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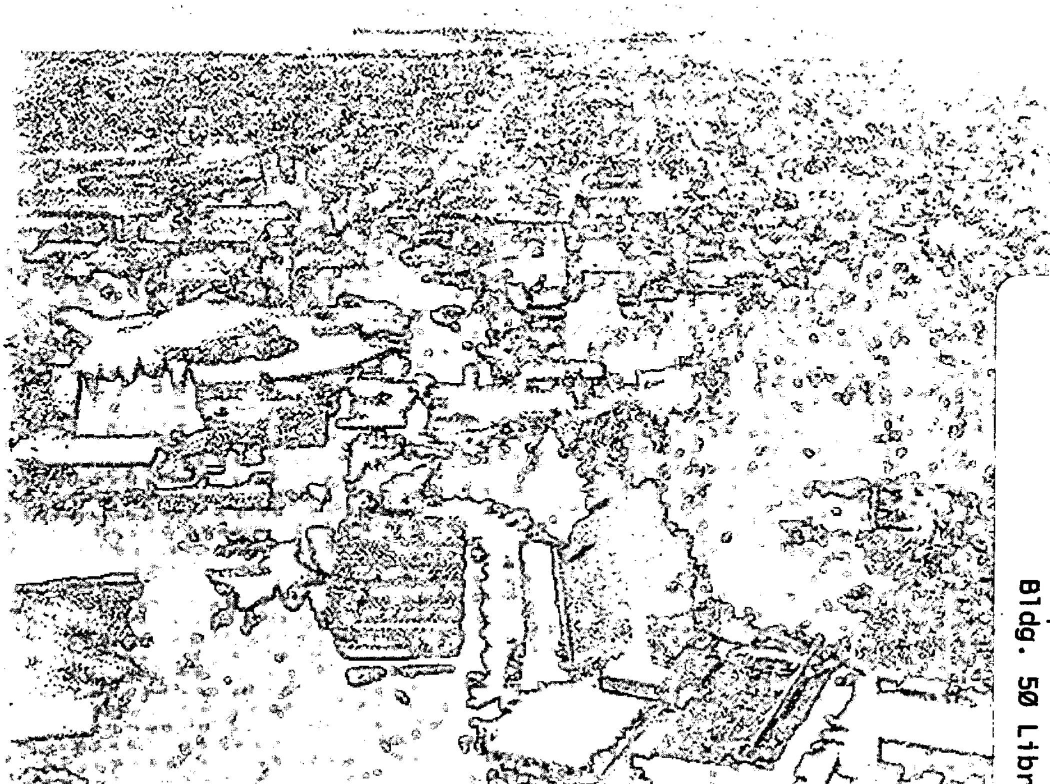

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Cogeneration Development and Market Potential in China

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Preface

China's energy production is based on fossil fuels, with coal contributing over three-quarters of the total supply. Although China has already made great strides in improving energy efficiency, energy use is still relatively inefficient. Also, China currently ranks third in global CO_2 emissions, with rapid economic expansion expected to raise emission levels even further in the coming decades. Accordingly, greenhouse gas emissions and other environmental impacts are of great concern in China and abroad.

Cogeneration provides a cost-effective way of both utilizing limited energy resources and minimizing the environmental impacts resulting from the use of fossil fuels. However, in the last ten years state investments for cogeneration projects in China have dropped by a factor of four. The combination of inefficient energy use, heavy reliance on coal, rapid economic growth and increasing dependence on non-state investment sources has prompted this study. Along with this in-depth analysis of China's cogeneration policies and investment allocation is the speculation that advanced US technology and capital can assist in the continued growth of the cogeneration industry, not only benefiting China, but the global environment and US industry as well.

This study provides the most current information available on cogeneration development and market potential in China. The principle findings include the following:

- Current cogeneration-related policies in China are contradictory, sometimes working against cogeneration profitability and further development. As we clarify later, this situation is mainly the result of a lack of policy coordination, and the difficulties inherent in moving from a planned socialist economy to a market-oriented one.
- The primary market barriers for cogeneration development in China are institutional in nature, a direct result of a monopolistic utility sector and regulated heat prices. These prices must be negotiated, and if the result is too low, profitability will suffer.
- China would benefit from the development and implementation of a comprehensive energy policy such as the US Public Utility Regulatory Policies Act (PURPA). Among other things, it would ensure a fair price for independently produced electric power.
- In addition to the opportunities of unmet electricity demand, each year in China there are over 400 million tons of coal burned inefficiently in boilers and small thermal power plants, providing a huge base of potential cogeneration conversion investment projects for US companies, and a significant opportunity to reduce global greenhouse gas emissions.

Introduction

This study was funded by the US Department of Energy and jointly conducted by researchers from the China Project, Energy Analysis Program, Energy and Environment Division at Lawrence Berkeley National Laboratory and the China State Planning Commission's Energy Research Institute. This report, and the accompanying appendices, were prepared and written for all individuals and firms interested in pursuing cogeneration opportunities in China, international analysts and decision makers concerned about reducing the growth of China's greenhouse gas emissions, Chinese decision makers, and participants in the upcoming US - China Joint Workshop on Cogeneration Development in China. The expected participants are key Chinese government officials, and representatives of both public and private sectors in the US, all of whom are involved in cogeneration.

Cogeneration systems perform the dual functions of producing heat or steam for industrial, commercial, or residential uses and generating electricity. Compared with conventional thermal power plants, in which more than two-thirds of the heat energy is lost to cooling processes and the environment, the energy utilization efficiency for cogeneration systems can reach 70 to 80%. These cogeneration systems can also be used to replace smaller and relatively inefficient stand-alone boilers for heat and steam generation in district heating applications, cutting urban emissions and saving fuel.

The benefits of cogeneration are clear. China commissioned its first cogeneration plants in the 1950s. Today, these facilities account for over 11% of China's total electric power-generation capacity. However, since 1984 the share of direct state investment in cogeneration has been replaced by market-related funds. The Chinese government now has much less direct control over the types of electric power generation projects that are funded.

The government's response has been twofold: First, to investigate the current investment environment and consider policies that will ensure the success of efforts to promote cogeneration; and secondly, to actively seek foreign participation in building China's energy infrastructure. Also, severe shortages of electricity in the rapidly developing southeast coastal regions, coupled with the desire to increase the efficiency of energy use and improve the environment, make cogeneration projects very attractive to Chinese planners. These responses have led to this assessment of the investment environment for possible US commercial ventures and joint investment projects for reducing global carbon dioxide emissions.

This report provides a comprehensive view of cogeneration development and market potential in the People's Republic of China, beginning with the historical background of cogeneration development. This section briefly explains the special historical, political, and economic conditions that form the foundation of today's cogeneration environment. Next, we present the current cogeneration situation including development trends, geographical, sectoral, and cogeneration capacity-distribution patterns. This is followed by an explanation of the energy, macroeconomic, institutional, and policy frameworks, finance and investment allocation scenarios, environmental aspects, and technical issues. The primary purpose of this section is to provide the reader with a clear picture of cogeneration-related policies and the bureaucratic functions involved in fund allocation and program implementation. Finally, we present both the risks and opportunities for US investors interested in China's cogeneration market including market traits, the investment process, a detailed breakdown of both new and retrofit investment opportunities, and possible demonstration projects for emerging technologies.

The appendices include an up to date list of the key Chinese decision makers and the bureaucracies and utilities involved in cogeneration investment and regulation, as well as a detailed guide to cogeneration-application procedures and the approval process, including those relevant to foreign investors.

Chapter 1

The Historical Basis for Cogeneration Development

The political, economic, geographic, and technological conditions for cogeneration development in China are unique. Unlike the situation in the United States, a land of immigrants with a two-hundred year history of market economics and the free exchange of ideas, China's cultural foundation is based upon an ancient culture which changed very little for most of its several thousand-year history.

Along with the introduction of socialism in 1949, China borrowed a Soviet-style planned economy. The main tenets of this type of economy are central government top-down control, government fixed prices, and government-set production quotas. This was the structure of the Chinese economy until 1978. Central government control of the national economy required a gigantic bureaucracy. Fixed prices and production quotas meant that the market signals and motivations of profit and loss were nonexistent before 1978. Top-down management also stifled the development of management skills and a legal policy and regulatory framework, while leading to a habitual system of misreporting to higher officials.

In 1978, with the introduction of Deng Xiaoping's economic reforms, China was put on a gradual and sometimes regressive road to market economics. In this rapidly changing and sometimes unstable environment, cogeneration has at times made great gains and at others faltered. This is the reality that today's cogeneration developers face while the government and the economy are in transition.

In addition to its economic and political differences, China also has special geographical characteristics. Approximately the same size as the United States, but with over five times the population, China has most of its population and most of the demand for electricity and heat in the east, while most of the raw energy resources are located in the northwest. Transportation systems are over-burdened and under-developed. Because of geographical challenges and the realities of economic development, the Chinese government has long realized the benefits of cogeneration. Table 1.1 is a guide to these changes in cogeneration development over various time periods.

China's first cogeneration plants were imported from the Soviet Union in 1953. Originally there were nine 100-200 MW (Mega Watts, or 10^6 Watts) plants[1] built in the northeast for residential and industrial loads utilizing steam extraction turbines. These cogeneration plants were designed to provide steam for both existing and future customers, illustrating that the determination of heat load was already considered a crucial factor. The types and sizes of turbines were also restricted to a few Soviet models with most of 25 to 50 MW capacity and medium-level parameters in vapor temperature and pressure.[2]

The relative growth rate of cogeneration in the period from 1950 to 1965 was very high, with cogeneration accounting for 20% of new generation capacity—about 2.4 GW (Giga Watts, 10^9 Watts)—in this period.[3] The Chinese economy followed the Soviet model during this period with most of the growth occurring in heavy industry. The growth rate of the following period, 1965 to 1980, was in contrast very slow compared to overall growth, with less than 2 GW of additional capacity realized. Cogeneration accounted for only 6.4% of the new electric power-generation capacity for this period. Much of this stagnation can be accounted for by the upheavals generated by the Cultural Revolution occurring through most of this period, when the economy took a second seat to political matters and local self-sufficiency was pushed throughout the country.

In the early period, 1950 to 1965, cogeneration plants were typically large (>100 MW) and municipally controlled, accounting for 80% of the total cogeneration capacity of the period. All investment funds were allocated by the State Planning Commission (SPC).[4] Utilities, also part of the bureaucratic structure, managed and regulated all aspects of the cogeneration plants including investment, management, fuel, and price issues. Because of the total domination of the utilities, factory-owned cogeneration plants only provided steam and electricity for their own

Table 1.1

Cogeneration Development Over Different Time Periods

	1953-1965	1966-1980	1981-Present	2000
Capacity Ownership	Central government-owned and factory-owned	Central government -owned and factory-owned	Central government-owned, local government-owned, factory-owned, collectively-owned and joint-ventures	Stock-holders, collectively-owned, local government-owned, factory-owned, central government-owned, and joint ventures
Financing Mechanism	Central government investment	Central government investment	Central government investment and loans, local and collective funds, internal funds, foreign capital	Stocks, local and collective funds, central government loans, internal funds, and foreign capital
Technology	Large and small equipment imported from the Soviet Union. Trend toward larger systems	Small-scale equipment made in China, but large-sized equipment imported from the Soviet Union. Trend toward maintaining larger systems	>100 MW turbines and >24 tons of steam/h boilers still imported from abroad. Trend toward smaller systems	Equipment is available from domestic manufacturers
Operation Mode	Utility run nationally-owned plants serve both electricity and steam needs. Factory-owned plants meet own thermal needs	Same as the previous period	Independent cogeneration plants increase	Independent plants play a major role
Costs	Stable and controlled by planning systems	Stable and controlled by planning systems	More market-driven. Costs increase rapidly	Market driven and marginal costs
Government Policies	Encouraging development	No special attention paid to projects	Incentives for development	Formulating a comprehensive policy
Regulation	Both electricity and heat prices regulated	Both electricity and heat prices regulated	Flexible electricity prices and regulation of heat prices	Deregulating electricity and heat prices
Competition	Monopolies	Monopolies	Introducing competition	Increasing competition
Environmental concern	None	None	Increasing concern	Incorporating environmental constraints

Note: The changes in various factors projected for the year 2000 are detailed in the following chapters.

consumption, and none was sold.

The situation changed in the following period. By 1980 the factory-owned cogeneration plants accounted for 77% of the total cogeneration capacity,[2] most of them small scale (<25 MW). However, the utilities still monopolized ownership of cogeneration capacity with a 52% share, and more importantly, still controlled the price of electricity and access to the grid. The vast majority of investment was still SPC controlled. China had developed its own cogeneration technology, primarily on a small- and medium-sized scale. Environmental protection was never considered during either period.

The legacy of central control—poor management as a result of nonexistent performance incentives, low prices because products were seen as benefits of a socialist society to be given out free, or at extremely low subsidized levels, lack of competition for funds based on practical economic criteria due to the top-down allocation system, domination by utilities because control in the planned economy was crucial, and lack of a comprehensive legal and regulatory framework because of the dependence on political control—all remain as barriers in the current switch to a market economy.

It is important to note these preconditions of the current period. For example, it helps to understand that most of the current cogeneration policies are merely patches to solve specific problems, not integral parts of a comprehensive energy policy. The following sections should make apparent the importance of the legacy of China's centrally controlled planned economy.

Chapter 2

The Current Cogeneration Development Situation

2.1 Introduction

In addition to their impacts on Chinese society, the economic reforms begun in 1978 have had a profound effect on the development of cogeneration as well. With rapid economic development, an annual real GDP (Gross Domestic Product) growth rate of 9.5% during the period of 1980 to 1993,[5] inflation has soared and cogeneration costs have risen rapidly, driven by increasing capital costs and escalating fuel prices. The impetus driving cogeneration development has shifted away from bureaucratic control and toward market signals and policy incentives. Local government loans, collective funds, and internal funds have replaced central government investments and now comprise the majority of capital resources used for cogeneration development.

This diversification in cogeneration ownership has undermined the utility's monopolistic role in the power industry and increased competition. Meanwhile, the conflicts between utilities and independent cogeneration plants, have increased considerably. Cogeneration producers have been allowed more flexibility in negotiating electricity prices, but heat prices are still tightly regulated. Deregulation of heat prices is required to assure full cogenerator benefits, to enhance the economic feasibility of projects, and to improve the cogenerator's access to financing. Finally, increasing environmental concern, both via public awareness and government regulation, has become a factor in the choice between cogeneration and traditional thermal electricity generation and heat supply. This chapter identifies changes in cogeneration development during the period from 1980 until today, clarifies the major trends, and presents the main patterns of distribution.

2.2 Electric Power Growth

As indicated earlier, the annual GDP growth rate in this period was 9.5%. By the end of 1994 however, the growth rate of electric generation capacity fell behind, reaching a total of 198.2 GW[6,7] for an average annual growth rate of 7.6%. The national government has predicted a continued average annual GDP growth rate of 8 to 10% through the end of the century.[8] To keep pace with this predicted rate, electric power generation capacity would need to reach 300 GW by the end of the year 2000, requiring an additional 17 GW of capacity each year. The annual investment required to meet this demand is estimated at 70 to 80 billion yuan, or US$ 8.5 to 10 billion at current exchange rates. It is expected that 75% of the total investment will be raised in the domestic market and the rest will be provided by the international financial markets.[9]

The Chinese government has realized that electricity supply is one of the most important factors in securing sustainable economic growth. The national government has given the electric power industry priority over the other energy sectors during the last two decades. Thermal capacity growth has outpaced growth in total electricity generation, rising from nearly 41 GW in 1980 to about 137 GW in 1993 for an annual growth rate of 9.1%.[10,11] Although cogeneration has outpaced thermal power growth throughout this period (see Table 2.1), albeit from a smaller base, both cogeneration investment and capacity will face difficulties in keeping up with GDP growth rates through the end of the century.

2.3 Heating and Cooling Trends

Data for estimating the total heat demand in China are scarce and scattered. However, there are some data from which we have made rough estimations. We estimate here that as of 1993, the total industrial heat supply was 6.4 billion GJ (Giga, or 10^9 Joules), requiring over 280 mtce (million tonnes coal equivalent) including cogeneration.[12] Of this amount, cogeneration supplied about 11%, or about 700 million GJ in 1993. Currently, industry uses about 80% of the total heat supply, and residential heating and cooling about 15%. The remainder is used in the commercial sector, which is expected to grow rapidly in the future.[12]

In the previous periods the Chinese government strictly controlled the allocation of raw materials for residential heating use. Although electric space heaters have started to appear in

Table 2.1
Major Economic and Electric Power Industry Indicators, 1980 - 1993

Year	China's GDP in US $Billion[1]	Total Elec. Gen. Cap. in GW	Thermal Elec. Gen. Cap. in GW	Thermal Elec. as % of Total	Cogen. Elec. Gen. Cap. in GW	Cogen. Elec. as % of Total	Cogen. Elec. as % of Thermal	Elec. Consumption Elasticity[2]
1980	54.2	65.9	40.5	61%	4.4	6.7%	10.9%	0.84
1993	380.4	182.9	137.2	75%	15.4	8.4%	11.2%	0.79
Avg. Annl. Growth Rate	14.9%	7.6%	9.1%	-	9.4%	-	-	-

[1] Gross Domestic Product at 1995 $US exchange rate

[2] Electricity Consumption Elasticity = Increase in rate of electricity consumption/increase in GDP

Source: China Energy Annual Review, 1994, Department of Resource Conservation and Comprehensive Utilization, SETC

areas not formerly allocated space heating, the vast majority of space heating energy is still controlled by the central government. Figure 2.1 illustrates the heating zone in China. The dotted area distinguishes an area that receives fuel allocations from the national government for space heating, typically from six months in the northeast to three months in the southwest annually. Total residential heating space in the north has been estimated at 3 billion m^2 (square meters), and in the central area south of the current heating zone, at an additional 2.6 billion m^2. The central area requires heating for only two months of the year, but also requires space cooling in the summer. All together, 40% of the urban population, 134 million people, require space heating in the winter.[13] At the end of 1990, district heating accounted for 12% of the total residential heating space in the north, or about 123 million GJ for 213 million m^2 of floor space.[14] The government's goal for cogeneration in district heating and cooling is 15% of residential floor space by 2000, or 486 million GJ for 840 million m^2.[15]

Although district heating systems (and town gas-distribution systems) have made remarkable progress since 1980 (25% annual growth rate), they still fell far behind residential construction. The number of boilers, primarily for space heating, have increased from 200,000 to over 400,000 and the number of home coal stoves has risen by six million. These typically small and inefficient boilers consumed about 400 million tons of coal in 1994.

2.4 Cogeneration Scale

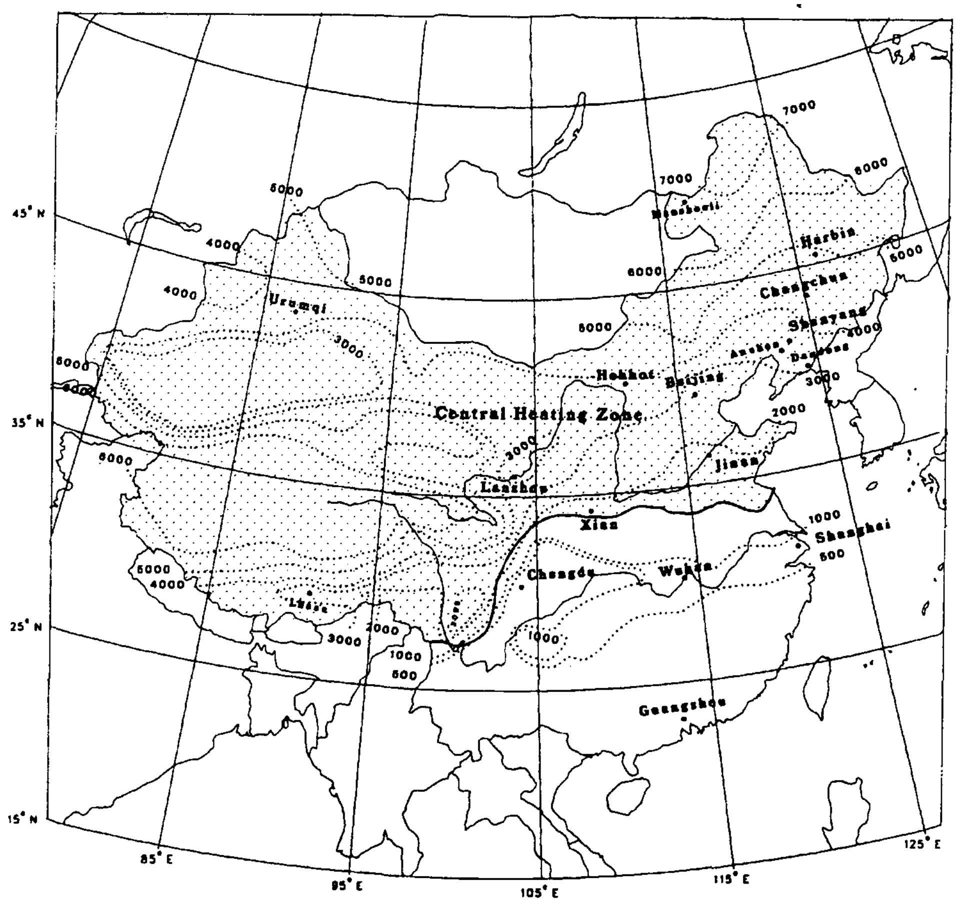
Cogeneration scale varies according to regulations, location, technology, and capital availability. In the early periods, most of the cogeneration systems were imported Soviet large-scale district heating plants. At that time there were few small, factory-owned plants because the large plants were seen as a social benefit and received most central government funding. As we pointed out previously, that trend changed during the late 1960s and through the 1970s due to the promotion of local self-sufficiency and lack of large residential construction, resulting in a very small average plant size by the end of the 1970s.

Statistics are available only for cogeneration systems with turbines larger than 6 MW; therefore we cannot provide exact figures. However, a close look at the existing data (see Table 2.2) does provide insight into the current trends. If we exclude the unknown number of turbines smaller than 6 MW, the average cogeneration plant size in 1993 has decreased to about 20 MW. This shows a shift away from the large systems typical in the 1960s. From 1981 to 1990, 291 cogeneration facilities with a capacity of 7.96 GW were approved by the government, averaging 27 MW in size.[12]

There are several reasons for this shift toward the small- to medium-scale systems. First, the economic reforms since 1978 have shifted the emphasis away from social benefits and toward economic benefits, while responsibility has shifted away from the government bureaucracy to individual enterprises. Since profit and loss are now in the management domain of the enterprise, the cost advantages of cogeneration have become more attractive. Also, the drop in direct central government investment has meant that more factories and municipalities have had to provide their own financing. On the other hand, inflation of construction prices, especially

Figure 2.1

The Central Heating Zone in China*



Source: Siwei Lang and Yu Joe Huang, "Energy Conservation Standards for Space Heating in Chinese Urban Residential Buildings," *Energy* Vol. 18, No. 8, pp. 871-892, 1993.

*The Chinese government defines a central heating zone, based on the severity of the climate, within which space heating is mandated. The areas where there are more than 90 heating days in a year are included in the zone. The heating day is defined as those days when the average daily outdoor temperature for any five successive days is lower or equal to 5°C.[13] This figure shows the heating degree day lines based on an indoor temperature of 18°C and accounting for only those days falling within the heating season. More detail can be seen in "Explanation of Urban Construction Index," Ministry of Construction, Beijing, China (1987).

Table 2.2

Cogeneration Scales and Their Capacity, 1993*

Size Catalog	Number of Turbines	Capacity (GW)	Share of Capacity (%)
> 50 MW	91	6.875	46.9
25 - 50 MW	132	3.300	22.5
12 - 25 MW	232	2.833	19.3
6 - 12 MW	268	1.637	11.1
Total	723	14.65	100

*Note: Excluding turbine capacities < 6 MW. Total with < 6 MW was 15.4 GW

Source: Statistical Summary in the Power Industry, Department of Planning of the MOEP, July 1994.

for large district heating systems, low heat prices, and avoidance of central government involvement in projects (any project with an investment cost greater than US$ 30 million must have central government approval) have all acted to keep the average size down. We will discuss the issue of approval in more detail later.

The criteria used to measure the economics of cogeneration scale are different for various owners and investors. Industrial firms usually only consider the cost-effectiveness of an investment (such as rate of return), to determine the optimum scale of cogeneration projects. The outcome is typically smaller, self-contained systems. The economic reforms that started in 1978 have made profit the primary incentive for individual firms. Industrial cogeneration projects, most of which use loans and internal funds, remain small to avoid the additional government regulation and management difficulties that large-scale cogeneration projects face.

However, the decision environment for utilities includes such additional factors as whole system efficiency, benefit optimization, social effects of increases in energy efficiency, reduction in resource utilization, and costs of environmental pollution. As a result, the government tends to build large-scale cogeneration plants to benefit the society, for example, district cogeneration systems and industrial park cogeneration plants, providing low-cost steam and heat for a large number of industrial and residential consumers.

Large-scale plants, those over 100 MW capacity, are typically found in petroleum refineries, large chemical plants, large food processing plants, and large district heating systems. Medium-scale cogeneration plants, between 25 and 100 MW, can be found in sugar mills and central cogeneration applications. The term "central cogeneration" as used here includes district heating and industrial park cogeneration plants, which supply heat and steam to surrounding industrial and residential areas. Small cogeneration systems, those less than 25 MW are commonly found in the chemical, textile, and paper industries. In 1993, cogeneration plants smaller than 6 MW capacity accounted for about 750 MW total generation capacity, much of it coming from retrofits of boilers and old power plants.

2.5 Ownership Trends

The change of ownership patterns has been one of the most salient features of the recent economic reforms. Up until the late 1970s, all cogeneration facilities were owned by the central government. At the end of 1980, utilities still owned 52% of the total cogeneration capacity. Cogeneration facilities are currently owned by utilities, municipalities, industrial parks, cooperatives, factories, shareholders, and local and foreign investors. Today, even in the remaining central government-owned plants, the amount of government ownership based on capital shares has dropped to about 35%.[15]

One of the primary economic reforms has been to transfer ownership—and at the same time financial responsibility—to non-central government entities. These reforms have also meant that central government direct investment has dropped considerably so that those interested in developing cogeneration have had to provide their own funding or seek it elsewhere. This change of funding sources has led to much more diversified ownership. These changes have increased the reliance on internal funds, bank loans, and other types of fund-raising.

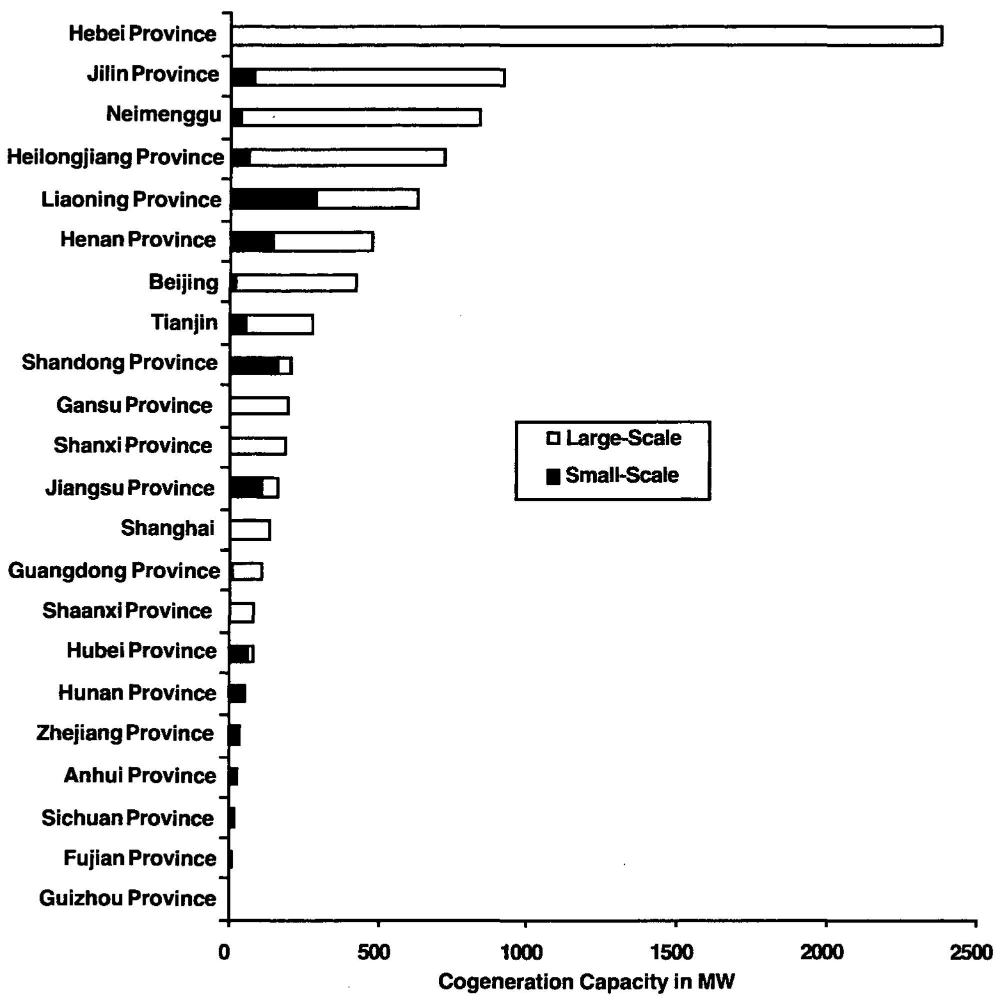
Still, government funds do make an impact. Central government funds for capital construction (new plants) in the industrial sector accounted for 7% of the total cogeneration capacity in this period. The Ministry of Electric Power (MOEP) and the State Economic and Trade Commission (SETC) also supply funding for cogeneration, the former for large cogeneration projects, and the latter for technological renovation projects. These sources have helped to add over 2 GW of cogeneration capacity in the last decade, about 25% of the total.[16] Funding will be discussed in more detail in Chapter 5.

2.6 Distribution Patterns

The differences in geographic distribution, mainly scale and ownership, are fairly straightforward. The large, municipally owned cogeneration plants used for district heating are primarily located in the heating areas of the north. Figure 2.2 illustrates the distribution capacities of small versus large systems. The large systems account for the majority of the capacity in the provinces of the heating zone. These large cogeneration systems are primarily municipally owned district heating systems. The south, which does not have the space-heating requirements or the fuel allocations of the north, is home to many more small factory-owned cogen-

Figure 2.2

Regional Distribution Patterns for Large- and Small-Scale Cogeneration



Source: Xu, Hong, "Cogeneration Development in the Last Decade and Its Perspective," *Energy Conservation Planning and Information*, Department of Resource Conservation and Comprehensive Utilization of SPC, February 1993. (Circulated in China only.)

eration systems. Although, as mentioned previously, with the increasing standard of living and the rapid industrial growth, especially in the southeast coastal region, industrial parks and district cooling may soon reverse this trend.

2.7 Other Patterns and Trends

Along with the findings outlined above, other characteristics of cogeneration development are worth mentioning. These include energy efficiency trends, energy raw material use-and-supply patterns, and the rising importance of environmental protection. As we will discuss later, energy efficiency in electric power and heat/steam generation have increased over this period. These increases are due not only to the cost-minimizing and profit-maximizing side effects of the switch to a market economy, but also to inflation, transportation bottlenecks, serious raw material and electricity shortages, increasing environmental awareness, and government policy.

Electricity shortages have been widespread throughout this period, coming to a peak in 1988.[15] However, policy reforms in the late 1980s that cut support to the large central government enterprises slowed the demand for electricity in some areas. In the northeast provinces of Heilongjiang, Jilin, and Liaoning especially, where large, central government-run heavy industries are concentrated and coal resources are more plentiful, there is at present a surplus of electric power. However, the provincial and power authorities there realize that the surplus will be short lived and are unsure about which is the best future policy. Their choices are to invest in increasing the electric power capacity or to use the same money to improve the efficiency of the central government-run organizations, thereby lowering demand.

Although the average efficiency levels of cogeneration facilities are much higher than those for standard thermal electric power-generation facilities, short operating hours, insufficient or unstable heat loads, and high electricity self-consumption rates can limit efficiency increases. The average energy efficiency range of conventional power plants is 30-35%, while cogeneration plants are typically 65-70%, approximately double. The average energy consumption in 1990 for conventional plant capacities larger than 200 MW was 390 gce/kWh (grams of coal equivalent consumed per kilowatt hour generated). Cogeneration plants with back-pressure turbines on average consumed 220 gce/kWh, and extraction condensing turbines consumed 350 gce/kWh.[12] Tables 2.3 and 2.4 illustrate both the energy efficiency gains in the industry as a whole and how important operating hours are for making use of the efficiency gains of cogeneration technologies.[17] Table 2.4 illustrates how on average, cogeneration facilities with electricity generation capacities greater than 50 MW are more efficient than small systems.

In addition, cogeneration plants utilize steam and/or heat from the combustion process. The average efficiency of boilers used in cogeneration was 80-90%, and the energy consumption for heat supply ranged from 40 to 36 kgce/GJ. The same energy indices, heat efficiency, and energy consumption for heat supply were 65-70% and 50-60 kgce/GJ respectively, for small-sized industrial boilers, compared with 85-90% in developed countries.[12] The energy efficiency of boilers also benefit from economies of scale. The promotion of cogeneration has helped the average capacity of boilers increase from 2.0 tons/hour (t/h) in 1980, to 2.3 t/h in 1990.[18]

Coal is the primary fuel for cogeneration in China, accounting for 95% of the total cogeneration capacity. The amount of coal used for heat supply in cogeneration was 41.88 tonnes million (29.9 million tce), accounting for 70% of the total fuel consumption. The remainder was provided by 6,809 million cubic meters of gas (9.06 million tce), accounting for 21% of the total cogeneration fuel consumption, and 2.72 million tons of oil (3.89 million tce), accounting for 9%.[19] So far, no reports or governmental information indicate no cogeneration plants using biomass, garbage, or other fuels have been built in China.[15] There is increasing public and political pressure to substitute other fuels for coal in urban areas due to the environmental effects of coal. Most fuel prices are now set at the market rates. Therefore price

Table 2.3

Energy Index Changes, 1980-1993

	Unit	1980	1993
Total Cogeneration Capacity	(MW)	4,434	14,650
Total Cogeneration Electricity Generation	(TWh)	11	64.6
Energy Consumption for Electricity Supply	(gce/kWh)	438	418
Energy Consumption for Electricity Generation	(gce/kWh)	404	383
Self-Use Electricity Rate	(%)	7.8	8.38
Total Heat Supply	(million GJ)	N/A	819.52
Energy Consumption for Heat Supply	(kgce/GJ)	N/A	39.43
Utilization Hours	(h/year)	2,500	4,410

Source: Statistical Summary in the Power Industry, Department of Planning of MOEP, July 1994.

Table 2.4

Economic Indices for Cogeneration in Capital Construction, 1981- 1990

	Total Capacity (MW)	Electricity Generation (GWh)	Coal Consumption for Supply (gce/kWh)	Coal Consumption for Generation (gce/kWh)	Self-Use Electricity (%)	Utilization Hours (h/year)
Total Thermal Power	101,844	494,968	427	392	8.22	5,413
Total Cogeneration	7,985	42,296	418	383	8.38	4,408
≥ 50 MW Cogeneration	6,834	37,798	412	378	8.36	5,560
< 50 MW Cogeneration	1,151	4,497	487	442	8.64	4,075

Source: Xu, Hong, "Cogeneration Development in the Last Decade and Its Perspective," *Energy Conservation Planning and Information,* Department of Resource Conservation and Comprehensive Utilization of SPC, February 1993. (Circulated in China only.)

and availability are more favorable for the coal producing areas in the north than the coal-poor and distant southeast coastal region.

Some cogeneration plants have even been able to utilize the solid waste and dust by-products to turn a profit by making bricks.[20] The environmental damage caused by acid rain and the global warming issue have raised concerns both in China and internationally to reduce China's current and future levels of SO_2, CO_2, and other pollutants. As is discussed in Chapter 3, promotion of energy efficiency and fuel switching in cogeneration are two of the cost effective methods the Chinese government has employed to improve this situation.[21] However, it is increasing local environmental concern that is the most important feature of this period, and the one that generates the most pressure for reform.

Finally, it is important to point out that with the increasing concern for the environment, cogeneration has become a much more attractive option for policy makers in recent years. The Chinese government has issued regulations to strongly encourage power plants, including cogeneration plants, to meet environmental standards on dust and SO_2 emissions, solid wastes, and water pollution. Environmental regulations call for fines of 20 fen/kg for SO_2 emissions. However, other pollutants such as CO_x and NO_x have not yet been addressed.

Chapter 3

Institutional Framework

3.1 Introduction

No single government agency is responsible for cogeneration in the chain of responsibility from proposal approval to project financing. The bureaucratic structure is quite complicated, and even some Chinese energy experts do not fully understand it. Before 1978, there were merely central government-run cogeneration plants. These plants were managed either by the utilities, the Ministry of Energy (MOE) in the central government and the Electric Power Bureaus in the provincial governments, or by other local agencies. As mentioned earlier, the majority of cogeneration plants in the previous period belonged to utilities. At that time, a proposal for a new cogeneration project had to first be submitted to the electric power administration to get preliminary approval. The State Planning Commission (SPC) then reviewed the cogeneration projects passed by the electric power administrations. Finally, the projects approved by SPC were included in the plan and were financed either through the direct investment allocated by the SPC or through government-run banks. Almost all power plants, including cogeneration plants, were under the control of government-run utilities at different levels of the administration before 1978. The cogeneration plants, either large- or small-scale, were parts of the monopolistic power industry.[22]

However, as we will point out, the pre-existing conditions for cogeneration development, as well as the economic reforms starting in the 1978, have both contributed to several major reforms of the administrative framework and a reshuffling of the major players in cogeneration development. We divide this chapter into two periods: the early reform period of the 1980s and the recent period, from 1990 until today. The purpose of this chapter is to introduce the principal players involved in cogeneration development, outline their responsibilities, and clarify the institutional structure in which they operate.

3.2 The Early Period, 1978 to 1989

The economic reforms that started at the end of 1978 greatly stimulated economic growth, breaking the fixed and planned relationships among sectors and causing energy demand growth to outstrip production. This rapid growth lead to an overall energy shortage throughout the country of a magnitude not previously experienced in China.[23,24] In the national energy conservation program, cogeneration was counted on as a cost-effective measure to cope with the energy shortage challenge. Cogeneration programs were emphasized as a top priority of energy-conservation policies and shared a major part of the investment.[25] Reorganization of the institutional structure and diversification of funding sources for cogeneration projects changed the ownership patterns and relationships within the power industry. In the following section, we review the institutional changes beginning in the late 1970s and follow them through the 1980s.

At the highest level of China's bureaucracy, the SPC was in charge of integrated economic planning in the medium and long terms, such as the "five-year" and "ten-year plans" for national economic development. Together with the MOE, they jointly formulated electricity development strategy and long-term planning. The SPC controlled the scope and the amount of fixed capital investment in the power sector and was responsible for cogeneration development policy and the approval of any large-scale power and cogeneration projects.

The first change in the institutional structure was to diversify sources of capital and reorganize the central government. The major concern of the central government was to create the proper institutional structures to stimulate energy-conservation projects and activities around the country. As a result, the Department of Resource Savings and Comprehensive Utilization (RSCU) was established in the SPC, and the Department of Energy was created in the State Economic Commission (SEC) to oversee the national energy-conservation programs. Special funds for energy-conservation programs were subsequently obtained from the national budget and then allocated by these two departments.[26] The provincial governments also established similar departments and fund-allocation mechanisms to correspond with the changes at the central government level.

Table 3.1 shows the responsibility and functions for different agencies in the early 1980s. The Department of RSCU of the SPC was responsible for allocation of capital construction funds (new cogeneration plants with a single generator of less than 12 MW, or in a few cases, medium-sized plants). The Department of Energy of the SEC was responsible for technological renovation funds, typically factory-owned cogeneration. The Ministry of Energy was in charge of cogeneration projects larger than 200 MW, in practice larger than 100 MW, or small-scale plants built with the MOE's internal funds. The MOE was also responsible for the following missions in the industry: formulating and implementing electric power-development strategies, developing policies and legislation in the power industry, drawing long-term plans, and managing annual production. The MOE, the SPC, and the SEC (State Economic Commission) also coordinated efforts for approvals of key large-scale capital construction and technical upgrade projects. The cogeneration plants from the previous period, whether large or small, were under the control of the MOE.

The State Science and Technology Commission (SSTC) was committed to organizing specialists and providing assistance to develop technology and solve technical problems. Beginning in the 1980s, the new central government-funded medium- and small-scale plants, along with small-scale power plants funded by non-power industry investment and loans, became independent from utilities. A weak competition began to be introduced into the power market for the first time.[23]

3.3 Recent Changes, 1990 through Today

By the end of the 1980s, it became apparent to the government that further structural changes were required to separate business management from the administration functions of government institutions. Structural change was continued. Although some competition in the power industry had begun as a result of earlier reforms, fund allocations, project approvals, and business management all suffered under the weight of the large bureaucracy and inefficient planning system that in many ways still existed. Too many basic economic changes had occurred through the 1980s for the institutional structure to function efficiently. Figure 3.1 shows the bureaucratic structures and government-run corporations in cogeneration programs at the end of 1994.[15] Several institutional structure changes should be apparent compared with the earlier period.

The Department of RSCU of the SPC was eliminated at the end of 1993, and its functions in energy conservation and renewable energy were

Table 3.1

Institutional Structures for Cogeneration Programs and Their Functions in the Early 1980s

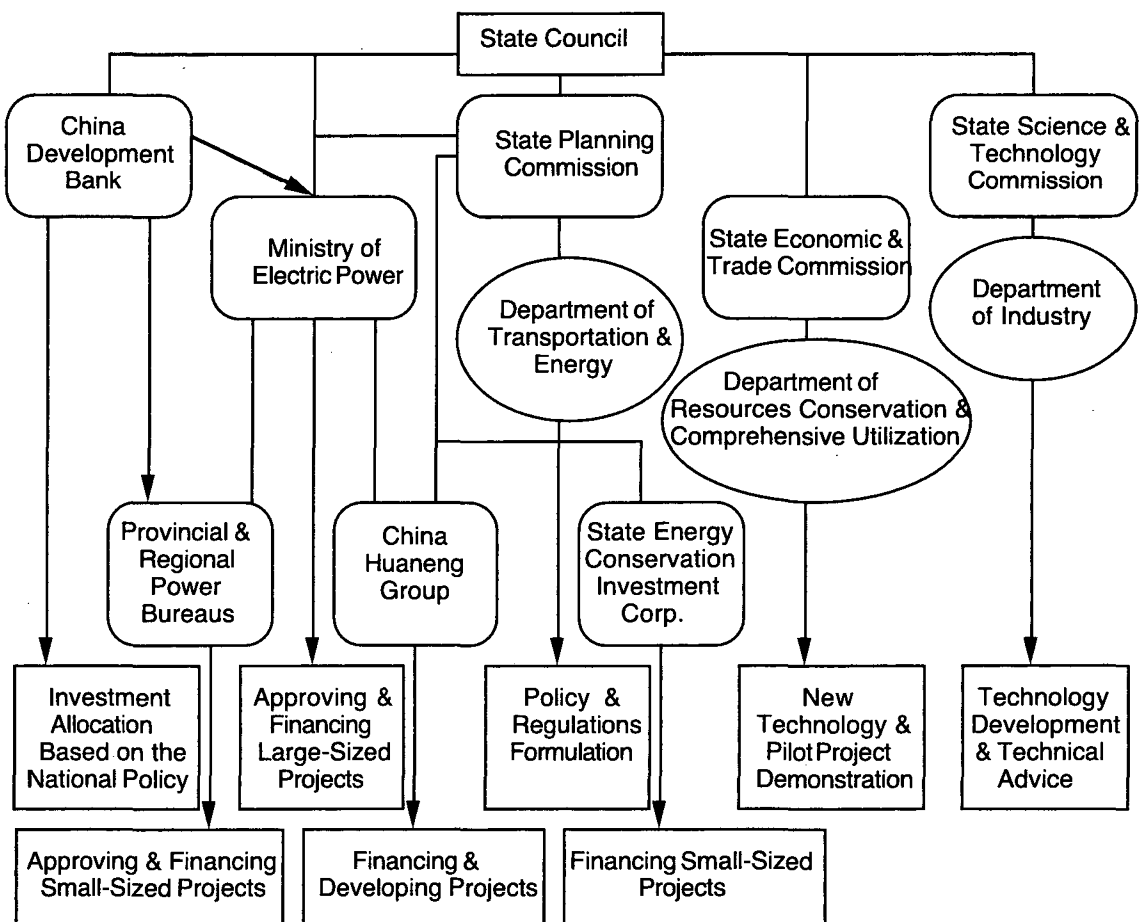
Government Institution	Responsibility	Investment sources
1. SPC	Approved large-scale cogeneration projects submitted by the MOE	Allocated central government investment and loans to projects through the MOE
Department of RSCU	Approved and funded projects with a single generator of less than 6 MW, or sometimes engaged in medium-sized projects with other sponsors	Special funds for capital construction in energy-conservation projects
2. SEC	Approved extension and technical upgrades for large-scale projects	Allocated central government technical funds to these projects directly
Department of Energy	Approved and funded small-scale in-plant projects	Special funds for technical upgrades or factory-owned cogeneration projects
3. MOE	Approved and funded projects with capacities larger than 200 MW, or special projects	National energy-investment funds and internal funds
4. SSTC	Developed technology and solved technical problems in programs	Science and technology funds

Source: Yang, Fuqian, et al., "A Review of China's Energy Policy," Lawrence Berkeley National Laboratory Report No. LBL-35336, August 1994.

merged into the "Division of Energy Conservation and Renewable Energy" of the "Department of Transportation and Energy" of the SPC. By this reduction to a division, the authority of the energy conservation and cogeneration programs in the SPC were weakened. Although the power of this division of the SPC is not as strong as it was as a department, it is still charged with policy formulation and decision making with respect to cogeneration in the long term. Which government administration will take the responsibility for interpreting and carrying out the policies and regulations made by previous administrations is unclear however. The SPC, a relic of the central planning system, has lost some amount of control over cogeneration development because it no longer controls investment allocation directly. In 1988, the function of allocating investment funds for energy conservation, including cogeneration, was relegated to a new investment enterprise under SPC supervision, the China Energy Conservation Investment Corporation (CECIC).

In place of central investments and fund management, a number of special central government-owned corporations and banks were formed to improve the performance and efficiency of investment allocation by using market mechanisms. The CECIC, led by the SPC, works with fixed capital investment in energy conser-

Figure 3.1
Institutional Structures in Cogeneration



Source: Yang Fuqiang, "China Trip Report on Cogeneration Development," December 1994.

vation, including cogeneration development. Special energy funds are directly assigned to the CECIC, about 2 billion yuan (US$ 242 million) each year. The corporation possesses the authority to approve small-sized cogeneration projects and to give special low-interest loans to the projects approved in accordance with the national energy policy. The CECIC also cooperates with foreign companies and investors to fund joint ventures. For new projects, the corporation splits capital investment with local governments and enterprises.

Although both are independent organizations, the Construction Bank of China (CBC) is responsible for monitoring the financial status of CECIC-funded cogeneration projects and insuring loan paybacks. The separation of responsibility for loan-allocation, managed by the CECIC, and loan payback, managed by CBC, is not an efficient way to use the limited capital resources. Not only does this arrangement provide little incentive for the CECIC to ensure project financial viability before allocating funds, it also wastes the resources of the CBC to perform financial re-evaluations and manage loan repayment delays.

The China Development Bank (CDB), formerly the Energy Investment Corporation of the SPC, was formed at the beginning of 1994. The former Energy Investment Corporation was merged into the CDB and the CECIC. As a national policy-oriented bank, the CDB is at the highest ministerial administration level in the institutional structure and under the leadership of the State Council. The CDB managed and allocated 28 billion yuan (US$ 3.4 billion) to power projects in 1994. Projects with a capacity larger than 200 MW are evaluated and financed by the CDB. However, the CDB does not allocate loans for projects in the regions along the coastal areas where loans from commercial banks are available. The monitoring of investment utilization and loan payback is done by the electric power administrations in the five regions and nine provinces.[15]

The State Economic and Trade Commission, which replaced the former SEC, is no longer responsible for cogeneration development with the exception of special projects employing new demonstration technologies. The organization within the SETC that is directly charged with this responsibility is the Department of Resource Conservation and Comprehensive Utilization.[13] Generally speaking, no SETC funds are available for projects; however, cogeneration projects with a financial investment of over 250 million yuan (US$ 30 million) must be approved by the SETC. Smaller projects are approved by the provincial economic and trade commissions.

In 1993 the MOE was abolished and two new ministries were created. One of these ministries, the new Ministry of Electric Power (MOEP), is in charge of all electric power and cogeneration development. The MOEP receives its funds from central government appropriations, China Development Bank (CDB), and other sources. In addition to the responsibilities taken over from the former MOE, the MOEP is now responsible for coordinating with the SPC for the approval of key large-scale cogeneration projects using capital construction funds and with the SETC for technical upgrade investments. The MOEP has final jurisdiction over decisions and policy making for cogeneration and power projects involving foreign investors.[23] Utilities are basically owned by the MOEP. Electricity prices are regulated by the MOEP through regional or provincial power bureaus. Whatever form the administrative jurisdiction, industrial organization, or investment allocation takes, MOEP emphasizes electricity development, and naturally manages the electric grid with monopolistic methods.

As indicated in Figure 3.1, newly created power corporations, such as the China Huaneng Group (CHNG), are under MOEP supervision, but also receive guidance from the SPC on long-term planning while enjoying the management freedoms of an independent enterprise, similar to Independent Power Producers (IPPs) in the United States. CHNG is one of the largest new government-subsidiary companies in China. CHNG is continuously involved in cogeneration development, particularly in the large-sized projects.[27] The role of the SSTC has remained unchanged, still providing cogeneration projects with the necessary human and technical resources.

The structure at the provincial and lower government levels for carrying out cogeneration projects are similar to those at the central government level. Some differences in the institutional structure and policy formulation at the provincial government level include:

- Merging of the provincial planning commission and the provincial economic and trade commission into one agency in some provinces

- The provincial electric power bureaus are under the leadership of both the MOEP and the provincial government

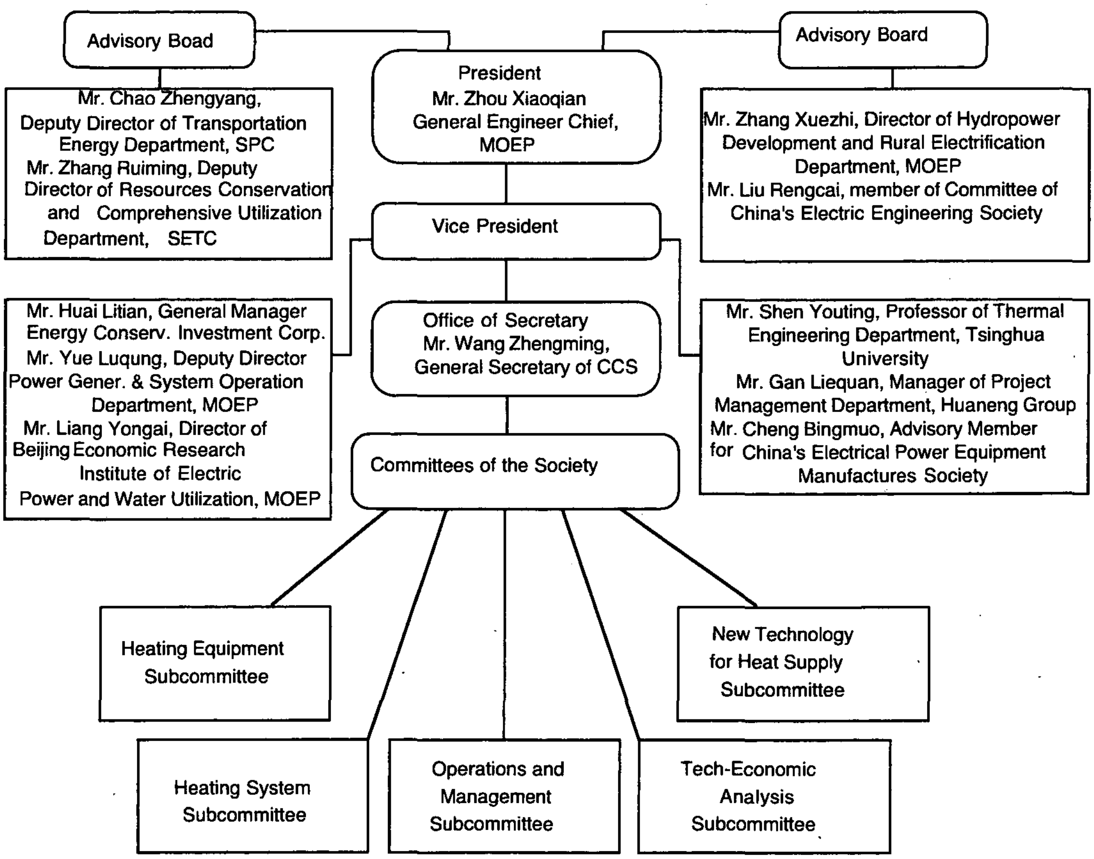
- More flexibility in decision making.

The Chinese Cogeneration Society (CCS) is a sub-society of the Chinese Electrical Engineering Society. The CCS is also a public non-profit organization with more than 330 members, including individual and collective members from universities, research institutes, design and construction companies, industry and government. The CCS plays an important role in cogeneration development because of its cogeneration experts and professional services. For example, the CECIC does not approve or make any investment decisions for cogeneration projects without getting prior evaluations and recommendations from the CCS expert team. Figure 3.2 illustrates the current organizational chart of the CCS.

As a public and academic entity, the CCS is committed to organizing conferences and workshops on cogeneration development, exchanging information and data, providing consultation for customers, publishing papers and magazines on relevant issues, and being an advisory board for government policy making and project evaluation in cogeneration development. The CCS gives advice to the SPC, SETC, MOEP and CECIC in policy formulation and project assessment.

Figure 3.2

The Organizational Chart of the Chinese Cogeneration Society



Source: Yang Fuqiang, "China Trip Report on Cogeneration Development," December 1994.

Chapter 4

Policy Environment

4.1 Introduction

This chapter discusses changes in the policies and regulations concerning cogeneration development in the recent period, 1980-1994. We break this policy examination into two parts: the first, for policies that overcome historical barriers, and the second, for policies that address the recent economic reforms. The discussion begins by examining the pre-existing conditions of the historical period and the policies designed to overcome them. Then we present the policies that address results of the reforms such as rapid economic growth, price and supply deregulation, and decentralized central government control. We continue by reviewing some of the key policy issues of interest to foreign investors. Finally, we describe the latest policy developments awaiting final congressional approval or have approval but await implementation.

Table 4.1 presents all the major cogeneration policies and regulations of this period, the issuing institutions, their effective dates, and their cogeneration-related content. The policies and regulations are divided into five groups: policies for removing the institutional barriers of cogeneration, cogenerator qualification standards and environmental guidance, finance and tax incentives, fuel type limitations, and government regulation of cogenerators.

4.2 Policies Addressing Historical Conditions

Cogeneration development was under complete control of the central government before 1979. As part of each national five-year plan, the government formulated a cogeneration plan that took into consideration the development priorities among economic sectors. Then the central authorities allocated investment resources to the specific cogeneration projects that had been approved and listed in the plan. The government monitored all activities, from construction to daily management; product and input pricing, fuel supply, maintenance, and so forth were all administered by the government. Government played the dual roles of allocation authority and business manager.[23]

The legacy of central control has provided several barriers for the creation of a market economy including a lack of clear and consistent macroeconomic and energy policies, price controls, subsidies, and other monopolistic market entry barriers. Even today, many utilities and water administrations control quantities and prices of electricity and heat/steam to the detriment of cogeneration development.

The first of several regulations designed to overcome these monopolies and encourage private and local investment was issued in 1985 (see Table 4.1 item 1A.) and in effect allowed non-utility generators to bargain for a rational profit margin. Unfortunately, it also required cogenerators to give 30% of their profit to the utility in lieu of grid-connection charges. Many utilities charged the connection fees in addition to the share of profit.[23] The State Council issued other regulations in 1985 (Table 4.1 item 3A.) that reinforced the regulations and gave tax incentives to cogenerators that used internal funds. These policies alone fell far short of what was needed.

Another set of regulations, passed in January of 1987, required the signing of contracts between cogenerators and utilities to protect the interests of both sides and imposed penalties for violations of contracts. Some 1989 regulations (Table 4.1 item 1F) went a step further in helping cogenerators by requiring utilities to purchase cogeneration electricity, guaranteeing fuel supplies, and not requiring cogenerators to participate in peak load adjustments. Special funds and low-interest loans for cogeneration were made available to give strong encouragment to small thermal plants and district heating plants to convert to cogeneration facilities.

In practice, electricity-purchase prices from cogeneration facilities are set by determining a starting point for the rate of return on investment, typically 15% at present. Then a price is reverse-calculated and judged for acceptability. If the local area suffers from electricity shortages, the local electricity price will be much higher than the grid price. High-cost electricity generated from local cogeneration plants is consumed

Table 4.1

Major Government Policies and Regulations Related to Cogeneration Programs

1. Policies for Removing Institutional Barriers for Cogeneration

Policy and Regulation	Issuing Institution and Effective Date	Major Contents Related to Cogeneration Programs
A. Temporary Regulations for Encouraging Electricity Development by Using Fundraising and Implementing Diversified Prices	The State Council, Guofa No. 72 of 1985; May 23, 1985	to create environment and move institutional barriers for non-utility power producers in alleviating severe electricity supply shortage • Established a new principle of "who invests, who consumes electricity, and who benefits" • Electricity prices are allowed to float and are determined by a new formula to acheive a "reasonable" profit margin • IPP and utility share 70% and 30% of profits, respectively
B. Circular for Regulations in Further Strengthening Electricity Savings	The State Council, Guofa No. 72 of 1985; March 20, 1987	• Encourages cogeneration projects using waste heat, pressure difference, and coal mine tailings for power generation • Cogeneration projects have higher priority in construction schedule of the government planning and are qualified to apply for low-interest loans. • Requires retrofitting boilers with capacity ≥10 ton/h and operation hours ≥45000 into cogeneration facilities
C. Circular for Development Outlines on National Integrated Resources Utilization During 1989-2000	SPC, Jizi No. 12 of 1989; January 10, 1989	• Topping cycle cogeneration projects using waste heat and pressure difference have a higher priority in the government planning and policy
D. Policy and Strategy Determinations for Current Sectoral Development	The State Council; March 15, 1989	• Cogeneration was listed in the key capital constructions which receive high priority in government policies and resource availability
E. Rigorously Restricting Construction for Small-Sized Condensing Power Plants	MOE and SPC, Nengnongdian No. 135 of 1989; March 24, 1989	• Restricts construction of small-sized condensing power plants with exception of using coal mine tailings and other low-quality fuels • Encourages cogeneration development

Table 4.1 (continued)

Major Government Policies and Regulations Related to Cogeneration Programs

1. Policies for Removing Institutional Barriers for Cogeneration (continued)

Policy and Regulation	Issuing Institution and Effective Date	Major Contents Related to Cogeneration Programs
F. Some Regulations for Encouraging Development of Small Cogeneration Plants and Restricting Construction of Small Condensing Power Plants	SPC, Jizi No. 973 of 1989; August 9, 1989	• Encourages cogeneration development by offering favorable policy and moving some institutional barriers • Requires utilities to purchase cogeneration electricity • Cogeneration plants are not engaged in peak-load adjustment • Establishes a special funds for cogeneration development and offeres low interest loans • Guarantees fuel supply for cogeneration plant • Retrofits district heating systems and small-sized condensing power plants into cogeneration plants
2. Cogenerator Qualification and Environmental Constraints		
A. The Environmental Protection Act of People's Republic of China	The People's Representatives Congress; September 13, 1979	• The environmental protection is one of the basic development strategies and laws for China • Any government policies and regulations must follow the Act
B. Environmental Protection Policy	The State Council, Guofa No. 64 of 1984; May 8, 1984	• Any projects having impacts on the environment must be accompanied by environmental studies and facilities for approval, design, construction, and operation.
C. Strengthening Management for District Heating Systems in Urban Areas	State Council, Guofa No. 22 of 1986; February 6, 1986	• Constructs cogeneration plants in urban areas for space heating • The utility control small-sized cogeneration plants are recommended to be under local administration or enterprises control • Offers intensive policy in tax reduction and rational pricing for heat rate
D. Circular for the Environmental Protection in Capital Construction	The Environmental Protection Committee of the State Council, SPC and SEC, Guohuan No. 3 of 1986; March 26, 1986	• Cogeneration projects must follow and obey the regulations for the environmental protection • A penalty is exercised on the project violating the environmental regulation and standards

Table 4.1 (continued)

Major Government Policies and Regulations Related to Cogeneration Programs

2. Cogenerator Qualification and Environmental Constraints (continued)

Policy and Regulation	Issuing Institution and Effective Date	Major Contents Related to Cogeneration Programs
E. Implementation of Technical Codes for Feasibility Studies of Small Cogeneration	SPC, MOE and Production Office of the State Council, Jizi No. 2186 of 1991; December 25, 1991	• The technical codes are formulated for small-sized cogeneration with single generator capacity ≤ 12 MW • There must be stable heat load and demand before a cogeneration plant is constructed • Three criteria should be met for the small cogeneration plants. Thermal output and overall energy efficiency must be ≥ 20% and ≥ 50% of the total energy output respectively. Energy consumption for electricity supply must be ≤ 0.36 kgce/kWh • Attached documents include contents of feasibility study, computing formulation and methods, investment-estimation scheduling, and economic evaluation methods in the feasibility study • No qualification criteria for renewable energy and waste energy
F. Energy Conservation Section Required in Feasibility Studies for Capital Construction and Technical Renovation	SPC, Economic & Trade Office of the State Council, Ministry of Construction, Jizi No. 1954 of 1992; November 3, 1992	• Feasibility study for any cogeneration projects must contain energy conservation and rational energy-use sections for approval
3. Financing and Tax Credit Incentive		
A. Circular for Temporary Regulations for Integrated Resources Utilization	The State Council, Guofa No. 117 of 1985; September 30, 1985	• Income and adjustment tax exemptions, and reduction in product tax are permitted for resources savings projects using internal funds for 5 years • Requires utility to connect IPP's facilities and purchase the electricity • The purchase price is determined based on the averaged profit margin of local electricity generation
B. Taxation Issues Regarding Integrated Resources Utilization	Ministry of Finance, Chaisui No. 334 of 1985; December 10, 1985	• Provincial government can approve reduction and exemption for product tax for cogeneration plants • The cogeneration plants using enterprises' internal funds are qualified for exemption in income tax for 5 years

Table 4.1 (continued)

Major Government Policies and Regulations Related to Cogeneration Programs

3. Financing and Tax Credit Incentive (continued)

Policy and Regulation	Issuing Institution and Effective Date	Major Contents Related to Cogeneration Programs
C. Regulations for Differing Interest Rates on Bank Loans for Capital Construction in Some Sectors	SPC, Ministry of Finance, People's Bank of China, and People's Construction Bank of China, Jizi No. 1258 of 1986; July 14, 1986	• Energy-conservation loans enjoy differing interest rates. The interest rates are reduced from 9.36% to 5.76 for projects that do not last 5 years, from 10.08% to 6.48% for projects between 5 to 10 years, and from 10.08 to 7.2% for projects that last longer than 10 years • Interest rate for the projects with changes from direct investment to loans is 2.4%, and the extra interest is subsidized by the government.
D. Award for Projects of Integrated Resources Utilization in State-Owned Enterprises	SEC and MOF, Jingzhong No. 272 of 1987; May 6, 1987	• The economically sound cogeneration plants can receive awards from the government • No tax is imposed on the money used for awards
E. Regulations to Adjust Interest Rates on Bank Loans for Capital Construction in Some Sectors	SPC, People's Bank of China, Jitou No. 383 of 1989; April 17, 1989	• Adjustment for different interest rates of bank loans for energy and cogeneration projects was made • Discount in interest rates was effective for the projects carried out before February 1, 1989, and would be no longer for the new projects afterward
F. Adjustment of Loan Interest Rates in Capital Construction in Thirteen Sectors	People's Bank of China, Yingfa No. 90 of 1991; 1991	• Upward adjustment for loan interest rates for energy and cogeneration projects was made
G. Temporary Regulations of Value-Added Tax in People's Republic of China	The State Council; December 13, 1993	• Imposing 13% of value added tax on heat, cooling and coal gas products
4. Fuel Types Limitations		
A. Circular for Establishment of Office of Special Funds for Replacement of Oil with Coal	The State Council, Guofa No. 78 of 1981; May 8, 1981	• Establishing an office under the State Council in charge of policy making • Reducing consumption for oil directly burning and replacing oil with coal to increase oil exports

Table 4.1 (continued)

Major Government Policies and Regulations Related to Cogeneration Programs

4. Fuel Types Limitations (continued)

Policy and Regulation	Issuing Institution and Effective Date	Major Contents Related to Cogeneration Programs
B. A follow-up series of documents of policies and regulations for restriction of burning oil and replacement of oil with coal	The State Council, SPC, SEC, Ministry of Foreign Trade, Ministry of Finance, issued a number documents from 1981 to 1988	• Prohibiting oil for power and heating in various aspects • Having a strong impact on cogeneration location because of no choice and exemption from fuel type restrictions
C. Temporary Regulations in Coal Rational Utilization and Limitation for Coal Consumption	SPC and Ministry of Materials, Wuran No. 323 of 1989; September 22, 1989	• Reducing and restricting coal supply for low energy-efficient facilities • Guaranteeing and limiting coal supply for cogeneration plants with energy consumption for electricity supply ≤ and > 400 gce/kWh, respectively.
5. Government Policy Regulating Cogeneration		
A. Circular for Management Regulations for Heat Supply	SEC, Jingneneg No. 41 of 1987; January 20, 1987	• Cogeneration producers and consumers for heat supply should sign contracts to protect both side interests • Heat rates are regulated by the Ministry of Water Utilization and Electricity • Penalty for violation of contracts
B. Regulations on Grid Electricity Transmission and Management	The State Council, Guofa No. 115 of 1993; June 29, 1993	• Both utilities and cogenerators are highly regulated, and no electricity "wheeling" is available

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1. *Handbook of Rational Resource Utilization,* China Science and Technology Publishing Inc., October, 1991.
2. *China's Reform and Open-Door Policy Canon,* Chinese Building Materials Publishing Inc., December 1993.
3. "Strengthening Management of District Heating Systems in Urban Areas—A Document of the Ministry of Construction," *District Heating,* Vol. 42, No. 1, pp. 5-10, 1992.
4. *A Collection of Tax Laws and Regulations of the People's Republic of China,* Foreign Tax Affaires Department of the State Taxation Bureau, China's Statistics Publishing Inc., April 1994.

by local markets, with the cogenerator paying a connection fee to the grid. However, utility companies will not purchase high-cost electricity unless a purchase contract has been made in advance.

The utilities, like provincial power development companies, are separated from provincial electric power bureaus on the surface, but they are still closely connected. As a matter of fact, the electric power bureaus often protect the utilities with their administrative powers. If cogenerators sue utilities for discrimination and unlawful treatment in accordance with government regulations and policies, the outcome is usually "no contest" or tedious negotiation rather than a winner or loser. In China, this is referred to as "people struggling against themselves," because both parties are government-owned.

At best, government policies only require utilities to purchase the electricity produced by cogenerators at rates determined by the utilities. The utilities are not obligated to follow central government guidelines to buy electricity from cogenerators and IPPs, even if these non-utility suppliers' electricity prices are competitive. There are often conflicts between utilities and cogeneration plants. Utilities treat cogeneration plants and utility systems unequally in terms of permitted electric power rates, fees for capacity additions, permitted operating hours, quantity of electricity sales, and backup electricity prices.

In 1992, the average cost of electricity generation for MOE-owned power plants was 0.11 yuan/kWh.[28] The utilities in some provinces purchased cogenerator's surplus electricity at rates lower than the average cost listed above. This practice forced some cogenerators out of business and some investors to stop construction of new cogeneration plants. Although negotiating the price and quantity of electricity sales with utilities can be tedious and time-consuming, it is an absolutely necessary for ensuring project viability.

The factory-owned cogeneration plants typically require back-up electricity from utilities to protect system safety and ensure production continuity. The utilities may either require cogenerators to pay high connection fees and capacity-added costs in terms of per kW capacity increase, or discriminate against cogenerators with back-up electricity at much higher prices. In the worst cases, utilities require the cogenerator to sell electricity to the grid at the fixed low price and then to purchase the electricity it needs at the higher market price. Instead of earning profits, cogenerators can incur heavy losses.

Most of the electricity generated by small-scale cogeneration plants is self-consumed or customer-consumed near the cogeneration plants. In most cases, only a small part of the electricity is typically transmitted over the grid, and then usually over short distances. However, utilities may require small cogenerators to pay the capacity-added fees at the MOE 1987 standard of 250-300 yuan/kW,[28] or in some cases (Jiangsu, 1994) as high as 400 yuan/kW.[15] Even if an electrical network is capable of accepting it without major modifications, free entry for cogeneration plants is usually impossible.

Government regulations offer cogenerators a right not to participate in peak load adjustment when cogeneration plants are supplying heat or steam for consumers. Utilities are not supposed to withhold back-up electricity quantities previously determined for cogenerators even under electricity supply shortages. In practice, few cogenerators are not required to engage in peak load adjustment, considerably reducing the overall efficiencies of the participating cogeneration plants.

There have been cases where some provincial electrical power bureaus required cogenerators with back-pressure turbines to engage in peak load adjustment, or cut the previously agreed quantity of electricity supply, in both cases indicative of monopolistic strategies to limit market entry. On the other hand, some cogenerators are asked to reduce electricity generation when they are producing steam for industrial consumers in the evenings. Thus, the cogenerators have to shut down generators and use boilers, decreasing the temperatures and pressures required for their heat customers. In these cases, cogeneration becomes merely electricity or heat generation, reducing cogeneration advantages and consuming more energy than expected.

Regulations for heat-pricing rates have been much tighter than those for electricity rates, seriously affecting cogeneration development for more than four decades. In fact, residential heat supply is treated as social welfare. No deregulation in heat rates has been made to date. The government policy on heat rates merely creates the possibility of cogenerators earning enough profit to cover heat supply costs. Actually, most of the cogeneration plants are not able to cover heat generation costs. The more heat or steam produced, the more the cogenerators lose. This is one reason why cogeneration, particularly large-sized cogeneration plants, are usually less financially attractive than other types of power projects. Few large-scale cogeneration plants can survive without government subsidization.[15] Cogeneration projects that make up for their losses in heat production with gains in electricity generation prolong loan payback periods and reduce their chances of profitability, causing investors to ignore cogeneration projects.

In addition to the problems generated by the incompatibilities of planned and market economies, the lack of a pre-existing legal framework has made it very difficult to implement regulations for these new macroeconomic policies. Sometimes policies intended to benefit the cogeneration development situation end up hurting it instead. For example, a 1989 policy designed to encourage the development of small cogeneration plants in the place of small thermal power plants has in practice encouraged both. Without detailed supporting legislation, these regulations provided "loopholes" for small condensing-type electric power plants to operate with the same benefits as true cogeneration facilities.

During this period, a few laws and regulations have been passed primarily to address environmental concerns and to encourage environmentally sound cogeneration. The first of these was the Environmental Act passed in 1979 (Table 4.1 item 2A). This law provides the legislative foundation of environmental regulations in China. Two other policies enacted in 1984 and 1986 (Table 4.1 items 2B and 2D) built on this legislative foundation by requiring environmental impact studies and all power facilities, including cogeneration facilities, to follow relevant environmental regulations or risk penalties. However, these regulations are rarely enforced because electricity in some areas is in such great demand. Economic growth still takes precedence over environmental concern.

Two other policies enacted in 1987 have had a very positive impact on cogeneration development and have helped address the historical problems listed above. The first (Table 4.1 item 1B) gave planning priority and low-interest loans to cogeneration facilities. It further promoted cogeneration development by strongly encouraging the use of waste heat and mine tailings and "requiring" that boilers with a capacity more than 10 t/h and more than 4000 operating hours per year be retrofitted to cogeneration.[18] This regulation has helped increase the average size of boilers used for district heating and accordingly, efficiency levels. The other policy incentive (Table 4.1 item 3D) gave cash awards to well-run cogeneration facilities. This incentive is no longer in effect.

4.3 Policies Addressing the Economic Reforms

The economic reform launched by Deng Xiaoping during the Third Plenum of the Eleventh Party Congress in December of 1978 has been a powerful vehicle for encouraging cogeneration development.[29] These reforms have brought great changes in the government policies, regulations, technology, and financing mechanisms related to cogeneration. From 1980 through the present, there has been a trend away from centralized control and toward the introduction of market mechanisms in cogeneration. However, the role the government plays in cogeneration development continues to be crucial.

These economic reforms created rapid economic growth and exacerbated the electric power shortages that have existed since 1968. This growth has also led to a worsening of environmental conditions, especially air quality in urban areas. In 1986 the State Council enacted regulations that directly addressed the urban environmental problem (Table 4.1 item 2C). These regulations were meant to encourage the building of cogeneration district heating plants in urban areas. Cogenerators under utility control were recommended to seek municipal guidance. Tax incentives and "rational" heat pricing were also addressed albeit ineffectively. Four more policies enacted in 1989 were created specifically to simultaneously address both the environmental issues and the continued shortage of electricity that was by some estimates[15] falling as much as 20% behind demand (Table 4.1 items 1C, 1D, 1E, and 1F). The intent of these policies was to give priority to cogeneration projects and limit the growth of small conventional power plants.

Another facet of the economic reforms was to deregulate raw material supply and prices. These changes have led to inflated input and construction prices and the unreliability of raw material supply for cogenerators. Utilities are guaranteed regular raw material supplies at low rates, but cogenerators must typically seek supplies at market prices. In response in 1989 the SPC issued regulations that limited coal supplies to inefficient power generators while guaranteeing supplies for efficient facilities (Table 4.1 item 4C). The power-generation efficiency cutoff level was 400 gce/kWh for generated electricity.

Average capital investment in terms of unit capacity has increased from 1,065 yuan/kW in 1980 to around 7,000 yuan/kW today. Heat-distribution systems for cogeneration plants require high initial capital investment, have long payback periods, and are given low depreciation rates by government regulations. Capital costs for cogeneration projects with extensive district heating networks can go as high as 10,000 yuan/kW (US$ 1,200/kW).[15] Funding allocation changes intended to address these deregulation issues are discussed in detail in Chapter 5.

The central government has played a crucial role in initiating cogeneration development by issuing a number of policies and regulations which were intended to remove institutional obstacles. With further economic reform, more market mechanisms and tools have been introduced into policy formulation to make policy implementation more efficient. Government command-style policies are not as effective as before. The decentralization of power without pre-existing macroeconomic tools or a comprehensive energy policy has made it difficult for the central government to implement effective cogeneration regulations. Even though the conundrum of decentralization and control exists in many developed countries as well, it is primarily the instability and inconsistencies of the Chinese cogeneration policies and market conditions that contribute to the foreign investor's reluctance to be involved in cogeneration projects in China.

Two technically oriented sets of regulations were put into practice in 1991 and 1992 (Table 4.1 items 2E and 2F) to address the lack of detailed guidelines required in the current situation. These regulations provided guidelines for small cogeneration facilities, setting them apart as "qualifying facilities" to receive special tax breaks and other favorable treatment. These rules also were meant to limit the small thermal power plants from receiving the same favorable treatment afforded cogenerators. Energy efficiency limits were set, which correspond with levels equal to or better than 200 MW thermal plants.

Taxation and interest rates are two of the primary tools used in market economies to guide and manage enterprise behavior. Since the reforms began, the Chinese government has instituted several sets of preferential interest rates and taxation regulations, which have had both direct and indirect effects on cogeneration. In 1986 (Table 4.1 item 3C) the central government issued regulations that gave low-interest rates to energy-conservation projects and even helped to leverage commercial loans for projects not relying on direct government loans.[18] However, these subsidized rates were even lower than the inflation rate, leading to inefficient use (and misuse) of very limited capital resources. These rates were abolished in 1989 (Table 4.1 item 3E).[18] Again in 1991 (Table 4.1 item 3F) favorable interest rates were given to several sectors including energy conservation. This time, overall rates were kept higher to avoid the previous problems.[22]

Both the interest-rate policies enacted after 1986 (mentioned above) and the local flexibility allowed in determining a projects final tax rate had allowed relatively favorable tax treatment of cogeneration projects until 1993. Then, a set of regulations written in 1989 but not enacted until 1993 (Table 4.1 item 3G) added a 13% value added tax (VAT) to any operation that changed energy from one form to another. This new category of VAT was first applied to electricity generation in 1993, and then to heat, steam, and cooling in January of 1994, severely affecting cogeneration profitability. Although this 13% rate is lower than the 17% rate for the rest of industry, the 4% discount makes little difference to cogenerators already having to cope with both low electricity, and especially low heat and steam prices. Also, this policy has "teeth"—no local government is allowed to reduce or exempt taxpayers from this tax.

As we mentioned, there has been no legislation on cogeneration in China to guide and coordinate various policies and regulations issued by different government agencies. The higher decision levels of the central government are involved in creating and balancing policies. However, sectoral administration documents are less effective and less enforceable across sectors, so when inconsistencies or conflicts arise among these documents, no rule can be employed to make judgments. Furthermore, local governments and utilities use different methods to understand, explain, and implement central government policies and regulations on cogeneration. As long as local governments are permitted to interpret freely instead of being legally bound to comply with minimum standards, long-term development of cogeneration will be adversely affected.

More importantly, limitations, inconsistencies, and shortcomings in previous policies and regulations exist, which mislead and confuse the people who regulate and develop cogeneration. In practice, a forcible implementation of cogeneration polices and regulations has not been emphasized or undertaken. One result is that a number of cogeneration plants are operated like pure electricity power plants, but enjoy favorable treatment accorded to cogeneration plants under current policies.[15] Questions about which tax and investment credits the cogenerators can enjoy are not clearly or easily answered. This situation may even challenge the officials who manage the cogeneration programs when asked specific questions about the number of policies on cogeneration that have been issued, and which are still effective.

4.4 Recent Policy Developments

The Chinese government has projected that GDP growth rate would remain at 8-10% annually at least through the end of the century, while energy production growth could only reach an average growth rate of about 4%. To cope with this production shortfall and growing environmental problems, the Chinese government has realized that energy conservation needs further strengthening in the national energy policy. The "Energy Conservation Law" was approved by the State Council in January of 1995, for submission to the National People's Congress (NPC.) The NPC will likely consider the legislation in 1996.[30] The law emphasizes the incorporation of energy conservation with environmental protection and promotes the saving of energy by promoting energy-efficient technologies and methods. Under this policy umbrella, cogeneration projects should have a stronger legislative basis for development.

The State Council is actively involved in guiding foreign investment and cooperation. The concept of mutual benefit is the core of the policy. The government requires Chinese partners to employ "market competition mechanisms" to choose the best partners from a selection of qualified candidates. At the same time, to stimulate foreign investment in the sectors and projects that are in high demand, the central government is planning to issue a series of documents to direct foreign investment. These documents list preferred sectors, regions, and projects, describe development strategies, but most importantly, formulate specific policies that provide foreign investors with favorable conditions.[31] The officials of the SPC's Department of Foreign Investment, announced that the policy guiding foreign investment has just been formulated and approved by the State Council.[32] Projects in energy development, energy conservation, comprehensive utilization of resources, waste treatment, and environmental protection are all listed as priorities in this policy. Clearly, cogeneration projects fit this priority list and are an option for foreign investment.

With progress in economic reform, the role played by the central government has weakened, and the impacts of decision making by provincial and local governments on cogeneration have increased significantly. Provincial governments tend to be more flexible in policies and decision making regarding cogeneration projects. Negotiations with local authorities is crucial not only because they set prices, but also because they have a strong influence on land purchases, construction schedules, and other operation costs. Regional economic conditions, administrative attitudes, and technology availability should also be accounted for in project screening.

Most power and cogeneration plants are either national or local government-owned enterprises. Accordingly, the utilities should offer independent cogenerators reasonable electricity rates, but in practice the policy is rarely executed as intended. One of the main government reforms of 1994 was to separate routine business from government administration, making enterprises more independent of government control. However, worries about political conflict and social instability make progress in this direction quite slow.

To further the reforms, the SPC and MOEP have recently set policy guidelines for local governments, allowing "new pricing for new plants" so that newly built foreign joint-venture power facilities can charge higher prices to gain better investment returns. Even though there is currently no specific policy to stimulate foreign investment in cogeneration, large-scale cogeneration projects could fall into the category of large-scale power projects and benefit from the SPC and MOEP guidelines.

According to officials at the MOEP, there are no explicit policies that put a ceiling of 15% on the rate of return for foreign investors. This 15% "limit" appears to be an informal directive coming from the highest circle of leaders, and can be changed in the light of "implementing effects." In other words, if foreign investors do not respond to the allowed level of returns, higher rates may be allowed in the future.

Finally, ownership limitations for large-scale power projects (single generator >300 MW and a total project capacity of >600 MW) are not necessarily applicable to cogeneration projects. For example, although foreign investors are not allowed to own more than 49% of the stock in >600 MW thermal power projects, they can own 100% of a cogeneration joint-venture, regardless of size.

Chapter 5

Investment Allocation

5.1 Introduction

From 1949 through 1979, all cogeneration investments came from central government funds allocated by the SPC. The economic reforms of the late 1970s unleashed rapid economic growth, which resulted in serious electric power and investment capital shortages. The increase in central government investment was unable to keep up with inflation,[33] and without diversified funding sources, the electricity supply shortage would have only become more critical. This chapter presents an overview of the financial system, the sources of cogeneration investment, investment mechanisms, and a breakdown of investment by source, project size, new versus retrofit funds, type of technology, and industrial sector.

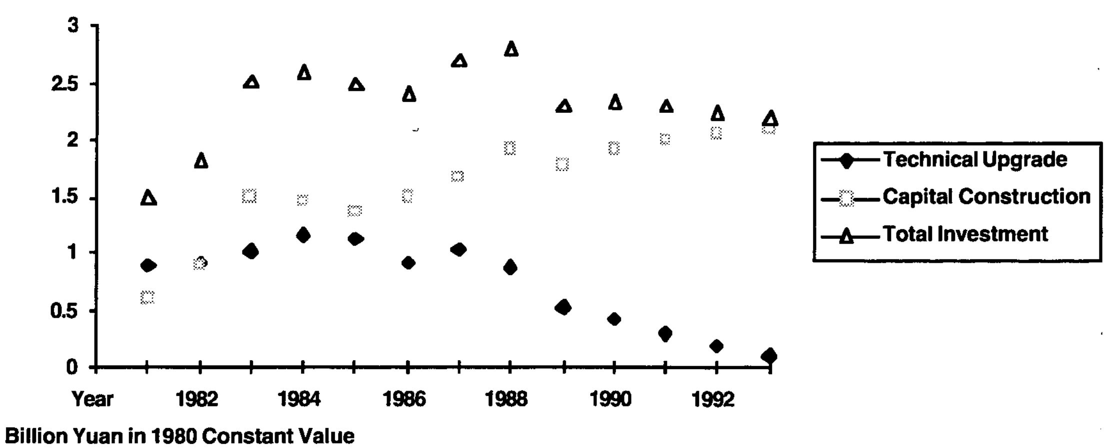
5.2 Financial System Overview

The economic reforms mentioned also greatly impacted the financial system. The impact was twofold, promoting market-style financial tools and diversifying sources of funding. Since the beginning of the economic reforms, the Ministry of Energy and the utilities alone have not been able to cope with the shortage of electricity supply. In response, the Chinese government developed far-reaching policies at the end of the 1970s that placed equal emphasis on both energy-supply development and energy conservation, but with a higher priority for energy conservation in the short term.[23] A milestone reflecting policy changes was the establishment of special central government energy-conservation investment funds. These funds were allocated by the central government for investment in cogeneration projects (see Figure 5.1). The goals were to alleviate the overall energy shortage crisis and severe environmental pollution in urban areas across the country.

During the period from 1981 to 1985, 3.9 billion yuan (US$ 470 million in 1980 value), or 35% of the total central government allocated energy-conservation funds, were invested into cogeneration projects yielding 1.5 GW of electricity generation capacity. At that time, interest rates for central government loans were subsidized at about 3%.[34] However, these interest-free and low-interest funds exacerbated the already critical capital shortage problem and did little to

Figure 5.1

Energy Conservation Investment Funds, 1981 - 1993



Source: Liu Zhiping, et al., "Industrial Sector Energy Conservation Programs in the People's Republic of China during the Seventh Five-Year Plan," (1986-1990), Lawrence Berkeley National Laboratory Report No. LBL-36395, September, 1994.

improve the inefficient use of this capital.

Based on their policy-making and implementation successes and failures in energy conservation between 1981 and 1985, a severe shortage of capital, and a desire to improve the cost-effectiveness of energy-conservation investment, the central government altered its investment patterns significantly. Beginning in 1986, they canceled direct investments (essentially free capital) in technical upgrade projects, channeled money into central government loans, raised loan interest rates to around 7-8%, and encouraged enterprises to invest in cogeneration with their internal funds.[35] During this period, 1986 to 1990, central government loans and internal funds used in cogeneration development were almost equal in value. In this period, central government investments of 6.8 billion yuan (US$ 825 million in 1980 value), or 53% of the total amount of energy-conservation funds, yielded an additional 4.5 GW of generating capacity. Figure 5.2 contrasts the changes in funding patterns between these two periods.

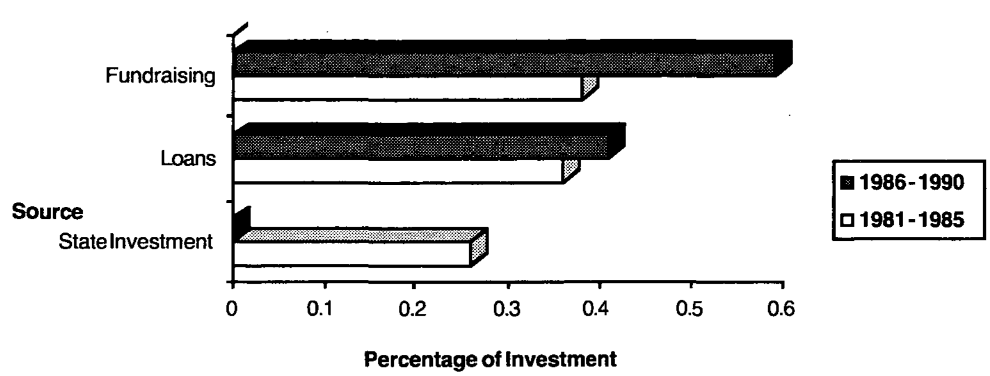
In addition to loans, the central government continued to support the dissemination of energy-conservation technologies and practices, and contributed available funds to demonstration cogeneration projects using new technology that had the potential to spread across the country. The government gave low-interest loans to the enterprises that carried out demonstration projects. During the 1980s, these capital construction and technical upgrade funds had saved an estimated 7.8 and 6 mtce/year of energy, respectively.[18] One downside to this funding situation has been the effects of inflation. Figure 5.3 illustrates the reality of the investment situation when inflation is taken into account.

Since 1990, the sources of capital for cogeneration have been further diversified. In 1994, the central government funds for energy conservation were around 2.3 billion yuan (US$ 280 million) in current value, of which 600 to 700 million yuan (US$ 73-85 million) were allocated for cogeneration projects. Cogeneration capacity has been realized at a rate of about 1.2 GW annually between 1991 and 1994. In 1994, these CECIC allocated energy-conservation funds amounted to 200 million yuan (US$ 24 million), or 30% of total cogeneration funding, adding about 450 MW, or 38% of the total new cogeneration capacity. Local governments and enterprises account for the balance of investment through local government investments, bank loans, and newer investment mechanisms like bond issues.[36]

Due to fears of losing control over inflation and the financial markets, a series of financial system reforms instituted in 1994 have tightened capital investment criteria and money supply. Many projects are competing for limited capital,

Figure 5.2

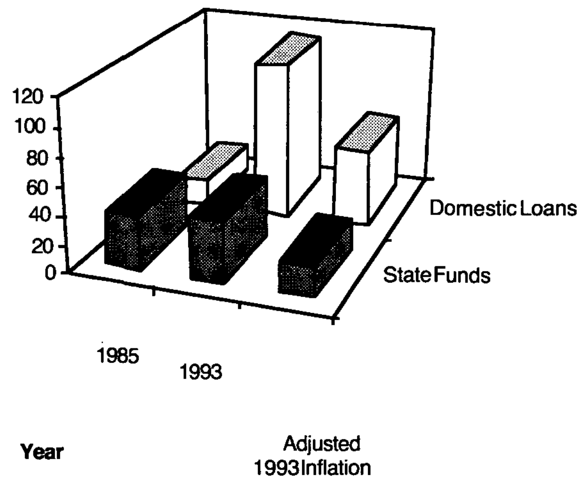
Changes in Technical Upgrade Investment Patterns in the Sixth and Seventh Five Year Plans



Source: Liu, Zhiping, "Evaluation of Investment and Benefits for Energy ConservationPrograms in the Last Decade," *Energy of China*, Vol. 13, No. 6, pp. 35-38, June 1993.

Figure 5.3

Inflation Effects of Capital Construction Investment in the Power Sector, 1985 - 1993



Source: Zhou, Xiaoqian, "Small-Sized Cogeneration Development," *Cogeneration Technology,* Vol. 41, No. 1, pp. 14-19, March 1994.

which results in investors, even those with energy-conservation funds at their disposal, preferring projects with higher rates of return than cogeneration facilities. Some energy conservation funds are even diverted into investments entirely unrelated to energy, like real estate.[15]

Although special funds in energy conservation made remarkable contributions to cogeneration in the past 14 years (1981-1994), severe nationwide monetary and electricity supply shortages may cause central government investment funds for cogeneration projects to shrink, in turn hurting cogeneration development in the coming years. Therefore, opening multiple-channels of investment becomes an increasingly crucial issue for cogeneration development.

5.3 Investment Sources

There are many different sources of investment capital for cogeneration in China, and the list is growing. However, these sources can be put into four main categories: central government investment, domestic loans, foreign investment, and fundraising. We use these categories for two main reasons. First, most of the Chinese statistical data are based on these categories and second, these categories are fairly representative of the main sources of funding for electric power including cogeneration, in China. Cogeneration utilizes part of the investment for each of the funds listed below. However, the lack of distinction in the statistical data and frequent changes in the institutional structure make it difficult if not impossible to accurately catalogue the exact amount of cogeneration funds.

With decentralization of both the political and economic systems, local governments have gained more power in decision-making regarding local policies and regulations. Generally speaking, local administrations are more enthusiastic about cogeneration development and more flexible in their policies concerning cogeneration development. In fact, in many municipalities, cogeneration projects are known as "mayor's projects."[15]

Local government financial sources for cogeneration come from such sources as local administrative appropriations for power development, part of a .02 yuan/kW fee on electric power capacity, or a special cogeneration fee imposing .02 yuan/kW on cogeneration capacity, local funds shared from energy and transportation infrastructure funds, local utilities' internal funds, and a share of the revenues from increases in the local utilities' electricity rates. Cogenerators pay .02 yuan/kW maximum, with no double charging.

Since the mid-1980s, the most significant increases in financial resources for power development have come from fundraising. Fundraising as it is used here refers to local government capital, internal enterprise funds, collective savings, union funds, private savings, and stocks and bonds. Without the participation of fundraising and other funds in the financial pool, the electric power and cogeneration industries would not have been able to develop exponentially. Figure 5.4 illustrates the trend of central government investments versus the new diversified sources of capital for the electric power industry in the past decade.

The central government financial sources for power development can be divided into the following categories:[22]

- electricity development funds in the national budget
- banks loans
- special oil-substitution funds for power plants which are collected from the export revenues of the substituted oil
- special energy-conservation funds for capital construction
- a special tax fund in which a .02 yuan/kWh fee is imposed on electricity consumers
- special funds in energy and infrastructure development

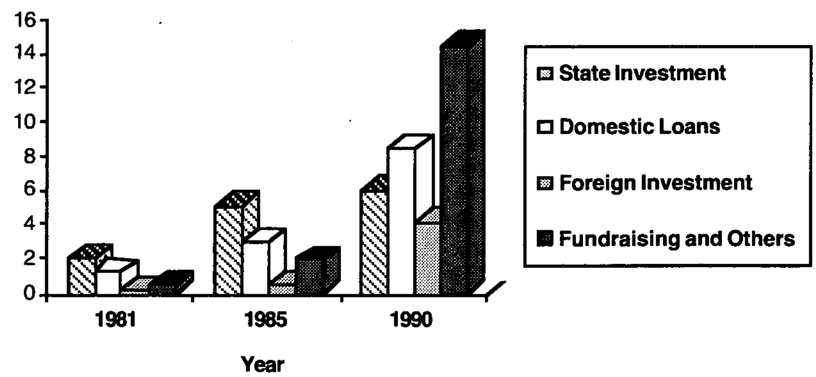
Several government administrations, banks, and enterprises are charged with allocating or managing these funds, while some use central government funds and other sources of capital. The MOEP (formerly the MOE) is in charge of allocating central government investments and managing cogeneration projects larger than 200 MW (in practice usually those above 100 MW). As mentioned in Chapter 3, the SETC allocated special funds for technological renovation in cogeneration projects but has been restricted recently to only providing special funds for demonstration technologies.

Currently, the CECIC allocates the special central government energy-conservation capital construction funds for cogeneration projects smaller than 24 MW, or partial funding for medium-scale plants, which were formerly allocated by the SPC, but does not manage them. The Construction Bank of China (CBC) is responsible for monitoring the financial performance of cogeneration projects that use these funds and insuring loan payback. However, in its drive toward commercialization, the CECIC may eventually take over the administration of loans from the CBC as well. Entirely different from the evaluation methods listed below, the current methods employed by CECIC are very close to the ones prevailing in western countries, allowing investors an opportunity to evaluate cogeneration projects with comparable standards.[15]

The CDB (formerly the Energy Investment

Figure 5.4

Diversified Capital Resources in Electricity Development



Source: *Handbook of Rational Resource Utilization,* China Science and Technology Publishing Inc., October, 1991

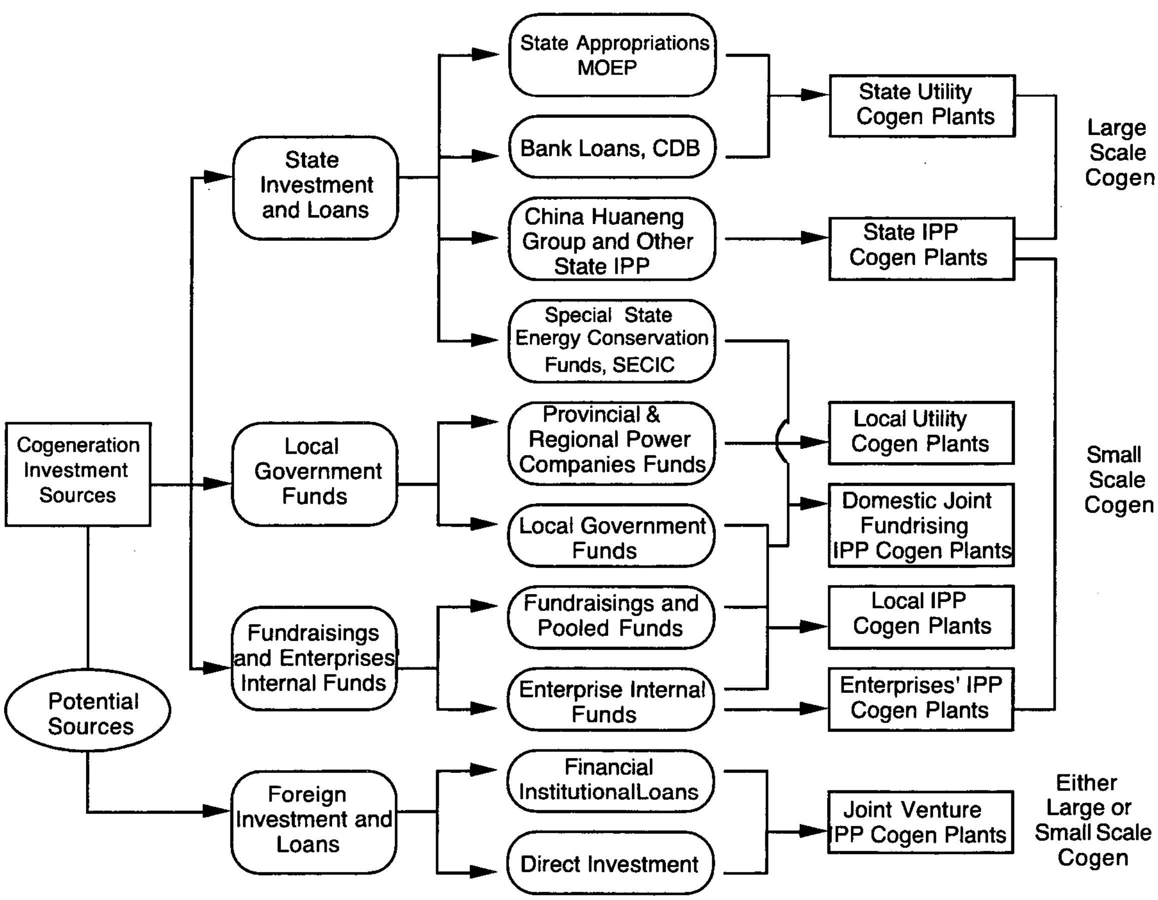
Corporation of the SPC) allocates national policy-oriented bank loans approved by the SPC. With increased central government attention on basic infrastructure and support sectors, CDB will invest more funds into these sectors in accordance with national plan. Power projects, including cogeneration, with capacities larger than 200 MW are evaluated and financed by the CDB.[38] However, as mentioned in Chapter 3, the CDB no longer allocates loans to power plants in coastal areas where loans from commercial banks are readily available. The bank's financial sources are government appropriations, bond issues, commercial banks loans, and the international financial market.

The China Huaneng Group (CHNG), was established in 1986 and was initially funded from the central government's special funds for oil substitution. It is a large-scale industrial group, China's first IPP, and one of the largest government-owned and financed companies in China, consisting of 11 member corporations and over 200 subsidiaries. Xingli Power Incorporated, another large-scale IPP and subsidiary of the China International Trust and Investment Corporation (CITIC), has not yet been engaged in cogeneration development.[29] Figure 5.5 shows the sources and typical channels of funding for cogeneration development.

Finally, foreign investors are also becoming more active in the cogeneration market, though their involvement is still limited to the early stages of negotiations and project feasibility studies. As of this writing, no private foreign capital has been invested in cogeneration projects in China. Chapter 7 explains in detail the potential for foreign cogeneration investment, and more importantly, identifies the institutional

Figure 5.5

Financial Sources in Cogeneration Development



Source: Yang Fuqiang, "China Trip Report on Cogeneration Development," December 1994.

and market barriers that must be overcome to make cogeneration investments more attractive to foreign investment.

5.4 Finance Mechanisms

As early as 1981, the Chinese government employed a mechanism for allocating central government energy-conservation funds that compared energy-conservation savings with the alternative cost of electricity supply. Throughout the Sixth and Seventh Five-Year Plan periods, 1981 to 1990, the central government employed the gross unit investment (GUI) and the net unit investment (NUI) tools as the main criteria for selecting energy-conservation investments.[57] GUI was the unit cost of the energy-conservation project and NUI was the unit cost of the conserved energy. The NUI was compared with the unit energy supply cost of the best alternative. The energy-conservation cost had to be cheaper than energy supply costs. Table 5.1 presents this data. With the NUI, or unit cost of conserved energy, lower than the alternative unit energy supply cost, it is clear why cogeneration programs were emphasized in the national conservation policy (a more detailed analysis can be seen in Liu's paper).[39]

Starting in 1986, environmental benefits were considered in cogeneration project selection for both capital construction and technology upgrade investments. Although environmental effects were not accounted for in the physical value, they were given weight when comparing several projects competing for limited resources. Decision makers understood the important role of cogeneration for urban areas in northern China and industrial areas with energy supply shortages in southern China.[40]

The most recent reforms of the financial system started at the end of 1993. As a result, the CDB has gained more power in cogeneration project evaluation and financing. The SPC still approves large-scale projects, but no longer has the power to allocate funds to projects. The CDB now finances the projects approved by the SPC. The SPC and CDB coordinate with each other in the allocation of financial resources in order to avoid over-supply of monetary funds. This is known as "SPC digging the holes, while CDB plants the trees."[41] The CDB also evaluates project economic feasibility and establishes the availability of financing for cogeneration projects.

Power development corporations supervised by the CDB are now responsible for project construction, scheduling, and quality. The main problems experienced so far in the financing of cogeneration projects have been overspending of loans, poor coordination among construction companies, discontinuity between equipment supply and installation, and the delay of loan payback due to insufficient cash flow. The CDB participates in the international financial market and has established cooperative relationships with more than 70 internationally recognized banks to borrow from the international market. They rely on loans from commercial banks and customer savings for domestic funds, periodically adjusting loan interest rates to balance borrowing, and lending loan rates.[42]

The day-to-day monitoring of loan utilization and payback is done by the electric power

Table 5.1

Cogeneration Investment Energy Savings, 1981 - 1990

Project Funding	Investment) (million yuan	Savings) (million tce	Gross Unit Cost) (GUI) (yuan/tce	Energy Supply Cost) (yuan/tce	Net Unit Cost) (NUI) (yuan/tce
1. Capital Construction					
6th FYP (1981-85)	2,380.8	2.13	1,117	800	560
7th FYP (1986-90)	7,167.7	5.70	1,257	1,000	817
2. Technical Upgrade					
6th FYP (1981-85)	1,574.9	4.43	356	800	N/A
7th FYP (1986-90)	813.3	1.5	542	1,000	N/A

Note: All values are in current yuan.
Source: Liu, Zhiping, "Evaluation of Investment and Benefits for Energy Conservation Programs in the Last Decade," *Energy of China,* Vol. 13, No. 6, pp. 35-38, June 1993.

administrations of the five regions and nine provinces (see Appendix A). The main criterion for the financing of cogeneration projects is meeting a set internal rate of return (IRR).[15] This new criterion raises an important issue. Cogeneration plants are currently regulated by the government in both electricity and heat rates. Without further utility deregulation and strict implementation of new policies designed to address the inequities of electricity and heat pricing, cogeneration projects face difficulties in meeting the economic criteria for loan approval.

5.5 Investment Breakdown

The share of central government direct investments and loans in total cogeneration investment has declined annually since 1980. The three central government financial components, special funds for oil substitution, domestic loans, and direct investments, decreased from around 92% of the total in 1981 to about 53% in 1990, and has declined even further in the 1990s.[43,44] The oil-substitution funds remained fairly constant in the 1980s but are expected to diminish through this decade because China has become a net oil importer and is reducing oil exports.

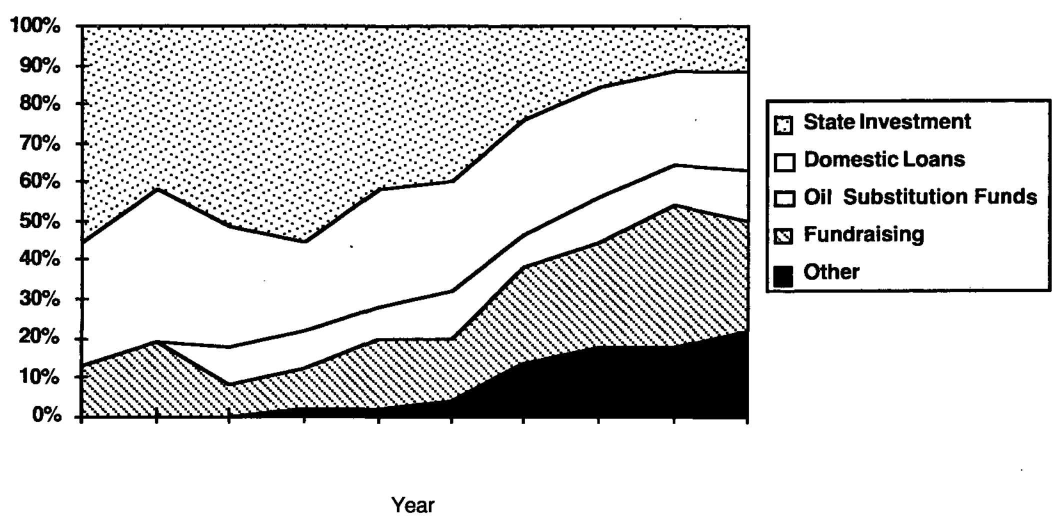
Compared to conventional electric power projects, cogeneration not only shares less of the central government investment proportionally, but obtains fewer and fewer direct investments and loans from the national government. No more cogeneration projects are being 100% financed by government loans. Overall, central and local governments share less than 50% of the total current cogeneration investment and will share even less in the future. The CDB has an investment cap of one-third for cogeneration projects in general, with slightly more going to projects in the coastal areas. Figure 5.6 shows the trends of various funds in the total investment in capital construction in the power sector.

Non-government funds now play a major role in cogeneration development. This change from central government investment to diversified funding strongly suggests that cogeneration projects have become "local" projects which have to meet local economic conditions and customer requirements. The benefits of cogeneration projects in both the economic and environmental dimensions have been widely recognized by local government officials and the public. Since fundraising and other non-governmental funds rely on financial market mechanisms, cogeneration projects should use these investments more efficiently under the current capital constraints.

Cogeneration projects had a high priority in

Figure 5.6

Trends of Various Central Government Funds in Cogeneration Investment, 1981 - 1990



Source: *Handbook of Rational Resource Utilization,* China Science and Technology Publishing Inc., October, 1991

the national energy-conservation policy, sharing 54% of the total capital construction funds over the last decade, and 35% and 53% of total energy-conservation investments from 1981 to 1985, and 1986 to 1990 respectively.[39] Under the pressure of severe electricity shortages, more central government investments (central government appropriations and domestic loans) are expected to be allocated into conventional electric power rather than large-sized cogeneration. Some ministries invested in electricity-generation projects with sectoral funds (a kind of central government investment), but rarely in the cogeneration projects.

The MOEP built six large-scale cogeneration plants in the last decade for a total of 3.7 GW of capacity.[17] All of these plants are located in northern China, providing steam for industrial consumers and space heating for residents. The CDB has also contributed to cogeneration development in the current decade. In 1993, a total cogeneration capacity of 1.3 GW was put into operation, 11% of all new capacity in China during the same period.[45] The CDB allocated a total of 28 billion yuan (US$ 3.4 billion) to power projects in 1994.

In the China Huaneng Group (CHNG) investment structure, approximately 77% of the total capital is invested in the power sector. In 1993, the special oil substitution funds declined to 31%, while fundraising and foreign capital shared 28% and 29% of the total available capital.[45] With growing self-sufficiency and favorable government policies, the Huaneng Group will become a more noticeable developer and a financial source in power and cogeneration development.

Huaneng Power Generation Corporation (HPGC) is a large-scale power enterprise and a subsidiary of CHNG. HPGC manages or shares three large-scale cogeneration plants in northern China with a total capacity of 933 MW, and is now engaged in the Beijing Cogeneration Plant project (300 MW) at Gaopeidian. CHNG and HPGC are actively responsible for environmental protection. The plant will import dust-reburning liquid exhaust boilers from Germany which produce no dust and need no field for dust exhaust. Meanwhile, they will build a brick plant using waste solids in order to avoid waste shipment and solid waste storage. The total investment of this project is estimated at about 3 billion yuan (US$ 360 million). Other Huaneng corporations are planning to take the opportunity to be involved in small-sized cogeneration projects.[15]

A large number of small-sized condensing power plants in urban areas were required by the government to be retrofitted into cogeneration or shut down for their high pollution and low efficiencies. However, fearing government regulation and a lack of economic promise, investors were reluctant to invest in retrofitting projects. Many retrofitting projects have had to be stopped because they were unable to secure capital resources.

Looking back to Figure 5.1, it becomes apparent that technical upgrade funds diminished rapidly over the last decade.[7] This trend indicates that expansion, retrofit, and bottom-

Table 5.2

Cogeneration Investment Shares in the Special Energy Conservation Funds during the Last Decade, 1981-1990

	Energy Conservation Investment in Capital Construction			Energy Conservation Investment in Technical Upgrades			Total Energy Conservation Investment		
	Subtotal (billion¥)	Cogen (billion¥)	Capacity (MW)	Subtotal (billion¥)	Cogen (billion¥)	Capacity (MW)	Total (billion¥)	Cogen (billion¥)	Capacity (MW)
1981-85	5.779	2.307	660	5.179	1.539	853	10.959	3.846	1513
1986-90	8.902	5.642	3571	3.776	1.181*	928	12.678	6.823	4499
Total	14.682	7.949	4230	8.955	2.720	1781	23.637	10.669	6011

* The number is estimated based on the available data related

Source: *Handbook of Rational Resource Utilization,* China Science and Technology Publishing Inc., October, 1991

cycle technology cogeneration projects were developed at a slower pace than new facilities. In many cases technical upgrade projects are more cost-effective than the capital construction projects, requiring shorter construction periods and less initial capital. Increasing technical upgrade investments is an effective way to solve the capital constraint problem while giving cogeneration enterprises a competitive edge.

Based on the administrative jurisdiction for financial resource allocation, bottom-cycle (which uses the exhausted heat from processing) and cogeneration expansion projects are financed by technical upgrade funds. Since retrofit projects utilizing waste heat and pressure differentials were relatively inexpensive and technically feasible, 2,329 projects during the Sixth Five-Year Plan (1981-1985) and more than 1,000 projects during the Seventh Five-Year Plan (1986-1990) were completed to produce both electricity and other forms of energy. A total of 2.7 billion yuan, about 30% of all technical upgrade funds, were allocated for these projects, and 1.8 GW of cogeneration capacity was realized.[46,47] With technological progress, the utilization of waste heat was extended to medium or low temperatures. These bottom-cycle cogeneration plants typically used the waste heat or pressure from blast furnaces in the steel industry, furnaces, and kilns in the cement industry, and reaction and production processes in the chemical industry, among others.

From 1980 to 1991, capital construction investment in bottom-cycle cogeneration amounted to a total of about 144 million yuan, resulting in 150 MW of added cogeneration capacity.[16] The central government funds for capital construction (new plants) in the industrial sectors occupied a small part of the total, with the capacity of industrial sector cogeneration sharing only 7% of the total. The chemical, textile, and paper subsector cogeneration projects received the most funding. Table 5.3 shows the results of this investment.

Finally, compared with other countries, cogeneration development in China's commercial sector is underdeveloped. However, due to the current rapid urban expansion, many hotels, government, and commercial buildings, hospitals, shopping centers, and universities have and will continue to be erected. Considering the combination of electricity and heating and cooling needs, cogeneration could play a major role in this sector as well.

Table 5.3

Sectoral Cogeneration Patterns for the SPC Capital Construction Funded Projects, 1981-1990

	Number of Projects	Total Capacity (MW)	Electricity Generation (GWh)	Average Project Capacity (MW)
Central Cogeneration	77	7,451.9	40,148.93	97
Chemical	20	194.5	652.06	10
Textile	9	90	408.94	10
Paper	6	90	310.79	15
Sugar	3	112.6	592.5	38
Steel and Iron	3	18	99.44	6
Food	2	7.5	43.47	4
Manufacturers	1	12	6.11	12
Drug	1	9	33.73	9
Total	122	7,985.5	42,295.97	65

Source: Xu, Hong, "Cogeneration Development in the Last Decade and Its Perspective," Energy Conservation Planning and Information, Department of Resource Conservation and Comprehensive Utilization of SPC, February 1993 (circulated in China only).

Chapter 6

Environmental Considerations

6.1 Introduction

China still has a considerable portion of its society living in poverty. Even in the comparatively wealthy coastal regions, many people live just above this level. Not only is the Chinese government anxious to raise living standards for its people, it is also concerned with local pollution issues. Cogeneration is considered an effective way to reduce energy consumption and environmental pollution. Price, payback, and cost-effectiveness are considered first when choosing among energy technologies.

6.2 China's Current Environmental Position

The Chinese government's attitude toward a climate change treasury is based on finding a balance between the total amount of emissions for the country and the amount of emissions per capita.[27] Because China is the most populous nation on earth, the government views the quota of emissions share based on total emissions as unfair and unacceptable. However, the Chinese government has promised to be more active in cooperating with international organizations and other countries to cope with environmental challenges. Agenda 21 and the new Energy Conservation Law are examples of recent efforts to protect and improve the environment.[15]

Although the Chinese government is making some progress in support of global warming and other international environmental issues, improving local environmental conditions has been and remains its primary motivation. Local air pollution conditions in many areas often exceed both daily and annual national and international air quality standards. New regulations, such as a US$ 0.024/kg fine for excessive SO_2 emissions, and others regulating air, water, and solid wastes, are also being implemented. Tables 6.1, 6.2, and 6.3 show effluent standards, fines, and stack heights for power plants in China, respectively. Environmental protection is emphasized by improving water and air quality in urban areas, at the present time, and in coming years.

The Chinese government wants to improve the environment, but not at the expense of economic growth. Improving energy efficiency is seen as a cost-effective way to reduce greenhouse gas emissions and other pollutants, without hurting economic growth. Cogeneration, under the proper conditions, can meet these twin criteria, environmental improvement and economic growth.[21]

6.3 Cogeneration Benefits

Energy-efficient technologies such as cogeneration can provide several environmental benefits. Reduced coal consumption as a result of increased efficiency means that less coal needs to be mined and washed, reducing soil erosion and water pollution. In addition, less coal has to be

Table 6.1

TSP and SO_2 Air Pollution Standards for China

Pollutant Type	Time Period	Concentration Limit (micrograms/m³) Level 1	Level 2	Level 3
TSP - Total	Daily Average	0.15	0.30	0.50
Suspended Particulates	Maximum Limit	0.30	1.00	1.50
SO_2 - Sulfur Dioxide	Annual Daily Average	0.02	0.06	0.10
SO_2 - Sulfur Dioxide	Daily Average	0.05	0.15	0.25
SO_2 - Sulfur Dioxide	Maximum Limit	0.15	0.50	0.70

Source: April 6, 1982, PRC National Environmental Protection Agency's Atmospheric Environment Quality Standard

Table 6.2

SO_2 Air Pollution Fines for China

Pollutant Type	Amount Exceeding	Emissions Limit		
SO_2 - Sulfur Dioxide	<400%	400 - 600%	600 - 900%	>900%
Fine (yuan/ton coal burned)	3.00	4.00	5.00	6.00

Source: February 5, 1982, PRC National People's Congress Temporary Pollution Fee Regulations

shipped, saving on transportation energy use and reducing the burden on an already overtaxed transportation system. Reduced coal consumption for energy production, especially the replacement of extremely inefficient boilers, ovens, and household stoves, results in the reduction of local air pollution, regional acid rain, and global warming impacts. Saving energy also lowers costs for companies that utilize heat energy, in turn improving their bottom line.

Cogeneration can help to alleviate electricity supply shortages and improve the urban environment. For example, Jingzhou Cogeneration Plant, which was built in 1986 to alleviate electric power shortages, also provides steam for 28 industrial consumers and 1.3 million square meters of residential heating area. One hundred and fifteen small boilers were eliminated. Based on measurements from the local environmental agency, by 1990 SO_2 and particulate concentrations in the area had declined 32% and 48%, respectively.[17] The improvement of the local environment has been attributed to the replacement of the small boilers and household stoves.

Cogeneration is increasingly providing energy sources for in-space cooling in summer. It helps reduce the demand for peml-loan electricity. A new approach for cogeneration is to supply steam, electricity, and fuel gas for cooking. Although almost all of China's coal-fired boilers lack any type of environmental controls and have low stack heights, new and retrofitted cogeneration facilities are required to meet minimum stack height limitations and emission standards. Some cogeneration plants have found profitable ways of utilizing recovered dust and solid wastes. For example, some plants use recovered dust to produce bricks of much better quality than standard construction bricks.[25]

The environmental damage caused by acid rain has focused attention both nationally and internationally on how to reduce SO_2 emissions. For example, small-scale cogeneration plants are usually equipped with particulate-removal equipment of better than 95% efficiency, desulfurization equipment with 15% or better efficiency, and 80 meter-high chimneys to reduce localization effects and meet national emissions standards for environmental protection. No cogeneration plants have been fitted with modern and effective desulfurization equipment in China except the Taiyuan Cogeneration Plant, a 200-MW Chinese-Japanese joint demonstration project that employs desulfurization equipment imported from Japan. Other pollutants, such as CO_x and NO_x, have not been targeted for removal at this time.

The potential for energy savings, greenhouse gas reductions, and local and regional improvements of air quality are enormous. It is estimated that by 1994, there were more than 450,000 non-utility boilers in China, of which there were around 200,000 industrial-use and about 250,000 commercial and residential-use boilers, consuming approximately 400 million tons of coal per year, one-third of total coal consumption.[48, 49, 15] In addition, millions of urban households still rely on raw coal and coal briquette stoves for

Table 6.3

Industrial Boiler Stack Height Limits for China

Boiler Design Output (tons/hour)	< 1	1 - 2	2 - 6	6 - 10	10 - 20	20 - 35
Minimum Stack Height (meters)	20	25	30	35	40	45

Source: September 14, 1983, PRC National Environmental Protection Agency's Boiler Dust Emissions Standards their cooking, space heating, and water heating. Drinking water in China is boiled prior to consumption.

Although the impact of cogeneration on environmental protection has not been fully incorporated into government policy making or cogeneration project evaluation, the Chinese government has begun to take advantage of this potential. In 1987, the central government issued regulations to strongly encourage that boilers with volumes larger than 10 tons/hour, and more than 4,000 operating hours per year, be retrofitted as cogeneration facilities.[18] Also, between 1981 and 1990, a total of 1,781 MW of bottom-cycle cogeneration plants built with state energy conservation funds.[47]

The cogeneration project approval process could be strengthened to examine fuel types, environmental effects, and to encourage the installation of environmental protection equipment. In addition, the avoided costs of the emissions mitigation provided by cogeneration have not been quantified or included in the project evaluation and approval process. This type of policy reform would help to promote the import of badly needed advanced technologies, such as gas turbines, gas/steam combined cycle, desulfurization equipment, fluidized-bed combustion, and solid waste-recycling systems. Fuel-switch for cogeneration plants located in urban areas should be examined in the context of environmental protection. Natural gas can be used for cogeneration. The formulation of fuel-type policy will have a significant impact on the promotion of environmental quality.

Although critics of cogeneration might conclude that cogeneration is a stop-gap measure at best and that latent demand will negate energy efficiency gains, without energy efficiency gains both China's economic and environmental situation would be far worse. Recently collected data have shown that energy efficiency gains have contributed to the rapid improvement of China's energy intensity.

Chapter 7

Potential for Further Cogeneration Development

7.1 Introduction

In the preceding chapters we presented the history of cogeneration development in China, outlined the trends, presented the institutional structures, policy environment, and financial allocation situation, and discussed some of the special environmental considerations associated with the conditions in China. This chapter summarizes investment opportunities and risks for investors.

7.2 New Construction Investment Opportunities

Table 7.1 presents data from one forecast for cogeneration development to the year 2000. In this forecast the share of cogeneration capacity is projected to reach 12% of the total thermal power capacity by 2000, although the recent rapid buildup of non-cogeneration capacity makes this percentage figure appear optimistic. If cogeneration development follows this forecast, gross cogeneration capacity additions for this decade will reach 11.4 GW. Table 7.1 takes into account the replacement of small power plants, yielding a net gain of 8 GW of new generation capacity.

Under this scenario cogeneration could save 15 million tons of coal annually after the year 2000. At an integrated investment rate of 3,500-4,000 yuan/kW, 2.8-3.2 billion yuan (US$ 340-385 million) would be required each year until the end of this decade for cogeneration development. However, only 0.8 billion yuan (US$ 96 million) of state energy-conservation loans for capital construction of cogeneration projects are available each year. A capital investment requirement of 2-2.5 billion yuan (US$ 240-300 million) would need to be raised each year via diversified investment sources such as bonds, collective funds, and foreign investment in the establishment of joint ventures.

There is untapped potential for cogeneration in the iron and steel, chemical, paper, rubber, textile, and printing and dyeing industries. Feng, et al.[50, 51, 52, 53] analyzed cogeneration programs and predicted their potentials for future development in the textile, food, paper and medicines industries. Table 7.2 shows the predicted production capacities and steam demand for these industrial sectors in 2000, and Table 7.3 provides data on their cogeneration potential.

In 1990, energy consumption in the textile sector (including the synthetic fabrics industry) accounted for 5.6% of the total industrial energy consumption, about 37.8 Mtce. Currently, the cogeneration capacity of this sector is 300 MW, of which there is a 100 MW share in each of the over 12 MW, 3 to 12 MW and less than 3 MW categories.[50] The subsectors of the textile industry,

Table 7.1
Cogeneration Development Forecast - 2000

	1981-1990	1991-1995	1996-2000
Ratio of Cogeneration to Thermal Electric Power Capacity (%)	11.3	11.7	12
New Cogeneration Capacity for Period (GW)	7.95	4	4
Average Energy Consumption for Electricity Supply (gce/kWh)	332	300	280
Annual Energy Savings at the End of Period (Mtce/year)	7.8	8	15
Average Annual Investment (billion 1995 yuan)	1.0	2.8-3.2	2.8-3.2

Note: No devaluation of foreign exchange is accounted for in the table.
Source: Xu, Hong, "Cogeneration Development in the Last Decade and Its Perspective," Energy Conservation Planning and Information, Department of Resource Conservation and Comprehensive Utilization of the SPC, February, 1993. (Circulated in China only.)

such as wool and flax spinning, textiles, synthetic fabrics, printing and dyeing, and knitting, operate at more than 6,600 hours per year and have high steam requirements. Steam is used for drying, heating, washing, printing and dyeing, and other processes.

The textile industry is capable of supporting the growth of 400 MW of additional cogeneration capacity between now and 2000. If we use 200 gce/kWh as the average unit of energy saved, the total conserved energy for these cogeneration projects could be as high as 1 Mtce/year by the end of the century.

The food industry consumed 32.8 Mtce of energy in 1990, or 4.9% of total industrial energy consumption. The wine, beer, salt, tobacco, and sugar subsectors require considerable steam supply during processing, creating further potential for cogeneration projects. Wine and beer plants typically operate for more than 8,000 hours per year, but since steam demand is unstable, no cogeneration plants have yet been built in these two subsectors.[51]

There are a few cogeneration plants in the salt refining or tobacco industries, but the development of cogeneration in the sugar refining industry has been remarkable. Cogeneration plants with 400 MW of capacity are currently providing 1.4 TWh (tera, or thousand billion Watt-hours) of electricity. More than 400 plants already have boilers and turbines, indicating further potential for cogeneration retrofits. The forecast for cogeneration development in these three subsectors in 2000 is an additional 280 MW of cogeneration capacity, enough to save 0.8 Mtce per year after 2000.

The pharmaceutical industry is expected to grow at an annual rate of over 3%. Steam is used for heating, maintaining temperature, drying, and sterilization. Due to stable steam demand and long operating hours of more than 8,000 hours per year, pharmaceutical plants have proven to be profitable. It is predicted that cogeneration capacity in the pharmaceutical sector will reach 111.6 MW by 2000, adding 36 MW over the next five years. If this potential is met,

Table 7.2

Sectoral Production Capacity Forecast - 2000

Sector	Unit M=million	Growth Rate (%)	Production Capacity		Steam Parameters bar/hours per year	Steam Demand (tons/hour)	
			1988	2000		1988	2000
1. Textile Sector							
Wool	M spindle	10	2.27	7.11	4/6600	2481	7786
Flax	M spindle	12	0.42	1.26	4-5/6600	486	1372
Chemical Fabrics	M ton	7	1.25	2.75	4-13/6600	1134	2492
Printing & Dyeing	M meter	5	9523	17102	4/6600	6369	11437
Knitting	M units	1	1627	1833	4/6600	1733	1952
2. Food Sector							
Well-Salt Refinery	M ton	7	3.69	8.35	4-5/6800	920	1941
Tobacco	M box	8	30.5	76.8	8/6800	775	1953
Sugar Refinery	M ton	3	5.43	7.74	3-4/3600	6787*	9670*
3. Medicine Sector							
Pharmaceuticals	ton	3.3	65,377	100,000	5/8000	1149	1702
4. Paper Sector							
Large-Sized	M ton	10	250	800	8-10 or 3-5/8000	1116	3000
Medium-Sized	M ton	10.5	241	800		1075	3000
Small-Sized	M ton	-4	650	400		2904	1500

Source: References 50-53.

Table 7.3

Cogeneration Potential Forecast for Four Industrial Sectors—2000

Sector	Minimum Scale for Cogeneration	Projected Share of Cogen in Total Production Capacity	Cogeneration (MW) 1988	2000
1. Textile Sector			399	804
Wool	> 10,000 spindles/year	29%	61.7	34.7
Flax	> 10,000 spindles/year	30%	10.8	30.4
Chemical Fabrics	> 10, 000 tons/year	48%	40.7	89.3
Printing & Dyeing	> 1,500 meters/day	50%	251.4	451.5
Knitting	> 1,000 units/day	20%	34.7	39
2. Food Sector			540	821
Salt Refinery	> 40,000 tons/year	90%	62.8	132.4
Tobacco	> 80,000 boxes/year	9.3%	0	10
Sugar Refinery	> 400 tons/day	90%	476.1	678.8
3. Medicine Sector			75.3	111.6
Pharmaceuticals	> 500 tons/year	85%	75.3	111.6
4. Paper Sector				
Large-Sized	Steam supply > 10 tons/hour and pressure of <5 bar	50%	580	1568
Medium-Sized			237	758
Small-Sized			200	667
(<10 kt/year)			143	143

Source: References 50-53.

overall energy consumption could decrease 2% from the 1988 level.[52] Although the production of traditional Chinese medicine is prolific, the scale of factories is usually small, with fluctuating steam demand and limited operating hours.

Average energy consumption in the paper industry was 1.9 tce/ton in 1990, much worse than the 1.1 to 1.2 tce/ton common in other countries. The paper industry consumes more than 7 Mtce of fuel and 8 TWh of electricity per year. Steam generation in the sector accounted for over 1% of total industrial steam production. Stable steam demand and more than 8,000 operating hours per year make cogeneration an attractive option for the paper industry.[53]

Small-scale paper mills, with capacities of less than 10,000 tons/year, dominate the output of the paper industry. It is estimated that large-, medium-, and small-scale paper mills share 29%, 21%, and 57% of the sectoral production capacity, respectively. Eight out of fourteen processes require steam, mainly 8-10 bar steam for the boiling process and 3-5 bar for the drying process. Average steam consumption is currently 7 tons per ton of paper and is expected to decrease to 6 tons in the future.

The capacity share of small-scale paper mills is expected to decrease from 6 million tons of output in 1988 to 4 million tons of output in 2000. This capacity will be replaced by the large- and medium-scale paper mills. It is not economical for the small-scale paper mills to build cogeneration plants where steam demand is less than 10 tons/hour. The predicted (50) cogeneration potential up to the year 2000 is 1.5 GW. If only one-third of this potential is developed, then about 500 MW of cogeneration will be added in this period, saving as much as than 0.8 Mtce per year.

Natural gas-fired cogeneration may provide another area for new cogeneration development. The Chinese government has emphasized coal-fired cogeneration to use coal more efficiently. However, natural gas-fired cogeneration plants can be built in cities and residential areas where even the coal-fired cogeneration plants are rejected. Some of the preferred areas for gas cogeneration investment are residential districts and buildings, industrial parks, commercial office buildings, hospitals, hotels, large shopping centers, and education centers. Natural gas is allocated by the state government as a raw material for the chemical fertilizer industry. Regional economic development and energy supply differences determine the areas where natural gas-fired cogeneration is a practical option. Chemical fertilizer plants in some areas could apply natural gas-fired cogeneration to provide electricity and heat supply rather than burning coal shipped from long distances.[52]

There are more than 1,000 small cities and towns across the country with at least 20 tons/hour of heat load and more than 4,000 annual hours of heat utilization. If half of these towns and small cities, especially those having year-round heating and cooling requirements, built small-scale cogeneration plants by the year 2000, 40 billion yuan (US$ 4.8 billion) of investment would be needed to build 10 GW of cogeneration capacity, yielding 55 TWh of power generation.[17]

In addition to providing heat for industrial processes, cogeneration can also provide cooling. In 1987, the State Council issued document #25 "to guide the adoption of LiBr (Lithium Bromine) technology and equipment for commercialized space cooling." There are more than 50 manufacturers of LiBr equipment in China, and more than 1,000 systems have been installed throughout the country.

Because fluctuations in seasonal heat load directly affects the economics of cogeneration plants, maintaining a stable heat load during the summertime is a critical issue. Cogeneration plants often release steam into the air or idle part of their capacity during the summer. Development of cooling technologies such as LiBr (Lithium Bromine) that use steam can help to make cogeneration more competitive. Commercialized LiBr cooling systems are relatively simple, are easily equipped and maintained, use low parameter steam (0.98 Mpa or 0.2 Mpa), and have been successfully employed in some production processes as a cooling source.[54]

Also, air conditioners are becoming a common requirement for households as more people are able to afford small electric room air conditioners. Statistics show that sales in shopping centers can benefit as much as 20% when the space is air conditioned. From 1993 to 1994 the estimated summer peak load for air-conditioning in Beijing rose from 200 to 250 MW, and increase of 25%. Hotels, hospitals, shopping centers and other commercial buildings, as well as improvements in the working conditions in factories, all add to space-cooling demand. Space cooling puts heavy pressure on electricity loads during peak periods. Utilities are often forced to shut down or schedule electricity supply to protect the grid. The rapidly increasing growth in space-cooling demand challenges an electricity industry already faced with severe shortages in both base and peak load periods.

As discussed in Chapter 3, there is tremendous residential heating and cooling potential in the belt between the Huai and Yangtze rivers, as much as 2.6 billion m^2. Compared to district heating centers and electrical air conditioning, trigeneration (the generation of heat, cooling, and electricity) has the advantage of high efficiency with low energy consumption, investment, and operation costs. It uses low-pressure steam, consumes less electricity than conventional air conditioners, and provides heat load in the summer. On the other hand it has the disadvantages of localizing environmental pollution (coal-fired), long construction periods, and is difficult to retrofit for existing buildings.

7.3 Retrofit Investment Opportunities

The possibilities for cogeneration retrofits in China are enormous. In addition to the 450,000 boilers discussed in Chapter 6, in 1992, there were over 1,000 conventional power plants with condensing turbine capacities of less than 125 MW. The average capacity of these small-scale power plants is 26 MW, and in total consume 40 million tons of coal annually, 1-2 times more energy per kWh than large-sized power plants.[55]

If 10%-15% of these 450,000 boilers could be retrofitted into cogeneration, electricity supply would increase 40-50 TWh per year. The pressure parameters for these boilers are mainly between 13 kg/cm^2 and 25 kg/cm^2, and should be enhanced to 40 kg/cm^2 or higher. Generally speaking, these small-scale boilers and power plants can be retrofitted into cogeneration plants.[15]

Power plants with condensing turbines built in city suburbs in the 1950s and 1960s could be retrofitted into cogeneration quickly.[56] Total retrofit potential in China is about 20 GW. In some cases, retrofitting these old and inefficient power plants into cogeneration appears to be more cost-effective than building new cogeneration plants. Retrofits can require less capital investment and have shorter construction times. Also, in northern China, it is economically feasible to retrofit district heating centers into cogeneration plants.[57] It has been calculated that 5 GW of district cogeneration capacity in these large- and medium-size cities could be developed, requiring 20 billion yuan (US$ 2.4 billion) of capital investment.[17]

In 1994 the chemical fertilizer industry produced over 23 million tons of ammonia. If one-half of the chemical fertilizer plants were retrofitted to utilize cogeneration, the total generation capacity could reach 1 GW, and produce 5.5 TWh per year. One-third of the electricity consumption for ammonia production could be provided by cogeneration plants, saving about 1.5 Mtce per year.

In general, the categories of technical upgrade, expansion, retrofit, and bottom-cycle cogeneration can in many cases conserve more energy with less capital investment than new construction. The average unit investment cost of a 200-MW coal-fired and domestically produced generator is 1,800 yuan/kW. The average unit investment in the electricity generation part of cogeneration, after the unit investment in the heat supply portion is subtracted out from the investment in the overall cogeneration system, is only 1,307 yuan/kW, 27% less than building a new conventional plant.[58]

7.4 Demonstration Projects for Emerging Technologies

Another potential market for cogeneration can be found in rural areas, where a great amount of forest and agricultural waste are available as fuels for power generation. There are currently no biomass-based cogeneration plants in China. Officials in the Ministry of Forestry (MOF) and the Ministry of Agriculture (MOA) are interested in such biomass cogeneration projects and would like to see a demonstration project showing its feasibility.

From an energy use point of view, the forest is a renewable energy resource. More rational utilization of forest resources, increasing supply and promoting consumption efficiency, needs to be emphasized. In some rural areas, people burn wood for space heating in extremely inefficient household stoves (5 to 20% overall efficiency). A demonstration project for cogeneration in these areas is viewed as a viable option.

A significant change in biogas development is the recent shift from small household digestors to large-scale public digestors, which are more economical and energy-efficient. These large-scale digestors, fed by organic wastes from pig farms, dairies, and chicken farms, provide fuel gas for town and village residents, enterprises, and even power generation plants. By the end of 1993, a total of 80,000 households were supplied with biogas fuel by large-scale digestor plants. The MOA has already provided total funding of 30 million yuan in 1994, and will allocate an additional 50 million yuan to large-scale biogas digestor plants which also are potential candidates for cogeneration, electricity, and gas fuel.[59]

7.5 Investment Risks

Any business venture has its risks, and cogeneration development in China is no different. It is not so much the risk itself that keeps investors and entrepreneurs away, but the lack of clear knowledge about what the specific risks are and the relative levels of risk exposure. Table 7.4 presents these risks, relative levels of exposure, and the expected impact on profitability.

Probably the most important risk to any cogeneration venture in China is the rates the cogenerator will receive for the electricity and heat or steam that is sold. Negotiation of price and purchase contracts is absolutely essential. In the shift from a planned to a market economy, a monopolistic utility sector and price subsidization practices linger. On the other hand, the Chinese government is hungry for capital to develop its cogeneration and electric power sectors. Because cogeneration is often seen as the best option to meet heat and electric power needs while satisfying environmental requirements, investors should find government officials who are both aware of the risks involved and receptive to negotiation of heat and electricity quantities and rates.

Due to a wide variation in local conditions, an equally broad range of heat and electricity rates (and fuel prices) can be expected. Current wholesale electricity rates typically range from 0.21 yuan/kWh (US$ 0.025/kWh) in the energy-rich northeast, to 0.50 yuan/kWh (US$

Table 7.4

Cogeneration Investment Risks

Risk		Exposure	Impact
1.	Electricity Rates	Medium	High
2.	Heat/Steam Rates	High	Medium to High
3.	Rate Structure	Medium	Medium
4.	Miscellaneous Utility Charges	High	Low to Medium
5.	Utility On/Off Peak Control	Low	Medium
6.	Profit Repatriation/Convertibility	Medium	Low
7.	Foreign Capital Exchange Rates	Medium	Medium to High
8.	Contract Enforceability	Low	Low to Medium
9.	Inflation / Raw Material Costs	Low to Medium	Medium
10.	Transportation	Medium	Medium to High
11.	Taxes	Low	Low to Medium

0.06/kWh) in the rapidly growing and energy-starved southeast coastal areas.[15] Although there are tax incentives for electricity producers in special economic zones, electricity and heat rates are not necessarily more favorable there.

In most places, electricity prices are still regulated by the provincial or regional electric power administrations, but in a few, such a Jiangsu Province[15], the local governments are involved in negotiating electric rates between the producer and utility. Having an intermediary in the negotiation process has proven beneficial to investors under the current conditions. As discussed earlier, although utilities typically employ a rate of return of around 15% on investment as a starting point for calculating project electric rates, local governments are often willing to negotiate this rate. The kind of deal obtained depends very much on local conditions.

Heat rates are regulated by the local water administrations that in many cases still see heat as a benefit of the socialist economy, and not a commodity. Because heat prices are not arrived at via market conditions, it is not uncommon for the prices that heat producers receive to be lower than their costs. Heat and steam, especially in the residential sector, are still considered a basic necessity, like rice. Prices are held artificially low to meet basic human needs and to avoid adding fuel to an inflation problem that threatens to upset urban social stability. A clear pricing formulation is required in both cases. One advantage of in-plant cogeneration is that heat rates are inconsequential.

Foreign investors can expect a simple rate structure. Although the central government has promulgated several policies to conserve electricity, including the differentiation of electric rates for on-peak and off-peak periods, demand charges, and different customer classes, in practice the lack of time-of-use and demand metering equipment has limited these practices to a few energy-short demonstration areas only.

Although the rate structure is relatively simple, the investor should be aware of a myriad of other charges that the utility can apply. These other charges should be taken into account in any purchase or price contract. These charges can include but are not necessarily limited to grid connection fees, grid safety charges, grid construction fees, Three Gorges construction fees, and self-use demand and electricity fees. Another issue is the requirement of electricity transfer to the grid during on-peak periods or the restriction of electricity transfers during off-peak periods, or large rate differentials between these two time periods.

Foreign investors are allowed to repatriate profits. However, investors must be aware of processing delays, administrative overhead, and uncertainties in exchange rates. There are no guarantees of compensation for losses to investors for either the Chinese or foreign partners if the Chinese Renminbi (RMB) is devalued. In some cases Chinese partners are willing to share the risks of exposure to exchange rate fluctuations in proportion to their share of the total investment.

Next is the issue of price and purchase contract enforceability. Well-publicized cases such as the Beijing McDonalds incident cast doubts on the ability of China's under-developed legal system to handle contractual disputes. However, the government has been taking steps to rectify the situation with the recent creation of international arbitration boards.

One of the most widely publicized risks is inflation. Capital investment costs for cogeneration have been increasing rapidly. Average unit investment costs for cogeneration projects between 1981 and 1985 were 2,000 to 2,900 yuan/kWe. These costs have increased to between 3,500 and 4,500 yuan/kWe (current value) between 1986 and 1990. Currently, the unit investment costs for coal-fired power plants with 300 MW generators range from 3,500 to 4,500 yuan/kWe. By comparison, unit investment for small- (<24 MW) and medium-scale (24-100 MW) cogeneration sets is estimated to be 4,500 to 5,500 yuan/kWe for the in-plant type, 5,500 to 6,000 yuan/kWe for the industrial park type, and 6,500 to 7,500 yuan/kWe for district heating plants, including the heat-distribution systems. For large-scale (>100 MW) district heating cogeneration projects, unit investment can reach over 10,000 yuan/kWe.[15] These costs include land purchase, construction materials and labor, buildings, heat-distribution systems, equipment, installation, grid connection costs, and other related costs.

Heat prices have not caught up with increases in fuel and other material prices over the last decade. Ninety-five percent of China's cogeneration capacity is coal-fired. With 200 billion tons of coal reserves and supply currently meeting demand, coal prices are expected to increase only slightly in the near future. The greatest uncertainty associated with coal prices and supply is related to transportation infrastructure conditions rather than to coal-production costs. Compared to international coal prices, Chinese coal is cheap. Retail coal prices vary considerably for different areas, ranging from 230 yuan/ton (US$ 27/ton) in the coal producing regions of the north, to 400 yuan/ton (US$ 48/ton) in the coal-poor southeastern coastal region for run-of-mill bituminous coal. Washed and sized coal prices are 100 to 200 yuan/ton higher. Care should be taken to ensure adequate and stable coal supplies by negotiating medium- to long-term raw material purchases and transportation agreements.

Finally, depreciation periods are 17-21 years for cogeneration and 25 years for heat-distribution systems. The annual depreciation rate for a small-sized cogeneration plant is low, usually 4% to 6%, and no portion of the total depreciation can be used for the owner to pay back the loan.[15] Table 7.5 lists applicable tax rates which may differ by location.

Table 7.5

Cogeneration Joint Venture Taxes

Tax	Definition	Tax Rate
Value Added Tax	Based on the total quantity	
1. Electricity	of sale for change in form of energy	17%
2. Heat	(i.e. heat to electricity)	13%
Income Tax	Based on pre-tax income	33%
1. National		30%
2. Local		3%
Personal Income Tax	800 yuan deduction, sliding rate	5% - 45%
Customs Duty	Imported commodities	Common duty and the lowest duty Duty free on the goods as foreign capital inputs*

* To be abolished in 1996.

Source: A Collection of Tax Laws and Regulations of the People's Republic of China, Foreign Tax Affairs Department of the State Taxation Bureau, China's Statistics Publishing Inc., April 1994.

7.6 Project Evaluation and Selection in China

Unfortunately, project-evaluation procedures for cogeneration project pre-feasibility and feasibility studies, approvals, and financing are inconsistent. In many cases, the projects selected and financed are not the best in terms of economic, financial, technical, or environmental merit. Some evaluation methods (including software tools) developed by Tsinghua University and other institutes have proven useful in practice but are being ignored in the current project-evaluation practices. Project managers end up being more concerned about getting project and loan approval than paying attention to project profitability.[15] In China the evaluation for pre-feasibility approval is not necessarily based on economic or financial viability. Instead these factors may be relegated to a secondary role while criteria such as job creation, reputation, political capital, and *guanxi* (relationship) with the decision makers, become the decisive factors. Appendix C provides a detailed explanation of the approval process.

7.7 Conclusion

From a return on investment point of view, the best type of cogeneration projects are likely to be in-plant cogeneration facilities serving a single industrial enterprise. These relatively small investments could also provide a least-risk market entry strategy for large power development firms that would like to gain experience and gain and cultivate relationships in China's power market. The next most desirable would be small- to medium-scale district cogeneration plants, and lastly large central cogeneration plants. In-plant cogeneration projects generally benefit from a stable heat load and electricity demand, require only local approvals, can benefit from high local electricity rates and more flexible local government attitudes and do not require expensive heat-distribution systems. Large-scale district heating cogeneration systems typically allocate about one-third of their total investment to the heat-distribution system alone. Furthermore, they must cope with central government involvement in the project approval process, long construction periods, large variations in heat load, and insufficient management skills.

Appendix A

Regional, Provincial, and Local Electric Power Administrations

Electric Power Bureaus (EPB)

Regional Electric Power Grid

1. THE NORTHERN EPB
   Beijing Municipal EPB
   Tianjin Municipal EPB
   Hebei PEPB (Provincial EPB)
   Shanxi PEPB
   Neimenggu Autonomous Region EPB

2. THE NORTHEASTERN EPB
   (Liaoning Province)
   Jilin PEPB
   Heilongjiang PEPB

3. THE EASTERN EPB
   Shanghai Municipal EPB
   Jiangsu PEPB
   Zhejiang PEPB
   Anhui PEPB

4. THE CENTRAL EPB
   Henan PEPB
   Hubei PEPB
   Hunan PEPB
   Jiangxi PEPB

5. THE NORTHWESTERN EPB
   (Shaanxi Province)
   Gansu PEPB
   Qinghai PEPB
   Ningxia Autonomous Region EPB
   Xinjiang Autonomous Region EPB

Individual Local Electric Power Grids

Shandong PEPB
Sichuan PEPB
Guizhou PEPB
Yunnan PEPB
Fujian PEPB
Guangxi Autonomous Region EPB

Note: ( ) means the regional electric power bureau also acts as the provincial electric power administration.

Electric Power Utilities (EPU)

Regional Electric Power Groups

1. THE NORTH CHINA ELECTRIC POWER GROUP (EPG)
   Tianjin EPC (Electric Power Company)
   Hebei PEPC (Provincial EPC)
   Shanxi PEPC
   Neimenggu Autonomous Region EPC

2. THE NORTHEAST CHINA EPG
   Jilin PEPC
   Heilongjiang PEPC

3. THE EAST CHINA EPG
   Shanghai EPC
   Jiangsu PEPC
   Zhejiang PEPC
   Anhui PEPC

4. THE CENTRAL CHINA EPG
   Henan PEPC
   Hubei PEPC
   Hunan PEPC
   Jiangxi PEPC

5. THE NORTHWEST CHINA EPG
   Gansu PEPC
   Qinghai PEPC
   Ningxia Autonomous Region EPC
   Xinjiang Autonomous Region EPC

Subsidiary Electric Power Companies

Shandong PEPC
Sichuan PEPC
Guizhou PEPC
Yunnan PEPC
Fujian PEPC
Guangxi Autonomous Region EPC

Local Electric Power Companies

Guangdong PEPC
Hainan PEPC

Huaneng Group
Huaneng International EPC
Huaneng Power Generation Company

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Appendix C
Cogeneration Application Procedures and Approval Process

C.1 Involvement of Foreign Investors in Cogeneration Development in China

The scarcity of local investment capital offers foreign investors opportunitied in China's energy market. Many foreign investors have already talked with local officials in several provinces about opportunities in cogeneration development. Although some projects are in the process of negotiation and feasibility studies, as far as we know, no foreign funded cogeneration venture has so far been fully established and put into operation.

Before foreign investors put capital into cogeneration projects, they should understand Chinese government cogeneration policies and regulations, procedures for applications, approvals, and permits, relationships between cogenerators and utilities, contracts for fuel supply and electricity and heat rates, technology adoption and deployment, ownership and control, labor relationships, and Chinese culture and management traits. In this appendix we outline the possible modes of cogeneration investment participation for foreign investors, the general application and approval process for cogeneration facilities, and the procedures for foreign investors involved in a cogeneration joint-venture.

There are three possible forms of foreign direct investment in cogeneration, equity joint-ventures: (*hezi*), contractual joint-ventures (*hezuo*), and wholly foreign-owned (*duzi*) ventures. The equity joint-venture partners must follow Chinese cogeneration legislation and related laws in negotiating and determining proportions of equity and investment, joint management, and shares of profit and loss. Equity joint-venture partners each have a limited amount of equity investment in the venture and hold stock.

Legal contractual joint-ventures are based on a contractual agreement among the partners regarding conditions of cooperation, allocation of profits and final products, share of risks and losses, management methods, and property ownership at the end of the cooperation period. In this form of joint-venture there is no equity investment by the foreign partner. The Chinese government prefers such a form of "Build-Operate-Transfer" cooperation for cogeneration projects, particularly for large-scale projects.

The wholly foreign-owned enterprise is the other potential form of involvement and is welcomed by the Chinese government. However, market imperfections, political uncertainties, and other medium- to long-term investment risks combine to make this type of investment much less desirable to foreign investors.

Small- to medium-scale cogeneration projects are relatively simple to build and operate and have fewer risks and uncertainties associated with them. Table C.1 contrasts the advantages and disadvantages of cogeneration project

Table C.1

Comparison of Large and Small-Scale Cogeneration Projects

Aspect	Large-Scale Cogeneration Projects	Small-Scale Cogeneration Projects
Capital Criteria	> US $30 million	< US $30 million
Government Contacts	SPC/SETC, MOEP, MOFTC	PPC/PETC, PEPB, PFRC, PIBAB
Approval time	Long and time consuming	Relatively short and quick
Official Attitude	Active and restricted (local and central)	Active and flexible (local only)
Construction and Payback Period	Long	Short
Fuel Prices	Certain and guaranteed	Uncertain and contracted
Fuel Delivery	Scheduled and guaranteed	No schedules or limitations
Foreign Currency Repatriation	Available, State arranged	Depends on local foreign currency reserves, locally arranged
Management	Complicated	Simpler

investment based on scale. As is apparent from the table, there are trade-offs to consider while evaluating the optimum cogeneration scale for investment. These differences will be explained in more detail in the following sections.

C.2 General Cogeneration Application and Approval Processes

Due to the various levels and complex structures of the electric power administrations and other government offices involved in project approval, as well as frequent policy changes during the current economic transition period, the procedures for cogeneration project approvals are dynamic and complex. However, two factors, project scale and the financing source, may be used to sort how and where project approval should be obtained.[c1]

As shown in Figure C.1, there are usually four steps in the cogeneration project application and approval process. In the first step, a project proposal, and pre-feasibility study carried out by an engineering and construction firm, are submitted to the responsible government agency for approval at various levels. Eventually, the government agency at the highest level of project jurisdiction issues a project task proposal to the project application initiator.

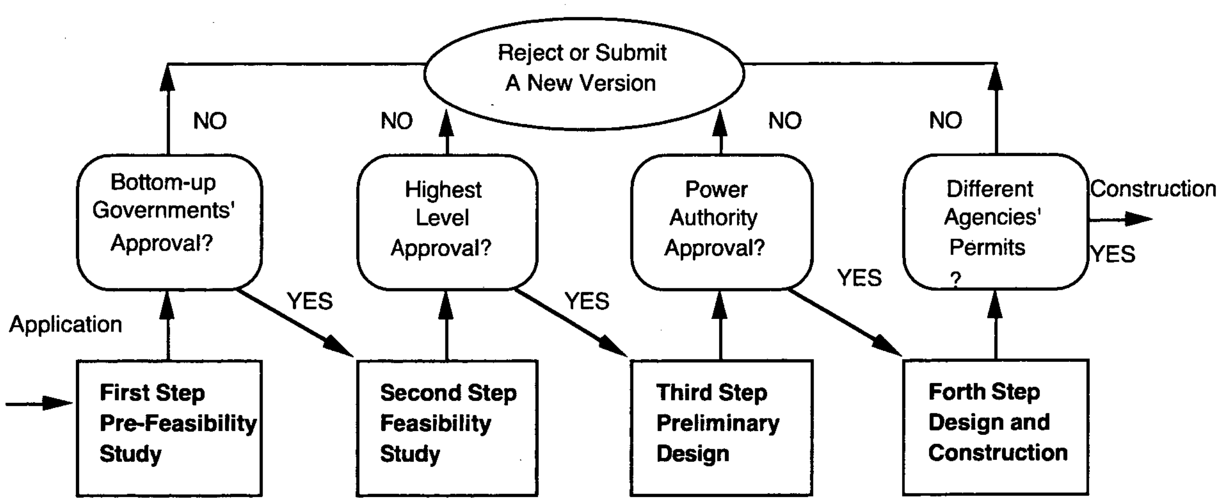
A feasibility study is carried out for the second step. After gathering all information and data needed for the study, a special group writes the feasibility report and submits it to the electric power administrations for review. After evaluation by an expert advisory board and approval by relevant officials, the project is included in the government plan, such as the electricity development plan. The relevant planning commission issues, either jointly with other related government agencies or by itself, a project approval document.

The third step is the preliminary design of the cogeneration plant. The relevant electric power administration evaluates the design from the aspects of technology, safety, and reliability. The designer must have a valid license and be recognized by the power authority. Once the electric power approval authority approves the preliminary design, the project can advance to the final step of approval.

The fourth and final step is the completed design and construction. A series of permits issued by several different government agencies, including the environmental protection agency, must be obtained before ground breaking is undertaken. This step is typically tedious and time consuming.

Figure C.1

Cogeneration Project Application Procedures



Source: Xin Dingguo, "Cogeneration Policy and Market Analysis," working paper, Energy Research Institute, January, 1995

As mentioned, this process differs based on the scale of the project. A new small-scale project should first pass local government planning commission approval and then go to the provincial government planning commission for final approval. If the project is sponsored by utilities, it is also required to have the approval of its provincial superior (power bureau). To attain state loans or special funds, the project is required to submit to the evaluation and approval of government financing organizations, such as the CECIC, after the provincial government has given the green light to the project. Small cogeneration projects are then listed in a local or provincial development plan.

Large-scale cogeneration projects are generally sponsored by the provincial or regional utilities and must pass the evaluation of their direct superior (power bureau) and the corresponding provincial government administrations. A large-scale project must proceed step-by-step through both the electric power administration system and the planning commission system for various approvals. If the project ultimately obtains SPC approval, it can then be included in the national electric power development plan. Extension projects fall under the jurisdiction of technical renovation and are approved by the various economic and trade commissions at different levels of government. A renovation project with a financial investment of over 100 million yuan (US$ 12 million) must be submitted to the SETC for approval.[c2] Smaller projects fall under provincial economic and trade commission jurisdiction.

Figure C.2 illustrates the three main approval levels in the institutional structure for cogeneration project approval. The highest decision level includes the SPC, the MOEP, and the SETC. The middle decision level contains the state-owned IPPs, such as the Huaneng Group, regional electric power bureaus (EPB), provincial electric power bureaus, and provincial governments, particularly provincial planning commissions and economic and trade commissions. As illustrated in Appendix A, there are five large regional and nine independent provincial electric power administrations across the country. The regional electric power bureaus represent the MOEP in the management of various aspects of the inter-provincial grids. These regional bureaus can construct new grids, or expand their existing grids and have administrative jurisdiction over the provincial electric power bureaus in their territory. The provincial electric power bureaus are under the leadership of MOEP, but are also responsible to their respective provincial governments.

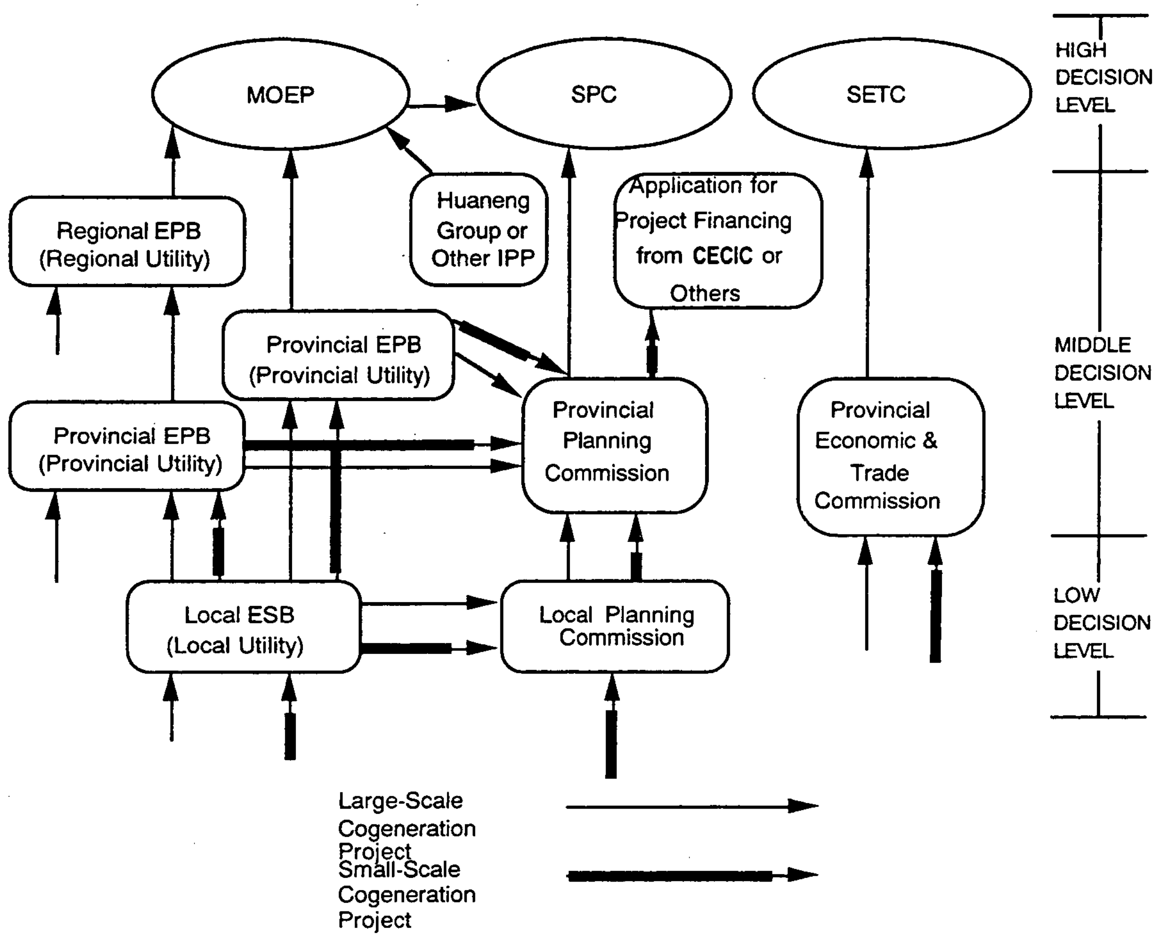
The structures in the lower decision levels of the local governments are similar to the levels above. The local governments and electricity supply bureaus (ESB) evaluate and pre-approve cogeneration projects, usually the small- and medium-scale ones, and then submit these reports with their approvals to the next higher level of government. The final approval for projects does not come from the lower decision levels, but the reports rejected by the lower decision levels cannot be sent to higher levels for review.

One of primary components of the recent economic reforms in the power industry is to separate production management tasks from the government's administrative functions.[c3] All municipal, county, provincial, and regional electric power bureaus have established their own utility companies which in some ways are similar to independent enterprises. In theory these utility companies are financially independent. They are involved in developing power plants, constructing power grids, and managing electricity distribution. However, in practice utility companies and power administrations still have many administrative, managerial, financial, and resource connections. They have yet to be completely separated. The local, provincial, and regional utilities are typically involved in the small-, medium-, and large-scale projects, respectively. If a cogeneration project applies for state funding, there are four basic requirements that it must meet before receiving government approval: scale standards, operation standards, fuel type standards, and efficiency standards. Figure C.3 illustrates the process that is involved. For the first requirement, scale or size standards, if the cogenerator's single generator electric power capacity is smaller than or equal to 12 MW, it must also meet the other three requirements. For facilities larger than 12 MW capacity, the facility qualifies automatically and does not have to meet any of the following requirements.

A cogeneration facility is defined as a plant that uses any type of fuel to sequentially produce energy to be used for residential, commercial, or industrial heating or cooling purposes and energy of one other form, in most cases electricity. If this definition cannot be met, the facility is classified as merely a small power producer, failing

Figure C.2

Cogeneration Project Approval at Different Levels of Government



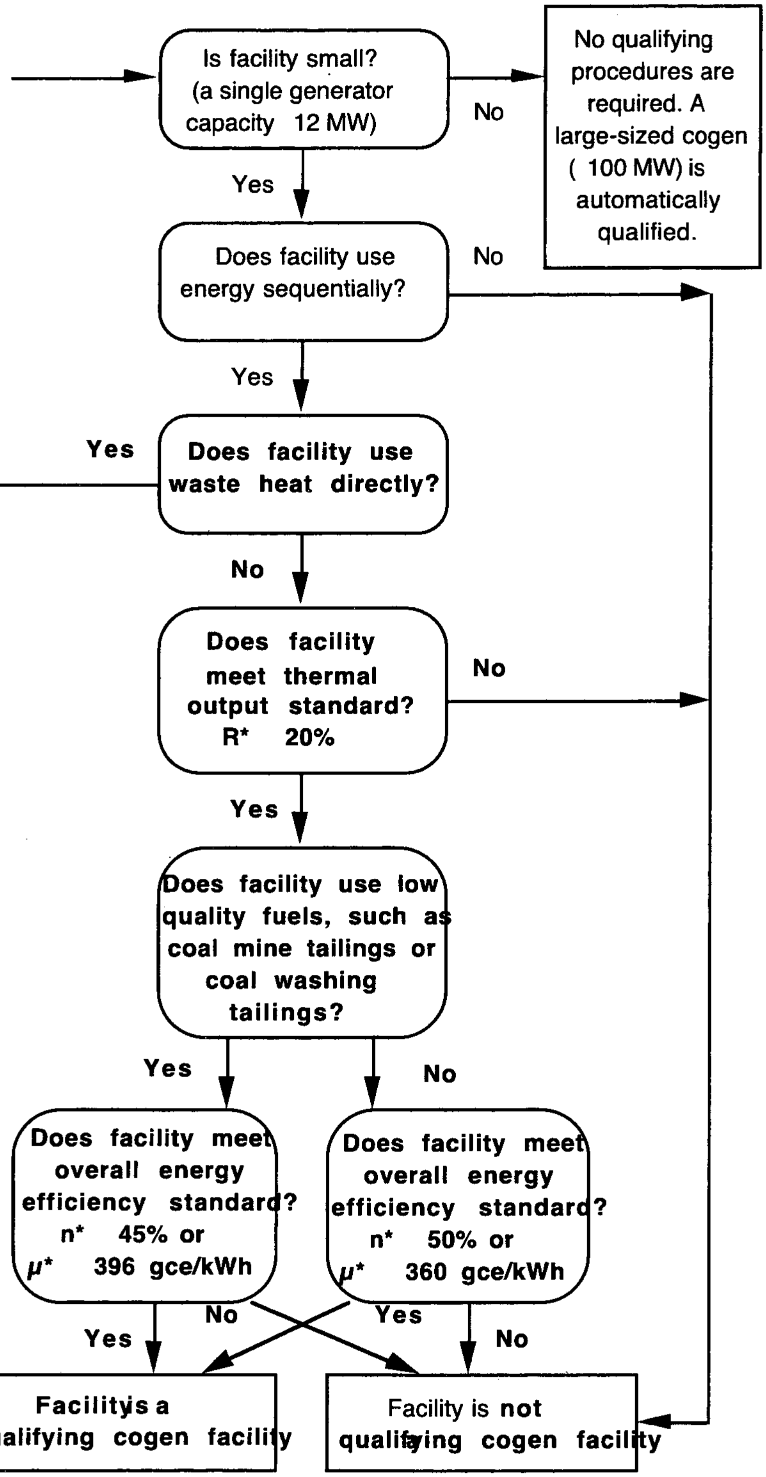
Source: Xin Dingguo, "Cogeneration Policy and Market Analysis," working paper, Energy Research Institute, January, 1995.

the operation standard requirements. If a bottom-cycle cogeneration facility is using waste heat, exhausted steam, or pressure differences from an industrial process to drive turbines, it is automatically qualified as a qualifying facility. All top-cycle cogeneration facilities must go on to the next step. In this step the useful thermal energy output of the facility must be equal to or greater than 20% of the total energy output (heat plus electricity) during any calendar year. This requirement is needed to assure that the cogeneration does produce a significant quantity of useful heat, and is not simply a "disguised" thermal power plant. These standards are defined in Table C.2

The next requirement is the fuel type standard. This step classifies cogeneration facilities into two groups, each having different efficiency requirements. If waste or low quality fuels, such as coal mine tailings or washed coal tailings are consumed, the heat efficiency for the whole cogeneration system must be greater than or equal to 45%, and the energy consumption for electricity supply must be less than 396 gce/kWh. Otherwise, heat efficiency must be equal to or greater than 50%, and energy consumption less than 360 gce/kWh. The electricity supply energy-consumption value comes from the ideal concept that the small-scale cogeneration plants should consume no more energy than the average large-scale power plant (capacity >200 MW = 360 gce/kWh). It should be noted that these two energy efficiency indices may not be consistent because the index of electricity sup-

Figure C.3

A Schematic Representation of the Qualification of a Cogeneration Facility



Source: Feasibility Study, Technical Codes and Related Documents for Small-Sized Cogeneration Projects, SPC, OOSC and MOE, 1992.

Table C.2

Cogeneration Qualifying Facility Standard Definitions

Term	Definition
Operation Standard	The useful thermal energy output of the facility as a percentage of the total energy output within a given time period.
Useful Thermal Energy Output	$R = Q/(Q+W) \geq 20\%$ where R=thermal output standard; Q=useful thermal output per year in kJ; and W=total electrical output per year in kJ
Heat Efficiency	$n = (Q+W)/(t_i h_i$ where n=facility energy efficiency in %; t_i=total quantity of fuel consumed inpower generation in tons; and h_i=average heat value for fuel type in kJ/ton
Energy Consumption for Electricity Supply	$u = ((t_i h_i - (q_i h_i)/We$ where u=electricity supply energy consumption in gce/kWh; and q_i= energy consumption of fuel type i for heat supply in tons/year We = W - Ws - Wt where We=total electricity supply from the facility inkWh/year; W=total generated electricity in kWh/year; Ws=self-consumed electricity in kWh/year; and Wt=total transmission and distribution electricity losses in kWh/year

ply energy consumption changes over time. Generally speaking, heat efficiency would be a more stable index for the efficiency test standard.

A cogenerator that meets all of the qualifying requirements listed above is referred to as a qualifying facility, which means that the cogenerator can enjoy the benefits guaranteed in the governmental policies. However, no certificate is issued by the authorities for the qualifying facility.

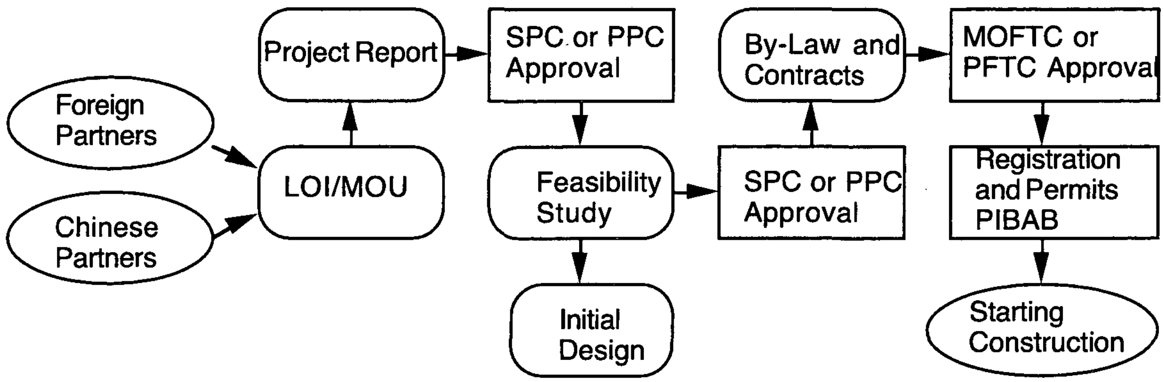
C.3 Special Procedures for Foreign Investors

We have already mentioned the general project application and approval procedures for Chinese-owned cogeneration projects in the preceding paragraphs. Generally speaking, the procedures for joint-ventures are similar.[c4] Figure C.4 presents the application procedures for equity and contractual cogeneration joint-ventures. It is usually much less risky and time consuming for foreign investors to get involved in projects that have already been approved by the relevant government agencies and are allowed to use international funding. For the time being, US$ 30 million is the foreign investment cut-off level for central government involvement in the project approval process. The provincial governments have the ability to approve projects under their jurisdiction with no more than US $30 million of foreign investment.[c5, c6]

The first step in any joint-venture project is for the Chinese and foreign partners to discuss and negotiate key issues such as the form of joint-venture, the shares of investment and profit, and electricity and heat rates. The partners then sign a "letter of intent" (LOI) or "memorandum of understanding" (MOU). The Chinese partner is responsible for writing the necessary pre-feasibility reports and submitting them to the relevant government agencies. The local gov-

Figure C.4

Procedures for Joint Venture Cogeneration Project Approval



Source: Guidance for Chinese-Japanese Cooperation in power Development, Energy Research Institute, January 1993.

ernment, or provincial government, also submits its approval with these reports to the next higher level of government.

After the related government officials approve the cogeneration project, the joint-venture partners can start preparing a feasibility study containing economic evaluations, a technology assessment, equipment and reliability schedules, financial proposal with sources, legal agreements, and contracts. Again, the completed feasibility study should be submitted to the relevant government agency (the provincial planning commission for instance). During this period, the supervising government agency evaluates the feasibility study with other agencies, such as the electric power bureau, People's Bank of China, interior services, foreign currency control agencies, and foreign trade and cooperation agencies on aspects of the project. This step may also involve engineering and economic consultant firms to provide special analyses for the project. Table C.3 lists the required contents for the various reports submitted during the approval process.

Negotiations and the signing of joint-venture by-laws, articles, and related contracts proceed immediately after the feasibility study is approved. An initial design for the cogeneration project can also be started. This crucial negotiation stage reflects the interests and differences of both sides. Both mutual consideration and negotiation skills are required. The joint-venture by-laws and contracts become legal and enforceable once they are approved by the relevant foreign trade and cooperation agency. Any violations of the contract will be penalized based on the terms of the contracts. Contractual issues are settled either by a negotiation among partners, or if that is unsuccessful, an appeal for arbitration before the International Economic Arbitration Commission (IEAC) under the Ministry of Foreign Trade and Cooperation can be made. The decision made by the IEAC is the final judgment and no further appeal will be accepted. To improve the equity and quality of judgments, international specialists are invited to join the commission. Other arbitration agents can be selected with the agreement of both sides.

Once the joint-venture has received the necessary approvals, they must apply for a business license from the Industrial and Business Administration Bureau (IBAB) within 30 days. As we indicated above, other permits, such as environmental evaluations and permits, must be obtained before the start of plant construction. As an electricity and heat producer, the joint-venture has to sign contracts with utilities on generated electricity sales and back-up purchases, and with industrial consumers or wholesalers for heat/steam supply.

Table C.3
Required Content of Various Reports and Contracts for Joint Ventures

Item	Contents
1. Project Initial Report (pre-feasibility report)	Project requirements, size, estimated investment, investment and financing means and sources, initial economic evaluation, applications for favorable regulations, construction conditions, and key design points
2. Feasibility Study	Total investment, registration of equity capital, project demand and allocation, fuel supply, site conditions and selection criteria, assessment of adopted technology types, environmental protection issues, foreign and domestic capital arrangements, evaluations of economic, technical, financial,and other aspects
3. Equity Joint-Venture Contracts	Names, country and place of registration, purposes, shares and means of capital, terms for capital due, proportion and share of profits and losses, management system and staff appointments, technology and equipment adoption, fuel supply and heat/electricity sales contracts, deployment for foreign currency in and out-flows, financing principles, accounting and supervision, and joint-venture terms
4. By-Laws and Articles	Names and addresses, purposes and terms, total investment and registration of Equity Joint-Venture capital, proportions and shares of profits and losses, board of directors and its rights, management and obligations, principles for finance, accounting, and supervision
5. Contractual Joint-Venture Contracts	Names, nationalities and addresses for all partners, purposes of cooperation investment shares, production processes and operation means provided by partners, pricing for equipment and others, obligations, duties and rights for partners, allocation of profit shares, operation methods and management for finance, foreign currency, production, distribution, sale, purchase and control, terms of operation due, and ownership after dissolution
6. By-Laws and Articles of Contractual Joint-Ventures	Same as the by-laws for equity joint-ventures listed above

Source: Guidance for Chinese-Japanese Cooperation in power Development, Energy Research Institute, January 1993.

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