developed.

Much of the Chinese population relies on direct combustion of biomass (firewood, manure, and agricultural wastes) for its energy needs. The high reliance on biomass, which accounts for about 70-80 percent of rural energy needs, is the primary driving force behind massive deforestation and the non-sustainable uses of agricultural residues. Part of the Chinese government's attempts to raise rural welfare has been to promote efficient biomass combustion. Improved stoves have raised the efficiency of combustion from 11 to 24-40 percent with relatively simple design alterations. However, efforts to promote biogas digesters have been considerably less successful. Large-scale biomass gasification remains at the demonstration stage. At present, the shortage of rural energy resources remains a major obstacle to rural development.

Regional Energy Development

Figure 5.4 shows that China has six administrative regions, they are: (1) North China, which includes Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia; (2) Northeast China, which includes Liaoning, Jilin, and Heilongjiang; (3) Northwest China, which includes Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang; (4) East China, which includes Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, and Shandong; (5) Southwest China, which includes Sichuan, Guizhou, Yunan, and Tibet; and (6) Central South China, which includes Henan, Hubei, Hunan, Guangdong, Guangxi, and Hainan. Regional statistics of coal reserves and oil and gas resources are based on the administrative regions.

However, in discussing China's coal resources and economic development levels, China is divided into 8 regions as shown in Figure 5.5, which we will use when refering to economic regions. They are: (1) the Central Region (Shanxi, Shaanxi, Gansu, Ningxia, and Qinghai); (2) the West Region (Xinjiang); (3) the North Region (Inner Mongolia); (4) the East Region (Beijing, Tianjin, Hebei, Shandong, Henan, and Anhui); (5) the South Region (Yunan, Guizhou, and Sichuan); (6) the Northeast Region (Liaoning, Jilin, and Heilongjiang); (7) the Southeast Region (Fujian, Jiangxi, Jiangsu, Zhejiang, Hubei, Hunan, Guangdong, Guangxi, Shanghai, and Hainan); and (8) the Southwest Region (Tibet).

Regional Distribution of Energy Resources

China's regional distributions of energy resources are highly skewed. As shown in Figure 5.6, around 86 percent of China's coal resources are concentrated in the Central, North, and West region. However, these regions are underdeveloped economically. Table 5.9 shows that the social output value of these regions only accounts for 8 percent of the nation's total. The South region and the East region account for 12 percent of China's coal resources and 35 percent of social output value, while the Northeast region and Southeast region account for only 2 percent of coal resources but 57 percent of social output value.

The exploration of oil and gas in China is also uneven. About 85 percent of the proven oil reserves are concentrated in the eastern portion of China and in the region north of the Yangtze River. Northeast China accounts for about half of China's total oil and gas reserves, followed by East China (18.2%), North China (14.4%), and Northwest China (14%). Central South and Southwest China have very little oil and gas reserves.[1]

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[1] Note we have switched to the administrative regions in discussing the regional distribution of oil and gas resources, as well as coal reserves, due to the availability of regional statistics.

Figure 5.4. China's Administrative Regions

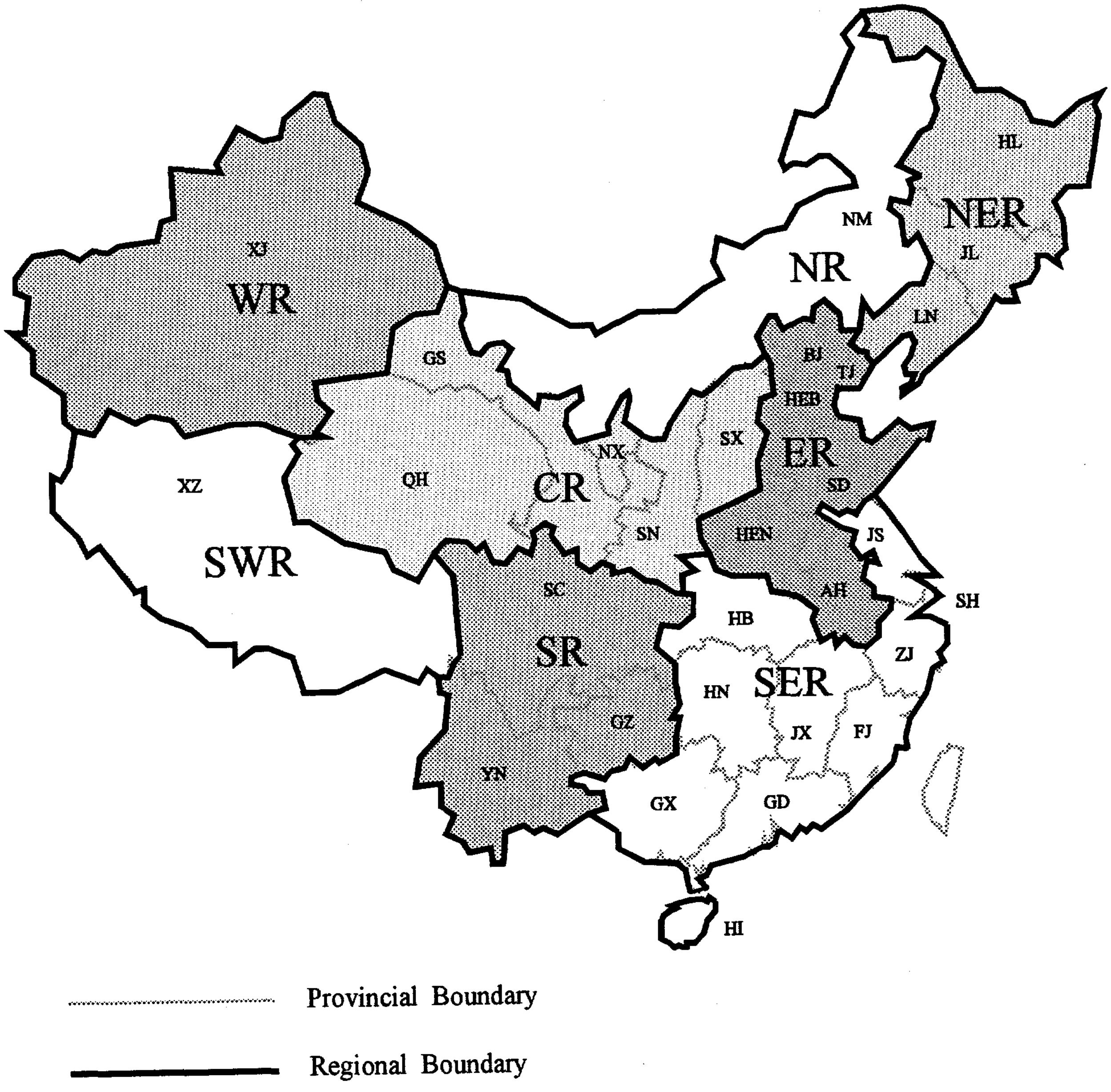


Figure 5.5. China's Economic Regions

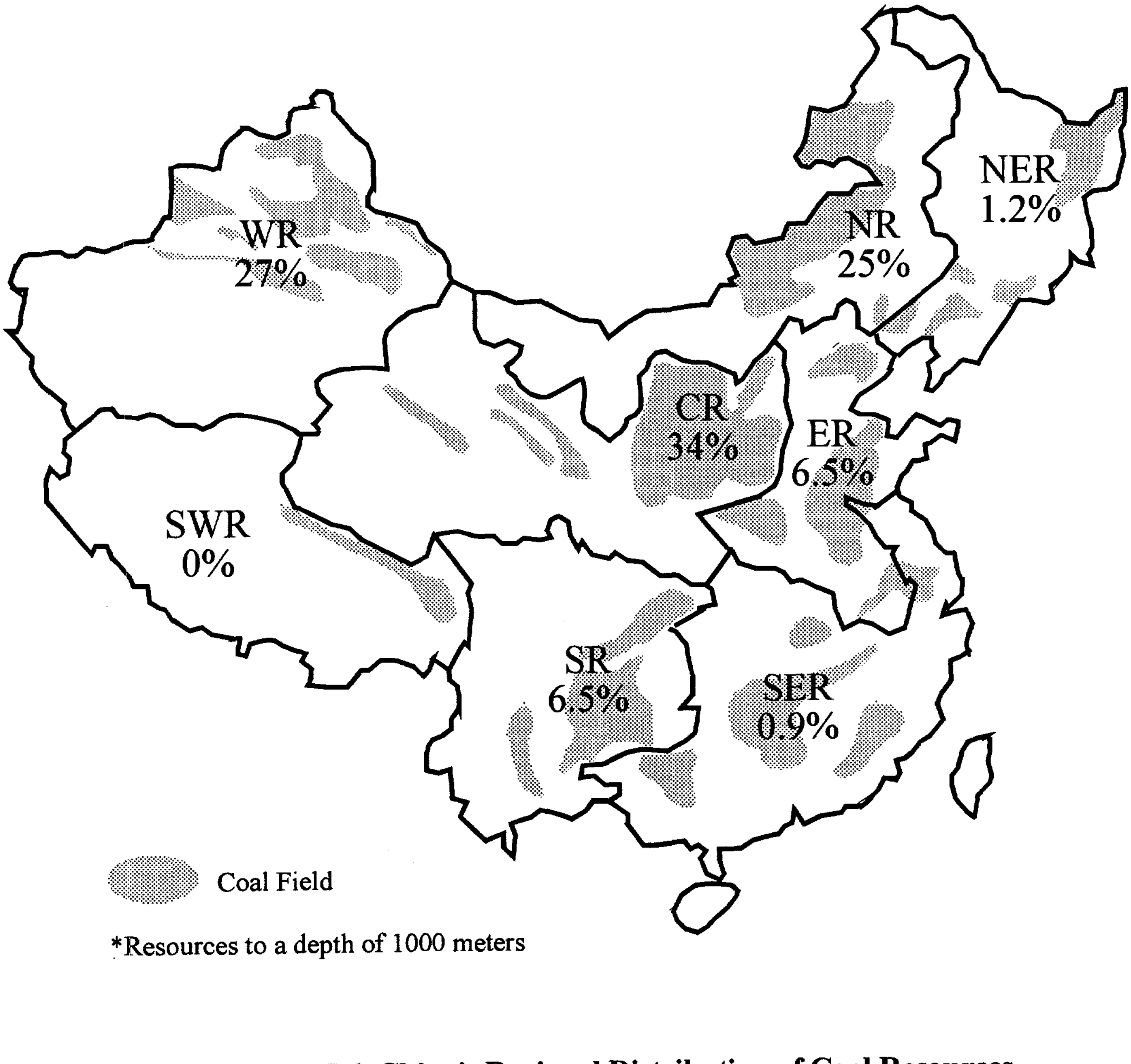


Figure 5.6. China's Regional Distribution of Coal Resources

Table 5.9. Regional Distribution of Coal Resources and Economic Development Levels

	Units	Central	West	North	East	South	Northeast	Southeast	Southwest
Coal Resources									
Resources (<1000M)*	BT	686	558	505	112	134	25	18	0
Share of China	%	34	28	25	6	7	1	1	0
Resources (<1500M)*	BT	1237	1282	912	222	269	54	24	1
Share of China	%	31	32	23	6	7	1	1	0
Resources (<2000M)*	BT	1934	2023	1407	400	332	79	28	1
Share of China	%	31	32	23	6	5	1	0	0
Economic Indicators:									
Social Output Value	%	6	1	1	26	9	13	44	0
Industrial Output Value	%	5	1	1	26	8	13	46	0
Steel Production	%	6	1	4	23	9	23	35	0
Electricity Generation	%	12	10	3	26	9	15	35	0
Cement Production	%	7	1	1	26	10	11	41	0
Fertilizer Production	%	8	2	1	29	16	7	37	0
Coal Production	%	31	2	4	25	12	14	12	0
Coal Consumption	%	12	2	3	28	11	17	26	0

* Coal resources within the depth of 1,000, 1,500, and 2,000 meters accordingly.
Source: Energy of China, June 1994.

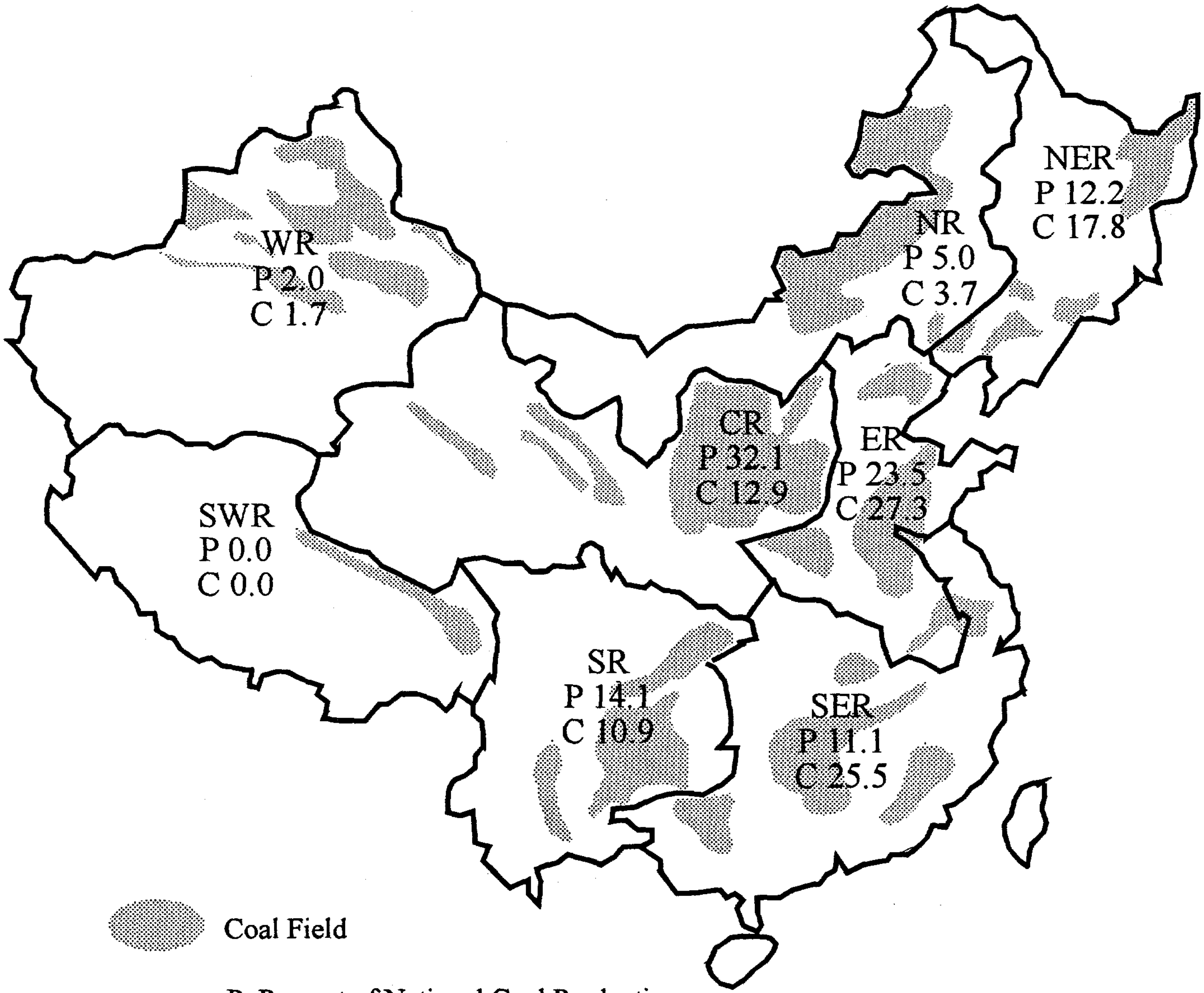
The distribution of coal reserves is similar to the distribution of coal resources. More than 80 percent of China's coal reserves are located in North, Northwest, and Northeast China. Shanxi, Inner Mongolia, and Shaanxi provinces account for 27, 21, and 16 percent of China's total coal reserves, respectively. In the south, coal reserves are concentrated in Southwest China (10.7%). With total reserves of about 50 billion tons, Guizhou Province is the most important coal base south of the Yangtze River. Coal production in Guizhou is projected to increase from 45 Mt in 1993 to 60 Mt in 2000 and over 100 Mt in 2020. About 6 percent of China's coal reserves are located in East China, where Anhui Province has the most coal reserves (25 billion tons). Central South China is the most coal-deficient region, with only about 3 percent of China's total coal reserves.

Thermal coal reserves are mainly located in North China and Northwest China, which account for about 85 percent of the national total thermal coal reserves. The top seven provinces are: Inner Mongolia, Shaanxi, Shanxi, Xinjiang, Guizhou, Ningxia, and Yunnan.

Regional Energy Balances and the Needs for Transportation

Although coal resources are highly concentrated in the northern regions, coal is mostly consumed, and to a large degree produced, in the eastern regions. As shown in Figure 5.7, with only 8.6 percent of the nation's coal resources, the three eastern regions (Northeast, East, and Southeast) account for more than 70 percent of total coal consumption and 47 percent of coal production. However, in the major industrial provinces of Northeast, East, and Southeast China, economically recoverable reserves are rapidly being depleted. As a result, the share of coal production in the three eastern regions decreased about 15 percentage points from 62 percent to 47 percent over the past 15 years. This trend is expected to continue given the availability of coal resources in these region.

The eastern half of the country must rely increasingly on supplies from surplus-producing areas in the North and Central China, centered in Shanxi and its neighboring provinces: Shaanxi, Henan, Ningxia, and Inner Mongolia. This area is commonly referred to as China's Energy Base. The long distance between suppliers and consumers add to the already great pressure on the transport system. A centerpiece of China's coal development strategy is to increase the already large coal production and transport capacity in the Energy Base. Although additional railway capacity is one of the most important ways to solve transport bottlenecks, other options can reduce the demand for coal transport, such as coal washing, mine-mouth power plant and long distance electricity transmission. However, development of coal washing and mine-mouth plants are limited by the availability of water resources in the Energy Base. It is difficult to add more than 25 GW new mine-mouth plants in the Energy Base because of water shortages.



Coal Field

P: Percent of National Coal Production

C: Percent of National Coal Consumption

Figure 5.7. China's Regional Distribution of Coal Production and Consumption

Coal beneficiation can play a valuable role in reducing the burden of transportation, since steam coal supplied to many users, particularly to small users, often contains 20-30 percent ash by weight, and a high percentage of coal fines. Although coal washing offers environmental and transport benefits, plus lower disposal and boiler maintenance costs, some carbon is also lost in the process. In power plants, washed coal can be more efficient than raw coal if the boiler is designed for it. In 1994, 23.15 percent of coal was washed in China, compared with more than 50 percent in most Western countries. The percentages of washed coal are 49 percent for state mines, 19 percent for local state mines, and almost zero for TVP mines. Most coking coal and some anthracite for chemical fertilizer production are washed, but less than 10 percent of steam coal is washed. Almost none of the plants used for washing steam coal are designed for that purpose; they are mostly designed for washing coking coal and anthracite. There is a large potential to increase the share of steam coal which is washed.

Relocating energy intensive industries from the east to the west is also an important energy strategy in China; however, the relocation process appears very difficult, costly, and time consuming due to various social, political, and economic reasons. Continued transportation difficulties will promote the relocation process.

The remaining coal resources in the eastern regions, although occurring in increasingly less economical locations, depths, seam thicknesses, and amounts, have become strategically important for relieving shortages in the eastern regions. An important ancillary coal development strategy is to continue or accelerate mining in select eastern regions in order to buy time or fill gaps while the transport capacity out of the energy base is expanded to reach the demanding regions. The tradeoff in cost is that production from the limited eastern coal reserves is increasingly expensive and of poorer quality.

The Central Region. The major part of the Energy Base is located in the Central region. Coal production in the Energy Base is planned to reach 540 Mt by 2000 and 1,200 Mt by 2015, of which 800 Mt will be transported to other regions. Current coal transportation capacity from the Energy Base is about 200 Mt per year, planned new transportation projects may add another 300 Mt per year by 2015, and mine-mouth plants are unlikely to convert more than 80 Mt per year of coal from railway transportation to electricity transmission. There is a gap of at least 200 Mt per year of transportation needs to be filled, and transportation capacity shortages will be a long lasting phenomenon in China.

With one-third of China's coal reserves, Shanxi Province has become China's largest base in coal, power, metallurgical, and chemical industries. In 1994, Shanxi produced 324 Mt of coal, exported about 200 Mt to 26 provinces, and transmitted about 8.5 TWh of electricity to the Beijing-Tianjin-Tangshan area. In 1995, coal production in Shanxi increased to 340 Mt. Shanxi is not only abundant in coal reserves, but also has the highest quality coal in China. Shanxi coal generally is low in ash and sulfur but high in heat content. The coal seams are thick, and mining operation and capital costs are much lower than in southern or eastern regions. Transporting coal out of Shanxi Province is the major concern of Chinese planners.

The Datong-Qinhuangdao line is the most important railway to ship coal from Shanxi. In December 1993, the 653 km railway officially opened to traffic. This is the first dual-track heavy-duty electric line designed especially for transport coal out of Shanxi. The transportation capacity of this line is about 100 Mt per year. A similar line is planned to start at the Shenfu-Dongsheng coal mine at the juncture of Shaanxi and Inner Mongolia, to run across Shanxi, and to terminate at Huanghua Port in Hebei Province (820 km). A total investment of 10.7 billion yuan ($1.3 billion) is expected, and construction work is expected to last 6-7 years.

A 253 km rail line between Houma, Shanxi Province, and Yueshan, Henan Province was opened on November 20, 1994. This line is an important channel for transporting coal from Shanxi to Henan. It is designed as a double-line electric railway. The electrification of its first phase is expected to be finished in 1995, and the construction of the second track is underway. The Houma-Jiafeng section of the line can transport 20 Mt of freight annually, and 50 Mt when the second track is added. The Jiafeng-Yueshan part of the line has a capacity of 27 Mt and will reach 70 Mt when the second track is completed. Construction on the 3.3 billion yuan ($398 million) railway was begun in October 1989.

China also plans to construct an 800-km pipeline from Mengxian in Shanxi to Weifang in Shandong for coal transportation. The pipeline will be built with funds and technology from the United States. A feasibility study is being done jointly by the Chinese and Americans.

China's high quality steam coal is located in the west part of Inner Mongolia and the north part of Shaanxi Province. Most coals in this region have sulfur content below 0.5 percent, ash below 10 percent, and heat value around 7,000 Kcal/kg. Coal reserves in this region are estimated to exceed 130 billion tons. Reportedly, the presence of a coalfield with deposits of 4.4 billion tons of high quality coal has recently been verified in Shaanxi Province. The 730-square kilometers coalfield, located to the north of Yulin City, has been measured as having nine beds of coal totalling 17 meters in thickness (*China Daily* March 9, 1995).

The North Region. Although the North Region (Inner Mongolia) produced only 64 Mt of coal in 1995, with rich coal reserves, this region is expected to become a major coal surplus region in the future. Currently, coal development in Inner Mongolia is accelerating. With 230 billion tons of estimated coal reserves, the Shenfu-Dongsheng coal field at the juncture of Shaanxi and Inner Mongolia is a promising area for coal development. Since the first coal mine started production in 1990, total production capacity in the Shenfu-Dongsheng coal field has reached 1.65 Mt. Now a number of million-ton-scale coal mines are accelerating their development speed. The 3 Mt Bulianta Mine has started production by the end of 1994; the 3 Mt Shangwan Mine and the 2.4 Mt Wujiata Mine are projected to start production in 1995 and 1996 respectively; and the 4 Mt Batota Mine has passed its feasibility study. By 1996, total production capacity of Dongsheng Coal Field will reach 14.7 Mt.

With the approval of the State Council, Inner Mongolia is to open up the Wanli Coal Mine Area where about 1.8 Mt of coal have been produced per year. Covering 1,148 square kilometers of area, the Wanli area includes three coal mines: Tongjiangchuan, Chaidengnan, and Wanlichuan. The government has invested 5.3 billion yuan ($609 million) in developing the Wanli area. The first phase of construction aims to produce 15 Mt of coal per year.

Construction of the Zhunge'er coal field in Inner Mongolia is near completion and will have an open-pit mine capable of producing 12 Mt of coal per year. Total capital cost of this project is estimated at 6.79 billion yuan ($818 million) or 566 yuan per ton of production capacity (China Daily August 21, 1995). Proven coal reserves of the project are more than 20 billion tons. To transport coal to other places in the region, a 289 kilometer railway line is also under construction.

The Northeast Region. With coal consumption exceeding production by about 70 Mt, the Northeast region suffered coal shortages, and severe shortages for this region can be expected to continue due to its rapid economic growth and restricted transport capacity. The Northeast region has significant reserves of coking coal, but the current policy is that the Northeast should not use its coking coal for power generation. Therefore, the Northeast must supplement its own coal supply by shipping coal from south of the Great Wall.

Currently, there are three main routes to transport coal into the region, which include (1) the Qinhuangdao-Shengang railway line; (2) Jining-Tongliao railway line; and (3) shipping from Qinhuangdao to the ports at Dalian, Yingkou, and Dandong. All the three routes will be saturated by 2000. Furthermore, increasing capacity on these three routes cannot by itself solve the problem of shortages in the region because bottlenecks from the Energy Base will prevent coal from reaching Qinhuangdao and Jining. Coal imports also cannot solve the problem, because they are feasible only for the coastal port of Dalian but not for most interior cities, due to congestion within the region.

Expansion of the Hailar-Harbin railway and introducing heavy-haul technology in existing lines are foremost among the recommendations. Other strategies to reduce coal shortages in this region include (1) washing the steam coal which is transported from Shanxi to the Northeast; (2) increasing coal production within the region, despite the high cost of developing the remaining reserves; (3) developing mine-mouth power plants in Hailar (Inner Mongolia) and Tongliao, using the abundant cheap lignite reserves, and transmitting electricity to Harbin, Shenyang, and Changchun through new transmission lines. These measures are not enough to solve the energy shortage problem, and nearly 30 percent of the country's coal shortages may occur in this region. Energy conservation should be pursued vigorously in this region.

The East Region. The imbalance of coal production and consumption is less severe in the East region than in the Northeast. Because this region is close to the Energy Base, transport of coal into this region is much easier.

With 98 Mt of coal production in 1995, Henan Province is the third largest coal producer in China. In the future, an increase in coal production in Henan is planned, especially in coal fields near Zhengzhou, Yima, Pingdingshan, and Xinxiang. Henan will remain the most important coal producer in this region.

With proven coal reserves of 25 billion tons, Anhui is also a very important coal producing province in this region. In 1995, Anhui produced 43 Mt of coal. Endowed with convenient transportation facilities, Anhui began to develop provincial coal mines in the early 1980s to augment the expansion of state mines. Anhui spent about 200 million yuan (US$24 million) in 1993 on building eight mines. These mines, still under construction, will have combined production capacity of 5 Mt per year. Anhui's local mines produced 10 Mt of coal in 1993. Currently Anhui is accelerating coal development in Huinan, which is located 570 km from Shanghai. In 1993, coal production in Huinan was 12 Mt, and coal production in Huinan is expected to increase to 40 Mt in 10 years.

The Southeast Region. In the west part of the region (Hunan and Hubei), prior to the completion of the Three Gorges project, local sources of coal supply will fall short of demand, and the transport network will continue to be congested. However, because this area is centrally located, there are many energy supply options from other regions. With the exception of the Wuhan area in Hubei Province, coal shortages may not be severe in the long run. A combination of strategies has been considered to keep shortages to a minimum. First, a new railway line from Shenmu in Shanxi to Xiangfan, near Wuhan, will be built to transport coal from the Energy Base. Second, substantial electricity from the mine-mouth power plants will be transmitted to Hubei and Hunan. Third, if hydropower plants in Sichuan are built up quickly, electricity can be transmitted from Sichuan in the interim before the Three Gorges is completed. Once completed, the Three Gorges can transmit a great deal of electricity to Sichuan.

In the northeast part of the region (Jiangsu, Shanghai, and Zhejiang), coal shortages were very severe in 1987-1988. With the completion of the Qinhuangdao port and the Tatong-Qinhuangdao railway line, the situation has been improved. Coal transportation by ship becomes the most important way to transport coal into this area. The landlocked eastern cities are in greater danger of coal shortages. Electricity transmission from Changzhi (Shanxi) to Shanghai can play a important role, as can other lines from the Energy Base to the interior cities. This area is particularly vulnerable to stricter environmental regulations because of its poor coal quality. Coal imports will be able to help the coastal cities in this area. Three coal slurry pipelines are scheduled hear.

The southeastern coastal areas of the region (Guangdong, Fujian, Hainan, and Guangxi) shares some of the logistical problems faced by the Yangtze delta area, but its industrial development is more concentrated along the coast. Because of the long distance from the energy base, this area receives only a small part of its coal by rail. Instead, it relies mainly on water shipments and locally-produced coal. A new proposal for delivering coal to this area is to ship coal from Guizhou by rail to Nanning, and then by inland waterway to Guangzhou. The coal transported to Guangzhou, Xiamen, Fuzhou, and Haikou should be washed prior to shipment. This area has substantial potential for using imported coal.

The South Region. The south region, especially Sichuan Province, is somewhat isolated from the rest of China in terms of coal transport. With total coal reserves of over 30 billion tons, Guizhou is the most important coal base to the south of the Yangtze River. Guizhou produced 55 Mt of coal in 1995 and shipped half of its production to Guangdong, Guangxi, Yunnan, and Sichuan. Coal production in Guizhou is planned to increase to over 100 Mt by 2020. In the long run, only a small amount of coal can be exported to other regions, as demand in Chengdu, Chongqing, Kunming, and Guiyang soaks up nearly all the locally-produced coal. Only Guizhou can export some coal to the Southeast. If the economic growth rate is high, this region may face coal shortages. Some lignite reserves near the Sichuan-Yunnan border could be exploited, but at a high cost to the environment.

Table 5.10 shows the provincial energy production in 1995. Shanxi is the most important coal producer (26.3%), followed by Sichuan (7.7%), Henan (7.5%), Shandong (6.3%), and Heilongjiang (6.1%). Due to resource availability, the shares of Heilongjiang, Shandong, and Sichuan are expected to decrease while the shares of Shanxi, Shaanxi, and Inner Mongolia in the north and Guizhou and Anhui in the south are expected to increase in the future.

Table 5.10. China's Energy Production by Province

	Production of Energy in 1995				
	Coal Mt	Oil Mt	Gas BCM	Electricity TWh	Hydro TWh
Total	1292	149.02	17.60	986.45	188.00
Beijing	7	0.00	0.00	11.87	0.22
Tianjin	0	5.51	0.78	12.17	0.02
Hebei	76	5.24	0.33	59.41	1.35
Shanxi	340	0.00	0.05	49.57	0.79
Inner Mongolia	64	0.00	0.00	28.22	0.22
Liaoning	55	15.52	2.12	54.11	2.13
Jilin	24	3.43	0.22	28.01	6.85
Heilongjiang	78	56.01	2.32	38.74	0.90
Shanghai	0	0.00	0.00	40.55	0.00
Jiangsu	22	1.02	0.02	66.90	0.00
Zhejiang	1	0.00	0.00	39.65	6.96
Anhui	43	0.00	0.00	30.53	1.35
Fujian	8	0.00	0.00	25.73	13.59
Jiangxi	26	0.00	0.00	18.08	6.18
Shandong	82	30.00	1.31	73.02	0.11
Henan	98	5.94	1.24	54.29	1.91
Hubei	12	0.85	0.08	44.32	27.51
Hunan	55	0.00	0.00	33.00	16.06
Guangdong	9	6.51	0.00	77.32	13.36
Guangxi	10	0.14	0.00	21.37	12.92
Hainan	0	0.00	0.00	3.08	1.12
Sichuan	99	0.18	7.68	55.86	23.58
Guizhou	55	0.00	0.16	22.59	9.55
Yunnan	28	0.10	0.16	22.41	15.05
Tibet	0	0.00	0.00	0.36	0.29
Shaanxi	38	1.72	0.02	23.47	3.82
Gansu	21	2.62	0.05	23.32	12.24
Qinghai	3	1.22	0.07	5.92	6.40
Ningxia	13	0.39	0.04	10.77	1.12
Xinjiang	25	12.63	0.91	11.85	2.47

Table 5.10. China's Energy Production by Province (continued)

	Percent of Total Energy Production in 1995				
	Coal	Oil	Gas	Electricity	Hydro
China	100.0	100.0	100.0	100.0	100.0
Beijing	0.5	0.0	0.0	1.2	0.1
Tianjin	0.0	3.7	4.5	1.2	0.0
Hebei	5.9	3.5	1.9	6.0	0.7
Shanxi	26.3	0.0	0.3	5.0	0.4
Inner Mongolia	5.0	0.0	0.0	2.9	0.1
Liaoning	4.2	10.4	12.0	5.5	1.1
Jilin	1.9	2.3	1.2	2.8	3.6
Heilongjiang	6.1	37.6	13.2	3.9	0.5
Shanghai	0.0	0.0	0.0	4.1	0.0
Jiangsu	1.7	0.7	0.1	6.8	0.0
Zhejiang	0.1	0.0	0.0	4.0	3.7
Anhui	3.3	0.0	0.0	3.1	0.7
Fujian	0.6	0.0	0.0	2.6	7.2
Jiangxi	2.0	0.0	0.0	1.8	3.3
Shandong	6.3	20.1	7.4	7.4	0.1
Henan	7.5	4.0	7.0	5.5	1.0
Hubei	0.9	0.6	0.4	4.5	14.6
Hunan	4.3	0.0	0.0	3.3	8.5
Guangdong	0.7	4.4	0.0	7.8	7.1
Guangxi	0.8	0.1	0.0	2.2	6.9
Hainan	0.0	0.0	0.0	0.3	0.6
Sichuan	7.7	0.1	43.7	5.7	12.5
Guizhou	4.3	0.0	0.9	2.3	5.1
Yunnan	2.1	0.1	0.9	2.3	8.0
Tibet	0.0	0.0	0.0	0.0	0.2
Shaanxi	3.0	1.2	0.1	2.4	2.0
Gansu	1.6	1.8	0.3	2.4	6.5
Qinghai	0.2	0.8	0.4	0.6	3.4
Ningxia	1.0	0.3	0.2	1.1	0.6
Xinjiang	2.0	8.5	5.1	1.2	1.3

Crude oil is mainly produced in Heilongjiang (37.6%), Shandong (20.1%), Liaoning (10.4%), Xinjiang (8.5%), and Henan (4%). The Chinese government's current strategy in oil development is to find new sources of oil from all over the country, especially from the western part of the country, to compensate for the likely loss of production capacity in the east.

China's natural gas is mainly produced in Sichuan (43.7%), Heilongjiang (13.2%), Liaoning (12%), Shandong (7.4%), and Henan (7%); while hydro electricity is mainly produced in Hubei (17.4%), Sichuan (12.9%), Hunan (8.1%), Fujian (7.3%), and Guangdong (7.1%).

Table 5.11 shows the provincial distribution of energy consumption in 1990. Coal is consumed relatively evenly over the country, with Liaoning, Hebei, Shanxi, Shandong, Sichuan, Heilongjiang, Jiangsu, and Henan above 60 Mt, and others mostly below 40 Mt.

Natural gas is now mostly consumed near gas fields. Recently, China constructed two pipelines spanning 880 km under the South China Sea, supplying natural gas to Hong Kong and Hainan from Yacheng. A 780 km pipeline supplies 2.9 BCM of natural gas to Hong Kong each year started on January 1, 1996. The other 100 km pipeline supplies 500 million cubic meters of gas to Hainan. An additional 900 km gas pipe-line is planned to supply natural gas from the Shaanxi-Gansu-Ningxia gas field to Beijing and is projected to be operational in 1997. With the completion of the first phase, the pipe-line will be able to supply one billion cubic meters of gas annually to Beijing. The gas field in the Shaanxi-Gansu-Ningxia region, China's largest, covers about 2000 square km of gas-bearing structures. It is reportedly to have verified reserves exceeding 100 billion cubic meters (3.53 TCF).

Transportation Infrastructure Development

As mentioned before, China's coal production and consumption are critically determined by the nation's transportation capacity. One of the primary reasons for coal and electricity shortages is that coal traffic saturates the capacities of many major railway lines. As shown in Table 5.12, within the State Transportation Department system (STD), coal accounted for 42 percent of railway freight tonnage, 25 percent of waterway freight tonnage, and 23 percent of highway freight tonnage in 1992.

Table 5.11. China's Energy Consumption by Province

	Energy Consumption in 1990				
	Total MTCE	Coal Mt	Crude Oil Mt	Natural Gas MCM	Electricity TWh
China	987	1055	115	15015	623
Beijing	27	24	5	274	17
Tianjin	21	18	4	366	12
Hebei	61	79	4	20	35
Shanxi	47	77	1	0	26
Inner Mongolia	24	40	1	60	12
Liaoning	79	83	12	2042	46
Jilin	35	40	4	98	19
Heilongjiang	53	65	8	2247	30
Shanghai	32	27	8	0	26
Jiangsu	55	62	7	38	41
Zhejiang	26	25	3	0	23
Anhui	28	34	2	0	19
Fujian	15	13	1	0	14
Jiangxi	17	23	1	0	13
Shandong	68	73	10	1439	45
Henan	52	61	3	1389	34
Hubei	40	33	5	426	28
Hunan	38	40	3	306	23
Guangdong	41	30	11	0	36
Guangxi	13	16	1	0	13
Hainan	1	1	0	0	1
Sichuan	64	66	2	5682	35
Guizhou	21	27	1	28	10
Yunnan	20	22	1	0	12
Shaanxi	22	27	1	7	17
Gansu	22	19	3	33	18
Qinghai	5	5	1	51	4
Ningxia	7	9	0	7	6
Xinjiang	21	18	3	502	7

Table 5.11. China's Energy Consumption by Province (continued)

	Percent of Total Energy Consumption				
	Total	Coal	Crude Oil	Natural Gas	Electricity
Beijing	2.74	2.29	4.76	1.82	2.79
Tianjin	2.10	1.69	3.80	2.44	1.99
Hebei	6.20	7.46	3.34	0.13	5.68
Shanxi	4.77	7.26	1.18	0.00	4.10
Inner Mongolia	2.46	3.75	0.84	0.40	1.96
Liaoning	7.96	7.82	10.58	13.60	7.42
Jilin	3.57	3.80	3.19	0.65	3.06
Heilongjiang	5.35	6.18	6.55	14.97	4.76
Shanghai	3.22	2.60	6.93	0.00	4.25
Jiangsu	5.58	5.90	6.09	0.25	6.61
Zhejiang	2.61	2.36	2.78	0.00	3.70
Anhui	2.80	3.25	2.02	0.00	2.98
Fujian	1.47	1.24	1.06	0.00	2.19
Jiangxi	1.75	2.15	1.16	0.00	2.05
Shandong	6.92	6.88	9.05	9.58	7.20
Henan	5.27	5.78	2.85	9.25	5.43
Hubei	4.05	3.17	4.67	2.84	4.52
Hunan	3.87	3.75	2.33	2.04	3.64
Guangdong	4.12	2.83	9.17	0.00	5.76
Guangxi	1.33	1.48	0.91	0.00	2.02
Hainan	0.12	0.06	0.21	0.00	0.22
Sichuan	6.44	6.30	1.59	37.84	5.62
Guizhou	2.16	2.57	0.72	0.19	1.66
Yunnan	1.98	2.08	0.84	0.00	2.00
Shaanxi	2.27	2.59	1.17	0.05	2.73
Gansu	2.20	1.76	2.20	0.22	2.85
Qinghai	0.51	0.45	0.44	0.34	0.68
Ningxia	0.72	0.84	0.40	0.05	0.88
Xinjiang	2.09	1.74	2.95	3.34	1.12

Table 5.12. Freight Transportation of the State Transportation Department by Cargo in 1992

	Freight Transportation (Mt)				
	Total	Railway	Highway	Waterway	Pipeline
Total	2969	1523	675	624	148
Coal	949	641	153	156	0
Building Materials	368	119	107	142	0
Petroleum	294	67	5	74	148
Iron and Steel	175	85	70	20	0
Metal Ores	143	93	11	38	0
Grain	139	64	43	32	0
Non-Metal Ores	130	82	16	33	0
Chemical Fertilizers	76	38	23	14	0
Cement	74	41	22	12	0
Timber	58	34	14	9	0
Salt	24	12	6	6	0
Other	540	247	204	88	0
National Total	10458	1576	7809	925	148
Share of STD System	28	97	9	67	100
	Share of Freight Transportation (%)				
	Total	Railway	Highway	Waterway	Pipeline
Total	100	100	100	100	100
Coal	32	42	23	25	0
Building Materials	12	8	16	23	0
Petroleum	10	4	1	12	100
Iron and Steel	6	6	10	3	0
Metal Ores	5	6	2	6	0
Grain	5	4	6	5	0
Non-Metal Ores	4	5	2	5	0
Chemical Fertilizers	3	3	3	2	0
Cement	2	3	3	2	0
Timber	2	2	2	1	0
Salt	1	1	1	1	0
Other	18	16	30	14	0

Source: China Transportation Yearbook, 1993.

Between 1985 and 1989, bottleneck links on the railway network, where traffic in at least one direction reached 95 percent of capacity, leaping from 7 to 37 percent. The Ministry of Railways (MOR) continues to ration access to congested railway corridors by supplying only a fraction of the wagons requested by shippers. Underlying the railway congestion are long-term under-investment in transportation infrastructure and inefficiencies in transport. The average shipping distance of railway coal traffic increased from 368 km in 1978 to 558 km in 1992. The length of China's transportation routes and average distance of freight transportation is summarized in Table 5.13, while the freight transportation by type is summarized in Table 5.14.

Table 5.13. Length of China's Transportation Routes and Average Distance of Freight Transportation

	Length at Year End (1,000 km)					Growth (%/year)	
	1970	1980	1990	1992	1995	70-80	80-92
Railway (in Operation)	41.0	49.9	53.4	53.6	54.6	2.0	0.6
Multiple track	6.5	8.1	13.0	13.7		2.2	4.5
Electric Railway	0.3	1.7	6.9	8.4		18.9	14.2
Highway	636.7	888.3	1028.3	1056.7	1157.0	3.4	1.5
High Quality	23.0	157.9	260.0	301.7		21.2	5.5
Inland Waterway	148.4	108.5	109.2	109.7	111.0	-3.1	0.1
1 m and Deeper	57.4	53.9	59.6	61.4		-0.6	1.1
Airline	40.6	195.3	506.8	836.6	1128.9	17.0	12.9
International	4.4	81.2	166.4	303.0	348.2	33.8	11.6
Pipeline	1.2	8.7	16.0	15.9	17.4	21.9	5.2
	Average Distance of Transportation (km)					Growth (%/year)	
	1970	1980	1990	1992	1994	70-80	80-94
Total	304	220	270	279	282	-3.2	1.8
Railway	513	514	705	734	791	0.0	3.1
Highway	24	20	46	48	50	-1.8	6.8
Waterway	366	1184	1447	1433	1465	12.5	1.5
Civil Aviation	954	1573	2218	2330	2241	5.1	2.6
Pipeline	78	467	398	417	406	19.6	-1.0

Source: A Statistical Survey of China 1996; China Transportation Yearbook, 1993.

Table 5.14. China's Freight Transportation by Type

	Freight Transportation (Mt)					Growth (%/year)	
	1980	1985	1990	1992	1995	80-90	90-95
Total	5465	7458	9706	10459	12437	5.9	5.1
Railway	1113	1307	1507	1576	1659	3.1	1.9
Highway	3820	5381	7240	7809	9500	6.6	5.6
Waterway	427	633	801	925	1100	6.5	6.6
Pipeline	105	137	158	148	177	4.1	2.4
Civil Aviation	0	0	0	1	1	15.3	22.4
	Share of Freight Transportation (%)						
	1980	1985	1990	1992	1995		
Total	100	100	100	100	100		
Railway	20	18	16	15	13		
Highway	70	72	75	75	76		
Waterway	8	8	8	9	9		
Pipeline	2	2	2	1	1		
Civil Aviation	0	0	0	0	0		
	Volume of Freight (Billion ton-km)					Growth (%/year)	
	1980	1985	1990	1992	1995	80-90	90-95
Total	1203	1813	2621	2922	3538	8.1	6.2
Railway	572	813	1062	1158	1287	6.4	3.9
Highway	76	169	336	376	489	16.0	7.8
Waterway	505	770	1159	1326	1700	8.7	8.0
Pipeline	49	60	63	62	60	2.5	-0.9
Civil Aviation	0	0	1	1	2	19.3	21.8
	Share of Volume (%)						
	1980	1985	1990	1992	1995		
Total	100	100	100	100	100		
Railway	48	45	41	40	36		
Highway	6	9	13	13	14		
Waterway	42	42	44	45	48		
Pipeline	4	3	2	2	2		
Civil Aviation	0	0	0	0	0		

Source: A Statistical Survey of China, 1996.

The Railway System

China's railway system is referred to as "the last virgin territory of the planned economy." In 1994, the railway industry as a whole started to lose money for the first time. In 1995, it is expected to lose around 10 billion yuan ($1.2 billion). The low productivity of the railway system and the rigid transportation prices are two of the most important reasons behind the poor performance of the railways. Until 1995, all the revenues and profits of the railway system were turned over to the higher authorities, with losses subsidized from above, and the Ministry of Railway was responsible for all railway profits and losses. Under such a system, business managers had neither pressure nor motivation to improve productivity and profitability. Currently, China's railway system has 3.42 million employees, or 60 employees per km of railroads.

In the railway system, the most sensitive current issue is freight rate. China's current basic freight transportation price is 2.65 fen per ton-km, in addition to the basic rate, a railway construction fund of 2.7 fen per ton-km has been charged since 1991. Thus consumers pay a total of 5.35 fen (0.64 U.S. cents) per ton-km, which is the lowest freight rate in the world. While the freight rate is fixed, the railway shipping costs increased from 39.4 billion yuan ($4.7 billion) in 1992 to an expected 68 billion yuan ($8.2 billion). In 1994, the average freight transport cost was 3.8 fen per ton-km, 1.15 fen per ton-km below the base rate. In the first half of 1995, the railway's daily cost plus business tax was 169 million yuan, while the daily revenue was only 160 million yuan (FBIS September 21, 1995).

Railways are the predominant mode of transport for moving coal in China, accounting for about 70 percent of total coal freight tonnage. Table 5.15 shows that within the STD system, railway transported 358 billion ton-km (60%) of coal, waterways 233 billion ton-km (39%), and highways only 9 billion ton-km (1.5%). The major issue for future coal delivery is how to move enough coal out of Shanxi, Shaanxi, and western Inner Mongolia. Table 5.16 shows that coal transport through the railway system was 641 Mt in 1992, of which around 30 percent was from Shanxi Province. In the future, the role of Shanxi in the Chinese coal market will be more important.

Table 5.15. Volume of Freight Transportation of the State Transportation Department by Cargo in 1992

	Volume of Freight (Billion ton-km)				
	Total	Railway	Highway	Waterway	Pipeline
Total	2551	1155	37	1298	62
Coal	599	358	9	233	0
Building Materials	82	47	3	33	0
Petroleum	226	46	1	118	62
Iron and Steel	146	82	3	62	0
Metal Ores	198	45	1	152	0
Grain	308	72	2	234	0
Non-Metal Ores	95	44	1	50	0
Chemical Fertilizers	112	32	2	78	0
Cement	29	20	1	8	0
Timber	67	51	1	15	0
Salt	17	12	0	4	0
Other	671	347	13	311	0
National Total	2920	1158	376	1326	62
Share of STD System	87	100	10	98	100
	Share of Volume of Freight (%)				
	Total	Railway	Highway	Waterway	Pipeline
Total	100	100	100	100	100
Coal	23	31	23	18	0
Building Materials	3	4	7	3	0
Petroleum	9	4	2	9	100
Iron and Steel	6	7	8	5	0
Metal Ores	8	4	3	12	0
Grain	12	6	5	18	0
Non-Metal Ores	4	4	2	4	0
Chemical Fertilizers	4	3	5	6	0
Cement	1	2	4	1	0
Timber	3	4	3	1	0
Salt	1	1	1	0	0
Other	26	30	37	24	0

Table 5.16. China's Coal Flow Through State Railways in 1992

	Coal Flow to Arriving Provinces (Mt)																													
	Beijing	Tianjin	Hebei	Shanxi	Inner Mon.	Liaoning	Jilin	HeilongJ.	Shanghai	Jiangsu	Zhejiang	Anhui	Fujian	Jiangxi	Shandong	Henan	Hubei	Hunan	Guangdong	Guangxi	Hainan	Sichuan	Guizhou	Yunnan	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	Total
Total	20	20	110	21	17	62	30	46	1	48	11	26	7	11	49	23	33	15	13	10	0	21	6	6	13	11	2	6	2	641
BJ	3	2	1			0		0		0					1															7
TJ		0	0																											0
HEB	3	2	25		1	3	0	0	0	1	0	0			1	0	1	0												37
SX	14	14	78	21	2	14	2	0	0	15	2	5	1	1	22	6	8	3	1	2					2	0	0	0		214
NM	0	2	5		12	4	2	7																		0		1		32
LN					1	29	1	1																						31
JL					0	2	14	0																						16
HL					1	9	11	38																						59
SH											1		0																	1
JS									0	12	2	1	0	0	1	0														16
ZJ											1																			1
AH									0	6	2	17	1	0																26
FJ											0		4																	4
JX										0	1	0	0	6			0	0	0	0										8
SD		0	0						0	3	2	1	0	1	24		0	0												32
HEN		0	0			1	0		0	6	1	2	0	1	1	18	19	2	2	1					0					54
HB											0		0	0			0		0	0										1
HN														0			0	9	1	1										11
GD																			6											6
GX																			0	4										4
HI																					0									0
SC														0			2	0	0	0		20		0	0					23
GZ											0		0	0			1	0	2	1		1	6	1						13
YN											0		0					0	0	0		0		6						6
SN										5	0	0		0		0	2	0							10	0				17
GS										0							0								0	5	1			6
QH																											1			1
NX	0	1	0		0	1	0			0					0							0			1	3	0	5	0	11
XJ																										2			2	4

Note: A 0 reflects transportation less than 0.5 Mt, while a blank space reflects no shipment.

The effective strategies for increasing railway capacity from the Energy Base can be divided into two categories: building more line capacity, or increasing the throughput of existing assets. China in recent years has concentrated its railway investment more on adding incremental capacity to existing lines than on building new lines, and as a result has one of the highest densities of traffic per km of track in the world. In 1993, freight traffic in China averaged nearly 22 million ton-km per route-km. As planned, China will continue expanding the capacity of existing lines by multiple-tracking, diesel traction, electrification, additional sidings and conversion to heavier axle loads. Such improvements generally offer lower investment costs per unit of capacity and relatively faster completion than new construction.

This manner of capacity expansion, however, is not sufficient to provide the needed additional throughput capacity. New lines are desperately needed. In addition to the Shenmu-Huanghua line, several other railway projects are suggested by the government, the three most important being (1) the Shexian-Handan-Jinan line, a new east-west line from the southern part of the Energy Base to Shandong Province, which is scheduled for completion by 2005, (2) the Shenmu-Yanan-Xian-Baofeng line, a new north-south line from the far western part of the Energy Base (The Shenmu-Yanan section has been completed; the Yanan-Xian section is now under construction; and the Xian-Baofeng section is under planning), and (3) a dedicated passenger line between Beijing and Shanghai, now being actively studied, that would free up capacity on the existing Beijing-Shanghai line for coal transport. Heavy haul technology will be used in the new lines.

The efficiency of the railway system depends not only on decisions made by MOR, but also on the responses by railway users. Since rail tariffs have already approached long-run marginal costs, congestion pricing on bottleneck links is being considered for bringing in additional revenues to supply new capital investment, as well as for rationalizing demand for railway transport. The second area of policy reform should be to reduce the administrative allocation of railway capacity. Currently, 60 percent of capacity is allocated by planning instead of by market bidding.

China's railway sector took substantive steps in 1994 to establish a modern enterprise system. The reform allowed 12 railway bureaus across China to have more say in planning, finance, employment, and wages. The MOR has also offered to open China's railways to foreign investment. The first step will be issuing railway stocks and bonds in overseas financial markets to attract foreign investors to railway projects in China. According to the MOR's development plan, China will construct 6,600 km of new tracks, 4,100 km of multiple-track railroads and 5,600 km of electric railroads, to reach a total length of 60,000 km by the end of 1995. Freight transportation of existing principal railways are summarized in Table 5.17.

To meet the demand for transportation, local governments are also active in railway development. Reportedly, China will start the construction of more than 70 local railway lines with a total length of 7,000 km over the next ten years. By the end of 1993, China had 81 local railway lines with a total length of 4,800 km. Currently there are 20 local railway lines with a total length of 2,000 km under construction. In the past ten years, 4.6 billion yuan ($554 million) has been invested in local railway projects, the MOR accounted for less than 10 percent of the investment. By 2000, China plans to increase the total length of local railway lines in operation to 8,000 km, which will transport 100 Mt per year with 7 billion ton-km in volume of freight transport.

The Waterway System

There are no major navigable rivers emanating from the Energy Base; however, at least part of the journey to northeast and southeast China can be made by water, either by coastal shipping, the Grand Canal, or the Yangtze River. Table 5.18 shows the major coal transport routes from Shanxi to east China. Within the STD system, about 156 Mt of coal were trans-shipped from railway to waterway in 1992. If locally-owned shipping is included, about 230 Mt of coal was moved by water. Table 5.19 shows the throughput of principal ports by cargo. Coal accounted for 33 percent of seaport throughput and 25 percent of river port throughput in 1992.

Table 5.17. Freight Transportation of Principal Trunk Railways in 1992

	Freight Transportation			
	(Mt)	(%)	(Bt-km)	(%)
Total	561	100	970	100
Beijing-Guangzhou	81	14	229	24
Datong-Taiyuan & Yuci-Mengyuan	78	14	23	2
Lianyungang-Lanzhou	51	9	101	10
Harbin-Dalian	43	8	78	8
Xiuwen-Yueshan-Xinxiang	42	7	9	1
Beijing-Shenyang	42	7	117	12
Tianjin-Shanghai	38	7	142	15
Shijiazhuang-Taiyuan	37	7	19	2
Harbin-Manzhouli	29	5	21	2
Beijing-Baotou	25	4	47	5
Qingdao-Jinan	25	4	22	2
Hangzhou-Zhuzhou	22	4	41	4
Yueshan-Zhicheng	18	3	27	3
Harbin-Suifenhe	10	2	17	2
Beijing-Qinhuangdao	6	1	14	1
Zhicheng-Liuzhou	5	1	15	2
Yanzhou-Shijiusuo	3	1	4	0
Shijiazhuang-Dezhou	3	0	11	1
Shanghai-Hangzhou	2	0	11	1
Heze-Yanzhou	1	0	2	0
Xinxiang-Heze	0	0	2	0
Datong-Qinhuangdao	0	0	17	2
National Total	1576		1158	
Share of the 22 lines	36		84	

Source: China Transportation Yearbook 1993, p.491.

Table 5.18. Combined Rail-Water Routes from Shanxi to East China

	Distance (km)		
	Rail	Water	Total
Datong-Shanghai	1,840	0	1,840
Datong-Qinhuangdao-Shanghai	620	1,350	1,970
Taiyuan-Shanghai	1,500	0	1,500
Taiyuan-Qingdao-Shanghai	920	750	1,670
Taiyuan-Nanjing	1,190	0	1,190
Taiyuan-Wuhan-Nanjing	1,180	800	1,980

Intermodal competition in China is still biased toward railways. For many origin-destination pairs, rail and waterway costs are similar, but rail is priced lower. There are numerous cost add-ons for combined rail-water routes. In addition to a port's transfer charge, ports charge pollution fees, construction fees, and policy fees. These add-ons effectively impose a congestion surcharge onto port fees. When all the costs are added together, typical shipping costs from Datong to Shanghai for an all-rail route and a rail-water route (via Qinhuangdao) are the same, both around 20 yuan per ton in 1990 prices. However, even with the pricing biases, water transport is cheaper than rail over a longer distance. For example, from Datong to Guangzhou, the cheapest all-rail rate is 36 yuan per ton, compared with 26 yuan per ton for a rail-water trip (all in 1990 prices).

An important strategy for relieving pressure on the railway system is to shift more coal onto the coastal and inland waterways. About 140 Mt of coal (excluding exports) could be shipped in 2000 from north to south, nearly double the amount in 1990. The average distance for coastal shipping can be increased from the 1989 average of about 1,250 km to almost 1,500 km in 2000. All coal transported by water will be shipped at least as far south as Shanghai, except for coal shipped to ports in the northeast and on inland waterways. The increased distance represents the removal of over 200 billion ton-km from the railway system.

Table 5.19. Throughput of Principal Ports by Cargo in 1992

	Seaports (Mt)			River Ports (Mt)			Total
	Total	Output	Input	Total	Output	Input	(Mt)
Total	604	315	289	267	121	146	871
Coal	200	119	80	66	35	31	266
Oil and Gas	107	64	43	47	20	27	155
Crude Oil	76	45	31	36	14	22	112
Metal Ores	50	15	35	19	5	14	69
Grain	41	22	19	8	3	5	49
Building Materials	30	8	22	58	20	38	88
Iron and Steel	26	10	16	13	6	6	38
Chemical Fertilizers	22	5	17	5	3	2	27
Non-Metal Ores	18	10	8	21	13	8	39
Cement	13	9	4	6	5	1	19
Timber	9	3	6	4	2	2	13
Others	87	47	39	21	9	12	108
Share of Total	100	100	100	100	100	100	100
Coal	33	38	28	25	29	21	31
Oil and Gas	18	20	15	18	17	19	18
Crude Oil	13	14	11	14	12	15	13
Metal Ores	8	5	12	7	4	9	8
Grain	7	7	7	3	2	3	6
Building Materials	5	3	8	22	17	26	10
Iron and Steel	4	3	5	5	5	4	4
Chemical Fertilizers	4	2	6	2	2	1	3
Non-Metal Ores	3	3	3	8	11	6	4
Cement	2	3	1	2	4	1	2
Timber	2	1	2	2	2	1	2
Others	14	15	14	8	8	8	12

Source: China Transportation Yearbook 1993, p.519.

Constraints which limit the scope for the waterway option include railway bottlenecks to the loading ports along the northern coast and shortages in port capacity, especially at receiving ports. At present, Shanghai will need at least 25 Mt of new unloading capacity, while numerous other ports south of Shanghai and on the Yangtze River will need 10 Mt new capacity. Because of the shortage of loading and unloading capacity, sometimes coal is transshipped at general cargo ports lacking the specialized bulk equipment necessary for efficient handling.

China currently has 16 major seaports. The throughput of China's seaports are shown in Table 5.20. To achieve the targeted waterway transportation capacity mentioned before, ports and ships require significant investment. During the 1990s, in addition to projects underway at Qinhuangdao and Huanghua, receiving ports in the south east-central regions require substantial new capacity. Shanghai will need at least 25 Mt of new port capacity, while Wenzhou, Ningbo, Xiamen, and Yuxikou need at least 5 Mt each, and many other ports need up to 5 Mt each. China is also considering construction of a port at Gaolan, near Shenzhen, which has 14-meter deep water, and can handle ships of 100,000 dwt or larger. The problems of this suggested project include its relatively high investment, maintenance, and environmental costs. The suggestion to dredge part of Shanghai harbor to 14 meters faces similar problems. Further investigation of these proposals are required to obtain a definitive conclusion.

While inland waterway traffic is about 30 percent of the tonnage of coastal flows, and averages less than 600 km, they are nevertheless important to the transporting of coal to the east, and could be expanded rapidly. There might be about 22 Mt of coal moving down the Yangtze River by 2000. The major recipients of inland waterway traffic are cities, power plants, and steel complexes along the lower reaches of the Yangtze River, but Shanghai should mostly rely on coastal shipping. The capacity of China's major river ports are shown in Table 5.21. The major rail-to-inland waterway transshipment ports, from upstream to down stream, are Zhicheng, Wuhan, Yuxikou, and Nanjing. All these ports need new capacity, especially Yuxikou. China also plans to build a fifth major Yangtze River port between Wuhan and Zhicheng, where the Beijing-Guangzhou railway will cross the river. Because the railway bridge will be a bottleneck, a new port of 5 Mt capacity per year will be constructed to handle some of the coal flows.

Table 5.20. Capacity of Major Chinese Seaports

	Throughput (Mt/Year)		Productive Use in 1994			Non-Productive Use	
			Number of Berths		Length	Number	Length
	1992	1995	Total	10,000 t	(M)	(Berth)	(M)
Total	604	771	1476	375	174278	226	16467
Dandong	1		5	1			
Dalian	59	64	60	32	11328		4056
Yingkou	5	12	17	7	25782	3	81
Qinhuangdao	81	84	25	23	5769	12	677
Tianjin	29	58	60	45	10861	8	789
Longkou	6		12	3			
Yantai	11	14	24	9	3324	2	200
Weihai	1		6	1			
Qingdao	31	51	44	24	8734	3	553
Shijiusuo (Rizhao)	12	15	9	5	1827	7	320
Lianyungang	14	17	23	18	4454	4	449
Shanghai	163	165	140	68	18995	87	3634
Ningbo	44	69	38	17	5225	16	897
Zhoushan	3		24	2			
Haimen	4		8				
Wenzhou	4		17	2			
Fuzhou	7		25	3			
Quanzhou	2		41				
Xiamen	6		51	6			
Shantou	5	7	10		1165	3	49
Shekou	7		24	7			
Chiwan	4		8	4			
Guangzhou	55	73	101	22	9570	26	1419
Zhanjiang	16	19	29	23	5280	10	1048
Haikou	4	5	11	2	1619		
Basuo	4	2	8	4	1412		
Sanya	0	0	5		602		
Beihai	1		5	2			
Fangcheng	3		10	8			
Others	20	118	636	37	58331	27	2295

Table 5.21. Capacity of Major Chinese River Ports

	Throughput (Mt/Year)	Number of Berths 1992	
	1992	Total	10,000 t
Total	267	3312	30
Harbin	3	11	
Shahezhi	1	17	
Jiamusi	2	13	
Chongqing	4	49	
Pailing	1	19	
Wanxian	1	12	
Badong	0	26	
Yichang	2	16	
Zhicheng	2	11	
Shashi	1	16	
Yanli	0		
Chenlingji	6	5	
Huonghu	0		
Wuhan	17	34	
Huangshi	1	13	
Wuxiu	1	23	
Jiujiang	6	8	
Anqing	7	13	
Chizhou	1	10	
Tongling	2	10	
Wuhu	3	26	
Maanshan	4	14	
Nanjing	47	46	13
Zhenjian	14	19	4
Gaogang	3	15	1
Jiangyin	3	11	
Zhangjiagang	5	10	7
Nantong	12	31	5
Others	118	2834	

At present, 9-meter, 20,000 dwt ships make up the main part of the bulk shipping fleet. Because of the economics of ship size, the use of large ships is generally desirable, but the potential for this is quite limited in China due to the geographic conditions at most ports. Most harbors at receiving ports are only deep enough to accommodate 9-meter draught, 20,000 dwt vessels or 9-meter shallow-draught 35,000 dwt vessels. Of the main ports on the southern coast, only Ningbo can accommodate 12-meter 50,000 dwt ships. Xiamen is now being deepened to 12-meters, while the harbors of Wenzhou and Fuzhou are only now being deepened to the minimal depth of 9 meters. None can match the 14-meter depth of Qinhuangdao. Options to deepen harbors and to develop a Panamax-class or supercollier fleet must take into account the physical conditions at each port.

The current coal shipping fleet is estimated at about 300,000 dwt of barge capacity, 2.3 Mt of 9-meter general class ships, and 100,000 tons of 12-meter vessels. An additional 2.4-3.6 Mt of fleet capacity will be needed by 2000. These totals do not include another 200,000-300,000 dwt of inland waterway barge capacity. The largest domestically produced ships in widespread use are 9-meter shallow draft ships rated at 35,000 dwt. An even bigger 9-meter 50,000 dwt design is under development for production after 2000.

Further decentralization of port and shipping operations may hasten the ability of waterways to respond to China's transport problems. Currently, most coastal shipping operations are owned by the central government, though a fair number of local shipping companies are operating in the inland waterway system, and some power plants have started to operate their own ships. Most ports are owned by the municipal governments, with the central government approving their long-term plans. Qinhuangdao is the only port wholly owned by the central government, while Xiamen and Tianjin are wholly decentralized. Greater decentralization of the waterway system is expected in the future.

To meet the investment requirement of the targeted waterway capacity, foreign investments are also being introduced to develop China's waterway system. In October 1993, the Hong Kong-based Hutchison Whampoa-led consortium signed a major joint venture contract with China to develop the Yantian Port of Shenzhen into a world-class harbor. The facilities of the project's first phase, including two 50,000-ton container berths and four general cargo berths, have already been placed in service. The project's second phase will consist of three 50,000-ton container berths, scheduled to open in 1995.

The Highway System

Trucks are used to deliver coal to users near the mines, to collect coal from scattered mines and deliver it to railhead, and to distribute coal in cities. About 153 Mt of coal was carried by trucks in the STD system in 1992. Trucks are inefficient for long-distance transport of bulk coal, thus the average shipping distance of highway coal traffic was just 63 km per trip. However, there were reports of trucks moving coal as far as 1,000 km during the worst coal shortages.

The role of trucks in short distance transportation is very important. As shown in Table 5.22, the number of trucks increased 11 percent per year over the 1978-1992 period in China. To support the increased role in truck transportation, China plans to add 18,000 km of new highways in 1994. China will build 4 cross-country routes. One of the two north-south routes runs from Tongjiang in Heilongjiang, to Sanya in Hainan; the other extends from Beijing to Zhuhai in Guangdong. The first of the two east-west routes runs from Lianyungang in Jiangsu to Korgas in Xinjiang; the second route links Shanghai with Chengdu in Sichuan. Tables 5.23 through 5.25 list China's regional railway, highway, and waterway transportation situations respectively.

Table 5.22. China's Civilian Motor Vehicles and Vessels

	Number of Vehicles (1,000)			Annual Growth Rate	
	1978	1988	1992	1978-1992	1988-1992
Total	1358	4644	6917	12	10
Passenger Vehicles	259	1304	2262	17	15
Large	88	299	381	11	6
Small	171	1004	1881	19	17
Freight Trucks	1002	3179	4415	11	9
General Freight		3089	4279		8
Special Freight		90	136		11
Other Specialized Trucks		73	103		9
Specific Purpose Trucks		89	139		12
Wheel Tractors		3916	5371		8
Walk Tractors		2513	2592		1
	Number and Capacity of Vessels			Growth (%)	Units
	1980	1990	1992	1980-1992	
Total	296.8	425.9	386.7	2.2	1000
Net Carrying Capacity	19.9	38.4	40.8	6.1	Mt
Passenger Capacity	0.6	1.2	1.2	5.5	Million
Drawing Power	1.5	1.8	1.8	1.7	GW
Motor Vessels	64.3	325.9	302.3	13.8	1000
Net Carrying Capacity	12.8	29.1	31.2	7.7	Mt
Passenger Capacity	0.5	1.1	1.2	6.6	Million
Drawing Power	1.5	1.8	1.8	1.7	GW
Barges	119.5	82.5	71.3	-4.2	1000
Net Carrying Capacity	6.0	9.1	9.4	3.9	Mt
Passenger Capacity	0.1	0.1	0.0	-6.2	Million
Sailing Boats	113.0	17.6	13.1	-16.4	1000
Net Carrying Capacity	1.2	0.2	0.1	-16.3	Mt

Source: Statistical Yearbook of China, 1993, p.532, p.537.

Table 5.23. China's Railway Transportation by Province in 1992

	Length of Railway (1,000 km)				Freight Transportation			
	State Owned		Local Owned		State Owned		Local Owned	
	Total	Operating	Total	Operating	(Mt)	(Bt-km)	(Mt)	(Bt-km)
Total	68.5	53.6	5.7	4.5	1523	1155	53	3
Beijing	1.6	1.0	0.0	0.0	29	27	0	0
Tianjin	0.8	0.5	0.2	0.1	19	25	5	0
Hebei	4.8	3.0	0.9	0.6	110	141	7	0
Shanxi	3.4	2.3	0.1	0.1	245	50	2	0
Inner Mongolia	5.8	5.1	0.0	0.0	72	53	1	0
Liaoning	4.9	3.6	0.3	0.2	146	102	3	0
Jilin	3.8	3.5	0.0	0.0	65	41	1	0
Heilongjiang	6.5	5.0	0.5	0.5	133	73	2	0
Shanghai	0.4	0.2	0.0	0.0	14	4	0	0
Jiangsu	1.3	0.7	0.0	0.0	43	33	0	0
Zhejiang	1.2	0.9	0.0	0.0	19	17	0	0
Anhui	2.3	1.7	0.1	0.1	44	49	3	0
Fujian	1.0	1.0	0.0	0.0	21	13	0	0
Jiangxi	1.9	1.6	0.1	0.1	26	23	1	0
Shandong	3.0	2.0	0.2	0.2	83	63	3	0
Henan	3.9	2.1	1.8	1.4	87	112	7	1
Hubei	2.2	1.7	0.2	0.1	40	49	1	0
Hunan	2.9	2.3	0.3	0.2	48	64	1	0
Guangdong	1.2	0.7	0.4	0.3	42	21	7	0
Guangxi	1.8	1.7	0.4	0.3	23	28	7	0
Hainan	0.2	0.2	0.0	0.0	4	0	0	0
Sichuan	2.9	2.9	0.2	0.2	67	42	2	0
Guizhou	1.5	1.4	0.0	0.0	25	21	0	0
Yunnan	1.6	1.6	0.0	0.0	22	10	0	0
Shaanxi	2.2	1.8	0.0	0.0	30	36	0	0
Gansu	2.4	2.2	0.0	0.0	26	37	0	0
Qinghai	1.1	1.1	0.0	0.0	5	3	0	0
Ningxia	0.4	0.4	0.0	0.0	14	6	0	0
Xinjiang	1.4	1.3	0.0	0.0	18	13	0	0

Source: China Transportation Yearbook, 1993, p483-485.

Table 5.24. China's Highway Transportation by Province in 1992

	Road Length (1,000 km)		Freight Trucks		Special Trucks		Freight	
			Number	Tonnage	Number	Tonnage	Tonnage	Volume
	Total	Grade	1,000	1,000t	1,000	1,000t	(Mt)	(Bt-km)
Total	1057	787	4279	17604	136	742	7809	376
Beijing	11	10	166	516	4	41	310	6
Tianjin	4	4	105	372	6	8	161	4
Hebei	47	42	305	1469	12	81	522	30
Shanxi	32	26	205	808	3	15	398	21
Inner Mongolia	44	34	100	485	3	17	197	10
Liaoning	42	40	279	1190	15	80	563	17
Jilin	27	25	112	415	4	24	165	6
Heilongjiang	48	46	180	815	23	104	225	10
Shanghai	4	4	88	341	3	22	262	4
Jiangsu	25	23	205	1100	2	15	374	19
Zhejiang	30	24	123	681	2	42	305	14
Anhui	31	27	121	501	2	10	307	16
Fujian	42	31	81	335	2	15	213	10
Jiangxi	34	20	82	322	0	0	113	6
Shandong	43	42	331	1166	9	54	403	24
Henan	45	41	219	912	6	21	316	18
Hubei	48	27	140	699	4	24	402	14
Hunan	58	28	151	594	2	8	320	17
Guangdong	56	40	383	1263	2	12	764	43
Guangxi	37	21	91	363	1	6	140	11
Hainan	13	9	22	84	0	1	69	2
Sichuan	99	56	254	933	5	18	532	23
Guizhou	32	12	67	254	1	5	132	5
Yunnan	60	52	127	571	3	14	263	14
Tibet	22	8	17	92	0	2	6	1
Shaanxi	38	30	98	387	5	22	106	7
Gansu	35	24	76	292	0	0	97	6
Qinghai	17	12	27	128	1	7	25	2
Ningxia	8	8	24	92	1	4	24	1
Xinjiang	26	22	101	424	12	70	93	10

Table 5.25. China's Waterway Transportation by Province in 1992

	Freight		Motor Vessels		Barges		Sailing Boats	
	Tonnage (Mt)	Volume (Bt-km)	Number	Tonnage 1,000t	Number	Tonnage 1,000t	Number	Tonnage 1,000t
Total	925	1326	302313	31226	71255	9438	13123	142
State	295	1190	1496	19121	2423	2823	0	0
Tianjin	1	0	204	174	517	78	0	0
Hebei	4	4	1397	126	38	25	1093	29
Shanxi	1	0	289	4	1	0	26	0
Inner Mongolia	0	0	189	3	23	3	0	0
Liaoning	3	5	680	423	64	12	0	0
Jilin	0	0	195	0	107	24	0	0
Heilongjiang	2	0	245	3	242	87	0	0
Shanghai	34	3	5337	134	4921	191	0	0
Jiangsu	156	28	118793	3167	30191	1947	0	0
Zhejiang	96	21	56296	1416	7233	430	62	1
Anhui	43	10	28149	1529	4272	471	3	0
Fujian	13	10	4714	865	89	17	282	5
Jiangxi	10	3	7131	291	545	94	708	2
Shandong	8	5	4012	370	4338	371	224	3
Henan	3	1	3147	235	331	35	2	0
Hubei	30	11	6092	270	3170	829	377	1
Hunan	38	5	12017	333	3295	189	0	0
Guangdong	145	12	33408	1739	4635	633	266	14
Guangxi	17	6	11023	516	509	115	413	11
Hainan	3	3	1104	409	86	20	121	10
Sichuan	21	7	4206	74	3860	992	6248	54
Guizhou	1	0	748	8	262	35	2162	8
Yunnan	1	0	602	7	71	14	0	0
Tibet	0	0	0	0	0	0	0	0
Shaanxi	0	0	606	5	26	3	836	2
Gansu	0	0	164	1	1	0	300	0
Qinghai	0	0	0	0	0	0	0	0
Ningxia	0	0	69	0	5	0	0	0
Xinjiang	0	0	0	0	0	0	0	0

Chapter 6

Regional Development of Power System

China's Load Centers and Power Networks

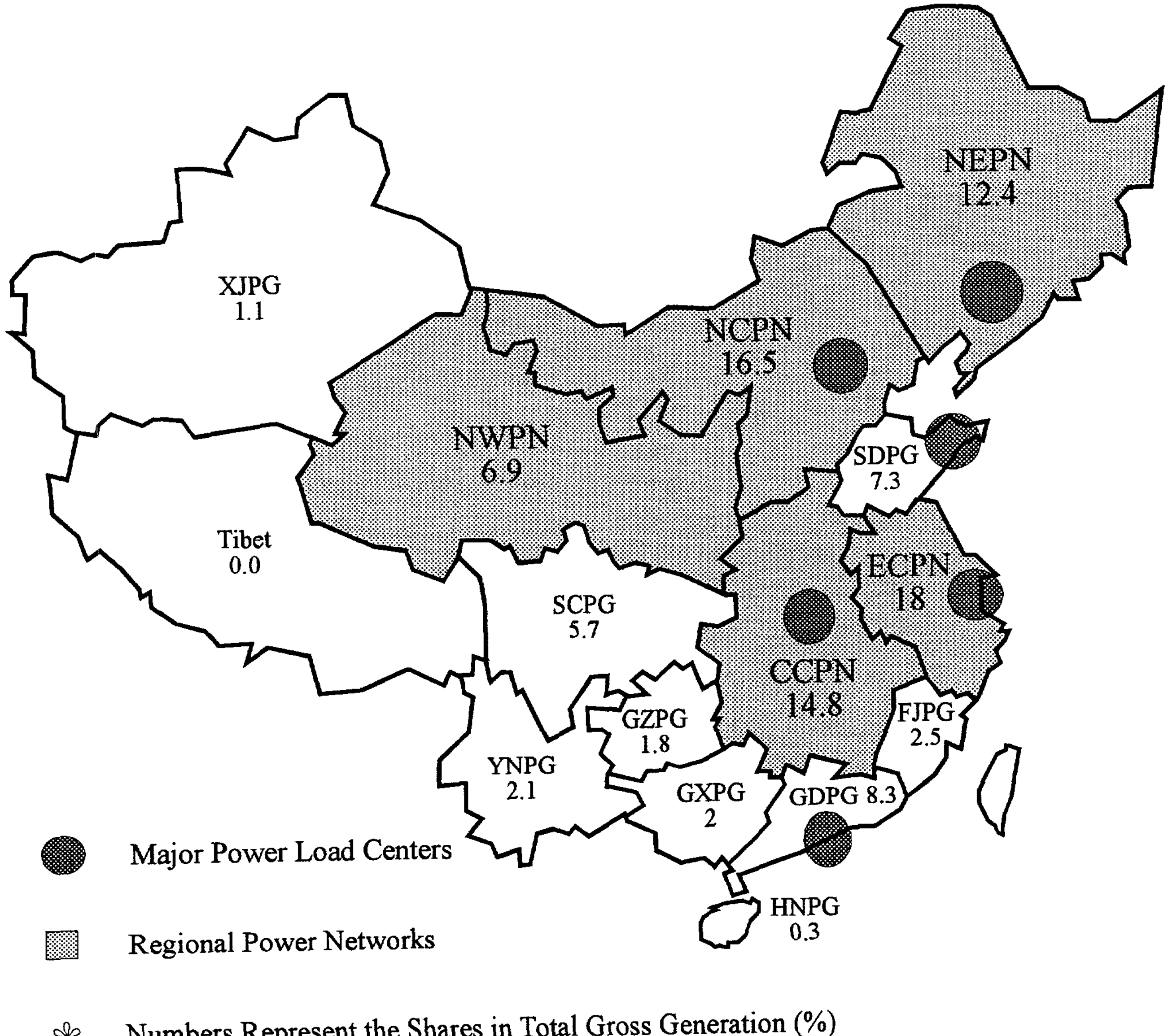


Figure 6.1. China's Power Networks and Load Centers

As shown in Figure 6.1, China has six major power load centers: (1) Liaoning Province, (2) the Beijing-Tianjin-Tangshan area, (3) the Jiaodong area in mid-Shandong Province, (4) the Changjiang Triangle, (5) the Zhuojiang Triangle, and (6) the Wuhan area in Hubei Province. These load centers account for about 5 percent of China's land area, 20 percent of population, and 40 percent of electricity consumption. China's power system comprises five regional power networks and nine provincial power grids. Figure 6.1 also shows each network/grid's share of China's gross generation. As shown in Table 6.1, as of the end of 1994, the East China Power Network (ECPN) was the largest regional power network in China, accounting for 18 percent of China's total electricity generation, followed by the North China Power Network (NCPN) 16.5 percent, the Central China Power Network (CCPN) 14.8 percent, the Northeast Power Network (NEPN) 12.4% percent, and the Northwest Power Network (NWPN) 8% percent. Among the nine provincial power grids, the Guangdong Power Grid (GDPG) has the highest share in China's gross generation (8.3%), followed by the Shandong Power Grid (SDPG) 7.3 percent, the Sichuan Power Grid (SCPG) 5.7 percent, the Fujian Power Grid (FJPG) 2.5 percent, the Yunnan Power Grid (YNPG) 2.1 percent, the Guangxi Power Grid (GXPG) 2 percent, and the Guizhou Power Grid (GZPG) 1.8 percent. The Hainan Power Grid (HNPG) and the Tibet Power Grid account for only 0.3 percent of China's gross generation. Figure 6.2 shows China's current generating capacity in each province; and Figure 6.3 shows the distribution of the existing coal-fired capacity.

In order to promote hydropower development in the southwest and transmit electricity to the east, the South China Electric Power Corporation (SCEPC) was established to provide power to Guizhou, Yunnan, Guangxi, and Guangdong Provinces. The four provincial power grids were interconnected in July 1993 to transmit electricity from the west to the east. Along with the construction of the Three Gorges project and the development of other large scale hydropower and thermal power bases, China will adopt extra-high voltage transmission lines. By 2000, China plans to create a united power network by connecting the NEPN, the NCPN, the ECPN, and the CCPN with 500 kV tie lines. A nationwide power network with Three Gorges as the center will be formed by 2010.

Table 6.1. China's Power Networks and Grids

	Capacity 1994		Generation 1994			Planned*
	Total (MW)	% of Hydro	Total (TWh)	% of Hydro	Share in China	Capacity 2000 (MW)
Northeast Network	25170	17.5	115.2	8.2	12.4	46000
North China Network	29860	4.3	153.3	1.6	16.5	57500
East China Network	36160	8.5	167.2	4.5	18.0	55000
Central China Network	29500	40.4	137.0	33.4	14.8	49432
Northwest Network	15080	38.6	73.9	30.6	8.0	25000
Shandong Grid	12060	0.6	67.8	0.1	7.3	23000
Fujian Grid	5380	62.5	22.9	47.1	2.5	10850
Guangdong Grid	19820	22.9	77.1	15.4	8.3	32540
Guangxi Grid	5020	60.4	18.7	61.8	2.0	7230
Sichuan Grid	11380	44.4	52.5	39.9	5.7	13890
Yunnan Grid	4950	73.1	19.4	65.5	2.1	8003
Guizhou Grid	3850	47.8	17.0	34.0	1.8	6270
Hainan Grid	1057	45.7	2.9	34.7	0.3	3000
Tibet Grid	167	72.5	0.4	73.4	0.0	410
Sub-Total	199454	24.4	925.1	17.6	99.7	338125
China Total	199897	24.5	928	18.0	100.0	300000

* The sub-total of planned capacity in 2000 exceeded the total planned capacity of China.

As shown in Table 6.1, the five regional power networks and nine provincial power grids accounted for 99.7 percent of China's total electricity generation in 1994. Hydropower played a very different role among these networks and grids. In the NCPN, hydropower only accounts for 1.6 percent of gross generation; while in the NWPN and the CCPN, hydropower accounts for more than 30 percent of gross generation. Although hydropower capacity accounted for 24.4 percent of total capacity, due to their relatively low capacity factors, electricity generated from hydropower plants in these networks and grids accounted for only 17.6 percent of gross generation, slightly lower than the national average of 18 percent. Table 6.1 also listed the planned generating capacity by 2000, it should be noted that the sum of the planned capacity is higher than the national total capacity planned for 2000 by the Ministry of Electric Power Industry.

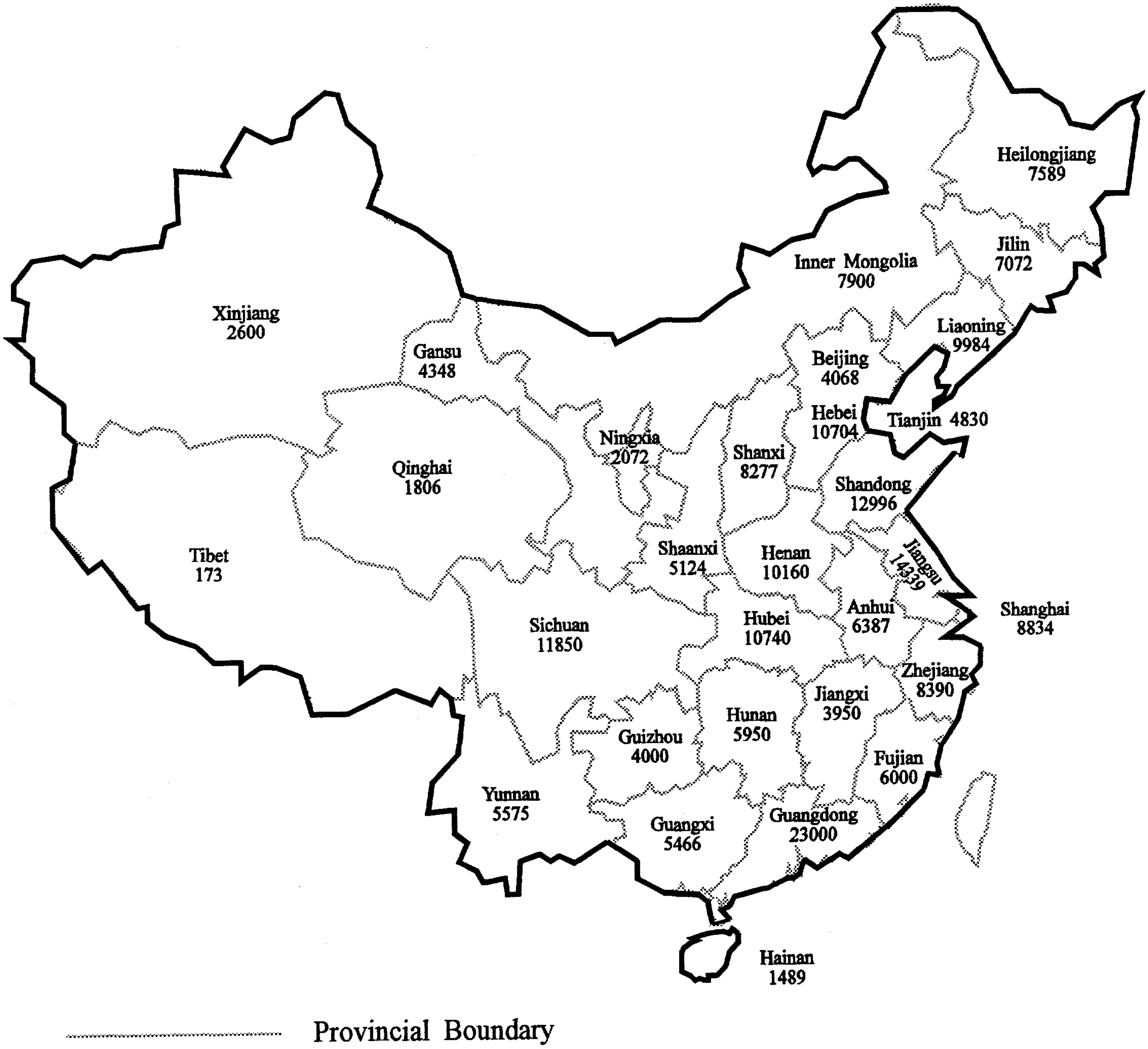


Figure 6.2. China's Existing Power Generating Capacity (MW)

Figure 6.3. China's Existing Coal-Fired Generating Capacity (MW)

The East China Power Network

The East China Power Network (ECPN) under the management of the East China Power Group (ECPG), covers Jiangsu, Zhejiang, Anhui, and Shanghai, with an overall area of 350,000 square kilometers. This relatively developed region accounts for about 22 percent of China's GDP and 16 percent of its population. With installed capacity of 38 GW (32 GW coal-fired), the ECPN is the largest regional power network in China. Total electricity generation of the ECPN was about 167 TWh in 1994, which accounted for about 18 percent of China's total electricity generation.

The ECPG has about 100 large and medium-sized power generating and dispatching enterprises, including 45 thermal power plants, 8 hydropower plants, 1 nuclear power plant, and 44 city and district power distribution companies. The locations of the principal existing power plants are shown in Figure 6.4. Currently about 89 percent of electricity is generated from coal-fired plants, 6 percent from oil-fired plants, 4 percent from hydropower stations, and less than 1 percent from nuclear power plant. Thermal efficiency in the ECPN is also higher than other power networks and grids. Between 1985 and 1994, the net coal consumption rate of principal power plants decreased from 407 to 377 gce/kWh.

The ECPN has 76,145 km of transmission lines of 35 kV and above (it has 2,617 km of 550 kV lines). As shown in Figure 6.5, a network of 500 kV transmission lines have been installed, stretching from Jiangsu in the east, Anhui in the west, and converging in Shanghai. Tianhuangping Pumped-Storage Power Station, Beilungang, Shidongkou (II), Waigaoqiao, and Changshu power plants will also be connected with the 500 kV system. The first 500 kV HVDC transmission line in China was built linking Gezhouba Hydropower Station in Hubei with Nanqiao Substation in Shanghai.

Electricity consumption in this region has been growing at about 9 percent per year over the past 10 years. Currently, heavy industry accounts for about 60 percent of total electricity consumption in this region, followed by light industry 22 percent, the residential sector 8 percent, agriculture 7 percent, and others 3 percent.

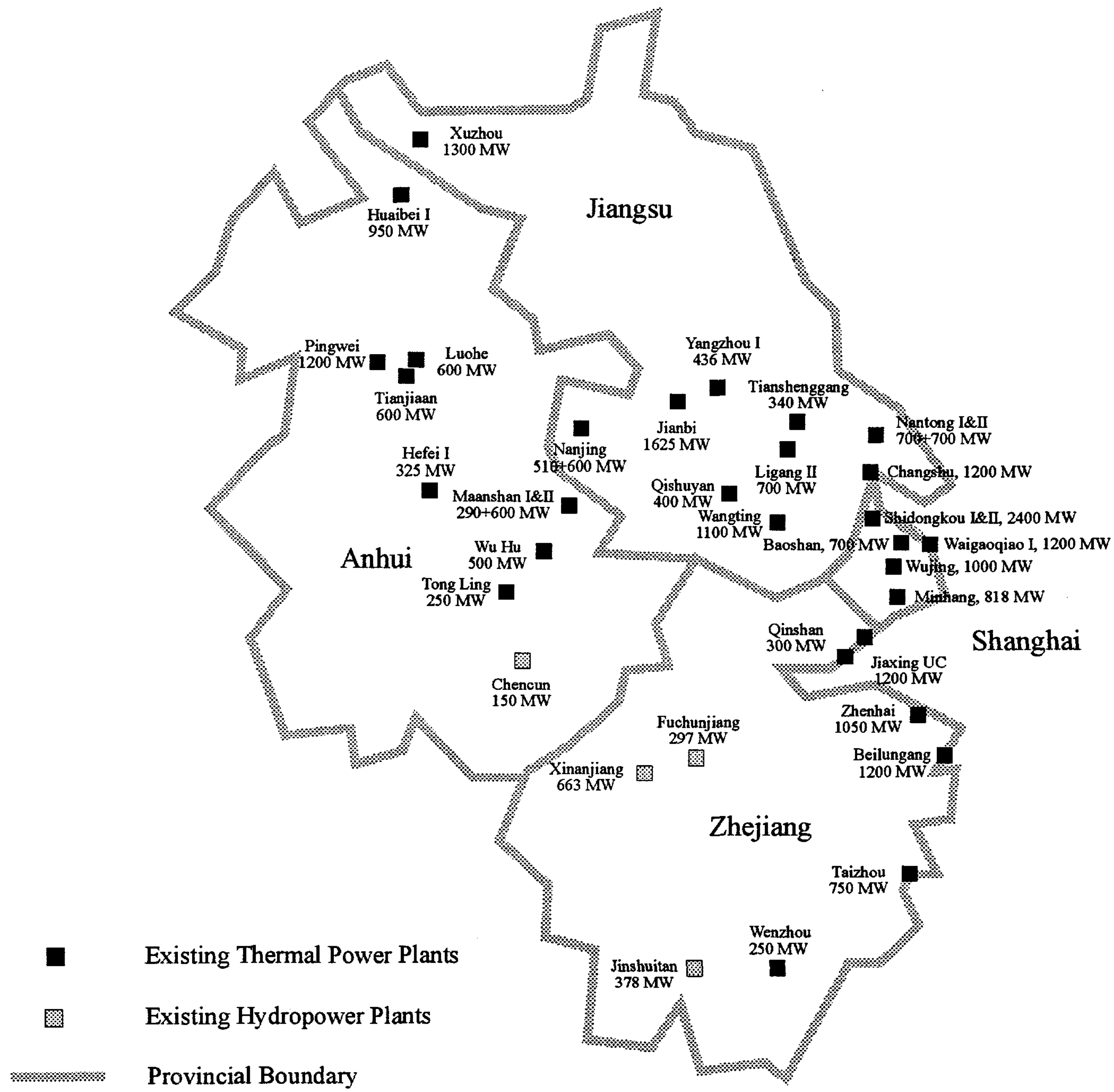


Figure 6.4. Existing Power Plants in the East China Power Network

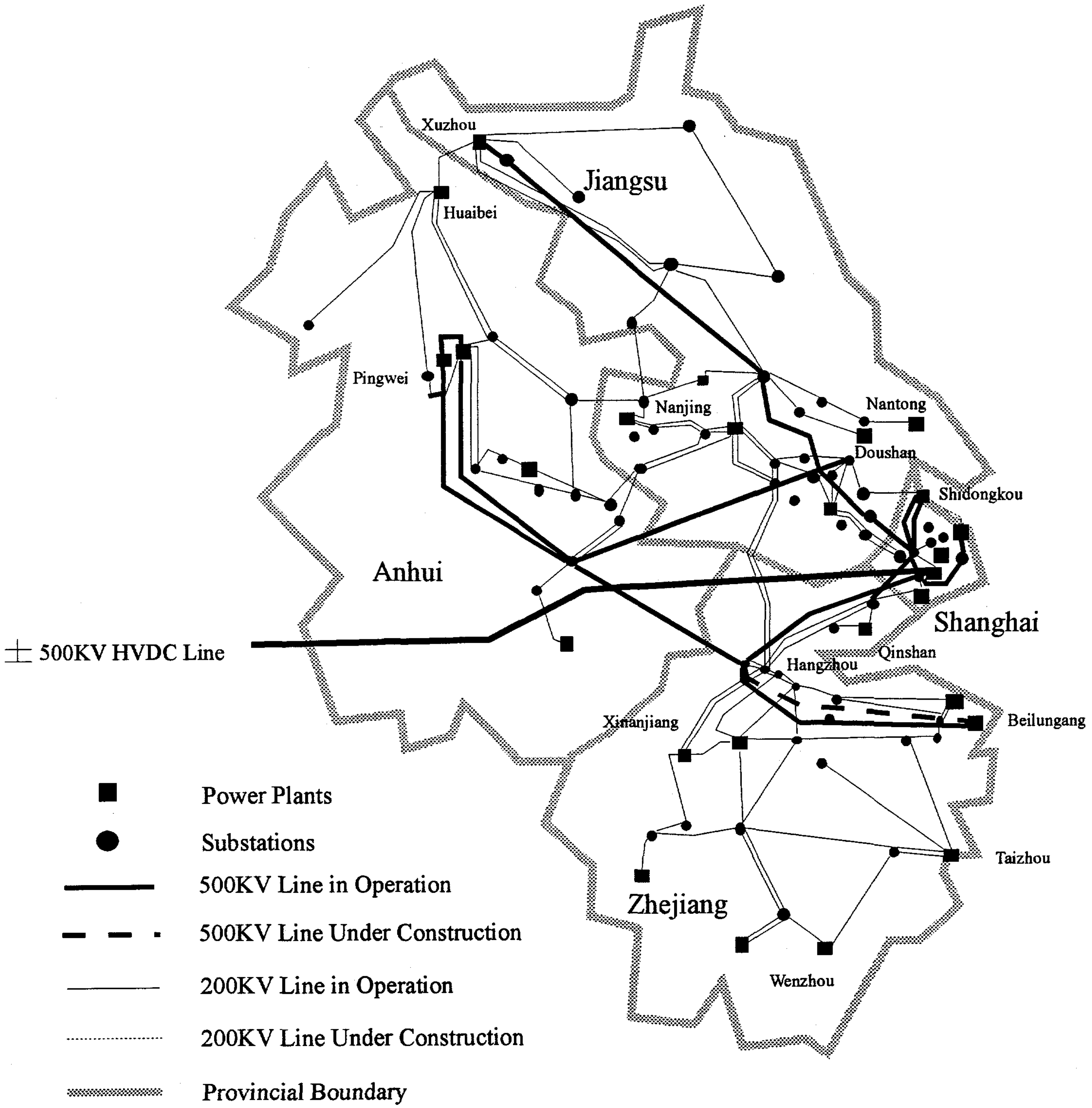


Figure 6.5. The East China Power Network

The ECPN is more sophisticated in technology development compared to other power networks and grids. It has constructed a series of power projects that are up to world standards, including China's first two 600 MW super-critical units in Shidongkou, the first 300 MW domestic nuclear power unit in Qinshan, the first 500 kV HVDC transmission line, the first 500 kV AC/DC substation, and the first large underground 220 kV substation. The ECPG has 15 large construction companies, 34 machine manufacturing and repairing companies, 12 national class A and class B research and design institutes, and 20 design divisions subordinate to the construction companies. This force makes the NEPG competent in the site investigation and engineering services of large thermal and hydropower plants, super high voltage transmission, and dispatching projects. Therefore the ECPG is less dependent on foreign technologies compared with other power networks and grids.

In the future, this region is expected to lead China's economic growth. To meet the increasing power demand driven by the booming economy and rising standards of living, the ECPG is very ambitious in power development. Total generating capacity is planned to reach 55,000 MW by 2000. To further extend the coverage of the network and transmit electricity from Shanxi Province and the Three Gorges in the long run, more than 3,000 km of 500 kV transmission lines and 15 million kVA of transforming capacity will be added, and total 500 kV transmission lines will exceed 5,000 km by 2000. Annual electricity supply is projected to reach 252 TWh by 2000.

This region is deficient of primary energy resources. Coal reserves here account for only 3.7 percent of the nation's total, and hydropower resources only 0.9 percent. Additional power plants in the ECPN will mainly be coal-fired, although hydropower plants, especially pumped-storage plants, and nuclear power plants will also be built. Along the east coast and the middle to lower course of the Yangtze River, the locations of several large thermal power plants have been selected. Figure 6.6 shows the locations and the planned capacities of these projects. The principal existing, under construction, and planned power plants in the ECPN are listed in Table 6.2.

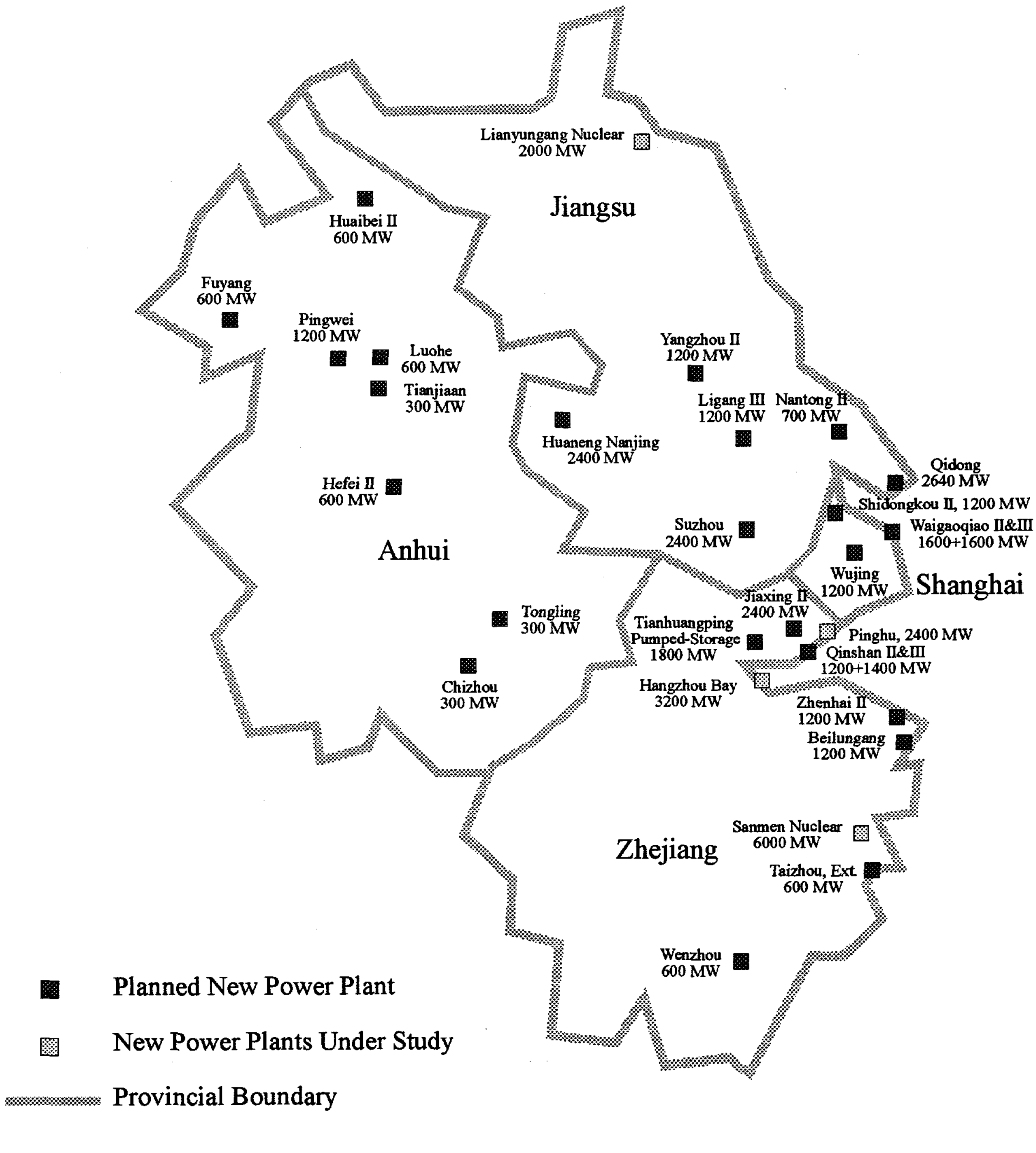


Figure 6.6. Planned New Power Plants in the ECPN

Table 6.2. Power Plants in the East China Power Network

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
ECPN total		**37950**	**12500**	**56498**	**106948**	
Coal-fired		**32017**	**8500**	**37290**	**77807**	**Coal**
Gas-fired		170	0	7258	7428	Gas
Oil-fired		2350	600	0	2950	Oil
Hydropower		3113	2200	2550	7863	Hydro
Nuclear		300	1200	9400	10900	Nuclear
Shanghai total	**SH**	**8834**	**1600**	**8000**	**18434**	
Shanghai coal-fired	**SH**	**8064**	**1600**	**5600**	**15264**	**Coal**
Baoshan No.1	SH	700			700	Coal
Baoshan No.2	SH	83			83	Coal
Congming	SH	140			140	Coal
Gaoqiao cogeneration	SH	228			228	Coal
Jinshan No.1	SH	275			275	Coal
Jinshan No.2	SH	125			125	Coal
Minhang	SH	818			818	Coal
Shidongko I	SH	1200			1200	Coal
Shidongko II	SH	1200			1200	Coal
Shinan	SH	130			130	Coal
Wujing	SH	1000			1000	Coal
Yangshupu	SH	216			216	Coal
Zhabei	SH	471			471	Coal
Other coal-fired	SH	878	1000		1878	Coal
Waigaoqiao I	SH	600	600		1200	Coal
Shidongko II, Ext.	SH			1200	1200	Coal
Waigaoqiao II	SH			1600	1600	Coal
Waigaoqiao III	SH			1600	1600	Coal
Wujing	SH			1200	1200	Coal
Other oil-fired	SH	600			600	Oil
Baoshan CC	SH	150			150	Gas
Other gas-fired	SH	20			20	Gas
Unidentified	SH			2400	2400	Gas
Jiangsu total	**JS**	**14339**	**3200**	**18998**	**37537**	
Jiangsu coal-fired	**JS**	**13864**	**2900**	**14390**	**31154**	**Coal**
Chacheng	JS	100			100	Coal
Changshu	JS	1200			1200	Coal
Datun	JS	1300			1300	Coal
Huaiyin	JS	500			500	Coal
Jianbi	JS	1625			1625	Coal
Jiangyin	JS	100			100	Coal

Note: Planned plants may over or under estimate the capacity that will actually be constructed.

Table 6.2. Power Plants in the East China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Jinling PETR Chemical	JS	100			100	Coal
Ligang II	JS	700			700	Coal
Nantong Huaneng	JS	700			700	Coal
Qishuyan	JS	400			400	Coal
Renzhuang	JS	740			740	Coal
Tianshenggang	JS	340			340	Coal
Wangting	JS	1100			1100	Coal, Oil
Xiaguang	JS	250			250	Coal
Xinghai	JS	462			462	Coal
Xutang No.1	JS	800			800	Coal
Xutang No.2	JS	50			50	Coal
Xuzhou	JS	1300			1300	Coal
Yancheng	JS	560			560	Coal
Yancheng City	JS	131			131	Coal
Yangtz Ethylene	JS	200			200	Coal
Yangzhou I	JS	436			436	Coal
Yizheng	JS	200			200	Coal
Nanjing	JS	510	600		1110	Coal
Other coal-fired	JS	60	1000		1060	Coal
Nantong II	JS		700		700	Coal
Pengcheng	JS		600		600	Coal
Huaneng Nanjing	JS			2400	2400	Coal
Lianyungang	JS			250	250	Coal
Ligang III	JS			1200	1200	Coal
Nantong II	JS			700	700	Coal
Yangzhou II	JS			1200	1200	Coal
Jiangsu	JS			2400	2400	Coal
Suzhou	JS			2400	2400	Coal
Qidong	JS			2640	2640	Coal
Southern Electric	JS			1200	1200	Coal
Suzhou GT	JS			58	58	Gas
Jiangsu CC	JS			2400	2400	LNG
Oil-fired plants	JS	400	300		1700	Oil
Hydropower	JS	75			75	Hydro
Xiwan PS	JS			150	150	Hydro
Lianyungang	JS			2000	2000	Nuclear

Table 6.2. Power Plants in the East China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Zhejiang total	**ZJ**	**8390**	**5400**	**24480**	**38270**	
Zhejiang coal-fired	**ZJ**	**4302**	**1700**	**14000**	**20002**	**Coal**
Banshan	ZJ	237			237	Coal, Oil
Beilungang	ZJ	1200			1200	Coal
Changxing	ZJ	250			250	Coal
Dinghai	ZJ	66			66	Coal
Hunzhou	ZJ	250			250	Coal
Juhua cogeneration	ZJ	124			124	Coal
Meixi	ZJ	75			75	Coal
Taizhou	ZJ	750			750	Coal
Wenzhou	ZJ	250			250	Coal, Oil
Zhenhai 3-6	ZJ	800			800	Coal
Other coal-fired	ZJ	300	500		800	Coal
Jiaxing	ZJ		1200		1200	Coal
Jiaxing II	ZJ			2400	2400	Coal
Beilungang, Ext.	ZJ			1200	1200	Coal
Taizhou, Ext.	ZJ			600	600	Coal
Wenzhou	ZJ			600	600	Coal
Pinghu	ZJ			2400	2400	Coal
Hongzhou Bay	ZJ			3200	3200	Coal
Zhenhai II	ZJ			1200	1200	Coal
Ying Long Shan	ZJ			2400	2400	Coal
Yuhuan County	ZJ			2400	2400	Gas/LNG
Zhenhai 1-2	ZJ	250			250	Oil
Other oil-fired	ZJ	1100	300		1400	Oil
Fuchunjiang	ZJ	297			297	Hydro
Jinshuitan	ZJ	378			378	Hydro
Xinanjiang	ZJ	663			663	Hydro
Other hydropower	ZJ	1100	400		1500	Hydro
Tianhuangping PS	ZJ		1800		1800	Hydro
Tankeng	ZJ			600	600	Hydro
Xikou	ZJ			80	80	Hydro
Qinshan	ZJ	300			300	Nuclear
Qinshan II	ZJ		1200		1200	Nuclear
Qinshan III	ZJ			1400	1400	Nuclear
Sanmen	ZJ			6000	6000	Nuclear

Table 6.2. Power Plants in the East China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Anhui total	**AH**	**6387**	**2300**	**5020**	**13707**	
Anhui coal-fired	**AH**	**5787**	**2300**	**3300**	**11387**	**Coal**
Anqing cogeneration	AH	150			150	Coal
Bengbu cogeneration	AH	50			50	Coal
Guichi	AH	50			50	Coal
Hefei I	AH	325			325	Coal
Huaibei I	AH	950			950	Coal
Tianjiaan	AH	600	300		900	Coal
Maanshan I	AH	312			312	Coal
Pingwei	AH	1200			1200	Coal
Tong Ling	AH	250			250	Coal
Wu Hu	AH	500			500	Coal
Luohe	AH	600	600		1200	Coal
Maanshan II	AH	300	300		600	Coal
Other coal-fired	AH	500	500		1000	Coal
Huaibei II	AH		600		600	Coal
Chizhou	AH			600	600	Coal
Fuyang	AH			600	600	Coal
Hefei II	AH			600	600	Coal
Pingwei	AH			1200	1200	Coal
Tong Lin	AH			300	300	Coal
Chen Cun	AH	150			150	Hydro
Other hydropower	AH	450			450	Hydro
Tushan PS	AH			600	600	Hydro
Xiangongdian PS	AH			120	120	Hydro
Xianshuijian PS	AH			1000	1000	Hydro

Since 1980, the core corporation and the tightly related enterprises of the ECPG have utilized more than $1 billion of foreign investment for power development. Foreign invested projects mainly include the Beilungang Power Plant (2X600 MW), Wujing Power Plant Extension (2X300 MW), Tianhuangping Pumped Storage Power Plant (6X300 MW), and the Xuzhou-Shanghai 500 kV transmission line. Currently the ECPG is seeking foreign investors for BOT projects. Most planned power projects are open to foreign investors.

Shanghai

Shanghai has about 8.8 GW generating capacity (8 GW coal-fired). All the 1.6 GW power plants under construction are coal-fired. Among the 8 GW planned power plants, only one unidentified plant (2.4 GW) is scheduled to use natural gas.

In the near future, two additional coal-fired power projects will be constructed, which include: (1) a 2X600 MW plant in the second phase of Shidongkou II; and (2) a 2X800 or 2X1000 MW in the second phase of Waigaoqiao and another 2X800 or 2X1000 MW in the third phase of Waigaoqiao. The central government plans to issue a competitive international BOT or BOO solicitation to private developers during the first quarter of 1996 for the Waigaoqiao second phase. An international consortium will develop the bidding materials and procedures. The consortium will also develop a structure designed to encourage international lenders to grant limited-recourse financing to the project, estimated to cost $1.5 billion. This project will be used as a pilot to introduce foreign investment. Shanghai plans to increase its generating capacity to 17 GW by 2005. At least one-quarter of the 17 GW are planned to be developed by the private sector. Bidders will be encouraged to concentrate on the price of electricity rather than a specific rate of return.

Jiangsu

Coal is and will be the primary fuel in Jiangsu's power generation. As shown in Table 6.2, Jiangsu currently has about 14.3 GW generating capacity, of which 13.9 GW are coal-fired. In addition, 3.2 GW of power plants are under construction (2.9 GW coal-fired), and 19 GW are being planned (14.4 GW coal-fired). Jiangsu currently produces 22 Mt of coal, but consumes more than 65 Mt. Due to limited reserves, coal production decreased from 24 to 22 Mt during the past 5 years. Increased coal demand is met by suppliers from other provinces.

In the near future, three new power projects have been scheduled, which include: (1) a 2X600 MW plant in the second phase of Yangzhou, with some financing committed from the World Bank; (2) a 2X600 MW plant in the third phase of Ligang; and (3) a 2X350 MW plant in Nantong.

Zhejiang

Zhejiang has almost no coal resources. It produces about 1 Mt and consumes almost 30 Mt of coal. Total generating capacity is now 8.4 GW (4.3 GW coal-fired). Among the 5.4 GW power plants under construction, 1.7 GW are coal-fired, 1.8 GW pumped-storage hydropower, 1.2 GW nuclear power, and 0.3 GW oil-fired. Although nuclear power has been planned to play an important role in Zhejiang, the high capital costs may postpone its planned development. Therefore, coal may have to play a more important role than currently planned.

Five new projects are under construction or being planned in the near future, and six projects are under study. These projects include: (1) the 1800 MW Tianhuangping Pumped-Storage project, which has started construction in 1994, and a $300 million World Bank loan has been extended to this project; (2) the 2X600 MW Qinshan Phase 2 nuclear project, which has started construction and is expected to be commissioned in early next century; (3) the 2X600 MW Beilungang Phase 2 project, with some financing committed from the World Bank; (4) the 4X600 MW Jiaxing Phases 2 and 3 Project; and (5) the 2X300 MW Wenzhou project. Major projects under study include: (1) the 4X600 MW Pinghu project; (2) the 4X800 MW or 4X1,000 MW Hongzhou Bay project; (3) the 2,400 MW Ying Long Shan project; (4) the 4X600 MW, gas-fired plant in Yuhuan County (Zhejiang is soliciting international private investors to participate in this project; (5) the 1,400 MW Qinshan Phase 3 nuclear project; and (6) the 6X1000 MW Sanmen nuclear power plant.

Anhui

Anhui now has about 6.4 GW generating capacity, about 5.8 GW are coal-fired. In Anhui, several additional coal-fired power projects are under construction or being planned in the near future, they are: (1) a 2X300 MW plant in Luohe; (2) a 2X300 MW plant in Huaibei Phase 2; (3) a 2X300 MW plant in Hefei Phase 2; (4) a 300 MW unit in Tianjiaan; and (5) a 300 MW unit in Maanshan II project. In addition, several other coal-fired power projects are under study, they are: (1) a 600 MW unit in Fuyang; (2) a 600 MW plant in Chizhou; (3) a 2X600 MW plant in Pingwei; and (4) a 300 MW unit in Tongling.

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The North China Power Network

The North China Power Network (NCPN) under the management of the North China Power Group (NCPG) covers Beijing, Tianjin, Hebei, Shanxi, and the western part of Inner Mongolia with an overall land area of 1.47 million square kilometers. This region accounts for about 12.8 percent of China's GDP and 11.6 percent of population. Total installed capacity of the NCPN is about 33 GW, of which coal-fired capacity accounted for 91 percent, oil-fired 5 percent, and hydropower 4 percent. Currently, the NCPN has 180 large and medium-size enterprises under its jurisdiction including 63 power plants. Imported equipment accounts for 30 percent of total capacity. The locations of the principal existing power plants are shown in Figure 6.7.

Since 1990, installed capacity in this region has been growing at about 9 percent per year. However, the increased power supply still cannot meet the rapidly growing electricity demand. Power shortages have been a nightmare in this region for over 20 years. In 1993, a total of 433,000 blackouts were recorded, which affected 463 GW of load capacity. Because the NCPN is basically a thermal power system, there is very limited capacity to adjust for peak demand. Although administrative measures have been adopted to smooth the load curve, the difference between peak and valley is still very large.

As in other power networks facing capital shortages, the NCPN is also sacrificing the transmission and distribution (T&D) systems. During the 1986-1990 period, the share of T&D investment was only 16.7 percent of total power sector investment. During the 1991-1995 period, the share increased only slightly. As a result, the construction of the 500 kV transmission networks has been delayed. As shown in Figure 6.8, currently 500 kV transmission lines have been put into operation to transmit electricity from Shanxi to the load center around Beijing and a tight-tied 500 KV backbone connecting Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia will be formed. The length of 500 kV transmission line reached 1,676 km by the end of 1994, including the Datong-Fangshan double circuits, the Shentou-Datong double circuits, the Fangshan-Tianjin circuit, and the Shalingzi-Changping double circuits. The total length of transmission lines reached 77,771 km by the end of 1994.

This region is rich in coal but poor in hydropower resources. The two major coal bases in this region account for half of China's total coal reserves, while hydropower resources in this region account for only 1.2 percent of China's total. Currently only about 1.6 percent of electricity in this region is generated from hydropower plants. Naturally coal is the dominant fuel used in power generation. In 1993, coal accounted for 93.75 percent of total fuel consumption in power generation, oil 6 percent, and gas only 0.25 percent.

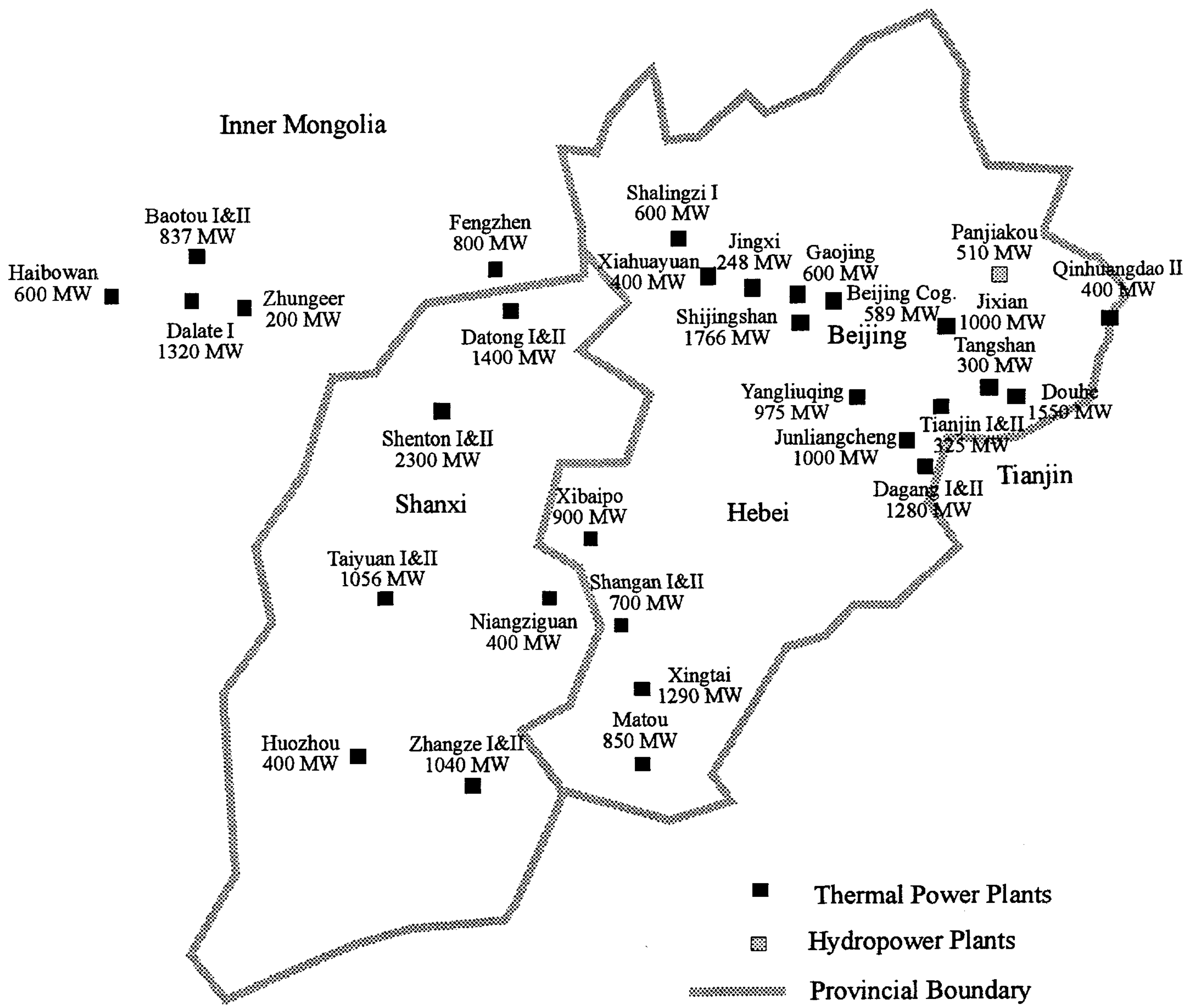

Figure 6.7. Existing Principal Power Plants in the NCPN

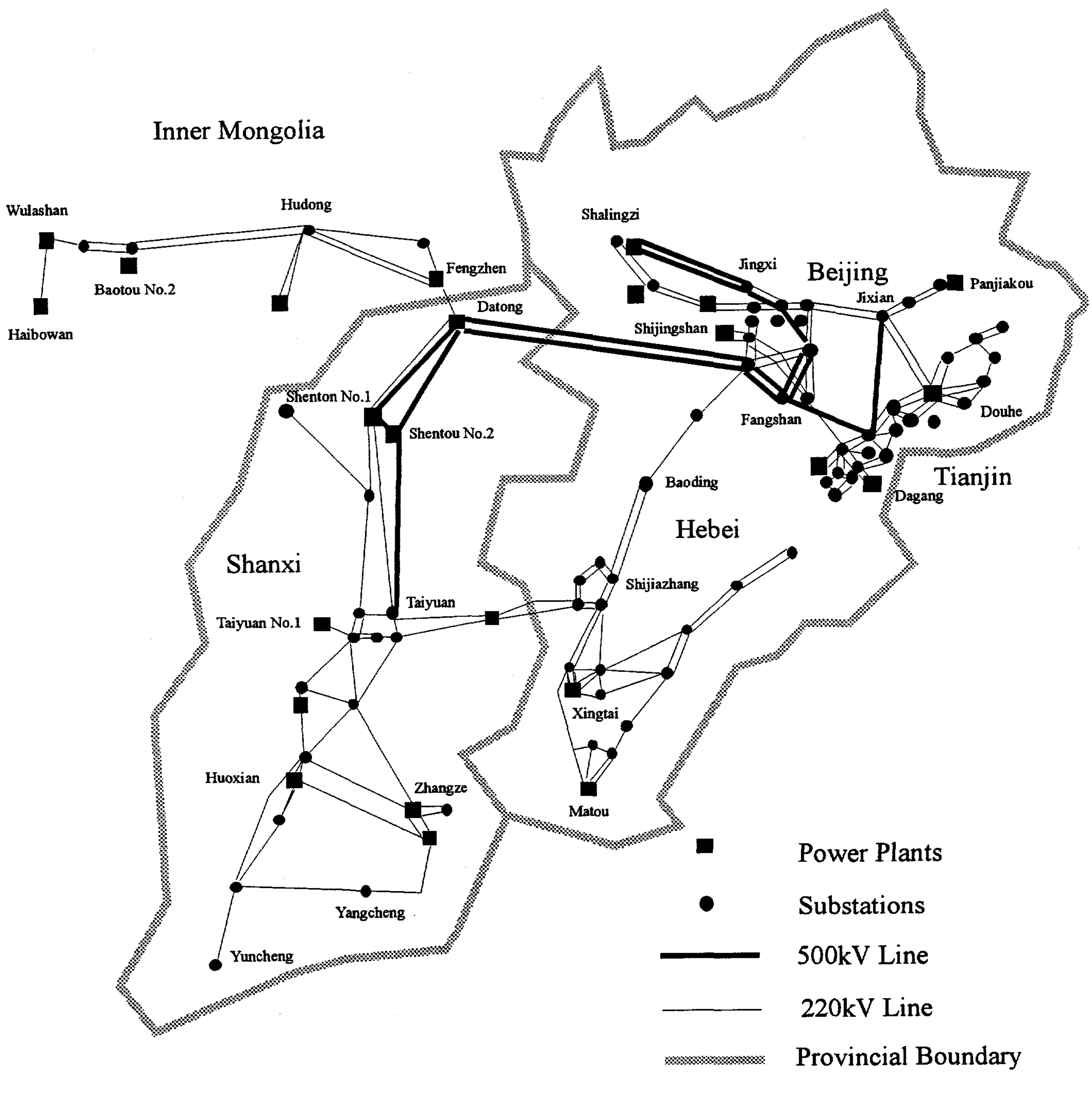

Figure 6.8. The North China Power Network

In the future, this region is expected to lead China's coal production and electricity generation. In the power load center of the east region, some power plants will be built to support the stability of the regional power supply. A large group of mine-mouth coal-fired plants will be built in Shanxi and Inner Mongolia to transmit electricity to the east part of the region and to Jiangsu Province in the ECPN. By 2000, the NCPN plans to build another two 500 kV lines to transmit electricity from Shanxi to the east part of the region, and three 500 kV lines from western Inner Mongolia to the east. The three 500 kV lines from Inner Mongolia to the east will transmit 3.57 GW of power to the east, and the four 500 kV lines from Shanxi to the east will transmit 3.28 GW to the east. To improve the environmental quality of large and medium cities, cogeneration units will be installed in the urban area. A number of pumped-storage projects will be developed to meet the peak load power demand.

International investments have been introduced in the NCPN since the 1980s, for example the Panjiakou pumped-storage project was financed by Italian Government Loans; the Dalate first phase (2X330 MW) was financed by French government loans; and the Shisanling pumped-storage project, which is now under construction, was financed by Japan's Overseas Economic Cooperation Fund (JOECF). The 600 MW Sanhe Project is also going to be financed by JOECF, and the 3,600 MW Tuoketuo I&II project may obtain some World Bank loans.

To realize the power development plans, international finance is increasingly important. It is estimated that international investment will account for 30 percent of total power investment in the NCPN. In the Beijing-Tianjin-Tangshan area, the share of foreign investment is expected to be 42 percent of total power investment; and the shares are expected to be 14 percent in the southern Hebei area, 25 percent in Shanxi, and 39 percent in Inner Mongolia. A more diversified and flexible international finance system will be adopted in the future. For example, the Shalingzi II project is considering to use export credit from Germany; the Datong II and Yangcheng projects are going to invite private investor to form joint venture firms; and the Beijing Datang Power Holdings is preparing to be listed in overseas stock markets.

Total generating capacity of the NCPN is currently planned to reach 57.5 GW by 2000. A total of 39 power projects with total generating capacity of about 44 GW has been identified to start construction before 2000, which include about 39 GW thermal plants and 5 GW pumped-storage plants. The principal existing, under construction, and planned power plants are shown in Table 6.3.

Inner Mongolia

Inner Mongolia is divided into two areas. The west part of Inner Mongolia belongs to the NCPN; while the east part belongs to the NEPN. As shown in Table 6.3, Inner Mongolia currently has about 7.9 GW of generating capacity, all coal-fired. In addition, 7 GW of coal-fired capacity are now under construction, and about 23 GW are being planned.

Inner Mongolia has agreed to become the chief supplier of electricity to the Beijing-Tianjin-Tangshan area in the NCPN and to Liaoning and Jilin in the NEPN. Inner Mongolia is also considering the supply of electricity to other part of Hebei Province. Mine-mouth coal-fired power plants will be built in east Inner Mongolia to transmit electricity to northeast China and in west Inner Mongolia to send electricity to Beijing. Six large coal-fired power plants (9.3 GW) are planned to start construction before 2000, and Inner Mongolia is soliciting international investors to build 7 GW of new coal-fired plants on a build-own-operate (BOO) basis. The international BOO projects will be joint ventures under terms to be negotiated. The Inner Mongolia Power Administration will likely want a significant equity stake in each project.

Inner Mongolia has rich coal reserves. Among the 8 key open-cast coal mines in China, 6 of them are located in Inner Mongolia. It also contain China's best steam coal.

Inner Mongolia also has rich wind resources. FloWind Capital Corp. of the U.S. and Inner Mongolia Electric Power Co. has signed an agreement to develop an $85 million, 110 MW wind power plant in Inner Mongolia on a joint venture basis.

Shanxi

Shanxi is China's major coal producing province. As shown in Table 6.3, Shanxi currently has about 8.3 GW of generating capacity, almost all coal-fired. In addition, about 4.2 GW of coal-fired capacity are under construction, and about 22 GW are being planned. A total of 11 coal-fired power projects (11.6 GW) have been planned to start construction before 2000. Recently, the Shanxi Electric Power Bureau has released an international solicitation for the 2,400 MW, coal-fired Yangcheng No.2 project to be build on a BOT basis. In addition, the rights to develop a power station in Hequ designed to transmit electricity to Beijing, Tianjin, and Tangshan were made available to foreign investors along with seven other power stations.

Hebei, Beijing, and Tianjin

Beijing and Tianjin are located within Hebei Province. The power system in this area includes two parts, one is the Beijing-Tianjin-Tangshan power grid, the other is the southern Hebei grid. Hebei now has about 10.7 GW of generating capacity, of which 9.6 GW are coal-fired. A total of 12 thermal power projects (13.4 GW) and 1 pumped-storage project (1 GW) has been identified in Hebei Province. Recently, Hebei was planning to issue an international solicitation for the $1.14 billion, 2,400 MW (first phase 1,200 MW) coal-fired Dingqu plant near the city of Baoding. The project will serve as a pilot project for introduction of the BOO concept in Hebei. The Dingqu project will offer no specific guarantees, nor will it limit return on investment. But provincial officials will guarantee a certain level of demand for the plant. Reportedly, a foreign investor's rate of return should fall somewhere between 15-20 percent, or higher if the plant is especially efficient. If successful, the solicitation will be followed by others to meet the growing power demand in the province.

In Beijing, current generating capacity is 4.1 GW, of which 3.4 GW are coal-fired. In addition, 1.4 GW of power projects are now under construction, and 3.5 GW are being planned to start construction before 2000. Additional electricity demand will have to be met from new mine-mouth power plants.

Tianjin currently has about 4.8 GW of generating capacity, about 3.9 GW are coal-fired. In addition, 5.2 GW power projects have been planned, of which 4.2 GW are coal-fired. A total of 2.4 GW coal-fired power plants have been planned to start construction before 2000.

Table 6.3. Power Plants in the North China Power Network

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
NCPN total		**33079**	**14340**	**65210**	**112629**	
Coal-fired		**30072**	**13540**	**61010**	**104622**	**Coal**
Gas-fired		0	0	200	200	Gas
Oil-fired		1640	0	0	1640	Oil
Hydropower		1367	800	4000	6167	Hydro
Nuclear		0	0	0	0	Nuclear
Inner Mongolia total	**IM**	**7900**	**7000**	**23020**	**37920**	
Inner Mongolia coal-fired	**IM**	**7900**	**7000**	**22800**	**37700**	**Coal**
West Inner Mongolia	**IM**	**5200**	**5400**	**23020**	**33620**	
West IM coal-fired	**IM**	**5200**	**5400**	**22800**	**33400**	**Coal**
Baotou I	IM	412			412	Coal
Baotou II	IM	425			425	Coal
Dalate I	IM	1320			1320	Coal
Genhe Electrical Bureau	IM	54			54	Coal
Haibowan	IM	600			600	Coal
Hohhot	IM	100			100	Coal
Huiliuhe	IM	100			100	Coal
Jungar	IM	100			100	Coal
Lingquan	IM	62			62	Coal
Wuda	IM	112			112	Coal
Urad	IM	200			200	Coal
Zhungeer	IM	200			200	Coal
Fengzhen	IM	800	400		1200	Coal
Other coal-fired	IM	715	5000		5715	Coal
Daihai	IM			1200	1200	Coal
Dalate II	IM			1200	1200	Coal
Tuoketuo I	IM			1200	1200	Coal
Tuoketuo II	IM			2400	2400	Coal
Zhenglanqi	IM			1200	1200	Coal
Baorixile	IM			1600	1600	Coal
Daban	IM			1200	1200	Coal
Dalate III	IM			3600	3600	Coal
Huhhot	IM			7200	7200	Coal
Zhungeer	IM			2000	2000	Coal
Unidentified I	IM			110	110	Wind
Unidentified II	IM			110	110	Wind

Note: Planned plants may over or under estimate the capacity that will actually be constructed.

Table 6.3. Power Plants in the North China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Beijing total	**BJ**	**4068**	**1440**	**3450**	**8958**	
Beijing coal-fired	**BJ**	**3368**	**640**	**2250**	**6258**	**Coal**
Beijing Cogeneration	BJ	589			589	Coal
Gaojing	BJ	600			600	Coal
Capital Iron Company	BJ	165			165	Coal
Jingxi	BJ	248			248	Coal, Oil
Shijingshan	BJ	1766			1766	Coal
Huaneng Beijing	BJ		640		640	Coal
Gaobeidian	BJ			700	700	Coal
Pinggu	BJ			1200	1200	Coal
Zhoukou EXE	BJ			250	250	Coal
Shunyi	BJ			100	100	Coal
Beijing Airport	BJ			200	200	GAS
Oil-fired plants	BJ	450			450	Oil
Hydropower	BJ	250			250	Hydro
Shisanling PS	BJ		800		800	Hydro
Banqiaoyu PS	BJ			1000	1000	Hydro
Tianjin total	**TJ**	**4830**	**200**	**5200**	**10230**	
Tianjin coal-fired	**TJ**	**3940**	**200**	**4200**	**8340**	**Coal**
Dagang II	TJ	640			640	Coal
Jixian (Panshan)	TJ	1000			1000	Coal
Tianjin I	TJ	225			225	Coal
Tianjin II	TJ	100			100	Coal
Yangliuqing	TJ	975			975	Coal
Junliangcheng	TJ	1000	200		1200	Coal
Beitang	TJ			1200	1200	Coal
Dagang III	TJ			600	600	Coal
Jixian II	TJ			1200	1200	Coal
Tianjin New	TJ			1200	1200	Coal
Dagang I	TJ	640			640	Oil
Other oil-fired	TJ	250			250	Oil
Taohuashi PS	TJ			1000	1000	Hydro

Table 6.3. Power Plants in the North China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Hebei total	**HEB**	**10704**	**3100**	**11800**	**25604**	
Hebei coal-fired	**HEB**	**9564**	**3100**	**10800**	**23464**	**Coal**
Baoding No 1	HEB	225			225	Coal
Baoding No 2	HEB	50			50	Coal
Cangzhou	HEB	50			50	Coal
Douhe	HEB	1550			1550	Coal
Fengfeng	HEB	112			112	Coal
Handan	HEB	146			146	Coal
Kailuan	HEB	57			57	Coal
Lingshan	HEB	50			50	Coal
Luanhe	HEB	249			249	Coal
Matou	HEB	850			850	Coal
Qinhuangdao	HEB	600			600	Coal
She Xian 105	HEB	200			200	Coal
Shijiazhuang	HEB	400			400	Coal
Tangshan	HEB	300			300	Coal
Weishui	HEB	100			100	Coal
Xiahuayuan	HEB	485			485	Coal
Xingtai	HEB	1290			1290	Coal
Shalingzi I	HEB	1200			1200	Coal
Shang'an I&II	HEB	700	600		1300	Coal
Xibaipo	HEB	900	300		1200	Coal
Other coal-fired	HEB	50	1000		1050	Coal
Hengshui	HEB		1200		1200	Coal
Dingqiu	HEB			1200	1200	Coal
Douhe II	HEB			1200	1200	Coal
Hanfeng	HEB			1200	1200	Coal
Huangzihua	HEB			800	800	Coal
Qinhuangdao II	HEB			600	600	Coal
Sanhe	HEB			600	600	Coal
Shalingzi II	HEB			1200	1200	Coal
Shang'an III	HEB			1200	1200	Coal
Yixian	HEB			1200	1200	Coal
Dingqiu, Ext.	HEB			1200	1200	Coal
Tangshan Exp.	HEB			200	200	Coal
Zunhua Exp.	HEB			200	200	Coal
Oil-fired plants	HEB	300			300	Oil
Panjiakou	HEB	300			300	Hydro
Panjiakou PS	HEB	210			210	Hydro
Other hydropower	HEB	330			330	Hydro
Zhangjiawan PS	HEB			1000	1000	Hydro

Table 6.3. Power Plants in the North China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Shanxi total	**SX**	**8277**	**4200**	**21960**	**34437**	
Shanxi coal-fired	**SX**	**8000**	**4200**	**20960**	**33160**	**Coal**
Datong I	SX	200			200	Coal
Datong II	SX	1200			1200	Coal
Huozhou I	SX	400			400	Coal
Huxian *cogeneration*	SX	200			200	Coal
Niangziguan	SX	400			400	Coal
Shanxi Aluminium	SX	61			61	Coal
Shentou I	SX	1300			1300	Coal
Shentou II	SX	1000			1000	Coal
Taiyuan I	SX	806			806	Coal
Taiyuan Iron Company	SX	76			76	Coal
Yongji	SX	180			180	Coal
Zhangze I&II	SX	1040			1040	Coal
Houma	SX	100		400	500	Coal
Taiyuan II	SX	250	400		650	Coal
Other coal-fired	SX	787	2000		2787	Coal
Liulin	SX		200		200	Coal
Yangquan II	SX		1200		1200	Coal
Yushi I	SX		200		200	Coal
Liulin	SX		200		200	Coal
Datong I, Ext	SX			400	400	Coal
Datong II, Ext	SX			1200	1200	Coal
Gujiao	SX			600	600	Coal
Hejin	SX			2400	2400	Coal
Heqiu	SX			1200	1200	Coal
Houzhou II	SX			1200	1200	Coal
Liulin II	SX			600	600	Coal
Taiyuan I, Ext.	SX			600	600	Coal
Wangqu	SX			1320	1320	Coal
Yangcheng I	SX			2400	2400	Coal
Yushi II	SX			600	600	Coal
Zhangze III	SX			600	600	Coal
Datong I, Ext	SX			2400	2400	Coal
Shentou II, Ext.	SX			2640	2640	Coal
Yangcheng II	SX			2400	2400	Coal
Hydropower	SX	277			277	Hydro
Xilongchi PS	SX			1000	1000	Hydro

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The Central China Power Network

The CCPN covers Hubei, Hunan, Henan, and Jiangxi with an overall area of 730,000 square kilometers. This region accounts for about 15 percent of China's GDP and 21 percent of population. Total installed capacity of the NCPN is about 30.8, of which 17 GW are coal-fired, and 12.7 GW are hydropower plants. Total electricity generation in 1994 was about 137 TWh, of which hydropower accounted for about one-third. The locations of the principal power plants are shown in Figure 6.9.

This region is rich in hydropower resources; however, 84 percent of its 50 GW exploitable hydropower resources are concentrated in the southern provinces of Hubei and Hunan, while 84 percent of its 24.5 billion tons of proven coal reserves are located in the northern province of Henan. Large hydropower plants are located in the west part of the region, but most load centers are in the east. To coordinate the operation of major thermal power plants in the north and hydropower plants in the south, and transmit electricity from the west to the east, a power transmission system has been developed.

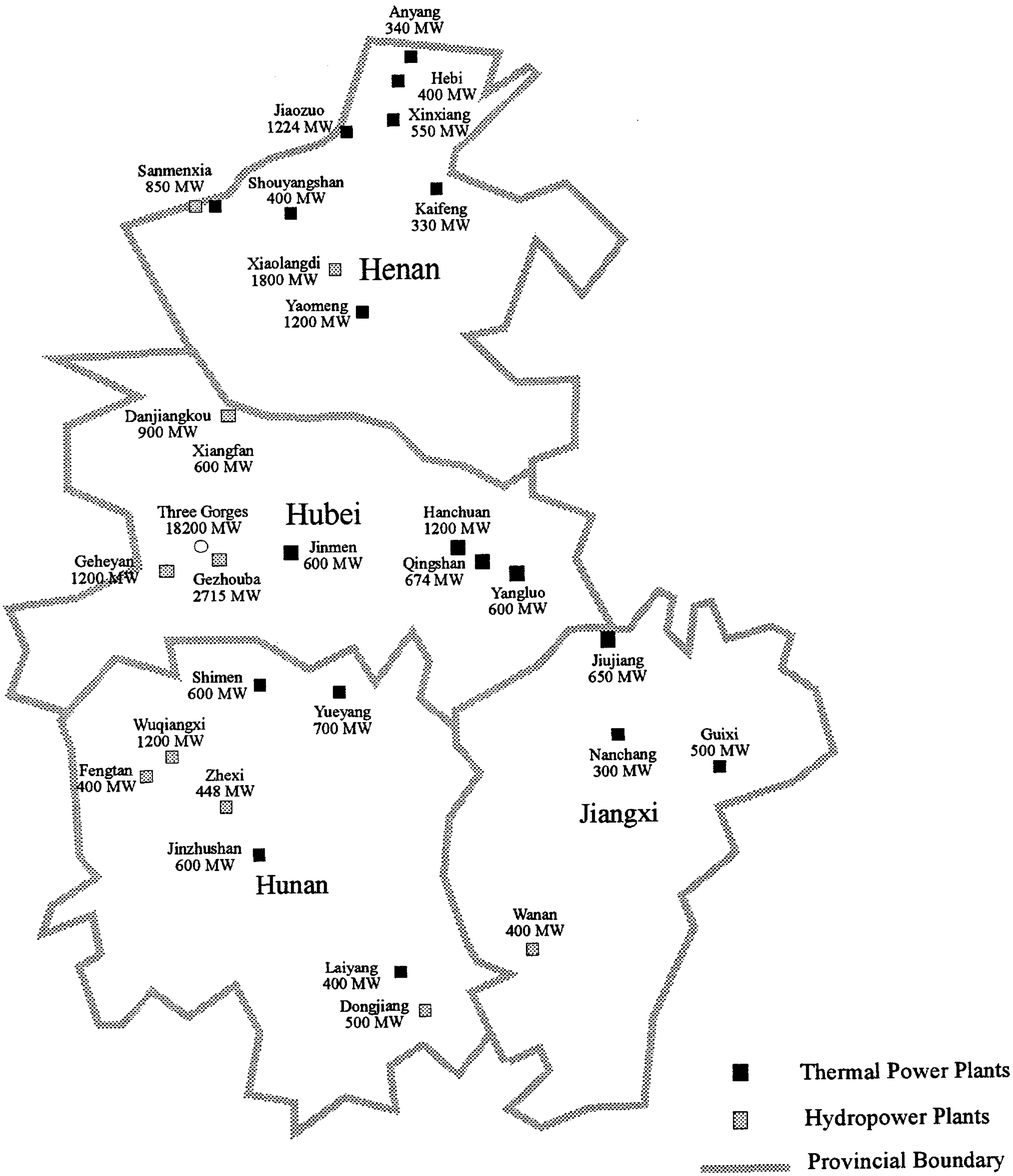

Figure 6.9. Principal Power Plants in the CCPN

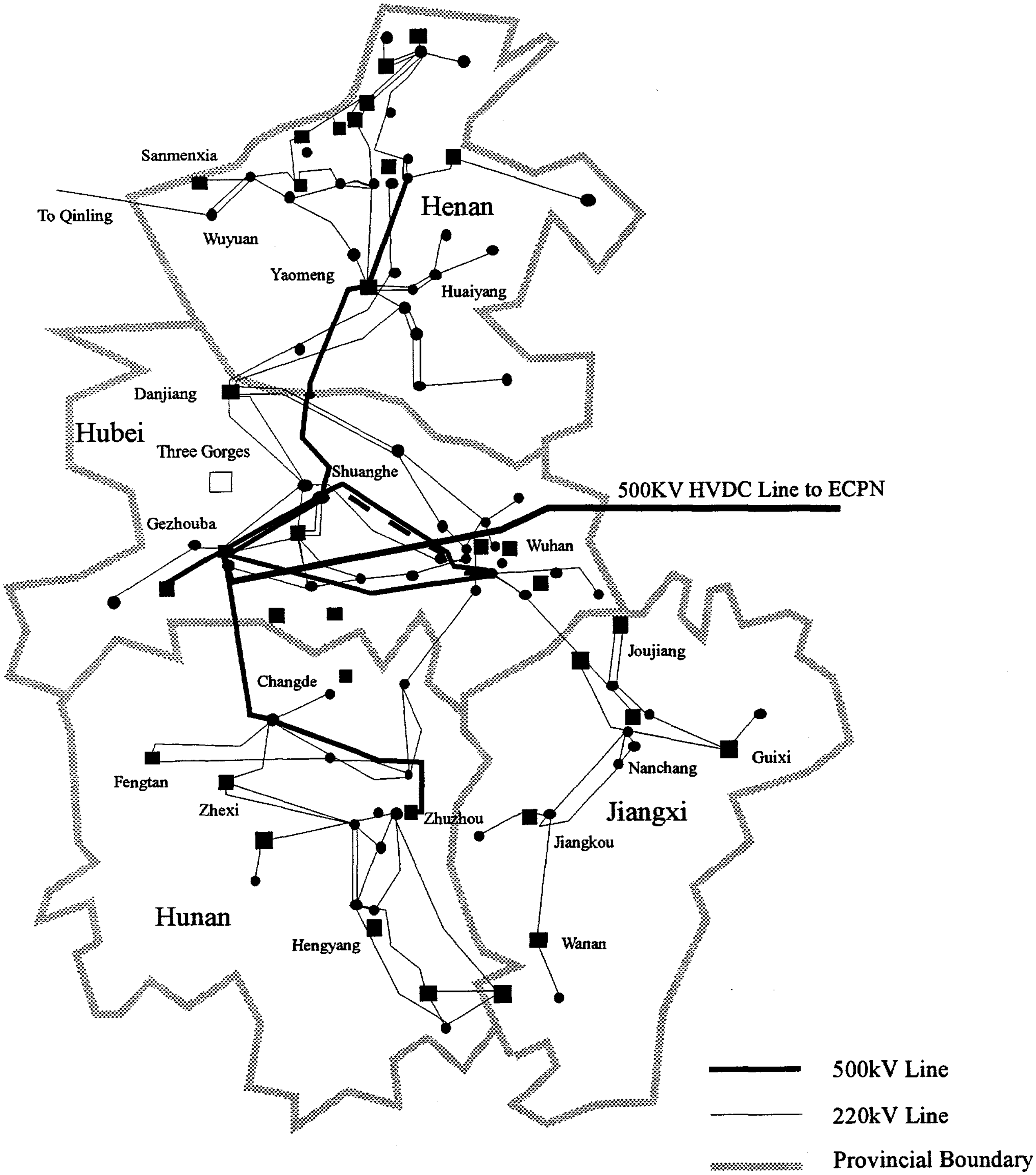

Figure 6.10. The Central China Power Network

As shown in Figure 6.10, by the end of 1994, ten 500 KV transmission lines with a total length of 2,261 km has been built, total length of transmission lines reached 98,941 km. In 1989, China's first 500 kV HVDC transmission line was built to link the CCPN with the ECPN. During wet seasons, electricity is transmitted from the CCPN to the ECPN with a maximum capacity of 1.2 GW, during dry seasons, electricity is transmitted from the ECPN to the CCPN.

Upon completion of the Three Gorges Project in the next century, 15-17 500 kV transmission lines with a total length of 5,000 km will be built within the CCPN to link the CCPN with other power networks and grids. Coal-fired electricity from the northwest and hydropower from the southwest will be transmitted to the load centers in the east and southeast regions through the CCPN. In the future, two circuits of 500 KV HVDC lines will be built to supply power to the ECPN, and several circuits of 500 kV lines will be built to provide electricity in the central China area and to Sichuan Province.

Power development in the CCPN has been slower than economic growth of this region. Currently power shortage is estimated at around 20-30 percent. To meet the increasing power demand, the CCPN plans to increase its total generating capacity to about 50 GW by 2000. A total of 35 GW of new power plants has been planned for the 1990s, of which 31 GW will be thermal, and 4 GW will be hydropower. The principal existing, under construction, and planned power plants in the CCPN are shown in Table 6.4.

Hunan

Hunan is located in the southwest of the CCPN. As shown in Table 6.4, total installed capacity in Hunan is now about 6 GW. In addition, projects totaling 3.4 GW of capacity are under construction, and 8.1 GW are being planned. Hydropower and thermal power plants are rather balanced here, each accounts for about half of the existing capacity. During the 1990s, more than 6 GW of thermal power will be installed or under construction. Projects looking for foreign investments include: (1) the 600 MW coal-fired Yiyang project (2X300 MW in the first phase and a total of 1,200 MW); (2) the 600 MW coal-fired Jinzhushan second phase; (3) the 600 MW coal-fired Fengyang project; (4) the 240 MW Lingjuntan hydropower project, with a financial commitment from the Asian Development Bank; and the 135 MW Centianhe hydropower project.

Henan

Henan is a thermal power base of the CCPN. It now has 10.2 GW of generating capacity, of which 8.8 GW are coal-fired. The 250 MW Sanmenxia project is the only major existing hydropower plant, although the 6X300 MW Xiaolangdi hydropower plant on the Yellow River has started construction in 1994. More than $1 billion will be borrowed from the World Bank and other international sources to finance the Xiaolangdi project. The first two units is planned to start generation by 2000. Future power development in Henan will also be based on coal-fired capacity. During the 1990s, more than 11 GW of thermal power plants will be added or under construction. Projects looking for foreign investments include: (1) the Yahekou Phase II (2X600 MW); (2) the Yongchen Power Plant (2X300 MW); (3) the Zhumadian (4X300 MW, first phase 2X300 MW) project; (4) a 250 MW expansion of the existing Zhoukou Power Plant; and (5) a 400 MW expansion of the existing Shangqiu Power Plant.

Jiangxi

The power industry in Jiangxi is relatively weak compared with other provinces in the CCPN. It now has about 4 GW of generating capacity, about half of the existing power plants are coal-fired, the other half are mostly hydropower. In addition, 3.3 GW of power projects are now under construction, and 6.3 GW have been planned. Although Jiangxi has about 5 GW of exploitable hydropower resources, the technical and economic conditions to develop these resources are not ideal. Local coal resources are very limited and coal transportation is difficult. In the long run, Jiangxi is considering development of nuclear power to meet its power needs. Power development in the near term will focus on thermal power projects. During the 1990s, about 6 GW of thermal power plants are scheduled to be installed or start construction. Projects looking for foreign investments include: (1) the 2X300 MW coal-fired Jinggangshan project; and (2) the 2X300 MW coal-fired Nanchang expansion project.

Table 6.4. Power Plants in the Central China Power Network

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
CCPN total		**30800**	**34309**	**48700**	**113809**	
Coal-fired		**16968**	**10400**	**42880**	**70248**	**Coal**
Gas-fired		117	0	0	117	Gas
Oil-fired		1000	0	0	1000	Oil
Hydropower		12715	23909	5820	42444	Hydro
Nuclear		0	0	0	0	Nuclear
Hunan total	**HN**	**5950**	**3400**	**8140**	**17490**	
Hunan coal-fired	**HN**	**2750**	**1700**	**4900**	**9350**	**Coal**
Jinzhushan	HN	600			600	Coal
Laiyang I	HN	400			400	Coal
Liyujiang	HN	204			204	Coal
Xiangtan	HN	70			70	Coal
Yueyang	HN	700			700	Coal
Zhuzhou	HN	250			250	Coal
Other coal-fired	HN	526	500		1026	Coal
Shimen	HN		1200		1200	Coal
Laiyang II	HN			600	600	Coal
Wangcheng	HN			1200	1200	Coal
Xiangtan	HN			1200	1200	Coal
Yiyang	HN			600	600	Coal
Yueyang II	HN			700	700	Coal
Zhuzhou II	HN			600	600	Coal
Oil-fired plants	HN	250			250	Oil
Dongjiang	HN	500			500	Hydro
Fongtan	HN	400			400	Hydro
Zhexi	HN	450			450	Hydro
Other hydropower	HN	1600	500		2100	Hydro
Wuqiangxi	HN		1200		1200	Hydro
Lingjintan	HN			240	240	Hydro
Pingjiang PS	HN			3000	3000	Hydro

Note: Planned plants may over or under estimate the capacity that will actually be constructed.

Table 6.4. Power Plants in the Central China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Henan total	**HEN**	**10160**	**5900**	**17780**	**33840**	
Henan coal-fired	**HEN**	**8793**	**3800**	**17780**	**30373**	**Coal**
Danhe	HEN	200			200	Coal
Hebi I	HEN	400			400	Coal
Jiaozuo	HEN	1224			1224	Coal
Kaifeng	HEN	330			330	Coal
Louyang cogeneration	HEN	175			175	Coal
Pingdingshan	HEN	175			175	Coal
Pingqiao	HEN	124			124	Coal
Puyang cogeneration	HEN	50			50	Coal
Shouyangshan I&II	HEN	1000			1000	Coal
Weishui	HEN	100			100	Coal
Xinanxian	HEN	50			50	Coal
Xinxiang	HEN	550			550	Coal
Yanshi A	HEN	400			400	Coal
Yanshi B	HEN	600			600	Coal
Yaomeng	HEN	1200			1200	Coal
Yuzhou City No.1	HEN	62			62	Coal
Zhengzhou	HEN	400			400	Coal
Zhongyuan Fertilizer	HEN	65			65	Coal
Zhoukou	HEN	100			100	Coal
Anyang	HEN	340	600		940	Coal
Luohe	HEN	600	600		1200	Coal
Sanmenxia	HEN	250	600		850	Coal
Other coal-fired	HEN	312	2000		2312	Coal
Changyang	HEN			600	600	Coal
Dengfeng	HEN	86		1400	1486	Coal
Hebi II	HEN			600	600	Coal
Hebi III	HEN			1200	1200	Coal
Mixian	HEN			1400	1400	Coal
Qinbei	HEN			3600	3600	Coal
Sanmenxia II	HEN			1200	1200	Coal
Shangqiu, Ext.	HEN			400	400	Coal
Shouyangshan III	HEN			1320	1320	Coal
Wanfang	HEN			250	250	Coal
Xinyang	HEN			600	600	Coal
Yahekou I	HEN			700	700	Coal
Yahekou II	HEN			1200	1200	Coal
Yaomeng, Ext.	HEN			660	660	Coal
Yongchen	HEN			600	600	Coal

Table 6.4. Power Plants in the Central China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Yuzhou	HEN			600	600	Coal
Zhoukou, Ext.	HEN			250	250	Coal
Zhumadian	HEN			1200	1200	Coal
Zhong Yuan Field	HEN	37			37	Gas
Other gas-fired	HEN	30			30	Gas
Oil-fired plants	HEN	350			350	Oil
Sanmenxia	HEN	250			250	Hydro
Other hydropower	HEN	700	300		1000	Hydro
Xiaolangdi	HEN		1800		1800	Hydro
Jiangxi total	**JX**	**3950**	**3300**	**6300**	**13550**	
Jiangxi coal-fired	**JX**	**1900**	**2300**	**6100**	**10300**	**Coal**
Fenyi	JX	200			200	Coal
Guixi	JX	500			500	Coal
Jingdezhen	JX	100			100	Coal
Jiujiang I&II	JX	650			650	Coal
Leping	JX	74			74	Coal
Nanchang	JX	300			300	Coal
Other coal-fired	JX	76	500		576	Coal
Fengcheng	JX		1200		1200	Coal
Jiujiang III	JX		600		600	Coal
Bencheng	JX			1200	1200	Coal
Fuzhou	JX			600	600	Coal
Gongqing	JX			1000	1000	Coal
Guixi	JX			600	600	Coal
Jian	JX			600	600	Coal
Jingdezhen, Ext.	JX			250	250	Coal
Jinggangshan	JX			600	600	Coal
Nancang	JX			600	600	Coal
Pjngxiang	JX			250	250	Coal
Xinyu	JX			400	400	Coal
Oil-fired plants	JX	100			100	Oil
Wan'an	JX	500		200	700	Hydro
Other hydropower	JX	1450	1000		2450	Hydro

Table 6.4. Power Plants in the Central China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Hubei total	**HB**	**10740**	**21709**	**16480**	**48929**	
Hubei coal-fired	**HB**	**3525**	**2600**	**14100**	**20225**	**Coal**
Automobile Factory No 2	HB	100			100	Coal
Gonxian No. 2	HB	50			50	Coal
Huangshi	HB	250			250	Coal
Jingmen I	HB	600			600	Coal
Qingshan	HB	674			674	Coal, Oil
Shashi	HB	50			50	Coal
Shashi cogeneration	HB	57			57	Coal
Songmuping	HB	50			50	Coal
Sujiawu	HB	100			100	Coal
Xinhua	HB	200			200	Coal
Hanchuan I&II	HB	600	600		1200	Coal
Yangluo I&II	HB	600	600		1200	Coal
Other coal-fired	HB	194	600		794	Coal
Huangshi	HB		200		200	Coal
Ezhou I	HB		600		600	Coal
Ezhou II	HB			1200	1200	Coal
Huanggang I	HB			1200	1200	Coal
Huangshi	HB			600	600	Coal
Jingmen II	HB			1200	1200	Coal
Qingshan	HB			300	300	Coal
Wuhan	HB			1200	1200	Coal
Xiangfan I	HB			1200	1200	Coal
Huanggang II	HB			1200	1200	Coal
Xiangfan II	HB			1200	1200	Coal
Xiangfan III	HB			1200	1200	Coal
Yangluo III	HB			1200	1200	Coal
Zhicheng	HB			2400	2400	Coal
Gas-fired plants	HB	50			50	Gas
Oil-fired plants	HB	300			300	Oil
Danjiangkou	HB	900			900	Hydro
Geheyan	HB	1200			1200	Hydro
Gezhouba	HB	2715			2715	Hydro
Huanglongtan	HB	150			150	Hydro
Other hydropower	HB	1900	800		2700	Hydro
Three Gorges	HB		18200		18200	Hydro
Wangpuzhou	HB		109		109	Hydro
Gaobazhou	HB			240	240	Hydro
Huanglongtan, Ext	HB			140	140	Hydro
Panko	HB			500	500	Hydro
Shuibuya	HB			1500	1500	Hydro

Hubei

Hubei is located in the center of the CCPN. It is a major hydropower base in the CCPN. Of the 10.7 GW of existing capacity in Hubei, about 64 percent is hydropower. The rest is mainly coal-fired. Aside from being the site of the 18.2 GW Three Gorges project, Hubei offers significant untapped and undeveloped hydropower and thermal power project opportunities. Its potential hydropower resources is 30.6 GW, nearly all of which could be harnessed by building large and medium-sized hydropower stations, each with a capacity of over 25 MW. Its total of exploitable hydropower resources is about 28 GW. Apart from the Three Gorges project, some other hydropower stations will also be developed, such as Shuibuya Power Station on Qingjiang River (1,500 MW), Pankou Power Station (500 MW), and Geobazhou Power Station (140 MW). All these stations are to be built in the next five to ten years.

Most of Hubei's hydropower plants are located in the west part of the province, while most thermal power capacity and power load centers are in the east. To develop a balanced hydropower and thermal power system in Hubei, more thermal power plants will be built in the future. Limited water levels in the province sometimes leave about 70 percent of the generators unable to produce electricity normally. Therefore the electricity shortages in Hubei become very serious during the dry season. As a result, provincial planners are seeking to develop thermal power stations in Hubei as an alternative. During the 1990s, about 10 GW of thermal power plants will be installed or under construction. Projects looking for foreign investments include: (1) the Huanggang Power Plant (2X600 MW in the first phase and a total of 2,400 MW); (2) the Huangshi Power Plant Expansion Project (2X300 MW); (3) the coal-fired Ezhou project (8X300 MW in several phases, the first 300 MW under construction is financed by the Japanese Overseas Economic Cooperation Fund); (4) the 500 MW Pankou Hydropower project in Zushan County; and (5) the 4X300 MW coal-fired Jinsha project in Shashi City. Hubei has only limited coal resources. The province currently produces about 12 Mt of coal containing 30 percent of ash and 5 percent of sulfur. The heat content of the coal is about 5,000 kcal/kg. Thermal power plants which will consume the poor-quality coal will utilize fluidized-bed boilers. Since Hubei is close to coal rich provinces of Shanxi, Shaanxi, and Henan, coal will also be transported from these provinces to Hubei to meet the increasing demand of thermal power generation in Hubei.

CONTACTS

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Hunan Provincial Electric Power Company, Division of Foreign Relations, 62 Shao Shan Lu, Changsha, Hunan Province, China; phone, (86-7) 3131195.

Henan Provincial Electric Power Company, Lin Kongxing, Song Shan Nan Lu, Zhengzhou, Henan Province, China; phone, 449982.

Jiangxi Provincial Electric Power Company, Division of Foreign Relations, 111 Yong Wai Zheng Jie, Nanchang, Jiangxi Province, China; phone, (86-79) 1227021.

The Northeast Power Network

The Northeast Power Network (NEPN) covers Liaoning, Jilin, Heilongjiang, and the eastern part of Inner Mongolia with a total land area of 1.2 million square kilometers. Northeast China accounts for about 11 percent of China's GDP and 8.6 percent of population and is China's major heavy industry base. Economic development is largely dependent on the growth of the electric power industry. Total installed generating capacity in the NEPN is about 27 GW, of which coal-fired plants account for 77 percent, and hydropower accounts for 16 percent. Total electricity generation in 1994 was about 115 TWh, of which hydropower accounted for only 8.2 percent. The locations and generating capacity of the principal existing power plants and plants now under construction in the NEPN are shown in Figure 6.11.

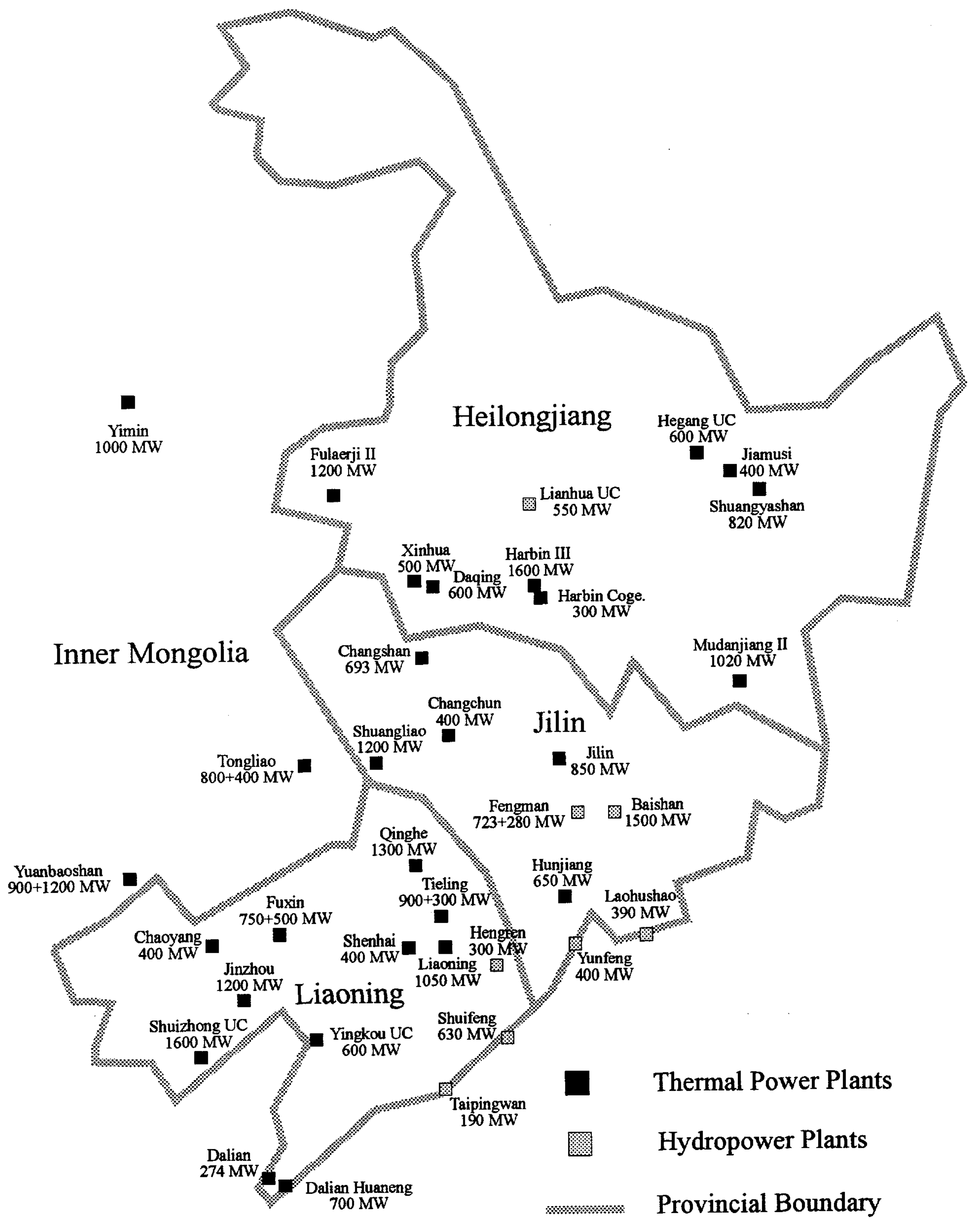

Figure 6.11. Existing and Under Construction Power Plants in the NEPN

This region lacks primary energy resources. Its hydropower resources account for only 2 percent of the nation's total. Most of the hydropower resources in Jilin and Liaoning have been utilized. Remaining hydropower resources are mainly located in the border rivers and unexploitable in the near future. Coal reserves in this region is estimated at 66 billion tons, of which three-quarters is lignite.

Lack of primary energy will be increasingly serious in the future, especially in Liaoning and Jilin. Based on this fact, future power development will focus on coal-fired mine-mouth projects and power plants located close to transportation terminals. Most new thermal power plants in the NEPN will be constructed close to the three large lignite strip mines in Inner Mongolia, the four major coal mines in the east part of Heilongjiang, the Tiefa coal mine In Liaoning, and the Huichun coal mine in Jilin. Power plants will also be installed close to major ports (Dalian, Yingkou, and Dandong) and railways (Shuizhong, Hashan, and Shuangliao). Traditional hydropower development will be limited in the future; however, pumped-storage hydropower projects will be developed to meet the system's peak demand. Nuclear power development is also considered in this region.

As shown in Figure 6.12, current transmission lines in the NEPN are mostly 220 kV lines. In recent years, however, 500 kV lines have gradually become the transmission backbone of the network and will further be expanded to transmit electricity from mine-mouth power plants to power load areas. By the end of 1994, 1,709 km of 500 kV lines had been built. In the future, 500 kV HVDC transmission projects and 750-1,000 kV transmission projects are also being planned.

To meet the increasing power demand, the NEPN plans to increase its total generating capacity to 46 GW by 2000. Thermal power units will mainly include 300, 500, 600, and 800 MW units. The size of new power plants will mainly be 1800-2400 MW. Table 6.5 shows the principal existing, under construction, and planned power plants in the NEPN. Planned power projects are mostly for the near future, long-term plans are not available.

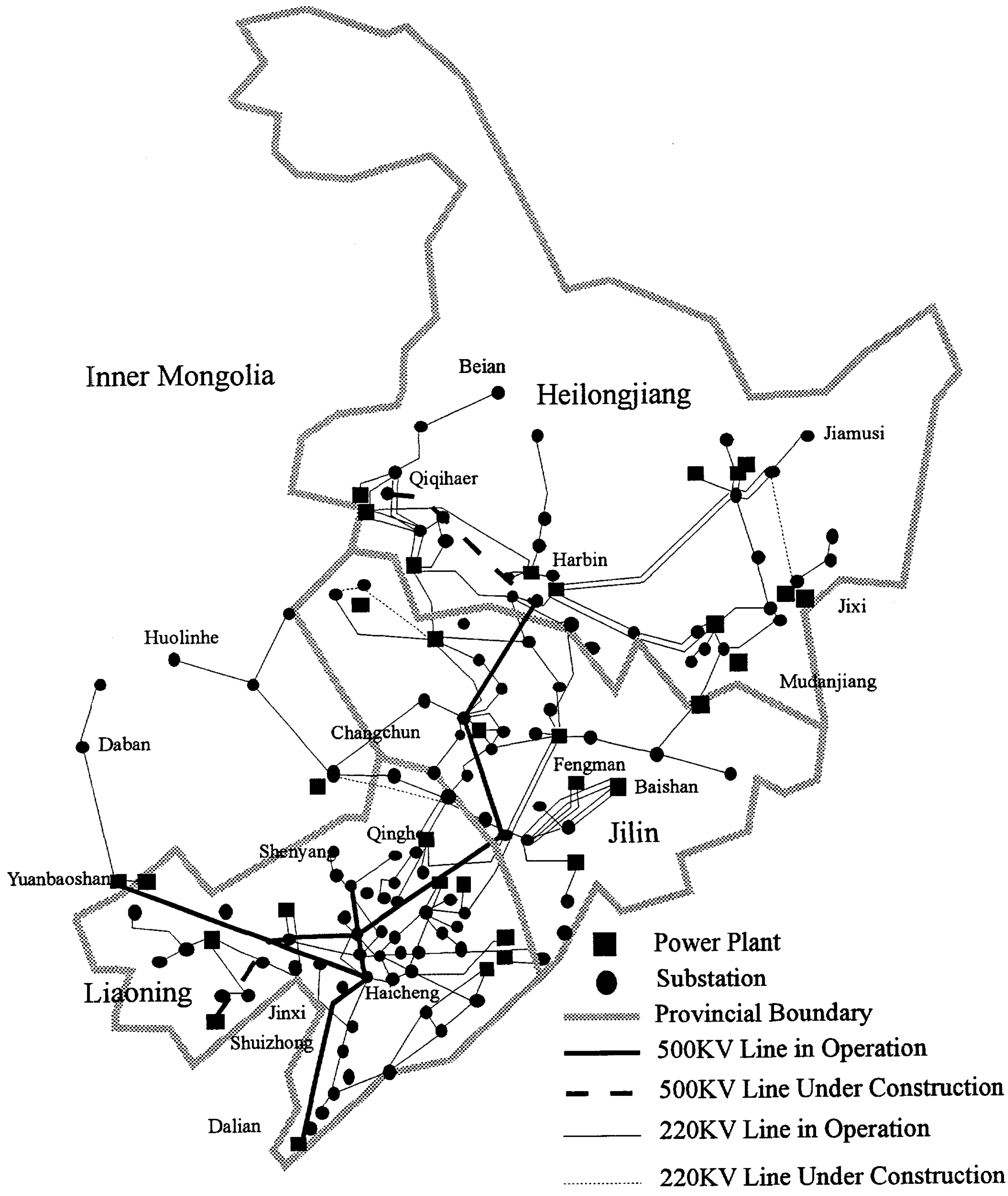

Figure 6.12. The Northeast Power Network

Table 6.5. Power Plants in the Northeast China Power Network

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
NEPN total		**27082**	**8280**	**18351**	**53863**	
Coal-fired		**20783**	**7450**	**11951**	**40334**	**Coal**
Gas-fired		251	0	0	251	Gas
Oil-fired		1600	0	0	1600	Oil
Hydropower		4448	830	2400	7678	Hydro
Nuclear		0	0	4000	4000	Nuclear
Heilongjiang total	**HL**	**7589**	**1150**	**5900**	**14639**	
Heilongjiang coal-fired	**HL**	**7242**	**600**	**4700**	**12542**	**Coal**
Daqing	HL	600			600	Coal
Didao	HL	50			50	Coal
Fularji Cogeneration	HL	150			150	Coal
Fularji II	HL	1200			1200	Coal
Harbin	HL	75			75	Coal
Harbin Cogeneration	HL	300			300	Coal
Harbin III	HL	1600			1600	Coal
Hegang Coal Mine	HL	50			50	Coal
Jiamusi	HL	498			498	Coal
Jiamusi Paper Factory	HL	54			54	Coal
Jixi	HL	75			75	Coal
Liangzihe	HL	200			200	Coal
Shuangyashan I&II	HL	820			820	Coal
Mudanjiang cogeneration	HL	50			50	Coal
Mudanjiang II	HL	1020			1020	Coal
Xinhua	HL	500			500	Coal
Hegang	HL		600		600	Coal
Jiamusi, Ext	HL			600	600	Coal
Harbin AES	HL			800	800	Coal
Qitaihe	HL			600	600	Coal
Shuangyashan III	HL			1200	1200	Coal
Xinhua, Ext.	HL			900	900	Coal
Shuangyashan III	HL			600	600	Coal
Daqing Shazong	HL	117			117	Gas
Other gas-fired	HL	30			30	Gas
Other oil-fired	HL	200			200	Oil
Lianhua	HL		550		550	Hydro
Huanggou PS	HL			1200	1200	Hydro

Table 6.5. Power Plants in the Northeast China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Liaoning total	**LN**	**9984**	**4050**	**10400**	**24584**	
Liaoning coal-fired	**LN**	**7047**	**4050**	**5200**	**16447**	**Coal**
Anshan Iron Company	LN	96			96	Coal
Beihaitou	LN	50			50	Coal
Benxi Iron Company	LN	216			216	Coal
Chaoyang	LN	400			400	Coal
Dahua	LN	100			100	Coal
Dalian	LN	274			274	Coal
Dalian Huaneng	LN	700			700	Coal
Fushun	LN	87			87	Coal
Fushun Cogeneration	LN	193			193	Coal
Fushun Power Company	LN	50			50	Coal
Jinxi	LN	200			200	Coal
Jinzhou	LN	1200			1200	Coal
Liaoning (coal)	LN	850			850	Coal
Petroleum No.2	LN	143			143	Coal
Qinghe (coal)	LN	500			500	Coal
Shenhai	LN	400			400	Coal
Shenyang cogeneration	LN	50			50	Coal
Shenyang Tiexi	LN	50			50	Coal
Taiping	LN	150			150	Coal
Tieling	LN	900	300		1200	Coal
Fuxin	LN	750	500		1250	Coal
Other coal-fired	LN	50	800		1000	Coal
Nianpiao	LN		250		250	Coal
Suizhong	LN		1600		1600	Coal
Yingkou	LN		600		600	Coal
Suizhong	LN			2600	2600	Coal
Yingkou II	LN			1200	1200	Coal
Dalian II	LN			700	700	Coal
Dandong	LN			700	700	Coal
Liao He Field GT	LN	74			74	Gas
Other gas-fired	LN	30			30	Gas
Liaoning (oil)	LN	200			200	Oil
Qinghe (oil)	LN	800			800	Oil
Other oil-fired	LN	200			200	Oil
Hengren	LN	301			301	Hydro
Shuifeng	LN	630			630	Hydro
Taipingwan	LN	190			190	Hydro
Other Hydropower	LN	150			150	Hydro
Pushihe PS	LN			1200	1200	Hydro
Wafangdian	LN			4000	4000	Nuclear

Table 6.5. Power Plants in the Northeast China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Jilin total	**JL**	**7072**	**1480**	**2051**	**10603**	
Jilin coal-fired	**JL**	**3794**	**1200**	**2051**	**7045**	**Coal**
Changchun	JL	400		451	851	Coal
Changchun Automobile	JL	91			91	Coal
Changshan	JL	693			693	Coal
Hekou	JL	50			50	Coal
Hunchun	JL	200			200	Coal
Hunjiang	JL	650			650	Coal
Jilin Chemical	JL	75			75	Coal
Jilin cogeneration	JL	850			850	Coal, Oil
Taoyuan	JL	55			55	Coal
Yiwuling	JL	200			200	Coal
Yongli	JL	180			180	Coal
Yushuchuan	JL	50			50	Coal
Shuangliao	JL	300	900		1200	Coal
Other coal-fired	JL		300		300	Coal
Changchun II	JL			600	600	Coal
Baicheng	JL			1000	1000	Coal
Oil-fired plants	JL	200			200	Oil
Baishan	JL	1500			1500	Hydro
Fengman	JL	723	280		1003	Hydro
Laohushao	JL	390			390	Hydro
Yunfeng	JL	400			400	Hydro
Other hydropower	JL	65			65	Hydro
East Inner Mongalia	**IM**	**2700**	**1600**		**4300**	
East IM coal-fired	**IM**	**2700**	**1600**		**4300**	**Coal**
Yimin	IM	1000			1000	Coal
Tongliao	IM	800	400		1200	Coal
Yuanbaoshan	IM	900	1200		2100	Coal

CONTACTS

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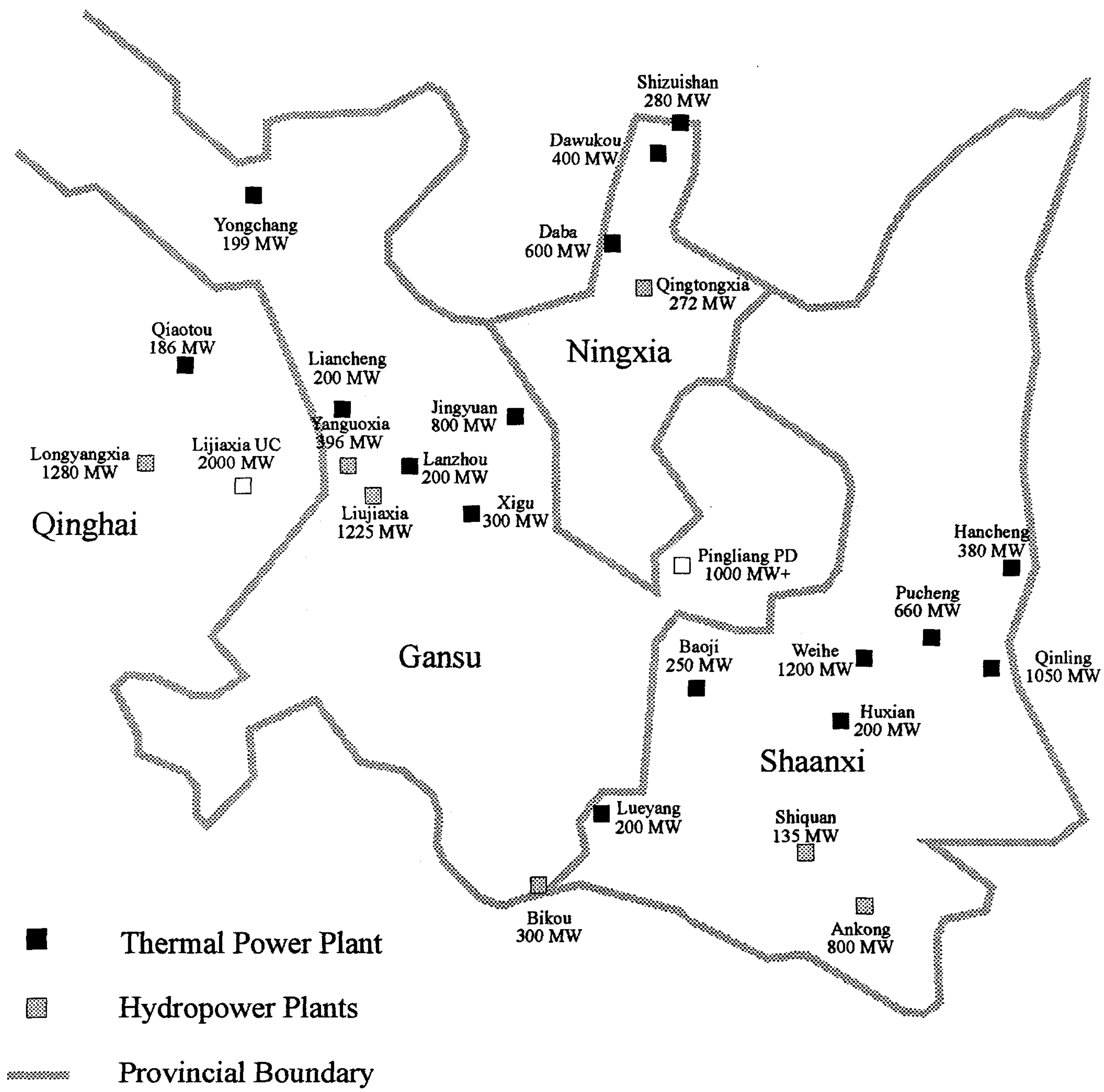
The Northwest Power Network and the Xinjiang Power Grid

China's northwest region include Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. The power systems in this region are managed by the Northwest Power Group (NWPG). This region is relatively backward economically compared to other regions. It accounts for about one-third of the nation's total land area, about 7 percent of total population, and only 5 percent of GDP. It has about 16 GW of generating capacity, coal-fired capacity accounting for about 57 percent. Total electricity generation in 1994 was about 74 TWh, of which hydropower accounted for about 31 percent. The principal power plants managed by the NWPG are shown in Figure 6.13.

In this region, the main power network is the Shaaxi-Gansu-Qinghai-Ningxia power network, or the NWPN. The Urumqi Power Grid in Xinjiang and the Jiuquan-Yumen Power Grid in the west part of Gansu are two independent small power grids. As shown in Figure 6.14, currently the NWPN has only adopted 330 kV transmission lines. By the end of 1994, the length of 330 kV lines reached 4,853 km, and the 220 kV lines reached 2,952 km. According to the ten year power development plan, by 2000 the NWPN will extend to the north part of Shaanxi Province, link with the Jiuquan-Yumen Power Grid, and interconnect with the Sichuan Power Grid. A total of 1,200 MW power will be transmitted to the Sichuan Province. In the long run, 500 kV transmission lines will be built to transmitted electricity to the NCPN.



Note: UC--Under Construction; PD--Planned.

Figure 6.13. Principal Power Plants in the NWPN

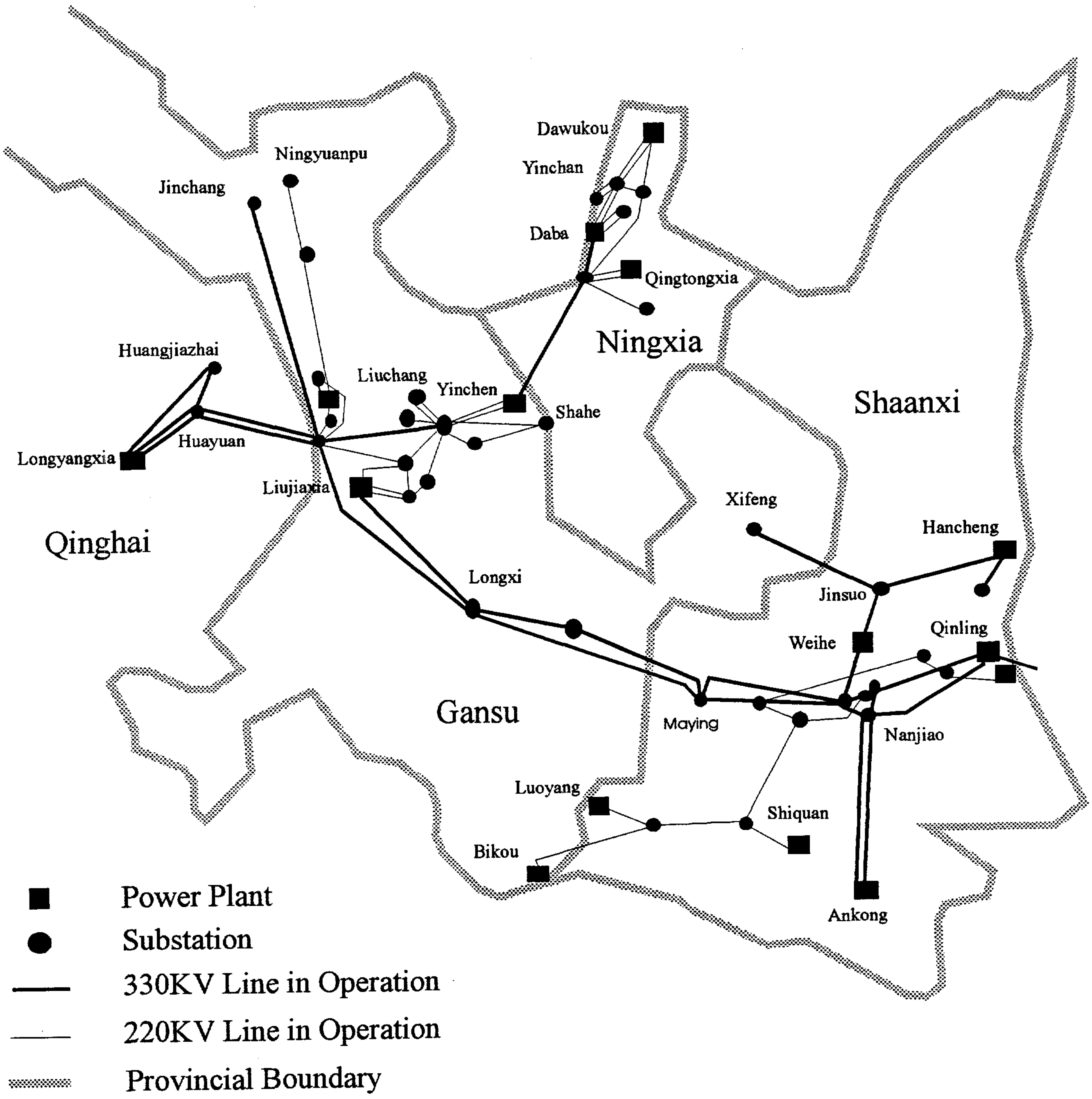


Figure 6.14. The Northwest Power Network

The northwest region is rich in hydropower resources. The theoretical hydropower resources in this region are 84 GW, ranking second in China. The exploitable hydropower resources in the upper Yellow River (from Longyangxia in the east part of Qinhai Province to Qingtongxia in the north part of Ningxia province), the Yilihe River, and the Hanjiang and Bailongjiang Rivers (both are tributaries of the Yangtze River) are more than 20 GW. Especially in the upper Yellow River, not only are hydropower resources rich, but development conditions are very attractive. The Longyangxia to Qingtongxia section of the Yellow River has a length of 918 km and a total fall of 1,465 meters. Five hydropower stations have been built in this area which include: (1) the 1,280 MW Longyangxia project; (2) the 1,225 MW Liujiaxia project; (3) the 396 MW Yanguoxia project; (4) the 180 MW Bapanxia project; and (5) the 272 MW Qingtongxia project. In the tributaries of the Yangtze River in the south part of Shaanxi, three major hydropower plants (1,235 MW) have been built.

This region is also rich in coal resources. Preliminary coal reserves are estimated about 380 billion tons in Shaanxi, 70 billion tons in Ningxia, 8 billion tons in Gansu, and 1,600 billion tons in Xinjiang. During the past 15 years, total coal production in this region increased from 49 to 100 Mt. The largest natural gas field in China is also discovered here. Several large coal-fired power plants have been developed in Shaaxi and Ningxia. According to the ten year power development plan of the NWPN, several GW scale coal-fired power plants will be built by 2000 in this region.

Power development in this region is constrained by relatively slower electricity demand growth. Higher capacity transmission lines will have to be built before electricity can be transmitted to the demanding NCPN and SCPG. The strategic shift of the production of electricity-intensive commodities to this region will take time to realize. The low income levels makes the adjustment of electricity tariffs to attract private investors in power development difficult. However, since building power plants is less costly in this region, developing power projects and transmitting electricity to the NCPN deserves serious consideration. Total generating capacity in this region is planned to reach 25 GW by 2000. Table 6.6 shows the principal existing, under construction, and planned power plants in the northwest region.

Table 6.6. Power Plants in the Northwest China Power Network

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
NWPN total		**15950**	**5900**	**22530**	**44510**	
Coal-fired		**9137**	**3000**	**13800**	**25937**	**Coal**
Gas-fired		25	0	0	25	Gas
Oil-fired		550	0	0	550	Oil
Hydropower		6418	2900	8730	18048	Hydro
Nuclear		0	0	0	0	Nuclear
Shaanxi total	**SN**	**5124**	**1000**	**3600**	**9724**	
Shaanxi coal-fired	**SN**	**4039**	**1000**	**3600**	**8639**	**Coal**
Baoji	SN	250			250	Coal
Hancheng I	SN	380			380	Coal
Huxian	SN	200			200	Coal
Lueyang	SN	200			200	Coal
Pucheng	SN	1200			1200	Coal
Qinling	SN	1050			1050	Coal
Weihe	SN	700	600		1300	Coal
Other coal-fired	SN	59	400		459	Coal
Baoji II	SN			1200	1200	Coal
Hancheng II	SN			2400	2400	Coal
Ankang	SN	800			800	Hydro
Shiquan	SN	135			135	Hydro
Other hydropower	SN	150			150	Hydro
Gansu total	**GS**	**4348**	**1500**	**1600**	**7548**	
Gansu coal-fired	**GS**	**1897**	**900**	**1600**	**4397**	**Coal**
Gansu 803	GS	75			75	Coal
Jinquan Iron Company	GS	122			122	Coal
Lanzhou II	GS	200			200	Coal
Lian Cheng	GS	200			200	Coal
Xigu	GS	300			300	Coal
Yongchang	GS	200			200	Coal
Jingyuan I&II	GS	800	600		1400	Coal
Other coal-fired	GS		300		300	Coal
Lian Cheng Extens.	GS			400	400	Coal
Pingliang	GS			1200	1200	Coal
Oil-fired plants	GS	150			150	Oil
Bapanxia	GS	180			180	Hydro
Bikou	GS	300			300	Hydro
Liujiaxia	GS	1225			1225	Hydro
Yanguoxia	GS	396			396	Hydro
Other hydropower	GS	200	300		600	Hydro
Daxia	GS		300		300	Hydro

Table 6.6. Power Plants in the Northwest China Power Network (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Qinghai total	**QH**	**1806**	**2300**	**6470**	**10606**	
Qinghai coal-fired	**QH**	**226**			**226**	**Coal**
Qiaotou	QH	186			186	Coal
Other coal-fired	QH	40			40	Coal
Longyangxia	QH	1280			1280	Hydro
Other hydropower	QH	300	300		630	Hydro
Lijiaxia	QH		2000		2000	Hydro
Gongboxia	QH			1500	1500	Hydro
Jishixia	QH			1000	1000	Hydro
Laxiwa	QH			3720	3720	Hydro
Sigouxia	QH			250	250	Hydro
Ningxia total	**NX**	**2072**	**800**	**8200**	**11072**	
Ningxia coal-fired	**NX**	**1500**	**800**	**6600**	**8900**	**Coal**
Dawukou	NX	400			400	Coal
Shizuishan	NX	280			280	Coal
Zhongning	NX	50			50	Coal
Daba	NX	600	600		1200	Coal
Other coal-fired	NX	170	200		370	Coal
Daba II	NX			600	600	Coal
Shizuishan II	NX			1200	1200	Coal
Lingwu	NX			1200	1200	Coal
Tianshuihe	NX			1200	1200	Coal
Yinchuan	NX			1200	1200	Coal
Yuquanying	NX			1200	1200	Coal
Qingtongxia	NX	272			272	Hydro
Other hydropower	NX	300			300	Hydro
Heishanxia	NX			1600	1600	Hydro
Xinjiang total	**XJ**	**2600**	**300**	**2660**	**5560**	
Xinjiang coal-fired	**XJ**	**1475**	**300**	**2000**	**3775**	**coal**
Manasi	XJ	600			600	Coal
Hongyanchi	XJ	300	100		400	Coal
Weihuliang	XJ	59			59	Coal
Other coal-fired	XJ	516	200		716	Coal
Hongyanchi II	XJ			1200	1200	Coal
Manasi, Ext.	XJ			800	800	Coal
Gas-fired	XJ	25			25	Gas
Oil-fired plants	XJ	400			400	Oil
Hydropower	XJ	700			700	Hydro
Jilintai	XJ			460	460	Hydro
Chahanwushu	XJ			200	200	Hydro

Shaanxi

The Shaanxi Province is located in the east part of the NWPN and close to the NCPN. It now has 5.1 GW generating capacity, of which coal-fired plants account for 79 percent. In the future, Shaanxi will become a major coal-fired power generating base in China. The two largest coal-fired power plants in the NWPN, the 1,050 MW Qinling project and the 1,200 MW Pucheng project, are located in Shaanxi. Shaanxi is now soliciting joint-venture partners for a $543 billion, 1,200 MW, mine-mouth coal-fired plant in Hancheng (phase one). The Hancheng No.2 Power Plant plans to install another 1,200 MW in the second phase. The Weihe Power Plant and the Baoji Power Plant will also be extended to GW-scale plants by 2000. Shaanxi now has 1,000 MW coal-fired capacity under construction, and 3,600 MW of coal-fired capacity being planned.

Gansu

The Gansu Province is in the middle of the NWPN. It has both large hydropower plants and coal-fired power plants. It now has about 4.3 GW of generating capacity, of which about 1.9 GW are coal-fired. Total installed capacity is expected to reach 8.1 GW by 2000. Major hydropower plants include the 1225 MW Liujiaxia project, the 396 MW Yanguoxia project, and the 300 MW Bikou project. The 800 MW Jingyuan project is the largest coal-fired plant in Gansu. It will be extended to 1,400 MW as the two 300 MW units currently under construction will be completed in 1996. Gansu also plans to build another large coal-fired plant (above 1,000 MW) in Pingliang.

Qinghai

Power development in Qinghai is mostly hydropower. Now hydropower plants account for 87 percent of the total 1.8 GW installed capacity in Qinghai. The 1,280 MW Longyangxia project is the largest hydropower plant in the NWPN. The 24.7 billion cubic meter reservoir associated with the Longyangxia plant has a multi-year water adjustability. The section of Yellow River in Qinghai Province has the best hydropower resources in the region. The 2,000

MW Lijiaxia project is now under construction, and the 1,500 MW Gongboxia project will soon start construction. In addition, a number of large and medium-sized hydropower plants have been planned in this section of the Yellow River including the 3,720 MW Laxiwa project, the 1,000 MW Jishixia project, the 250 MW Sigouxia project, and 7 medium-sized plants.

Ningxia

Ningxia has rich coal resources, and most coal reserves are located close to water sources and transportation terminals, therefore being ideal for development of coal-fired power plants. Total generating capacity in Ningxia is now about 2 GW, of which coal-fired accounts for 75 percent. In addition to the 800 MW of coal-fired capacity now under construction, 6,600 MW coal-fired capacity have been planned. Major power plants scheduled to be installed by 2000 include: (1) the 2X300 MW Daba second phase to be completed by 1997; and (2) a 4X300 MW plant in Shizuishan (first phase 2X300 MW) to be completed by 2000. In addition, several coal-fired power plant sites which are able to install GW scale plants have been identified in Lingwu, Yinchuan, Tianshuihe, and Yuquanying.

Xinjiang

Xinjiang now has about 2.6 GW of generating capacity and plans to increase its total capacity to 5 GW by 2000. Most existing power units in Xinjiang are small, less than 100 MW. The two principal power plants are the 400 MW Manasi project and the 300 MW Hongyanchi project. Major new power projects during the 1990s include: (1) the 6X200 MW Hongyanchi II project; and (2) the 800 MW Manasi extension project. The 460 MW Jilintai hydropower project and the 200 MW Chahanwushu hydropower project are also being considered for longer term development.

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The Sichuan, Yunnan, Guizhou, and Guangxi Provincial Power Grids

In the four southwest provinces of Sichuan, Yunnan, Guangxi, and Guizhou, hydropower resources are very rich. The four provinces account for more than half of China's total hydropower resources. Total generating capacity in this region is now about 26.9 GW, of which hydropower plants account for 56 percent, and coal-fired plants account for 40 percent. Future power development in this region will focus on hydropower projects. Among the 15.1 GW of power plants now under construction, about 69 percent are hydropower. About 68 percent of the planned 80 GW of new power plants are hydropower. Table 6.7 shows the principal existing, under construction, and planned power plants in the southwest region.

During the 1996-2000 period, 7 large hydropower plants, with a total capacity of 20 GW, will be build. More than ten joint venture power development agreements have been signed with foreign investors from the United States, Hong Kong, and Thailand in Yunnan, Sichuan, Guangxi, and Guizhou Province. A total of 65 large hydropower plants with a combined capacity of 120 GW are in the planning stage for Hongshui, Jinshajiang, Yalongjiang, Daduhe, Lancangjiang, and Wujiang Rivers. Some of the hydroelectricity generated in Guizhou, Yunnan, and Guangxi will be send to Guangdong Province.

Table 6.7. Power Plants in Southwest China

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Southwest total		**26891**	**15110**	**80381**	**122407**	
Coal-fired		**10838**	**4720**	**23490**	**39048**	**Coal**
Gas-fired		212	0	2000	2212	Gas
Oil-fired		642	0	0	642	Oil
Hydropower		15199	10390	54891	80505	Hydro
Nuclear		0	0	0	0	Nuclear
Sichuan total	**Sichuan**	**11850**	**5950**	**12600**	**30400**	
Coal-fired	**Sichuan**	**5808**	**1000**	**5300**	**12108**	**Coal**
Gas-fired	Sichuan	212	0	2000	2212	Gas
Oil-fired	Sichuan	300	0	0	300	Oil
Hydropower	Sichuan	5530	4950	5300	15780	Hydro
Nuclear	Sichuan	0	0	0	0	Nuclear
Yunnan total	**Yunnan**	**5575**	**2650**	**45000**	**53250**	
Coal-fired	**Yunnan**	**1475**	**800**	**9850**	**12125**	**Coal**
Gas-fired	Yunnan	0	0	0	0	Gas
Oil-fired	Yunnan	0	0	0	0	Oil
Hydropower	Yunnan	4100	1850	35150	41125	Hydro
Nuclear	Yunnan	0	0	0	0	Nuclear
Guizhou total	**Guizhou**	**4000**	**2990**	**14400**	**21390**	
Coal-fired	**Guizhou**	**1600**	**400**	**5820**	**7820**	**Coal**
Gas-fired	Guizhou	0	0	0	0	Gas
Oil-fired	Guizhou	142	0	0	142	Oil
Hydropower	Guizhou	2258	2590	8580	13428	Hydro
Nuclear	Guizhou	0	0	0	0	Nuclear
Guangxi total	**Guangxi**	**5466**	**3520**	**8381**	**17367**	
Coal-fired	**Guangxi**	**1955**	**2520**	**2520**	**6995**	**Coal**
Gas-fired	Guangxi	0	0	0	0	Gas
Oil-fired	Guangxi	200	0	0	200	Oil
Hydropower	Guangxi	3311	1000	5861	10172	Hydro
Nuclear	Guangxi	0	0		0	Nuclear

Table 6.7. Power Plants in Southwest China (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Sichuan total	**SC**	**11850**	**5950**	**12600**	**30400**	
Baima	SC	600			600	Coal
Chengdu	SC	325			325	Coal
Chongqing	SC	800			800	Coal
Douba	SC	300			300	Coal
Fuling Longqao	SC	50			50	Coal
Geliping	SC	200			200	Coal
Hemenkou	SC	200			200	Coal
Huangjiaozhuang	SC	400			400	Coal
Huayingshan	SC	300			300	Coal
Jiangyou	SC	884			884	Coal
Kaixian	SC	100			100	Coal
Luohuang	SC	700			700	Coal
Wutongqiao	SC	112			112	Coal
Xinzhuang	SC	100			100	Coal
Other coal-fired	SC	737	1000		1737	Coal
Baima, Ext.	SC			400	400	Coal
Huayingshan, Ext.	SC			600	600	Coal
Jiangyou, Ext.	SC			600	600	Coal
Luohuang II	SC			700	700	Coal
Chongqing II	SC			600	600	Coal
Guangan	SC			600	600	Coal
Hekou	SC			600	600	Coal
Huangjiaozhuang II	SC			600	600	Coal
Minjiang	SC			600	600	Coal
Huaneng Chongqing	SC	112			112	Gas
Other gas-fired	SC	100			100	Gas
Chengdu II	SC			2000	2000	Gas, Coal
Oil-fired plants	SC	300			300	Oil
Baozhusi	SC	175			175	Hydro
Gongzui	SC	1370			1370	Hydro
Nanyahe	SC	120			120	Hydro
Taipingyi	SC	260			260	Hydro
Yingxiuwan	SC	455			455	Hydro
Tongjiezi	SC	450	150		600	Hydro
Other hydropower	SC	2700	800		3500	Hydro
Baozhushi, Ext.	SC		700		700	Hydro
Ertan	SC		3300		3300	Hydro
Pubugou	SC			3300	3300	Hydro
Pengshi	SC			2000	2000	Hydro

Table 6.7. Power Plants in Southwest China (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Yunnan total	**YN**	**5575**	**2650**	**45000**	**53250**	
Kaiyuan	YN	236			236	Coal
Kunming	YN	236			236	Coal
Shennan (Xiaolongtan)	YN	600			600	Coal
Xuan Wei	YN	200			200	Coal
Xunjiansi	YN	100			100	Coal
Yangzonghai	YN	60			60	Coal
Other coal-fired	YN	43	800		843	Coal
Kaiyun	YN			250	250	Coal
Qu Qing	YN			1200	1200	Coal
Xuan Wei, Ext.	YN			600	600	Coal
Yang Jia Hai	YN			600	600	Coal
Fushen	YN			3600	3600	Coal
Shao Bian I	YN			1200	1200	Coal
Shao Bian II	YN			1200	1200	Coal
Shao Bian III	YN			1200	1200	Coal
Lubuge	YN	750			750	Hydro
Manwan	YN	1250			1250	Hydro
Xierhe	YN	255			255	Hydro
Yilihe	YN	322			322	Hydro
Other hydropower	YN	1523	500		2048	Hydro
Dachaoshan	YN		1350		1350	Hydro
Jinghong	YN			1500	1500	Hydro
Nana River Mouth	YN			600	600	Hydro
Qinwan	YN			1500	1500	Hydro
Xiaowan	YN			4200	4200	Hydro
Cao Zha Du	YN			5000	5000	Hydro
Ganlanba	YN			1250	1250	Hydro
No Kong Du	YN			5000	5000	Hydro
Nuozhadu	YN			5000	5000	Hydro
Xi Luo Du	YN			6000	6000	Hydro
Xiangjiaba	YN			5100	5100	Hydro

Table 6.7. Power Plants in Southwest China (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Guizhou total	**GZ**	**4000**	**2990**	**14400**	**21390**	
Pan Xian	GZ	200			200	Coal
Qingzhen	GZ	658			658	Coal
Shuicheng	GZ	100			100	Coal
Zun Yi	GZ	324			324	Coal
Other coal-fired	GZ	143	400		543	Coal
An Shun	GZ			2400	2400	Coal
Du Yun	GZ			600	600	Coal
Guiyang	GZ	175		1320	1495	Coal
Jin Sha	GZ			250	250	Coal
Kaili	GZ			250	250	Coal
Pan Xian, Ext.	GZ			600	600	Coal
Shui Cheng	GZ			400	400	Coal
Oil-fired plants	GZ	142			142	Oil
Qingxi	GZ	108			108	Hydro
Wujiangdu	GZ	630			630	Hydro
Tianshengqiao II	GZ	880	440		1320	Hydro
Other hydropower	GZ	640	440		1080	Hydro
Dongfeng	GZ		510		510	Hydro
Tianshengqiao I	GZ		1200		1200	Hydro
Goupitan	GZ			2000	2000	Hydro
Hongjindu	GZ			540	540	Hydro
Longtan	GZ			4200	4200	Hydro
San Ban Si	GZ			1000	1000	Hydro
Si Lin	GZ			840	840	Hydro

Table 6.7. Power Plants in Southwest China (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Guangxi total	**GX**	**5466**	**3520**	**8381**	**17367**	
Heshan	GX	505			505	Coal
Laibin	GX	250			250	Coal
Liuzhou	GX	400			400	Coal
Panxian	GX	300			300	Coal
Tiandong	GX	74			74	Coal
Other coal-fired	GX	426	600		1026	Coal
Laibin II	GX		600		600	Coal
Qinzhou	GX		1320		1320	Coal
Beihai	GX			1200	1200	Coal
Dadong	GX			120	120	Coal
Yujiang	GX			1200	1200	Coal
Oil-fired plants	GX	200			200	Oil
Bailongtan	GX	192			192	Hydro
Dahua	GX	400			400	Hydro
Tianshengqiao II (GX)	GX	360			360	Hydro
Yantan	GX	1209			1209	Hydro
Other hydropower	GX	1150	1000		2150	Hydro
Baise	GX			480	480	Hydro
Etan	GX			560	560	Hydro
Ghangzhou	GX			621	621	Hydro
Longtan	GX			4200	4200	Hydro

In the southwest region, three 500 kV transmission lines have been built to supply electricity to South China. The Tianshengqiao Station (II) will provide electricity to Guizhou, Guangdong, and Guangxi through 500 kV lines and will be connected to Yantan Station, Guangzhou Pumped-Storage Station, and Daya Bay Nuclear Power Station with 500 kV lines.

The Sichuan Power Grid

Sichuan has a land area of 560,000 square kilometers and a population of 112 million. Total exploitable hydropower resource in Sichuan is about 92 GW, so far only 5.5 GW have been developed. Total generating capacity is now 11.9 GW, of which hydropower accounts for 47 percent. Thermal power plants in Sichuan are mostly coal-fired. Sichuan produced 99 Mt of coal in 1995 (mostly high sulfur coal). Due to transportation difficulties, the coal produced is consumed locally, which has seriously affected Sichuan's environmental conditions. The first imported flue gas desulfurization (FGD) system was installed in Sichuan's Luohuang Power Plant. The principal power plants in Sichuan are shown in Figure 6.15.

Although Sichuan has very rich hydropower resources, electricity shortages have been common for over 20 years. The SCPG plans to increase total generating capacity to about 13.9 GW in 2000. The 6X550 MW Ertan hydropower project on the Yalongjiang River in southwest Sichuan was launched in 1991 and is expected to be completed by 2000. The 21 billion yuan ($2.5 billion) project is financed in part by the World Bank. Recently, the World Bank has approved financing of $400 million for the second phase of the Ertan project. The financing is also amplified by a further World Bank guarantee of $150 million for commercial financing and adds to the $380 million for the first phase. During the 1996-2000 period, the Baozhusi, Taipingyi, Nanyahe, and Zilanba hydropower projects, and the Chengdu, Chongqing, Jiangyou, Huangjiaozuang, Minjiang, and Hekou thermal power plants will be extended or completed; the Pubugou and Pengshi large hydropower projects will start construction. After 2000, Sichuan will develop the huge hydropower projects on the Jinshajiang River, the Yalongjiang River, and the Daduhe River, as well as the mine mouth coal-fired projects in south Sichuan, and transmit electricity to the east.

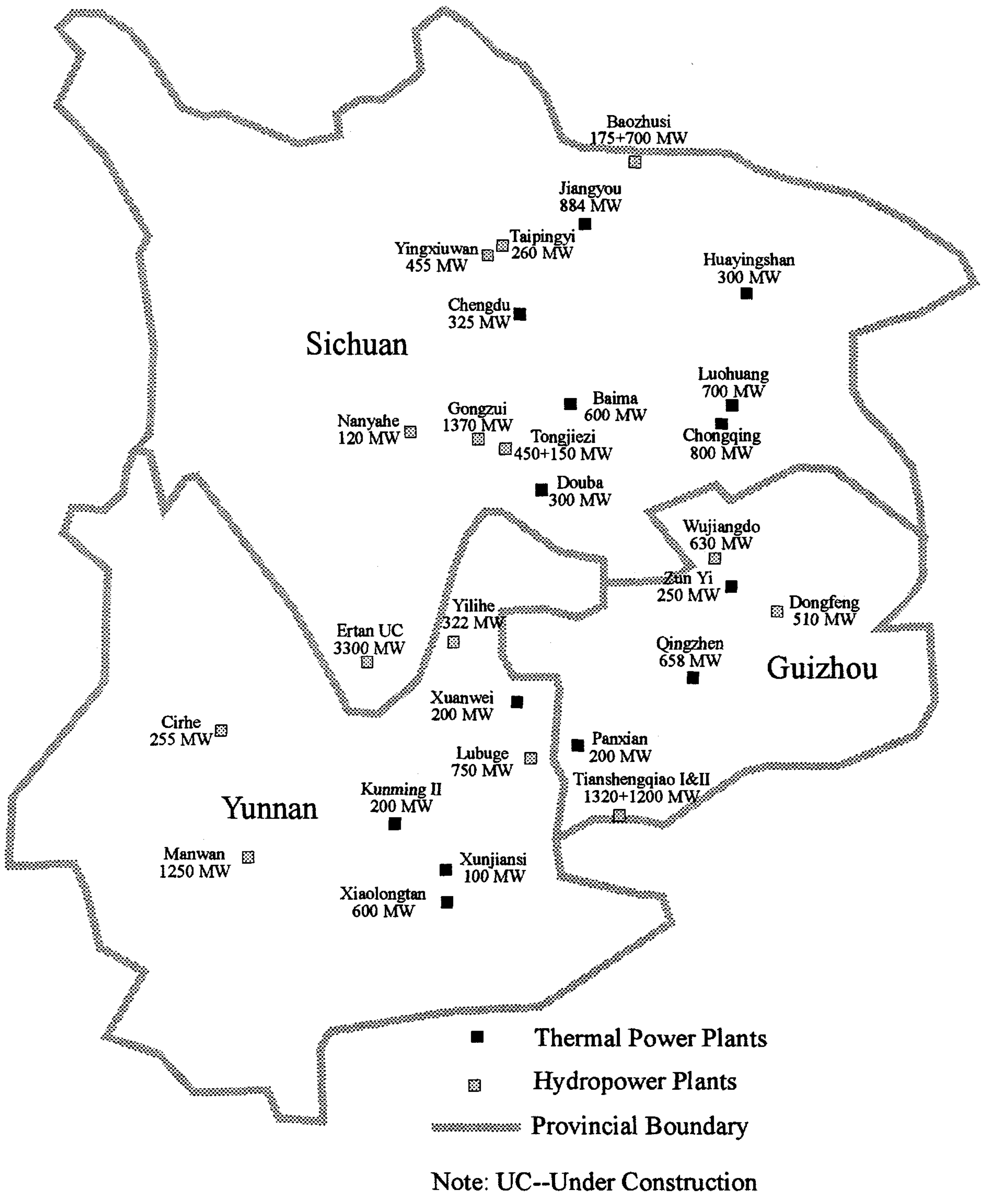

Figure 6.15. Principal Power Plants in the Sichuan, Yunnan, and Guizhou Power Grids

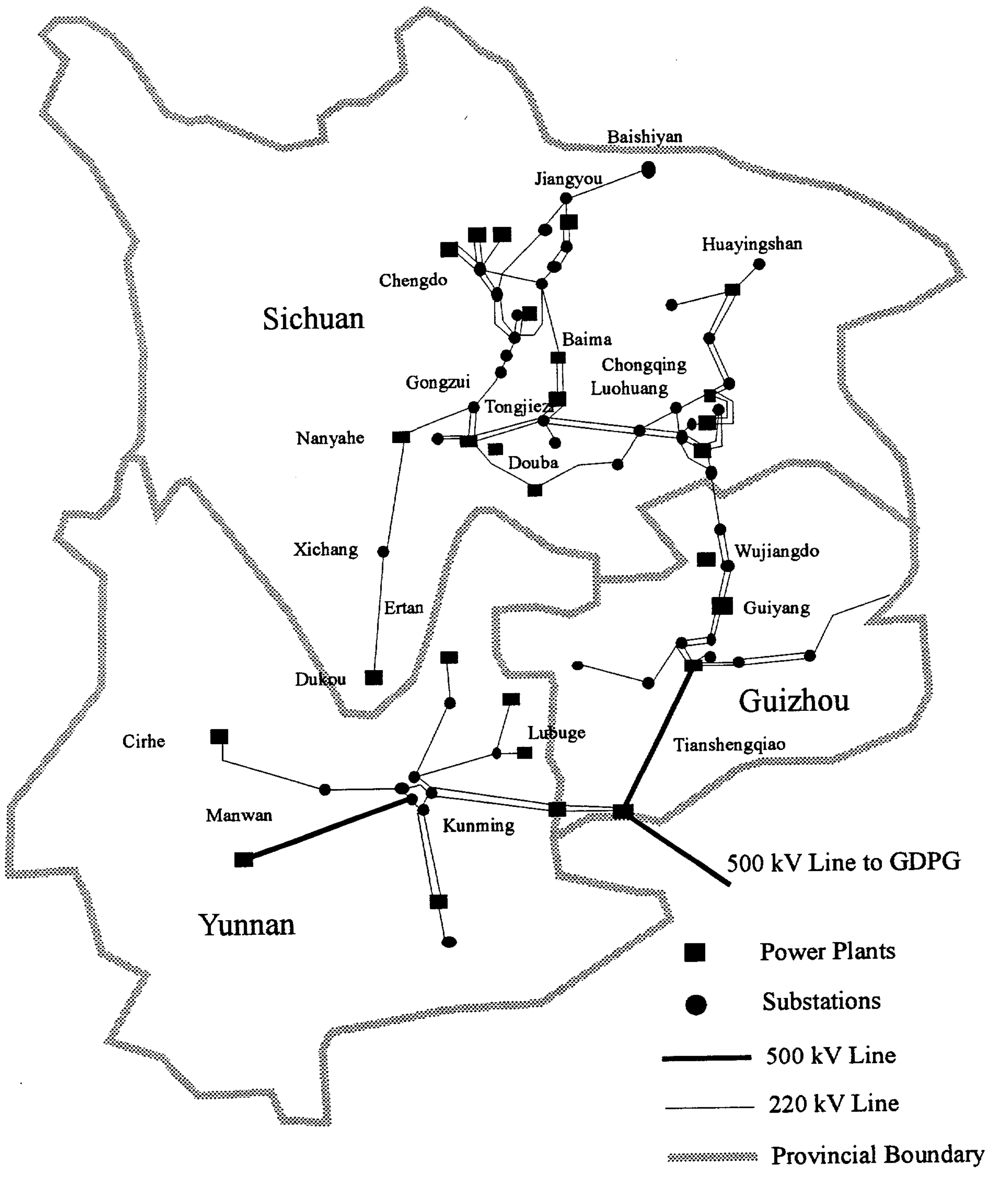

Figure 6.16. The Sichuan, Yunnan, and Guizhou Provincial Power Grids

As shown in Figure 6.16, the SCPG is basically an independent power grid, although it has been interconnected with Gansu and Guizhou by 220 kV transmission lines and with Yunnan by 110 kV transmission lines. Currently only 220 kV transmission lines are adopted in the SCPG. By the end of 1994, the SCPD had build 5,251 km of 220 kV lines and 10,126 km of 110 kV lines. With the development of Ertan hydropower projects, a 500 kV transmission network will be developed to link Ertan with Chengdo, Zigong, and Chongqing.

The Yunnan Power Grid

Yunnan has a land area of 380,000 square kilometers and a population of 39 million. Its hydropower resources account for more than one-fifth of the nation's total. Currently about 74 percent of its 5.6 GW of power plants are hydropower, the rest are almost all coal-fired. About 70 percent of the 2.65 GW power plants now under construction and 78 percent of the 45 GW of planned power plants are hydropower. Almost all Yunnan's new thermal power plants will be coal-fired. Yunnan has 23 billion tons of coal reserves, ranking eighth in China. Coal production was 26 Mt in 1994.

As shown in Figure 6.16, with the completion of the first unit in Manwan hydropower plant, a 500 kV transmission system has been adopted to send electricity to Kunming. Yunnan now has 221 km of 500 kV line and 2,073 km of 220 kV line. A strong united power network, composed of 500 kV and 220 kV lines, and covering Yunnan and its neighboring provinces, will be formed after 2000.

China intends to make Yunnan a hydropower base. The Yunnan Power Bureau plans to increase its total generating capacity to 8 GW by 2000 and 29 GW by 2010. A total of 39.5 GW of capacity is targeted by Yunnan officials by 2015. Yunnan, Guangdong, and the central government have agreed to jointly develop power projects in Yunnan, and foreign investments are invited in virtually all projects. The 1,250 MW Manwan project is the first joint venture project involving the state government and local governments in China. Major hydropower projects to be developed include: (1) the 1,350 MW Dachaoshan project to be completed in 2002; (2) the 1,500 MW Qinwan project to be completed by 2003; (3) the 1,500 MW Jinghong project to be completed by 2006; (4) the 4,200 MW Xiaowan project to be completed by 2012; (5) the 5,000 MW Nuozhadu project to be completed by 2012; and (6) the 12,000 MW Liluodu project, with 6,000 MW scheduled for completion by 2010 and another 6,000 MW by 2015.

According to an agreement between Yunnan and Guangdong, the latter will contribute 60 percent of the investment for the Xiaowan project and 35 percent for the Nuozhadu project. In return, for the next 20 years, Yunnan will continue to extend its power supply to Guangdong every summer and autumn. This represents 900 MW in the first 4 years and 1,800 MW in each of the following 16 years. Investment for the 6X700 MW Xiaowan project on the Lancang River will exceed 30 billion yuan ($3.6 billion), about 60 percent of the power generated by this plant will be transmitted to Guangdong, with the rest to meet local needs. Guangdong has committed 23 billion yuan ($2.8 billion) to the Xiaowan, Nuozhadu, and the 1,200 MW coal-fired Quqing project in Yunnan.

Coal-fired plants will also be developed in Yunnan. Major coal-fired plants scheduled include: (1) the 600 MW Yangjiahai project; (2) the 600 MW Xuanwei project; (3) the 1,200 MW Quqing project; (4) the 250 MW Kaiyun project to be completed by 2000; (5) the 3,600 MW Shao Bian project to be completed in equal phases in 2004, 2008, and 2012; and (6) the 3,600 MW Fushen project to be completed by 2015.

Reportedly, the MDX Power of Thailand has agreed to invest in three hydropower projects in Yunnan totalling about 2,000 MW on BOO terms. About half of the electricity generation is designated for export to Thailand. The projects are estimated to cost $2 billion. MDX will hold an equity stake of about 45 percent, while the remaining 55 percent will be held jointly by Yunnan province and the central government. The first unit is scheduled to begin operation in 2001, with the remaining units begining in stages through 2004. However, the Electricity Generating Authority of Thailand has not yet agreed to buy the electricity.

<u>The Guizhou Power Grid</u>

Guizhou has a land area of 170,000 square kilometers and a population of 35 million. Guizhou is heavily dependent on hydropower plants to provide electricity. Of the existing 4 GW of generating capacity installed in Guizhou, hydropower plants account for 54 percent, and coal-fired for 40 percent. About 87 percent of the 3 GW of power plants now under construction and 60 percent of the 14.4 GW of planned power plants are hydropower. The principal existing power plants in the GZPG are shown in Figure 6.15.

The Guizhou Power Bureau plans to increase its total generating capacity to 6.3 GW by 2000 and 17.7 GW by 2010. Currently, the 4X300 MW Tianshengqiao I station and the second phase of Tishengqiao II station (2X220 MW) are under construction and are to be completed by 1998. Other major hydropower plants planned by the GZPG include: (1) the 7X600 MW first phase Longtan project to be completed by 2003; (2) the 540 MW Hongjingdu project; (3) the 2,000 MW Goupitan project; (4) the 1,000 MW Sanbansi project; and (5) the 840 MW Si Lin project. Planned major coal-fired plants include: (1) the 600 MW Panxian project; (2) the 2,400 MW Anshun project, with 600 MW in the first phase; (3) the 1,320 MW Guiyang project; (4) the 600 MW Duyun project; (5) the 250 MW Kaili project; and (6) the 250 MW Jinsha project. Foreign investors are invited to be involved in most of the projects.

As a member of the SCEPC, Guizhou is committed to provide electricity to the economically booming Guangdong province. As shown in Figure 6.16, a 500 kV transmission line has been built to send electricity to Guangdong. The 1,261 km 500 kV line is starting from Guiyang City, passing through the Tianshengqiao Hydropower Station, Guangxi Province, and ending at Jiangmen City in Guangdong Province. A 500 kV HVDC line from Tianshengqiao to Guangzhou City will start construction soon. With the construction of the 4,200 MW Long tan hydropower project, 500 kV lines and HVDC lines will be build.

The Guangxi Power Grid

Guangxi has a land area of 230,000 square kilometers and a population of 45 million. It is rich in hydropower resources. Currently about 61 percent of its 5.5 GW of power plants are hydropower plants. Future power development in Guangxi will focus on the hydropower projects on the Hongshui River. Coal-fired projects will also be developed. The Guangxi Power Bureau plans to increase total generating capacity to 7.2 GW by 2000. The planned hydropower projects in the near future include: (1) the 4X140 MW Etan project; (2) the 480 MW Baise project; (3) the 621 MW Ghangzhou project; and (4) the 4200 MW Longtan project. The coal-fired power plants now under construction include the 600 MW Laibin phase two project and the 2X660 MW Qinzhou project. Planned coal-fired plants include the 4X300 MW Beihai project and the 4X300 Yujiang project. International solicitations for these projects will be issued.

Recently, the State Planning Commission is drafting a BOT solicitation for the Laibin project. The Laibin project can be wholly owned by foreign companies without an equity holding by a Chinese party. In addition, guarantees will be issued to back up the power-purchase agreement, fuel supply and convertibility of currency.

As shown in Figure 6.17, Guangxi is located between Guangdong and the energy rich southwest provinces. Electricity transmission lines from the southwest provinces to Guangdong have to pass through Guangxi. Guangxi has built 834 km of 500 kV transmission lines and 2,559 km of 220 kV lines. About 1,000 km of 500 kV lines and 3,000 km of 220 kV lines will soon start construction.

CONTACTS

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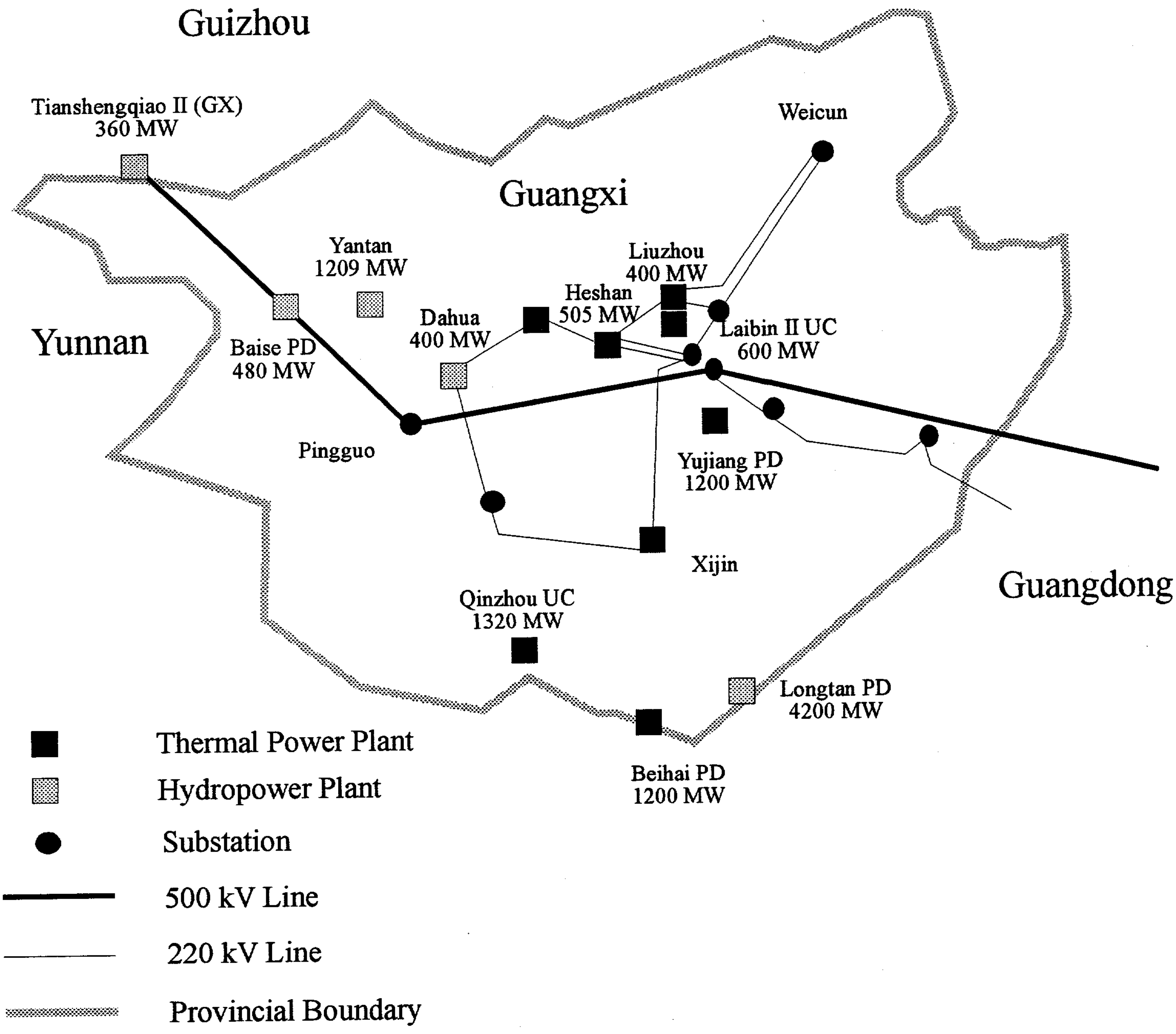
Guangxi Power Bureau, Li Jinwen, Deputy Director, 6 Minzhu Road, Nanning, Guangxi, China 530023; phone, (86-771) 561123; fax, (86-771) 563414.



Note: UC--Under Construction, PD--Planned.

Figure 6.17. The Guangxi Power Grid

The Guangdong Provincial Power Grid

Guangdong is blessed with a location far from the central government but close to the economic powerhouse of Hong Kong. The largest Special Economic Zones (SEZ) are in the province. In the SEZs, economic activities are mainly governed by market forces and both domestic and foreign investors are entitled to preferential treatments. Foreigners have found it easier to conduct business in Guangdong than in most other parts of China. As a result, Guangdong's economy has developed at a faster rate than any other province in China.

Rapid economic growth has led to increased demand for electricity. To make up its severe power shortfalls, Guangdong has been very active in the power sector reforms, encouraging extensive foreign involvement. Now all power projects can be built on a BOT or BOO basis. In the case of a BOT, the plant will be transferred to the local power company after 15 or 20 years, and the local power bureau will buy the electricity under a long-term power-purchase agreement to be negotiated and approved by the local government. Foreign investors are offered a number of incentives. For example, for the first two years of commercial operation, all income tax will be exempted and then the profits will be taxed at a reduced rate for the following three years. To promote faster power development, a bonus will be paid to the turnkey contractor who is able to complete the project ahead of schedule. In Shenzhen, the largest SEZ in China, electricity tariffs have been adjusted several times to provide power investors a rate of return slightly higher than the average rate of return of the city's industrial sector.

Power sector reforms have promoted Guangdong's power industry development. Between 1991 and 1995, installed capacity in Guangdong increased almost 25 percent per year, from 9.6 to 23 GW. The existing principal power plants are shown in Figure 6.18. Foreign investments are utilized in the 2X900 MW Daya Bay project, the 2X350 MW Shajiao' B project, the 2X300 MW Zhujiang project, the 4X300 Guangzhou pumped-storage project, the 3X660 Shajiao' C project, and a large group of small oil-fired plants. Guangdong is very ambitious in its plans to increase its total generating capacity to 34 GW by 2000 and to 60-80 GW by 2010. The existing and planned power plants are listed in Table 6.8.

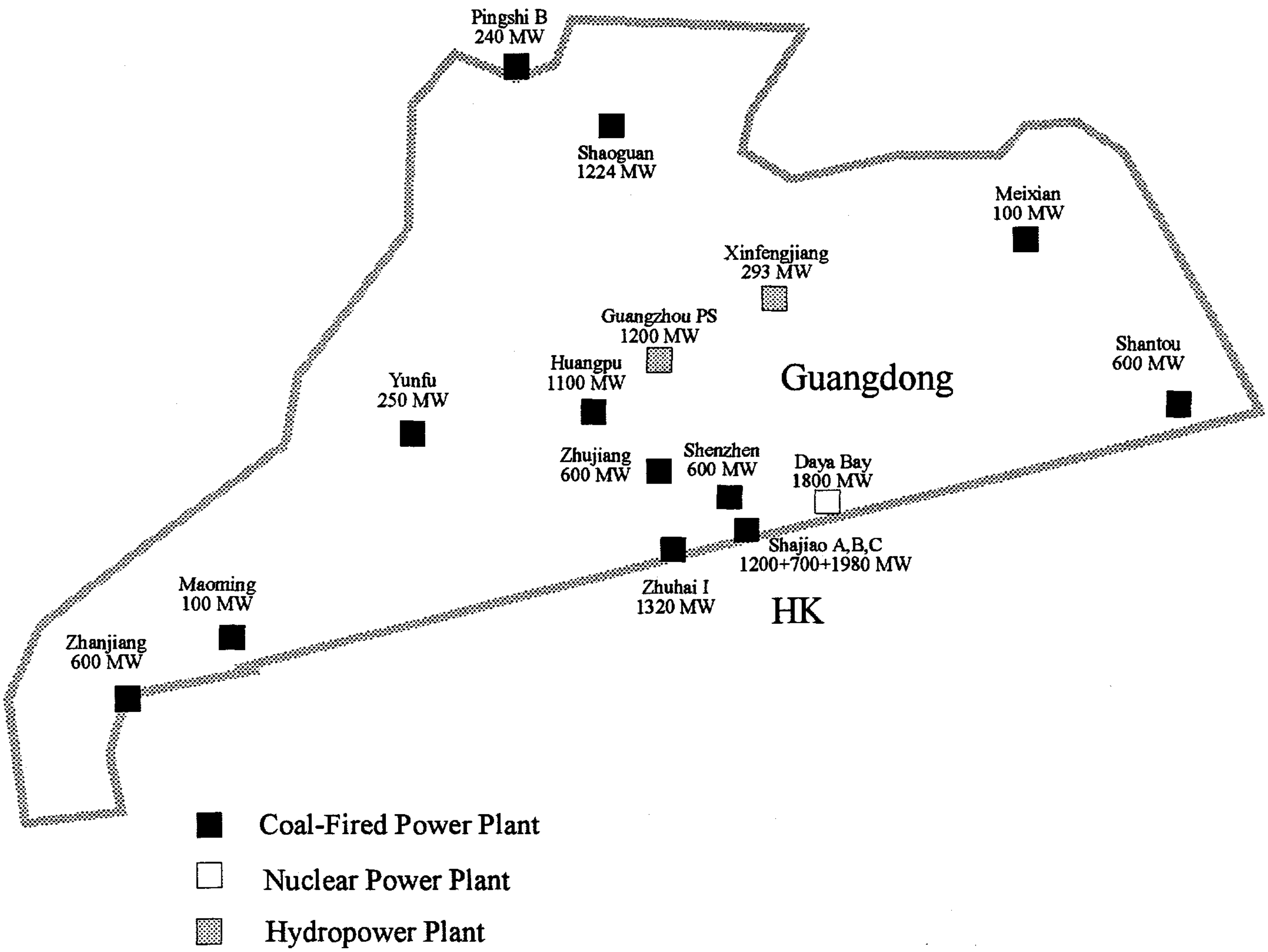


Figure 6.18. Existing Principal Power Plants in Guangdong Province

Table 6.8. Power Plants in Guangdong Province

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Guangdong total		**23000**	**6490**	**53430**	**82920**	
Coal-fired		**12585**	**4590**	**40060**	**57235**	**Coal**
Gas-fired		1162	100	4300	5562	Gas
Oil-fired		2682	300	70	3052	Oil
Hydropower		4771	1500	1000	7271	Hydro
Nuclear		1800	0	8000	9800	Nuclear
Guangzhou	GD	150			150	Coal
Huangpu	GD	1100			1100	Coal, Oil
Maoming	GD	100			100	Coal
Meixian	GD	100			100	Coal
Nantang	GD	171			171	Coal
Pingshi B	GD	240			240	Coal
Shajiao A	GD	1200			1200	Coal
Shajiao B	GD	700			700	Coal
Shajiao C	GD	1980			1980	Coal
Shantou	GD	300			300	Coal
Shaoguan	GD	1224			1224	Coal
Shenzhen Mawan	GD	600			600	Coal
Yunfu	GD	250			250	Coal
Zhongshan	GD	50			50	Coal
Zhuhai I	GD	1320			1320	Coal
Zhujiang	GD	600			600	Coal
Other coal-fired	GD	1500	500		2000	Coal
Huaneng Shantou	GD	300	300		600	Coal
Meixian	GD	100	150		250	Coal
Zhanjiang	GD	600	600		1200	Coal
Nanhai	GD		400		400	Coal
Taishan I	GD		2640		2640	Coal
Pingshi	GD			240	240	Coal
Shantou II	GD			700	700	Coal
Shenzhen East I	GD			2640	2640	Coal
Huidong	GD			4800	4800	Coal
Panyu	GD			2400	2400	Coal
Shanwei	GD			4920	4920	Coal
Shenzhen East II	GD			3960	3960	Coal
Taishan II	GD			3600	3600	Coal
Zhuhai II	GD			2400	2400	Coal

Note: Planned plants may over or under estimate the capacity that will actually be constructed.

Table 6.8. Power Plants in Guangdong Province (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Zhujiang East A	GD			4800	4800	Coal
Zhujiang East B	GD			4800	4800	Coal
Zhujiang West A	GD			4800	4800	Coal
Foshan GT	GD	200			200	Gas
Shunde GT	GD	196			196	Gas
Zhuhai CC	GD	116			116	Gas
Other Gas-fired	GD	250	100		350	Gas
Guangdong CC	GD	400		200	600	Gas
Taishan Taigang	GD			100	100	Gas
Donghai	GD			4000	4000	Gas
Shantou IC&CC	GD	244			244	Oil
Foshan A, B, C	GD	234			234	Oil
Huaneng Shantou A, B	GD	216			216	Oil
Huizhou	GD	207			207	Oil
Zhuhai Oil	GD	178			178	Oil
Meishi I	GD	170		70	240	Oil
Shengzhen CC&IC	GD	136			136	Oil
Nanhai	GD	135			135	Oil
Jiangmen	GD	128			128	Oil
Shunde IC	GD	127			127	Oil
Nanshan GT	GD	108			108	Oil
Other oil-fired	GD	800	300		1100	Oil
Conghua PS	GD	1200			1200	Hydro
Meixi	GD	60			60	Hydro
Xinfengjiang	GD	293			293	Hydro
Other Hydro	GD	3218	300		3518	Hydro
Conghua PS, Ext	GD		1200		1200	Hydro
Shenzhen PS	GD			1000	1000	Hydro
Daya Bay	GD	1800			1800	Nuclear
Lingao I	GD			2000	2000	Nuclear
Lingao II	GD			2000	2000	Nuclear
Yangjiang	GD			4000	4000	Nuclear

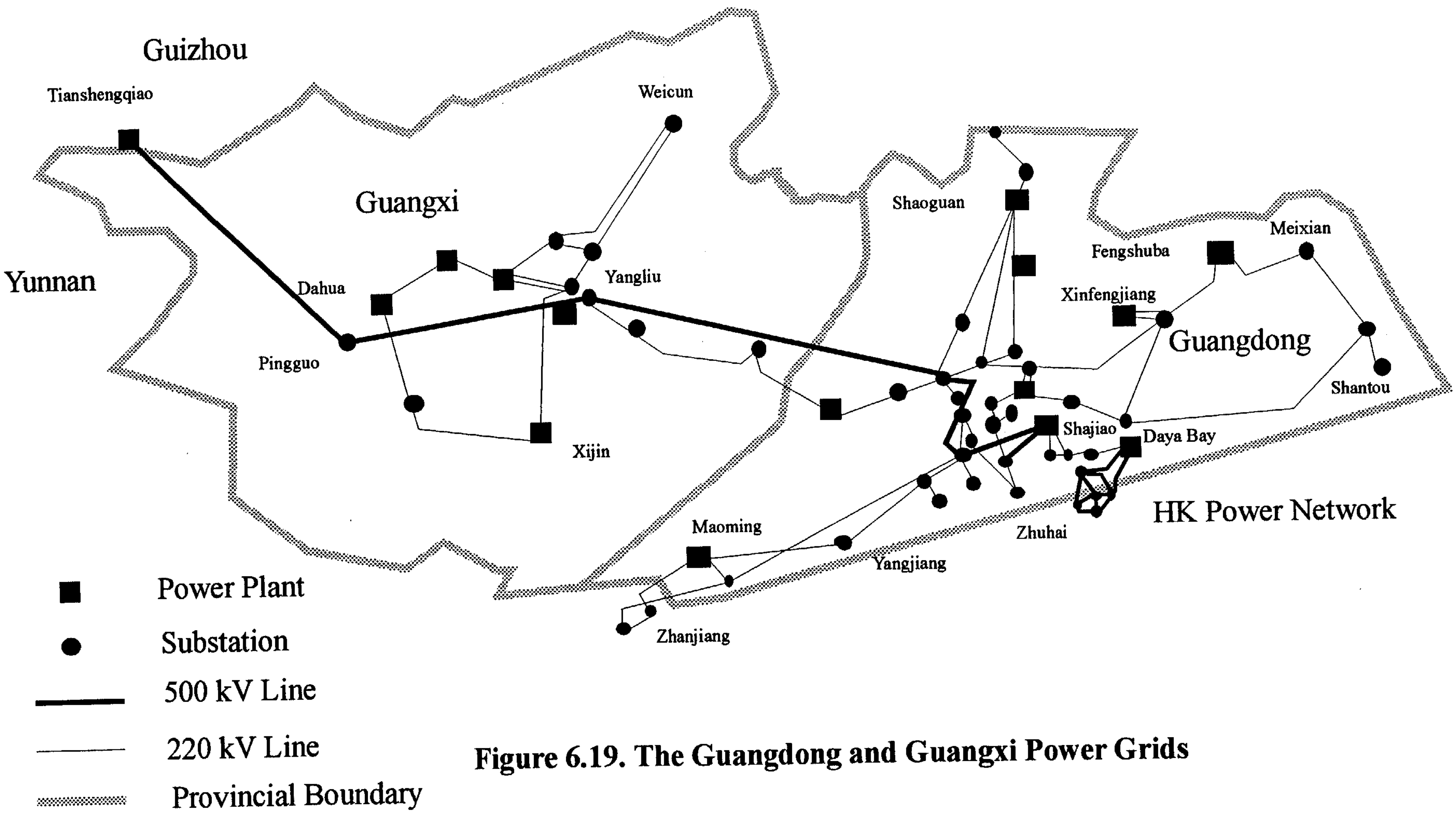


Figure 6.19. The Guangdong and Guangxi Power Grids

The Guangdong Power Grid (GDPG) is an independent power grid. As shown in Figure 6.19, it has 500 kV lines linking Shajiao Power Plant to Jiangmen, and most of cities in the province are linked by 220 KV lines. Guangdong is linked with Guangxi by 500 kV and 220 kV lines and is also interconnected with Hong Kong and Macaw. To meet the requirements of electricity transmission from the southwest to Guangdong, a 500 kV HVDC line will be built before 2000, and another one will be built before 2010. A number of 500 kV lines and 220 kV lines will be build within the province to form a strong power system based on 500 kV lines.

The GDPG enjoys a special status of "non-directly controlled" under the Ministry of Electric Power. In practice, this means that the GDPG has full control over its financing, personnel and materials, but only partial control over the project planning and approval process. Guangdong is able to make decisions about the types of power plants to develop and time tables for construction. However, all projects are still subject to central government "advice" regarding the availability and use of resources and the arrangement of fuel supplies. Projects of 250 MW and above must go through the formal approval process. Hydropower plants under 25 MW and thermal power plants under 500 kW are not subject to provincial approval. These units are handled by local power supply bureaus at municipal and county levels. Due to electricity shortages, more than 2 GW of small diesel and gas turbine units have been installed in Guangdong.

Because of the great influx of foreign investors, the Guangdong Electric Power Holding Company (GEPHC) was established in 1992 to handle negotiations with foreign investors. In addition, a stock company called Guangdong Electric Power Development Company has been formed in which the GEPHC holds 59 percent of the interest. It is listed on the Shenzhen Stock Market, and efforts are being made to list it in Hong Kong.

The planning department of the Guangdong Power Bureau is responsible for making the province's long-term power development plans. It requests the provincial electric power design institute to conduct a preliminary feasibility study on a range of factors including fuel transportation, water sources, geographical situation, and power transmission. The government stipulates that the power bureau must recommend three or more sites for each power plant from which the final decision on location is made. The power bureau must apply to the Guangdong Planning Commission for approval of a proposed project. The application must also be sent to the Economic Commission, since the latter decides, with the provincial price administration, the price of electricity of the power plant.

Guangdong receives no central government funds for power investment. Most power projects will have to invite foreign participation. In a joint venture project, the Chinese side normally holds 51 percent of the equity. Since no central government guarantees are available, non-recourse financing are employed. The Guangdong Power Bureau is also asking U.S. bidders to arrange U.S. Export-Import Bank financing.

Guangdong's 25 municipalities represent a second category of independent power opportunities. Each municipality is an independent electricity supplier to its area. They account for about half of Guangdong's total generating capacity. Most municipalities are driven by a desire to build new power plants as soon as possible. However, the provincial power bureau has recommended to the Guangdong Planning Commission that small thermal power plants should not be approved.

The Guangdong Power Bureau has one price (about 4.5 US cents/kWh) which applies to plants under its control. The provincial power bureau sells electricity to local power bureaus at this level, and local power bureaus may in turn negotiate with their end-users. Local power bureaus may set their own prices for plants which they have built. The price for the diesel plants are much higher.

Guangdong's coastal location has allowed it to obtain part of its domestic coal via shipments from Qinhuangdao rather than by rail. Coal is and will continue to be the main fuel used in Guangdong's power generation. Since the province has only limited coal reserves, substantial coal supplies originate from Shanxi and Inner Mongolia and are shipped through the port of Qinhuangdao. Only small quantities of coal have been imported from outside of China to date; however, new coal-fired power plants now under consideration are expected to relie on both domestic and imported coal. Until 2000, Guangdong will primarily build coal-fired plants. The provincial power bureau has its own fuel company to arrange supplies of coal for power plants. Guangdong so far has not had problems in arranging for its coal supply. It buys some of its capacity directly from the port of Qinhuangdao, but most from the central government.

The Guangdong Power Bureau will seek bids for four large-scale coal-fired plants which will require a total investment of $30 billion. These projects are: (1) the Zhuhai Project, which has an ultimate planned capacity of 3,720 MW (2X660+4X600 MW), the first phase will be 2X660 MW; (2) the Taishan Project, which has a total planned capacity of 4,920 MW (2X660+6X600 MW), two 660 MW units will be built in the first phase; (3) the Shanwei Project, which has a planned capacity of 4,920 MW (2X660+6X600 MW), and the first phase is 2X660 MW; and (4) the Shenzhen East Project, which has a total planned capacity of 6,600 MW (10X660 MW), and the first phase is 4X660 MW (see Figure 6.20 for their locations).

Guangdong's planned new coal-fired projects also include: (1) the 600 MW Zhanjiang II plant, to be completed in 1997-1998; (2) the 700 MW Shantou second phase, to be completed in 1997-1998 period; (3) the 600 MW Zhujiang second phase, to be completed in 1996-1997; (4) the 2,400 MW Panyu plant, to be completed in 1997-2000; (5) the 4,800 MW Huidong plant, to be completed in 2001; (6) the 4,800 MW Zhujiang East A plant, to be completed in 2001; (7) the 4,800 MW Zhujiang East B plant, to be completed in 2001; and (8) the 4,800 MW Zhujiang West A plant, to be completed in 2001. It should be noted that the planned capacity in Guangdong appears to be duplicating the planned capacity in the southwest provinces. If substantial electricity will be transmitted from the southwest, at least some of the planned power projects in Guangdong will be delayed.

Nuclear power is also considered a viable option for Guangdong. Currently there are plans to build two additional nuclear power plants, the 4X1000 MW Lingao plant (first phase 2X1000 MW) and the 4X1000 MW Yangjiang plant. China's largest commercial nuclear power plant (Daya Bay) is located in Guangdong.

Currently, using LNG to generate electricity is still considered too expensive, and the potential for pipe-line gas to generate electricity is uncertain. The main obstacles to introducing pipe-line gas are the competition of cheaper coal-fired electricity and huge initial capital requirement to build the pipe-lines. The availability of natural gas is also a question mark.

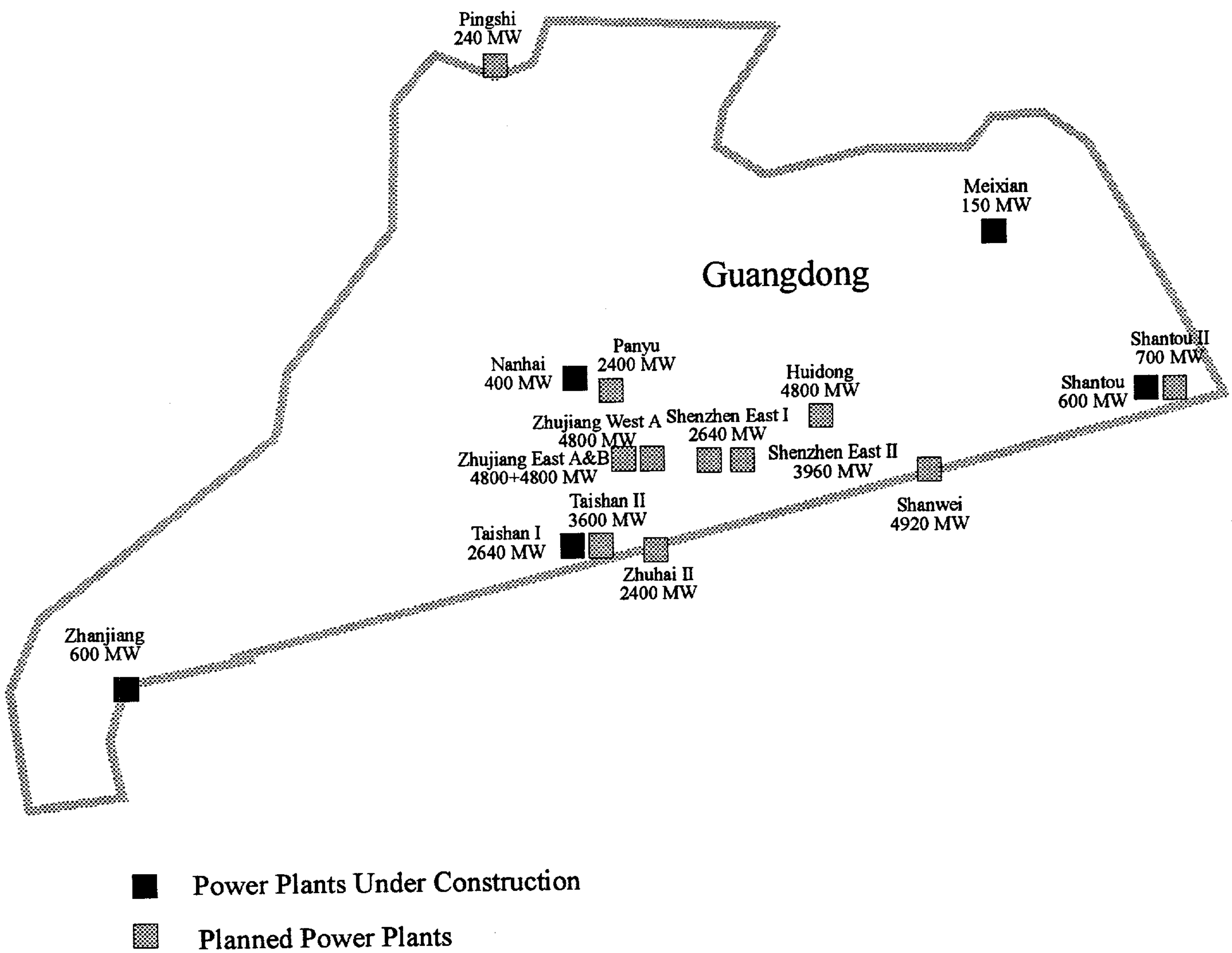


Figure 6.20. Planned Principal Coal-fired Power Plants in Guangdong Province

However, the Chinese do realize the advantage of natural gas as a much cleaner fuel than coal, much safer than nuclear power, and with a high level of efficiency. China is willing to pay a premium on natural gas-based electricity. As their environmental awareness improves and the availability of natural gas becomes more clear, Guangdong will likely move faster in developing gas based power plants. Reportedly, a Tokyo-based trading company, the Kanematsu Corp., plans to develop a $1.2 billion, 1,050 MW, gas-fired plant on Dachan Island, in Shenzhen. Kanematsu hopes to have the plant operating by 1998, using natural gas from offshore fields near Hainan Island.

Traditional hydropower projects are very limited in Guangdong, but pumped-storage plants will be built to meet peak demand. The 1,200 MW Guangzhou pumped-storage project is estimated to cost about $470 million, and Guangdong is considering construction of a 1,000 MW pumped-storage plant in Shenzhen. Guangdong is also looking for private investors to develop wind power projects in Shantou. Shantou has installed two windmills on its own as a pilot project and would like to work with a U.S. company for the development of more than 20 wind power projects over the next five years.

CONTACTS

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The Shandong Provincial Power Grids

Shandong is located in China's east coast. It has a land area of 156,700 square kilometers and a population of 87 million. The province was selected by the central government as one of the areas to experiment with China's open-door policies, consequently economic growth in Shandong is above China's average. The Shandong Power Grid (SDPG) is the second largest independent power grid after the GDPG. Its generating capacity reached 13 GW by 1995 (11.2 GW coal-fired), but electricity shortages are still very serious. According to government figures, the province's economic growth is outpacing the available electricity supply by 15 percent.

Shandong has very limited hydropower resources, almost all power plants are thermal, mostly coal-fired. Table 6.9 shows the principal power plants in the SDPG. Among them, only the 600 MW Xindian, the 400 MW Shengli II, the 250 MW Zhanhua, and the 150 MW Baiyanghe are oil-fired. The locations of the principal existing, under construction, and planned power plants are shown in Figure 6.21. By 2000, Shandong plans to increase its total capacity to 23 GW. The principal new power projects which is now looking for foreign joint venture partners include: (1) the 2,500 MW Rizhao project, with 2X350 MW in phase one; (2) the 2X600 MW Laicheng project; (3) the 1,200 MW Zouxian project; (4) the 2X300 MW Shiheng second phase; (5) the 2X300 MW Shiliquan project; and (6) the 4X300 Heze project.

Shandong is also considering development of nuclear power. Reportedly, the central government has approved construction of a 4X1,000 MW nuclear power complex in Shandong, which will rival the Daya Bay complex. The Shandong nuclear project will be located either in Yantai or in Weihai. The first two units are scheduled to start construction in 1998. Initial investment in the first phase will be 40 billion yuan ($4.8 billion). The proposed nuclear project in Shandong is not included in plans by the China National Nuclear Power Corporation.

The transmission system in the SDPG has developed rapidly. As shown in Figure 6.22, 500 kV transmission lines have emerged in the province, along with the construction of large thermal power plants in recent years. At the end of 1994, Shandong had 737 km 500 kV lines and 6,114 km of 220 kV lines.

Table 6.9. Power Plants in Shandong Province

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Shandong total	**SD**	**12996**	**3500**	**20910**	**37406**	
Coal-fired	**SD**	**11157**	**3400**	**15710**	**30267**	**Coal**
Gas-fired	SD	163	0	0	163	Gas
Oil-fired	SD	1600	100	400	2100	Oil
Hydropower	SD	76	0	800	876	Hydro
Nuclear	SD	0	0	4000	4000	Nuclear
Heze	SD	250			250	Coal
Hualu	SD	1200			1200	Coal
Huangdao	SD	670			670	Coal
Huangtai	SD	925			925	Coal
Jining	SD	300			300	Coal
Laiwu	SD	330			330	Coal
Linyi	SD	130			130	Coal
Longkou	SD	1000			1000	Coal
Nanding	SD	160			160	Coal
Qilu PC Company	SD	200			200	Coal
Qingdao	SD	132			132	Coal
Qingdao II	SD	600			600	Coal
Shengli	SD	200			200	Coal
Weifang	SD	600			600	Coal
Weihai	SD	250			250	Coal
Yantai	SD	200			200	Coal
Zhangjiadian	SD	57			57	Coal
Other coal-fired	SD	1293	1000		2293	Coal
Shiheng	SD	735	600		1335	Coal
Shiliquan	SD	625	600		1225	Coal
Zouxian	SD	1200	1200		2400	Coal
Jining II	SD			2400	2400	Coal
Laicheng	SD			1200	1200	Coal
Rizhao	SD			2500	2500	Coal
Shiheng II	SD			600	600	Coal
Weifang	SD			600	600	Coal
Weihai	SD			250	250	Coal
Xindian II	SD			600	600	Coal

Table 6.9. Power Plants in Shandong Province (continued)

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Heze	SD			1200	1200	Coal
Liaocheng	SD	100		2640	2740	Coal
Moushan	SD			600	600	Coal
Moushan, Ext.	SD			1200	1200	Coal
Shiheng II, Ext.	SD			600	600	Coal
Tanfang	SD			1320	1320	Coal
Shengli SPAB	SD	163			163	Gas
Baiyanghe	SD	150			150	Oil
Shengli II	SD	400			400	Oil
Xindian	SD	600			600	Oil
Zhanhua	SD	250			250	Oil
Other oil-fired	SD	200	100		300	Oil
Shengli II	SD			400	400	Oil
Hydropower	SD	76			76	Hydro
Tai'an PS	SD			800	800	Hydro
Yantai or Weihai	SD			4000	4000	Nuclear

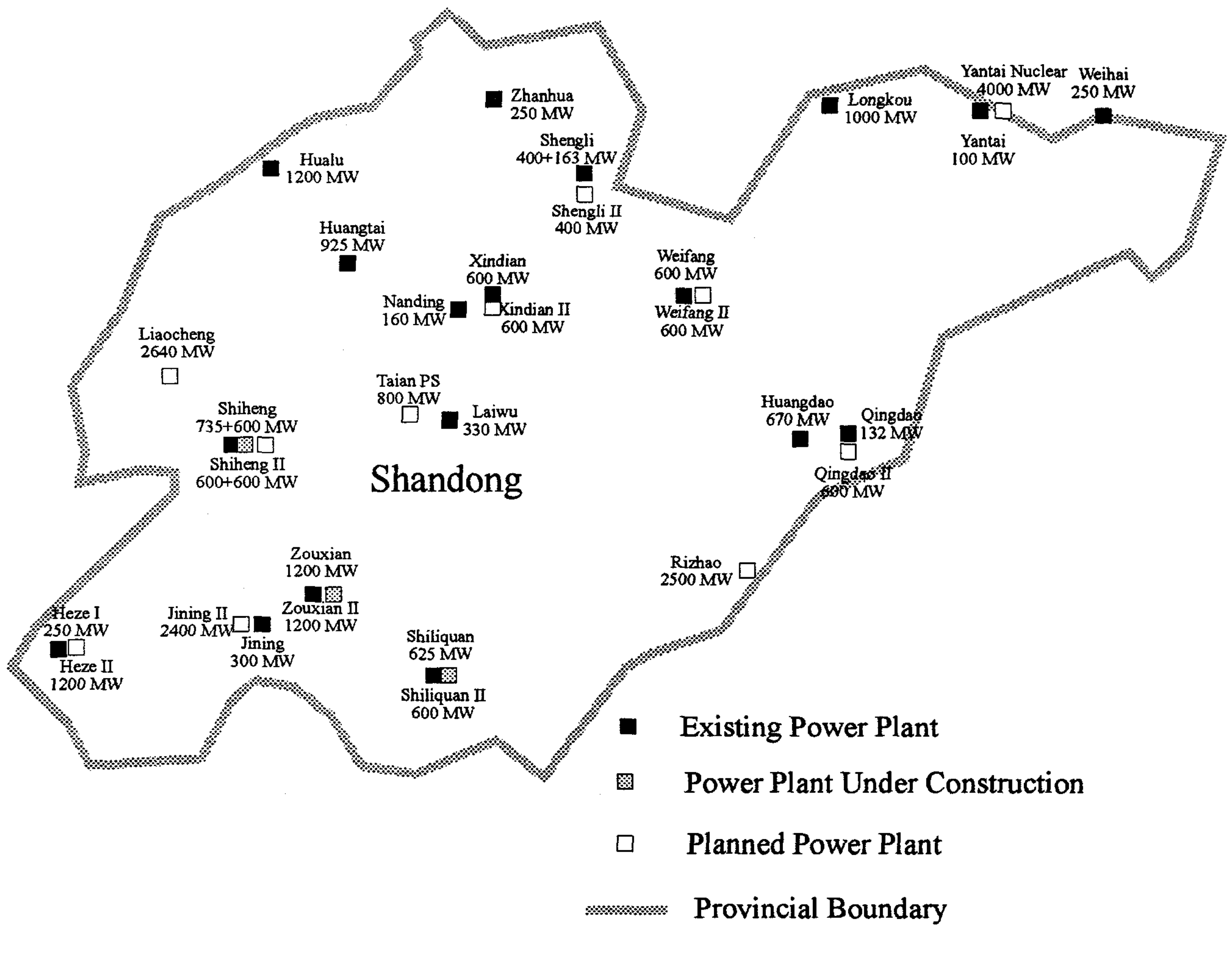

Figure 6.21. Principal Power Plants in the Shandong Provincial Power Grid

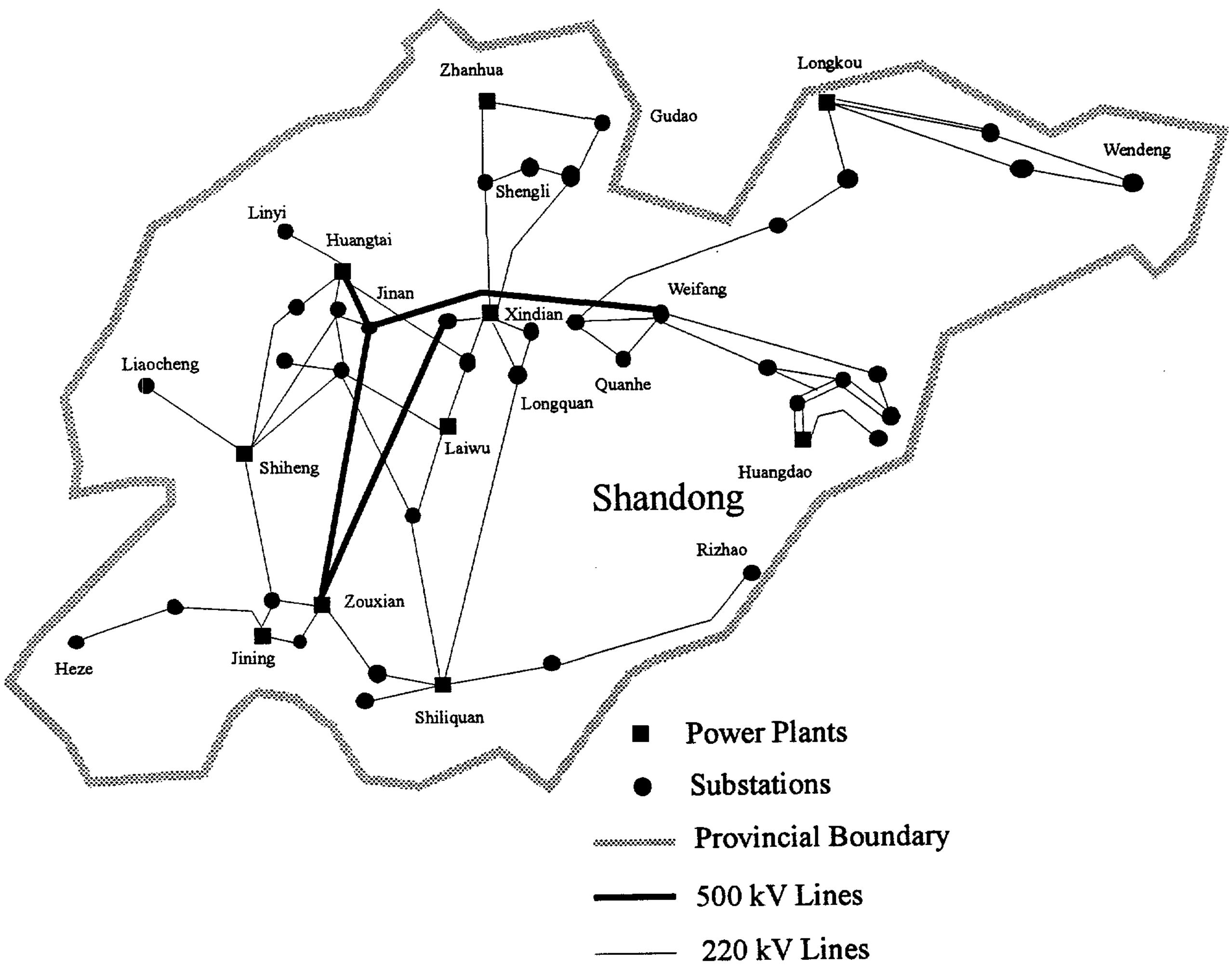

Figure 6.22. The Shandong Provincial Power Grid

Shandong is active in inviting foreign investors to participate in its power sector and has been chosen by the central government to experiment with share-holding systems in power projects. The Shandong Huaneng Power Development Corporation is the first Chinese power company listed in the overseas stock market.

CONTACTS

Shandong Provincial Electric Power Administration, Cha Keming, President, Jinan, Shandong, China 250001; phone, (86-531) 611-919.

The Fujian Provincial Power Grid

Fujian is located in China's southeast coast and close to Taiwan. It has a land area of 120,000 square kilometers and a population of 32 million. Promoted by investors from Taiwan, the economic growth in Fujian has been very fast in recent years. Although power development has been rapid since the late 1980s, demand for electricity has increased even faster. The province have not built any large-scale thermal power plants since the late 1980s, power shortages have become more and more serious since 1992, especially during the dry seasons.

Fujian has very limited coal resources; oil and gas resources are still being explored; and hydropower is the most abundant. As shown in Table 6.10, Fujian now has 6 GW of generating capacity, about 2.3 GW are coal-fired, and the remaining is mostly hydropower. Although hydropower plants account for 62 percent of the capacity now under construction, its role in the planned new capacity is very limited. Most of the planned capacity (88%) is coal-fired.

The Fujian Electric Power Bureau estimated that total exploitable hydropower resources in Fujian are 10.8 GW, about 35 percent has been utilized so far (including the 1,400 MW Shuikou project). Fujian's water resources are estimated at 181 billion cubic meters during the rainy season of April to September, but drops to only 50 billion cubic meters during the dry season of October to March.

Table 6.10. Power Plants in Fujian Province

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Fujian total	**FJ**	**6000**	**2600**	**4920**	**13520**	
Coal-fired	**FJ**	**2250**	**1000**	**4320**	**7570**	**Coal**
Gas-fired	FJ	0	0	0	0	Gas
Oil-fired	FJ	274	0	0	274	Oil
Hydropower	FJ	3476	1600	600	5676	Hydro
Nuclear	FJ	0	0	0	0	Nuclear
Fuzhou	FJ	700			700	Coal
Songyu	FJ	700			700	Coal
Xiamen	FJ	50			50	Coal
Yongan	FJ	350			350	Coal
Zhangping	FJ	400			400	Coal
Other coal-fired	FJ	50	1000		1050	Coal
Fuzhou II	FJ			700	700	Coal
Jian Xi	FJ			1320	1320	Coal
Meizhou Bay	FJ			1200	1200	Coal
Songyu, Ext.	FJ			500	500	Coal
Quanzhou	FJ			600	600	Coal
Xiamen II GT	FJ	75			75	LPG
Fuzhou City	FJ	149			149	Oil
Other oil-fired	FJ	50			50	Oil
Shaxikou	FJ	300			300	Hydro
Shuikou	FJ	1400	600		2000	Hydro
Other hydropower	FJ	1776	1000		2776	Hydro
Mianhuatan	FJ			600	600	Hydro

To meet the rapid growth of electricity demand, the Fujian Power Grid (FJPG) is promoting faster power development. During the 1996-2000 period, the province plans to start constructing 6.7 GW of power projects, and complete 4.7 GW (including the projects started before 1996). Total installed capacity is projected to reach 10.85 GW by 2000, with an annual electricity generation of 40 TWh.

To achieve the planned power sector growth, about 35 billion yuan ($4.2 billion) will be required before 2000, and the province is seeking diversified sources of investment. The 200 MW Zhangping first phase was invested jointly by the central government and the provincial government; the 1,400 MW (first phase 2X350 MW) Fuzhou plant was a joint venture between the Huaneng Group and the provincial government; the 1,400 MW Shuikou Hydropower Plant has utilized the World Bank loans; the 300 MW Shaxikou Hydropower Plant utilized loans from Kuwait; a total of 210 MW of medium-sized hydropower projects was jointly financed by local governments; the 700 MW (first phase) Songyu plant in Xiamen and the 200 MW Zhangping II plant, which started construction in 1992, are all joint ventures with Hong Kong investors (the Zhongyin Group in Songyu and the Fujian Power Investment Limited in Zhangping).

So far, a total of $30 million of foreign funds have been used in the province's power projects. Moreover, bidding has been completed for China's first sole foreign-funded power project, the Meizhou Bay Thermal Power Plant. Total investment in this project is expected to exceed $500 million. The province is also looking for further participation of foreign investors in the construction of 14 power projects. These projects will have a total generating capacity of 9 GW upon completion.

The FJPG is a independent power grid. As shown in Figure 6.23, the highest voltage used in power transmission is 220 kV. By the end of 1994, the FJPD had build 2,795 km of 220 kV lines and 4,432 km of 110 kV lines.

CONTACTS

Fujian Electric Power Bureau, 1 Shengfu Road, Fuzhou, Fujian, China 350001; phone, (86-591) 555-121.

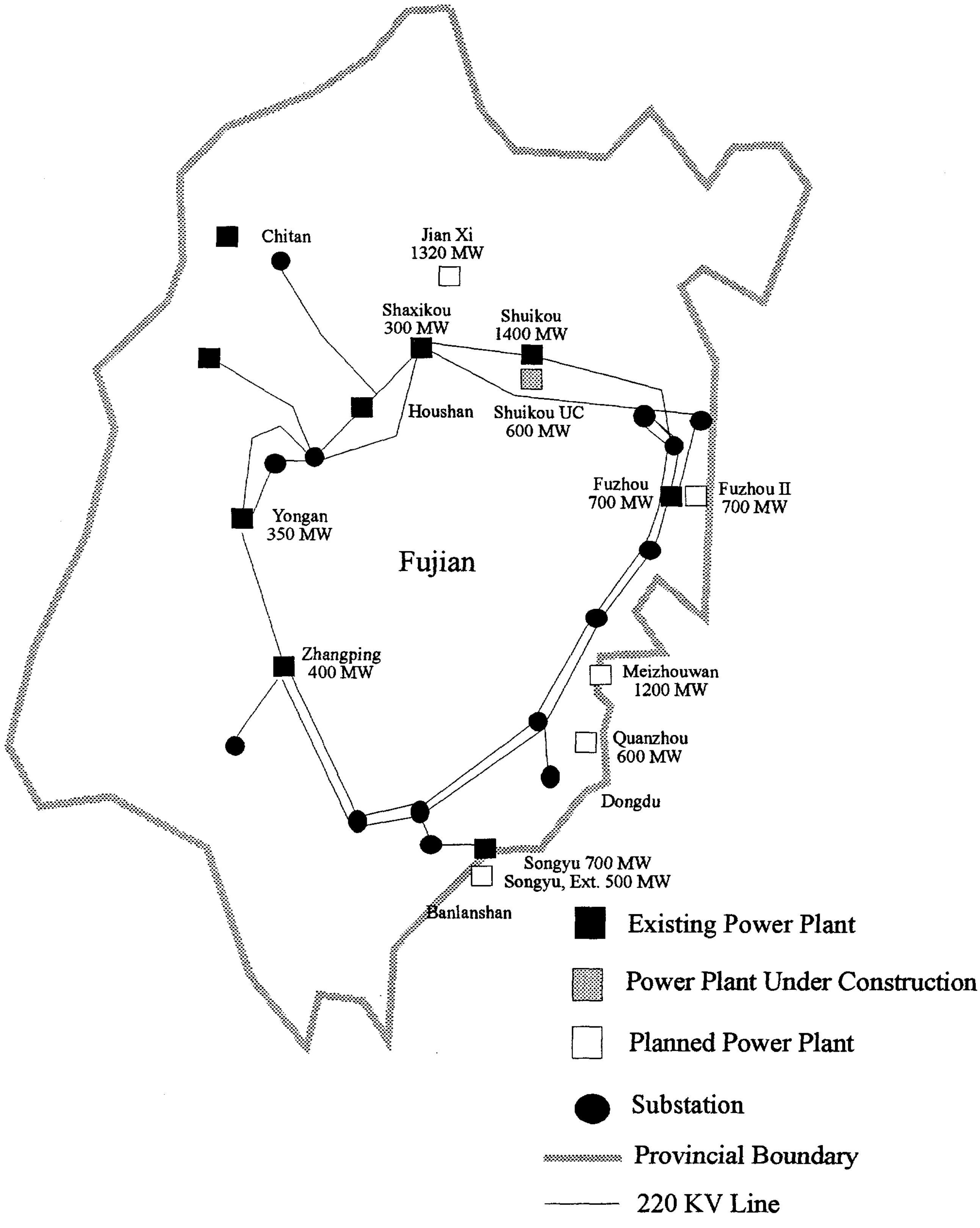

Figure 6.23. The Fujian Provincial Power Grid

The Hainan and Tibet Power Grids

With a land area of 34,000 square kilometers and a population of 7 million, Hainan is the smallest province in China. As a special economic zone, Hainan is facing much less central government regulations. With the rapid economic growth in the province, the demand for electricity is expected to grow at 30 percent per year, so power development has been accelerating. Total generating capacity in the Hainan Provincial Power Grid (HNPG) is projected to increase from 1.5 GW in 1995 to 3 GW by 2000. The Haikou plant is the largest thermal power plant in Hainan, currently it has a 400 MW capacity and will be eventually extended to 1,100 MW. The 240 MW Daguangba hydropower project has utilized $67 million loans from the World Bank. Table 6.11 shows the principal existing, under construction, and planned power plants in Hainan.

Tibet has very rich energy resources, its hydropower resources account for 17 percent of the nation's total. It also has some geothermal power potentials. However, since power demand is very limited in Tibet and transmission of electricity to the areas of demand is not feasible, power development has been very slow. So far, only 173 MW of generating capacity has been installed. Total capacity is projected to reach 410 MW by 2000.

Electricity Transmission and Line Loss

China has, for the most part, adopted 500/220/110/35/10 kV levels for its transmission lines. As shown in Table 6.12, by the end of 1994, the total length of transmission lines above 35 kV was 539.4 thousand kilometers. Of which, the 500 kV lines were 11,197 km, with 38.66 GVA of transformer capacity; the 330 kV lines were 4,924 km, with 8 GVA of transformer capacity; and the 220 kV lines were 91,216 km, with 161.8 GVA of transformer capacity.

The highest voltage in NEPN, NCPN, ECPN, CCPN, Shandong, Guangdong, Guangxi, Guizhou, and Yunnan is 500 kV. The highest voltage in the NWPN is 330 kV. Along with the construction of the Laxiwa hydro power station in the western portion of the Yellow River, the inter-network tie line between the NWPN and the NCPN will have to be built.

Table 6.11. Power Plants in Hainan Province

Plant	Province	Capacity (MW)				Fuel
		Existing	Under Construction	Planned	Total	
Hainan total		**1489**	**1000**	**3100**	**5589**	
Coal-fired		**750**	**650**	**0**	**1400**	**Coal**
Gas-fired		0	0	2100	2100	Gas
Oil-fired		589	0	300	889	Oil
Hydropower		150	350	0	500	Hydro
Nuclear		0	0	0	0	Nuclear
Hai Kou	HI	400			400	Coal, Oil
Hainan	HI	100			100	Coal
Machun	HI	250			250	Coal
Other coal-fired	HI		650		650	Coal
Hai Kou, Ext.	HI			700	700	Coal
Sithe Hainan	HI			2100	2100	Gas
San Ya Nanshan	HI	100			100	Oil
Yangpu CC& IC	HI	489			489	Oil
Meishan	HI			300	300	Oil, Gas
Hydropower	HI	150			150	Hydro
Three plants	HI		350		350	Hydro

Table 6.12. China's Transmission System Capacity

Overhead Transmission Line Length in 1994 (km)						
35 kV	66 kV	110 kV	220 kV	330 kV	500 kV	Total
247,390	42,214	142,473	91,216	4,924	11,197	539,414
High Voltage Substation Capacity in 1994 (MVA)						
35 kV	66 kV	110 kV	220 kV	330 kV	500 kV	Total
126,550	32,020	198,720	161,800	8,040	38,660	565,790

Overhead Transmission Line Length in 1992 (km)						
35 kV	66 kV	110 kV	220 kV	330 kV	500 kV	Total
243,924	40,370	127,895	82,070	4,253	8,660	507,319

High Voltage Substation Capacity in 1992 (MVA)					
	35-66 kV	110 kV	220 kV	330 kV	500 kV
No. of Transformers	36,860	7,232	1,215	31	119
No. of Substations	19,942	3,969	713	17	31
Capacity (MVA)	135,780	164,120	131,940	6,360	30,880

Increases in Transmission Line Length 1992-1994 (%)						
35 kV	66 kV	110 kV	220 kV	330 kV	500 kV	Total
1	5	11	11	16	29	6

The first 500 kV HVDC transmission line, from Gezhouba hydropower station in Hubei to Nanqiao substation with a designed capacity of 1.2 GW and 1,046 km in length, was commissioned in 1990. HVDC lines will link major hydropower resources to load centers (usually more than 1,000 km, some even up to 2,000 km), will supply electricity across the sea, and will link regional power networks in the future.

China's power dispatching and control system resembles a five-layered pyramid, which includes the national control center (NCC), 5 regional control centers (RCC), 25 provincial control centers (PCC), 250 district control centers (DCC), and more than 2000 county control centers (CCC). The functions of these control centers are as follows:

The responsibilities of the NCC are: (1) to coordinate power exchange and system operation among regional power networks and to maintain the security and stability of interconnected systems; (2) to organize RCCs to draft annual and monthly power generation and system operation plans and to supervise their implementation; (3) to supervise the implementation of generation plans for major hydropower stations; and (4) to coordinate maintenance and repair schedules of generation and transmission facilities for interconnected regional power networks.

The responsibilities of the RCC are: (1) to conduct the economic dispatch of the regional power system and maintain safe operation; and (2) to exercise direct control on major power stations, 500 kV transmission networks, and 220 kV interprovincial tie-lines.

There are two types of PCCs, the independent and the interconnected ones. The functions of the independent PCCs are the same as those of RCCs', and the interconnected PCCs are responsible for the provincial network operation and generation control of medium and small power plants. The DCCs and CCCs are responsible for distribution control in their respective areas.

Since 1980, the automatic dispatching systems have been developing rapidly to meet the needs of power system operation and control. Presently, the National Power Dispatching Center, all regional and provincial dispatching centers, 80 percent of DCCs, and 25 percent of CCCs have installed computer-based SCADA systems.

China reported a line-loss (transmission and distribution loss) of only 8.73 percent in 1994. However, this figure only includes losses of state power companies. In many cases, this excludes much of the low voltage system. Losses in the state companies are usually recorded only up to the stations which mark the point of sale. The substantial losses thereafter are the responsibility of the purchasing enterprises. According to a World Bank report in 1993, the actual line-loss could be as high as 16-20 percent. Some of the losses are due to electricity theft.

Underinvestment in transmission and distribution facilities is a direct relation to the high actual line-loss. The share of investment in power transmission dropped to only 16 percent in 1991 from 24 percent of total investment in 1980, before rising to 17 percent in 1993. This is a very low level by any standard. Generally speaking, investment in power transmission and distribution should amount to at least one-third of total investment. Rapid increases in generating capacity along with underinvestment in transmission facilities has resulted in an extremely heavy burden on the existing power networks.

The main reason for underinvestment in power transmission systems is local governments' perception of transmission and distribution as being peripheral to power generation. Until relatively recently, local government officials were judged by their ability to produce output. Increased generating capacity can be observed and praised much easier than improvement in the power network. With limited resources, generation has always had priority over transmission and distribution.

The trend of a declining share of investment in transmission facilities seems to have been halted in the early 1990s. As the crunch of a poor power network has been realized by both the central government and local authorities. However, since private sector investment in the transmission system is still very limited, it remains a question whether China can secure enough funding in the near future to accommodate its planned network improvements.

China's Future Power Development Plans

Figure 6.24 illustrates China's future power development plans. Mine-mouth coal-fired power plants will be built in east Inner Mongolia to transmit electricity to northeast China; in west Inner Mongolia to send electricity to Beijing; in north Shanxi to send electricity to Tianjin; in southeast Shanxi to send electricity to Shandong and Jiangsu; and in Guizhou to send electricity to Guangdong. Hydropower plants will be built in the southwest. Some of the hydroelectricity generated in the southwest will be sent to Guangdong. In July 1993, China's State Council approved the 18.2 GW Three Gorges project. Hydroelectricity generated from the Three Gorges will be transmitted to East China, Central China, North China, and Sichuan.

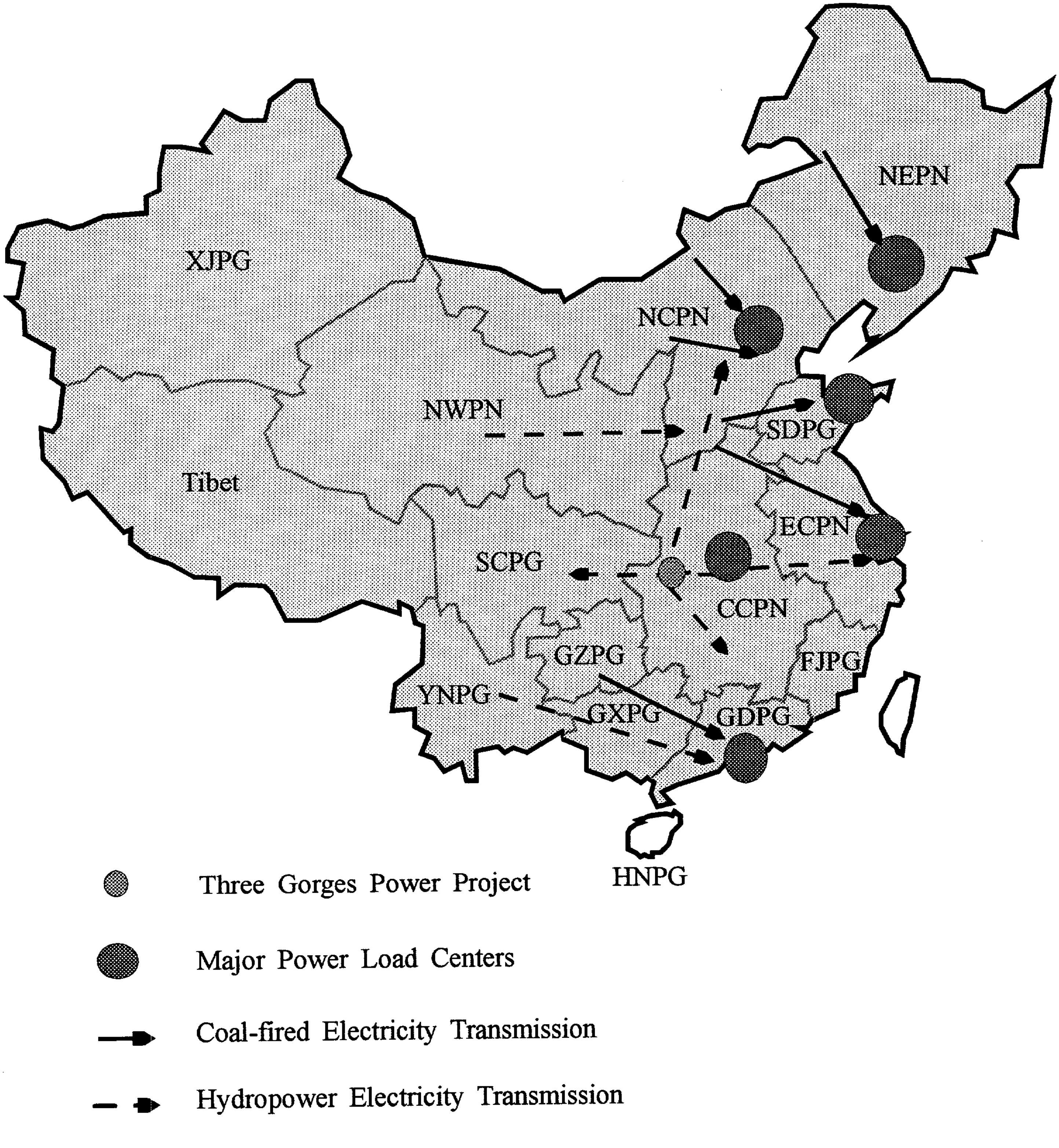

Figure 6.24. China's Planned Major Electricity Transmission

In the northwest, a total of 25 large and medium-sized hydropower stations, with total capacity of 17 GW are planned between Longyangxia and Qingtongxia in the upper Yellow River. Presently 5 plants, with a capacity of 3.3 GW and annual generation of 15.7 TWh have been built, and two additional plants (2.3 GW) are under construction. Another 2.4 GW of capacity will be added by 2000, and 4.5 GW of new capacity will be added by 2010. Surplus hydroelectricity in the northwest will be sent to the North China Power Network.

It is uncertain whether this energy development and electricity transmission strategy will be successful, as it will increasingly be influenced by economic factors and not rigid central government plans. The main concern of the importing provinces is that exporting provinces will reduce their electricity export when local demand uses up the excess capacity.