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# Foreign direct investment in China's power sector: trends, benefits and barriers

Allen Blackman[a,*], Xun Wu[b]

[a]Resources for the Future, 1616 P Street, NW, Washington, DC 20036, USA
[b]University of North Carolina at Chapel Hill, Department of Public Policy Analysis, Chapel Hill, NC 27599, USA

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## Abstract

Using data from an original survey of US private investors, official Chinese statistics, and other sources, we assess the volume and characteristics of FDI in China's power sector, its impact on energy efficiency, and the factors that limit this impact. Our five principal findings are as follows. First, the volume of FDI in China's power sector will likely fall short of the government's 1995 – 2000 capacity expansion target by a substantial margin, in part because of persistent institutional barriers to FDI. Second, to avoid the lengthy central government approval process for large plants and to minimize risk, early FDI tended to be in small-scale, gas- and oil-fired plants using imported equipment and located in coastal provinces. However, more recent FDI tends to be in larger coal-fired plants that use more Chinese equipment and tends to be located in the north as well as the east. Third, and perhaps most important, FDI is likely having a significant positive impact on energy efficiency. Almost a third of the 20 FDI plants in our survey sample use advanced efficiency-enhancing generating technologies, and a fifth are cogeneration plants. Fourth, the main factor that has hampered the contribution of FDI to energy efficiency is an institutional bias in favor of small-scale plants which are generally not as energy efficient as the large-scale plants. And finally, the most important institutional barriers to FDI generally are uncertainty associated with the approval process for FDI projects, electricity sector regulation, and the risk of default on power purchase contracts. © 2000 Elsevier Science Ltd. All rights reserved.

*Keywords:* Foreign direct investment; China; Electricity

## 1. Introduction

In the early 1990s, hoping to reduce chronic electricity shortages and enhance the productivity of Chinese power plants, China opened its doors to foreign direct investment (FDI) in electricity generation. China's efforts to attract FDI were met with a wave of enthusiasm. Hundreds of preliminary contracts for Sino-foreign joint ventures were drawn up. Yet, only a small fraction of these contracts have been realized. Moreover, many of the foreign-invested plants that have been built have not had the characteristics and impacts that the central government had hoped for.

China's success in attracting FDI into the power sector will have importance beyond boosting supply and enhancing productivity. China is the world's third leading source of greenhouse gas emissions and its power sector is responsible for almost a third of these emissions.[1] Hence, to the extent that FDI can enhance the energy efficiency of Chinese plants, it can reduce greenhouse gas emissions. Also, by improving energy efficiency, FDI can reduce emissions of conventional pollutants and can

* Corresponding author. Tel.:(202)-328-5073; fax: (202)-939-3460.
*E-mail address:* blackman@rff.org (A. Blackman)

[1] In 1996, China's emissions of carbon dioxide, the most important greenhouse gas, totaled 805 mtc, approximately 13% of the world's total (DOE, 1998). China's share of global emissions is expected to reach 15% by 2000 and 25% by 2050 (Rose *et al*., 1996). Power plants were responsible for approximately 183 million tons of carbon emissions in 1990, 29% of the country's total emissions (Zhai, 1993). This share will undoubtedly grow as the Chinese economy matures and new capacity is added. Since the vast majority of China's power plants will be coal-fired for the foreseeable future, improving energy efficiency, not fuel switching, will be the most practical means of abating greenhouse gas emissions.

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alleviate persistent coal supply and transportation problems.[2]

Thus far, the academic literature describing FDI in China's power sector has been thin.[3] The literature that does exist does not include detailed information on foreign investors' perceptions of the investment climate, on the volume and characteristics of FDI, or on the energy efficiency of FDI plants. This paper attempts to fill this gap by marshaling data from a variety of sources including an original survey of US private investors, official Chinese statistics, and trade journals. We address four specific questions regarding FDI in China's power sector:

- What have been its volume and characteristics?
- What has been its impact on energy efficiency?
- What factors limit this impact?
- What factors constrain FDI in the power sector generally?

The paper is organized as follows. The second section provides background information on the location, size, type, and efficiency of existing Chinese plants and on the supply and demand for electricity. The third section discusses the need for foreign investment in the power sector; popular institutional structures for FDI; the volume, origin, and location of FDI; the gap between contracted and realized foreign investment; and institutional barriers to FDI. The fourth section presents survey data on American investment in the power sector. The final section sums up and concludes.

## 2. Background

### 2.1. Location, type, size of power plants

China's power sector, comprised of approximately 12,000 plants with an installed capacity of over 220 GW, is the second largest in the world (Basic Statistics of Industrial Enterprises, 1996). Sixty-five percent of China's generating capacity is concentrated in relatively industrial and heavily populated East, South-Central, and Southwest regions (Table 1).

Seventy-five percent of China's generating capacity is thermal and the vast majority of the remainder is hydroelectric (Table 1). Ninety percent of all energy in the power sector is coal-derived, a fact that explains the power sector's importance as a source of $CO_2$ emissions (Tunnah *et al*., 1994).[4] Less than 1% of China's electric capacity is gas-fired. China has substantial gas reserves located offshore and in the Southwest and Northwest regions but lacks the infrastructure needed to exploit them.

Table 1
Location and type of installed generation capacity (1995)

| Region[a] | Hydro % | Thermal % | Other % | All % |
|---|---|---|---|---|
| North | 4 | 96 | 0 | 15 |
| Northeast | 17 | 83 | 0 | 12 |
| East | 14 | 86 | 0 | 29 |
| S.-Central | 34 | 63 | 2 | 26 |
| Southwest | 54 | 46 | 0 | 10 |
| Northwest | 37 | 63 | 0 | 8 |
| All | 23 | 75 | 2 | 100 |

[a]Definition of regions: North (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia); Northeast (Liaoning, Jilin, Heilongjiang); East (Shanghai, Jianngsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong); South-central (Henan, Hunan, Hubei, Guangdong, Guangxi, Hainan); Southwest (Sichuan, Guizhou, Yunan, Xizang); Northwest (Shannxi, Gansu, Qinghai, Ningxia, Xinjiang).
(Source: The Yearbook of Electric Power in China, 1995.)

Hydroelectric capacity is fairly limited, accounting for 23% of total capacity and mainly located in the western and southern regions. Although China's exploitable hydropower reserves, estimated at 380 GW, are regarded as the world's largest, less than 10% of these reserves have been developed (IPPQ, 1998 II). China plans to build many large hydropower plants in the next 20 years including the 18 GW Three Gorges project.

China's two operational nuclear plants in the coastal provinces of Zhejiang and Guangdong have a combined capacity of 2.1 GW, less than 1% of the country's total capacity. China plans to add a total of 20 GW in new nuclear capacity by 2010 (DOE, 1998).

Even by developing country standards, the average unit size in China is quite small. Fully 40% of generating capacity is in units smaller than 100 MW and only 23% of capacity is in units larger than 300 MW (Table 2). By comparison, in most industrialized countries 60–80% of capacity is in units larger than 300 MW (Murray *et al*., 1998).

A sizable percentage of electricity demand is met by private-use generators (these generators are not counted

[2] Power plants are a leading source of pollution in China. In 1994, they were responsible for 28% of the total emissions of particulates and 32% of total emissions of sulfur dioxide (Battelle, 1998).

[3] Two recent articles that discuss FDI in the Chinese power sector are Li and Dorian (1995) and Murray *et al*. (1998). The latter includes a discussion of two topics that are outside the scope of the present paper: non-direct foreign investment and the impact of foreign investment on pollution control.

[4] The power sector consumed 430 million tons of coal in 1995, a quarter of the country's total consumption. Consumption is expected to rise to 600 million tons by 2000, and 960 million tons by 2010 (Johnson *et al*., 1996).

Table 2
Size and origin of generating units (1995)

| Capacity (MW) | No. units | Installed capacity (GW) | % total installed capacity | % units imported |
|---|---|---|---|---|
| 300 + | 147 | 51.9 | 24 | 38 |
| 200–299 | 202 | 41.8 | 19 | 13 |
| 100–199 | 318 | 36.8 | 17 | 13 |
| 50–99 | 402 | 22.2 | 10 | 22 |
| 25–49 | 577 | 16.3 | 8 | 25 |
| 12–24 | 955 | 12.5 | 6 | 21 |
| 6–11 | 1,575 | 11.5 | 5 | 37 |
| 0–5 | [a] | 24.2 | 11 | [a] |
| All | 4,176[b] | 217.2 | 100 | 24[b] |

[a] Missing.
[b] For units larger than 6 MW.
(Source: The Yearbook of Electric Power in China, 1995.)

Table 3
Generating capacity and output, 1981–1995; targets 2000–2020

| Year | Total capacity (GW) | New capacity (GW) | Generation (TW h) |
|---|---|---|---|
| 1981 | 69.1 | 3.3 | 309.3 |
| 1982 | 72.4 | 3.2 | 327.7 |
| 1983 | 76.5 | 4.1 | 351.4 |
| 1984 | 80.1 | 3.7 | 377.7 |
| 1985 | 87.1 | 6.9 | 410.7 |
| 1986 | 93.8 | 6.8 | 449.6 |
| 1987 | 102.9 | 9.1 | 497.7 |
| 1988 | 115.5 | 12.6 | 545.1 |
| 1989 | 126.7 | 11.1 | 584.7 |
| 1990 | 137.9 | 11.3 | 621.3 |
| 1991 | 151.5 | 13.6 | 677.5 |
| 1992 | 166.5 | 15.1 | 754.2 |
| 1993 | 182.9 | 16.4 | 836.4 |
| 1994 | 199.9 | 17.0 | 927.9 |
| 1995 | 217.2 | 17.3 | 1006.9 |
| 1996 | 236.5 | 19.3 | 1079.4 |
| Target 2000 | 290 | 14.6[a] | 1400 |
| Target 2010 | 525 | 23.5[a] | |

[a] Average annual change required over previous 5 or 10 years.
(Source: Tan, 1997.)

as power plants Tables 1 and 2). Although most private-use generators are smaller than 1 MW, many are larger. In fact, over 7% of all power plants larger than 6 MW are for private-use (The Yearbook of Electric Power in China, 1995).

Approximately 24% of China's generating units are imported (Table 2). This proportion is higher for very large and very small units. Large units tend to be imported because China lacks the technological capability to build generators larger than 350 MW. Small units tend to be imported because small plants frequently install imported diesel equipment.

### 2.2. Power demand and supply

During the last 20 years, the rapid pace of economic development in China has fueled an equally rapid growth in electricity demand. Between 1980 and 1996 electricity demand increased by 258%, from 301 to 1079 TW h (Tan, 1997). The growth in demand has stemmed not only from a rapid increase in the total volume of economic activity but also from the mechanization of agriculture, rural electrification, and the proliferation of electric appliances and electricity-intensive industrial activities such as petrochemicals manufacturing. Using 1996 as a baseline, demand is projected to increase by 29–36% by 2000, by 107–164% by 2010, and by 220–340% by 2020 (Battelle, 1998).[5]

Not surprisingly, electricity supply has often failed to keep up with demand. In 1997, on the eve of the Asian financial crisis, supply fell 15–20% short of demand (DOE, 1998). The economic value of power shortages has been substantial. In 1993, $27.6 billion of industrial value added was lost due to power shortages, the equivalent of 7% of GDP (Li and Dorian, 1995).

Supply and demand conditions have varied regionally and temporally. The most severe shortages have been in the East, Northwest, and Central regions and in the Southwest region outside of Guangdong. Shortages have occurred mainly during peak periods of demand. China has few "peaking plants" devoted specifically to providing power during high-demand periods (IPPQ, 1998 II; O'Neill, 1997).

Recently, economic downturns associated with the Asian financial crisis, coupled with capacity expansion and power conservation measures have eliminated or greatly mitigated power shortages. In fact, some regions currently have an oversupply of generating capacity. However, given projections for continued rapid growth in electricity demand, oversupply in many regions is expected to be a relatively short-term phenomenon (Department of Energy, 1999).

During the early 1990s, China's central electric power authorities — formerly the Ministry of Electric Power (MEP) and now the State Power Corporation — developed ambitious plans to expand generating capacity to 290 GW by 2000, and 525 GW by 2010 (Tan, 1997).[6]

[5] In 1994, heavy industry accounted for 60% of electricity demand; light industry 15%, residential users 10%, agriculture 6%, public and commercial users 7%, and transportation and communication 2% (MEP, 1995).

[6] In March 1998, the Ministry of Electric Power was abolished. Most of its functions have been assumed by the State Power Corporation.

Table 4
Energy efficiency: average FDI sample plant heat rates versus targets for all Chinese plants, averages for new Chinese plants, and averages for new US plants

| Unit size (MW) | Gross heat rate (gCE/kW h) | | | | | |
|---|---|---|---|---|---|---|
| | Sample FDI avg. (n) | Chinese targets[a] | | | New[b] Chi. avg. (n) | New[c] US avg. (n) |
| | | 1995 | 2000 | 2010 | | |
| 500–600 | 282 (2)[d] | 364–380 | 353 | 348 | n/a | 358 (5) |
| 250–350 | 335 (2) | 375–380 | 353 | 348 | 378 (8) | 370 (1) |
| 125 | 327 (3)[e] | 402–435 | 424 | 413 | 432 (2) | 387 (2) |
| 0–50 (high pr.) | 351 (8)[f] | 467–478 | 457–467 | n/a | n/a | 412 (488) |
| All | 338 (15) | | | | | |

[a]Assuming 8% internal use rate.
[b]Plants with uniform unit sizes fitting the definition of 'large industrial enterprise' built between 1982 and 1992.
[c]US Plants with uniform unit sizes built between 1985 and 1995.
[d]Both units are larger than 600 MW.
[e]Includes one 115 MW combined cycle gas turbine (CCGT) unit.
[f]Includes three CCGT plants, one integrated gasification combined cycle (IGCC) plant, and one circulating fluidized bed (CFB) plant.
(Sources: Survey; MEP, 1993; Tunnah *et al.*, 1994; DOE, 1995.)

These targets imply that an average of 14.6 GW of new capacity per year must be added from 1996 to 2000 (the equivalent of three 400 MW plants per month), and 23.5 GW per year must be added from 2001 to 2010 (Table 3). The PRC made expansion of capacity in Central and Western regions an explicit goal for the year 2000 and beyond. Since 1980, China has installed over 150 GW of new capacity and growth has been accelerating (Table 3). In 1996, a record high 19.3 GW were installed.

### 2.3. *Energy efficiency*

The energy efficiency of power generation in China is quite low by industrialized country standards. The average thermal efficiency of China's power plants is 25–29% compared to rates of 35–38% in industrialized countries (Worldwide Electric Power Industry, 1996; Murray, 1998).

The low-energy efficiency of Chinese power plants is due to at least five factors. First, as described above, Chinese plants are quite small by international standards. For technical reasons, small thermal plants are rarely as efficient as large ones. The average thermal efficiency of China's smallest plants is roughly half that of its largest plants (Tunnah *et al.*, 1994). The prevalence of small plants is largely an historical artifact. As late as 1987, 86% of China's total generating capacity was comprised of plants smaller than 100 MW (Battelle, 1998). Widespread electricity shortages have caused small units to be kept on line as long as possible and new small plants to be built to meet urgent local needs. Second, even controlling for unit size, equipment used in Chinese plants is often relatively inefficient. In Chinese thermal plants in 1995, the percentage of electricity generated used internally (an indicator of efficiency) averaged 8%, 2–4 percentage points higher than the average in industrialized countries (The Yearbook of Electric Power in China, 1995; Sathaye, 1992.) The inefficiency of Chinese equipment is partly due to its age. Also, in the past, generating units made in China were simply not as efficient as those made abroad. As recently as the late 1980s, some 200 MW Chinese units had heat rates 10% higher than comparable sets made in industrialized countries (Sathaye, 1992).[7] Third, Chinese coal is generally of poor quality. Average ash content is 17% (versus 10% in the United States) so heating value is low (Hoppe, 1997). Northern coal is better quality than southern coal, and as a result, massive amounts of coal are shipped from the north to the south. Fourth, as noted above, China has relatively few peaking plants. As a result, power plants often run at less than full capacity during slack periods or

[7] Since this time, the quality of Chinese equipment smaller than 300 MW has improved. According to one trade journal, Chinese units smaller than 300 MW are now comparable in quality with those of Western manufacture (Starke, 1997). The willingness of international banks to provided limited recourse financing for Sino-foreign joint venture power projects that use Chinese equipment exclusively (e.g., the Changsha project described in Section 3.4) lends credence to this view.

are cycled on and off, practices that greatly reduce efficiency. Finally, for a variety reasons including a lack of competitive market pressures, bureaucratization, and bottlenecks in transmission and distribution, the management of many Chinese plants is suboptimal. The efficiency gains from adopting the management practices of industrialized countries are on the order of 2–4% (Yang, 1997).

Chinese power authorities have made improving generating efficiency a priority. Their plans call for increasing the average thermal efficiency of power generation to 33% by 2000 and 35% in 2010 by shutting down small plants, introducing high-efficiency units, and retrofitting or eliminating low-efficiency units (Li and Dorian, 1995). A 1994 report on energy efficiency prepared by the MEP in partnership with the United Nations and World Bank included ambitious energy-efficiency targets (Table 4). More recently, the Ninth Five Year Plan (1996–2000) sets forth a number of specific energy efficiency strategies including: replacing 8 GW of small units with 12 GW of large ones and encouraging the diffusion of cogeneration and advanced generating technologies (Tan, 1997). It will prove helpful to provide some background on the last strategy.

The four principal types of advanced thermal generating technologies are atmospheric fluidized-bed combustion (AFBC), pressurized fluidized-bed combustion (PFBC), integrated gasification combined cycle (IGCC), and combined cycle gas turbine (CCGT). All enhance efficiency. The two fluidized-bed technologies combust coal mixed with gases. The more advanced PFBC units operate at thermal efficiencies 40–42% as compared to 36–38% efficiencies of large conventional pulverized coal steam turbines. China currently has hundreds of domestically produced small AFBC units in operation as well as a number of larger imported units. It also has built small- and medium-sized PFBC demonstration units. IGCC technologies use gasified coal in combination with gas turbines to achieve efficiencies of 43%. CCGT technologies use natural gas or oil in combination with gas turbines and achieve efficiencies in excess of 50%. China does not currently have the capacity to manufacture IGCC or CCGT units domestically. However, it has bought and licensed 29 CCGT units. Except for CCGT, all of these advanced technologies have capital costs that are significantly higher than those for conventional coal-fired technologies (Battelle, 1998; Hoppe, 1997).[8]

Thus far, China's progress in improving energy efficiency in the power sector has been less than hoped for. Although 170.6 GW of new thermal power was added between 1980 and 1995 — a 259% increase — the average net heat rate for all plants only fell by only 8.7% from 448 gCE/kW h to 412 gCE/kW h and the percentage of electricity used internally stagnated at roughly 8% (Tan, 1997; The Yearbook of Electric Power in China, 1995; Tunnah *et al*., 1994).[9] Clearly, capacity expansion alone will not lead to significant reductions in energy efficiency. Indeed, the composition of recent investments has been less than ideal from the perspective of energy efficiency. For example, fully 14% of capacity added in 1995 was in units smaller than 6 MW (versus 13% nationwide; The Yearbook of Electric Power in China, 1995).

## 3. FDI in China's power sector

### 3.1. Requirements

In the early 1990s, it was widely believed that to meet its ambitious capacity expansion targets, China would need to attract foreign investment for two reasons. First, China lacked the manufacturing wherewithal to supply the needed generating equipment. Its production capacity was estimated at between 9 and 12.5 GW per year, significantly lower than yearly expansion targets of 14.6–23.5 GW (Dorian, 1995; Murray *et al*., 1998). More important, China lacked the required financial resources. Power authorities estimated that China would only be able to finance 80% of the investment needed to meet its year 2000 capacity target with domestic resources (Shi, 1997). This implied that a total of 18 GW of new foreign-funded capacity would be needed between 1996 and 2000. Assuming average capacity costs of $US 600 to 800 per kW, the total capital required would be $US 11 to 14 billion.

Traditionally, China had relied on public sector sources to supply foreign capital for the power sector. From 1979 to 1996, overseas sources invested approximately $14.3 billion in the Chinese power sector, approximately 10% of the total investment during that period (Tan, 1997). Eighty-five percent of the foreign funds were provided by foreign governments and multilateral lending institutions like the World Bank and Asian Development Bank (Dorian, 1995). Given the volume of funds required, these sources were seen as inadequate. The foreign capital needed between 1995 and 2000 was at least as great as the total amount of capital received from public-sector sources from 1979 to 1996. In addition, the short-time horizon envisioned by Chinese planners was

[8] According to Battelle (1998) capital costs (in US$ per kilowatt) for different technologies are: subcritical steam pressure conventional coal-fired, $603-63; super-critical steam pressure conventional coal-fired, $663-724; IGCC, $1,327; PFBC, $1,327; conventional CCGT, $603; and advanced CCGT, $850.

[9] Heat rates indicate the amount of energy consumed per unit of electricity generated. Net heat rates do not count electricity used by generating plants as output, while gross heat rates do. We use grams of coal equivalent (gCE) to measure energy. One metric ton of coal equivalent contains 20.9 gigajoules.

not compatible with the lengthy planning and approval processes associated with public sector funding. Thus, foreign direct investment was seen to be needed to cover expected financing short falls.

But FDI was not only attractive as a source of funds. As noted in the introduction, it has the potential to enhance energy efficiency by expediting the transfer of advanced generating technologies and management techniques and by introducing competition into a sector that has always been a bastion of state control.

Recognizing these needs and benefits, the central government made attracting FDI an explicit goal. In the mid-1990s it undertook a number of measures either designed explicitly to attract FDI into the power sector or that had that effect, including: raising electricity tariffs in August 1993; hosting a conference designed to attract FDI in May 1994; reforming foreign exchange in January 1994; initiating a sweeping reform of electricity regulation (the Law on Electric Power) including rules governing FDI in December 1995; issuing a notice for tendered Build-Operate-Transfer projects in August 1995; and creating the China Power Investment Corporation to raise international capital for power projects in late 1995 (Petroleum Economist, 1996). These actions resulted in a flurry of activity. Dorian (1995) estimates that by 1995 there were 400–500 FDI projects in various stages of negotiation.

### 3.2. Institutional arrangements

The institutional arrangements available for FDI in the Chinese power sector are: cooperative joint ventures, wholly owned foreign ventures, equity joint ventures, build-operate-transfer (BOT) projects, build-operate-own (BOO) projects, commercial loans, and stock and bond investments in existing Chinese power enterprises (Turner, 1997a).

Cooperative joint ventures accord foreign investors more control than equity joint ventures but less than wholly owned joint ventures. The advantage of cooperative joint ventures compared to wholly owned joint ventures is that they generally facilitate intangible but critical political alliances as well as more secure access to scarce inputs like fuel, foreign exchange and expertise. Foreign firms undertaking cooperative joint ventures usually do so with local power bureaus or other local governmental authorities.

BOT contracts, which have become increasingly popular in recent years, call for a foreign firm to finance, design, and construct a plant, to operate it for a fixed term, and then to turn it over to the state. The first BOT power project (Shajio B in Guangdong, a $2 \times 350$ MW coal-fired plant) was completed in 1987 by Hopewell, a Hong Kong firm and was to be turned over to China in 1997. BOT projects can be cooperative joint ventures, equity joint ventures, or wholly owned ventures.

Private entities generally provide commercial loans at less favorable terms (higher interest rates and shorter terms) than public sector sources. Loans are either made directly to a Chinese power company or are channeled through a Chinese bank.

### 3.3. Volume, origin, size, and location of FDI plants

Despite considerable efforts to attract FDI in the mid-1990s, actual levels of FDI in Chinese power generation have been moderate. By June 1998, 24 FDI plants with a combined capacity of 4.9 GW were in operation, and another 12 plants with a combined capacity of 9.0 GW were under construction (Table 5).[10]

Given that a power plant usually takes two to four years to build, only projects that have already begun construction are likely to be brought on-line by 2000. Therefore, at most, 14 GW of FDI-financed new capacity will have been added by 2000. But 8.9 GW of this investment was contributed by Chinese partners in cooperative joint ventures or was built before 1995. Hence, FDI will likely fall well short of the implicit target of 18 GW of foreign invested capacity between 1995 and 2000. Given the pace of foreign investment in the mid-1990s and the lag between project approval and operation, this shortfall would very likely have occurred even without the downturn in electricity demand that resulted from the Asian financial crisis (which began in the summer of 1997).

US companies are clearly the dominant players in FDI in the Chinese power sector. They are responsible for 25 of the 36 plants in operation and under construction (Table 5). The market is somewhat concentrated. Nineteen firms have projects that are in operation or under construction. Four of these firms — AES China Generating Co. Ltd., Sithe China Holdings, Coastal Power Production Co., and Consolidated Electric Power Asia — account for roughly half of the projects.

Over 60% of operational FDI power plants are smaller than 100 MW (Table 6). Plants under construction tend to be much larger. Over 40% are larger than 300 MW. Small plants are attractive to some foreign private investors because they do not require central government approval, require less capital, involve less risk, and can be built relatively quickly. The increase in plant size over time reflects changes in the government policy towards FDI in the power sector, changes in the investment environment, and the increasing experience and confidence of investors. We explore these issues in more detail in Section 3.4.

FDI plants in operation are heavily concentrated in eastern coastal provinces (Table 7). Two provinces alone

[10] Assuming a range of development cost of \$600–\$800 per kW h, and an average foreign share of 50%, total foreign investment in FDI projects that have come on line since 1995 or that are under construction is \$3.9–5.2 billion.

Table 5
FDI power plants in China[a]

| Developer | Country | Type | Size (MW) | Total ($US m) | For. shr. (%) | Location | Op. Date |
|---|---|---|---|---|---|---|---|
| *In Operation* | | | | | | | |
| AES China Gen. Co. Ltd. | USA | oil | 15 | 9.2 | 25 | Guangdong | 1996 |
| AES China Gen. Co. Ltd. | USA | hydro | 26.5 | 14.7 | 51 | Hunan | 1996 |
| AES China Gen. Co. Ltd. | USA | oil | 63 | 29.5 | 55 | Jiangsu | 1997 |
| AES China Gen. Co. Ltd. | USA | coal | 250 | 118 | 25 | Anhui | 1996 |
| AES China Gen. Co. Ltd. | USA | gas | 48 | 29.8 | 35 | Sichuan | 1998 |
| AES China Gen. Co. Ltd. | USA | coal | 50 | 30.4 | 70 | Sichuan | 1998 |
| AES China Gen. Co. Ltd. | USA | oil | 116 | 60 | 70 | Anhui | 1997 |
| AES China Gen. Co. Ltd. | USA | coal | 250 | 151.3 | 70 | Henan | 1998 |
| Coastal Power Pdn. Co. | USA | diesel | 40 | 26 | 60 | Jiangsu | 1997 |
| Coastal Power Pdn. Co. | USA | diesel | 72 | 43 | 80 | Jiangsu | 1997 |
| Coastal Power Pdn. Co. | USA | gas | 76 | | 60 | Jiangsu | 1996 |
| Cons. Electric Power Asia | USA | coal | 700 | 526 | 50 | Guangdong | 1987 |
| Cons. Electric Power Asia | USA | coal | 1980 | 1,870 | 27 | Guangdong | 1995 |
| Enron Global Power | USA | gas | 150 | 150 | 50 | Hainan | 1996 |
| GE Capital | USA | gas | 400 | 250 | 30 | Shanghai | 1997 |
| IES | USA | coal | 36 | 26 | 50 | Zhejiang | |
| Illinova Generating | USA | coal | 24 | 11 | 60 | Zhejiang | 1992 |
| Intraco | USA | coal | 10 | | | Jiangsu | 1998 |
| Sithe China Holdings | France | oil | 66 | | 48 | Guangdong | 1996 |
| Maeda, et al. Trading Co. | Japan | gas,dl | 173 | | | Hainan | 1994 |
| National Power Intl. | UK | coal | 65 | | 80 | Anhui | 1997 |
| National Power Intl. | UK | coal | 65 | | 68 | Shejiang | 1997 |
| National Power Intl. | UK | coal | 50 | | 70 | | |
| National Power Intl. | UK | coal | 145 | | 70 | Hubei | 1996 |
| *Under Construction* | | | | | | | |
| AEP Resources Intl. | USA | coal | 250 | 172 | 70 | Henan | |
| AES China Gen. Co. Ltd. | USA | coal | 2100 | 1600 | 25 | Shanxi | 2000 |
| CEA | USA | coal | 600 | 216 | 30 | Gansu | |
| Combined Energy Cos. | USA | coal | 50 | | | Henan | |
| Entergy | USA | coal | 24 | | 92 | Jiangsu | |
| New World Power Corp. | USA | hydro | 39 | | 12 | Fujian | 1998 |
| Panda Energy International | USA | coal | 100 | 155.2 | | Hebei | 1999 |
| Sithe China Holdings | France | coal | 100 | 128.4 | 40 | Hebei | |
| Sithe China Holdings | France | coal | 45 | | 80 | Jiangsu | |
| Siemens AG | GDR | coal | 750 | 650 | 25 | Shandong | 1999 |
| Siemens AG | GDR | coal | 1320 | 1000 | 25 | Hebei | 2000 |
| Formosa Plastics Group | Taiwan | coal | 3600 | 3800 | | Fujian | |

[a]We do not count investment from Hong King companies as foreign investment since Hong Kong returned to mainland China in July 1997. (Source: International Private Power Quarterly, 1998 II, Survey.)

— Jiangsu in the East region and Guangdong in the South-Central region — account for nine of the 24 plants in operation. FDI plants under construction are more evenly distributed geographically. Over 40% are located in the North or Northwest regions. Investors' location choices are influenced by, among other things, electricity demand, ease of doing business, and proximity to fuel supplies. For example, in Guangdong, which has attracted a large amount of FDI, electricity supply fell 20–30% short of demand for several years in the early 1990s (Li and Dorian, 1995). Also, the province is quite close to Hong Kong and boasts an abundance of 'western' business amenities. Recently, northern provinces such as Shanxi and Gansu have attracted considerable FDI. In part, this is due to reductions in shortages in the eastern coastal provinces and to the government's policy of encouraging mine-mouth generating plants to reduce pressure on the rail transportation system.

Only about half of the operational FDI plants are coal-fired (Table 8). The bias against coal-fired plants is partly due to the fact that largely imported gas- and oil-fired plants tend to be small and relatively easy to finance and build. In addition, several eastern coastal provinces where electricity demand is strongest do not have easy access to the coal. This bias is clearly diminish-

Table 6
Size of FDI power plants

| Size (MW) | In operation | Under construction |
|---|---|---|
| 300 + | 3 | 5 |
| 200–299 | 2 | 1 |
| 100–199 | 4 | 2 |
| 50–99 | 8 | 1 |
| 0–49 | 7 | 3 |
| All | 24 | 12 |

(Source: International Private Power Quarterly, 1998 II, Survey.)

Table 7
Location of FDI power plants

| Region | In operation | Under construction |
|---|---|---|
| North | 0 | 4 |
| Northeast | 0 | 0 |
| East | 12 | 5 |
| South-Central | 10 | 2 |
| Southwest | 2 | 0 |
| Northwest | 0 | 1 |
| All | 24 | 12 |

(Source: International Private Power Quarterly, 1998 II, Survey.)

Table 8
Type of FDI power plants

| Type | In operation | Under construction |
|---|---|---|
| Coal-fired (⩾ 200 MW) | 4 | 6 |
| Coal-fired (< 200 MW) | 9 | 4 |
| Gas-fired | 4 | 0 |
| Oil-fired | 6 | 1 |
| Hydro | 1 | 1 |
| All | 24 | 12 |

(Source: International Private Power Quarterly, 1998 II, Survey.)

ing. Half of the FDI plants under construction are large coal-fired plants.

FDI power plants in operation and under construction represent a small percentage of projects for which a formal agreement or contract has been signed. By 1994, at least 50 projects were awaiting the approval of the State Planing Commission and 400–500 projects were in various stage of negotiation (Tyler, 1994; Walker, 1994). There is clearly a sizable gap between contracted and realized FDI in the power sector. We discuss the institutional factors that account for the low conversion rate of contracted power projects in the next section.

### *3.4. Institutional barriers to FDI*

Institutional factors have weighed heavily in the decisions of private foreign investors. The central government intentionally put in place three "barriers" to FDI — ownership restrictions, rate of return restrictions, and project approval requirements — in order to limit foreign ownership of strategic infrastructure and, perhaps more important, to limit local control of FDI. After the central government opened the door to private investment in the power sector in 1993, concerns arose that foreign investors would negotiate unacceptably favorable terms with local governments which had strong incentives to both alleviate chronic power shortages and to raise revenue through Sino-foreign joint-ventures. The central government was also concerned about the impact that FDI projects might have on foreign exchange outflows and inflation (IPPQ, 1995 III). It refused to approve a single joint venture power plant for almost two years, from December 1992 to November 1994, holding up the construction of 50 projects (Tyler, 1994).

As discussed below, many of the most onerous ownership, rate of return, and regulatory restrictions have eased in the last two to three years, perhaps because they occasioned an unforeseen drop-off in FDI. The central government probably overestimated the enthusiasm of foreign investors early on, thinking that the initial surge of interest reflected sizable expected profits that would be robust to regulatory restrictions.

#### *3.4.1. Ownership restrictions*

The March 1994 "Interim Regulations for the Use of Foreign Investment for Power Projects", the first comprehensive attempt to codify rules governing FDI, mandated that Chinese partners in non-BOT joint ventures maintain a controlling interest in plants with a unit capacity larger than 299 MW or a total capacity larger than 599 MW. Wholly owned foreign ventures of any scale were allowed. Also, foreign entities were not permitted to own more than 30% of existing plants (Petroleum Economist, 1996). Given these regulations, foreign investors wanting to build large plants were left with two choices — minority control or full ownership — neither of which was ideal. Minority ownership created difficulties with shareholders, while full ownership precluded strategic alliances with Chinese partners. Ownership restrictions have eased in the last two years. Foreign partners in joint ventures are now allowed to have a controlling interest in all type of plants except nuclear plants and hydro plants larger than 250 MW.

#### *3.4.2. Rate of return restrictions*

Beginning in 1993, the State Planning Commission, which must approve all FDI projects costing more than $30 million, stopped approving projects with rates of return in excess of 12% and later 15%. Although rate of return caps on FDI power projects are not uncommon in developing countries, the Chinese cap was set at an unusually low level given the risks involved. In other Asian countries, rates of return in excess of 20% are the norm (Tyler, 1994; Lucas, 1994). The rate of return cap has had at least two impacts. First, many foreign investors have lost interest completely. And second, a bias has been created in favor of small-scale projects that do not need central government approval (Engardio and Einhorn, 1994, see discussion of government approval below).

Like ownership restrictions, rate of return restrictions have been relaxed. The present 15% cap is recognized to be "soft". Power authorities will allow higher returns when projects have attractive qualities such as the use of advanced technologies (Shi, 1997).

*3.4.3. Project approval requirements*

As proposals for FDI projects flooded into the PRC in the early 1990s, it quickly became apparent that there was no established process for government review and approval. Although the process has solidified since then, it remains ill-defined and time-consuming, lasting anywhere from 18 to 60 months. Deutsche Morgan Grenfell, a leading emerging markets investment banker, has described it as "tortuous" (Su, 1997).

As outlined in "Regulation for Utilization of Foreign Capital in China's Power Industry" published in August 1997, the approval process has three components: project establishment, final industry approval, and Ministry of Foreign Trade and Economic Cooperation (MOFTEC) approval.[11] The project establishment phase begins with submission of initial documentation to a lower level (municipal, county, or local) office of the power authority.[12] This office coordinates the review of the documents with outside governmental organizations (e.g., offices of environmental protection, fuel supply, construction, and planning), the most arduous and time-consuming part of the approval process. If project establishment is approved by local-level authorities, it may then require approval by the central government, namely by the central offices of the power authority, the State Planning Commission, MOFTEC, and the State Council. The power authority unofficially requires central approval for all projects larger than 25 MW; MOFTEC requires it of all projects costing more than \$30 million; and the State Council requires it of all joint ventures costing more than \$100 million. This policy has created incentives for foreign investors to build less-efficient small plants and/or to split projects into smaller phased projects. Aware that such investments undermine its energy efficiency goals, the central government has made it a point to discourage the building small-scale FDI projects (Tan, 1997).[13]

The second phase of the approval process begins with the submission of a detailed feasibility study report.[14] This report must pass through the same lengthy vetting process as the preliminary report.

The third and final phase of the approval process is review by the MOFTEC that focuses on enforcing compliance with relevant joint venture laws and regulations. Projects smaller than \$30 million need only obtain approval at the local branches of the ministry.[15]

The central government continues to use the approval process to encourage certain types of investment. The Ninth Five-Year Plan calls for "giving priority" to FDI projects that: (i) use domestic equipment; (ii) use domestic contractors and managers; (iii) are located in less developed Central and Western regions; (iv) are low-cost; and (v) are environmentally friendly, especially those that involve new technologies.

*3.4.4. Inefficiencies associated with state control*

State control of the power sector implies numerous rigidities and inefficiencies that discourage FDI (see, e.g., Shao *et al*., 1997). During the 1990s, the power authority has sought to move towards a decentralized

[11] This description is based on Turner (1997a). Complied by the MEP, the "Regulation for Utilization of Foreign Capital in China's Power Industry" is comprised of a number of relevant regulations including "Certain Provisions of Foreign Investment Power Projects," (March 20, 1997); "Interim Provision on the Application and Approval Procedures for Power Projects with Foreign Direct Investment," (December 9, 1996); and "Interim Measures on Standardizing the Administration of Power Purchase Contracts" (September 29, 1996).

[12] Initial documentation consists of a "preliminary feasibility study report" which outlines the financial, technical and contractual elements of the project, and for projects where a foreign partner has already been identified, a "letter of intent" and a "project proposal" which outline the division of responsibilities between the Chinese and foreign partners.

[13] This explicit policy has been reinforced by experiences of foreign investors who have avoided central government approval by building small plants. Many have found lack of central government approval makes it more difficult to secure the cooperation of stakeholders such as fuel suppliers and power agencies and to obtain bank credit (Turner, 1997a).

[14] The feasibility study report includes technical specifications of the plant as well as agreements on power purchase, grid access and dispatch, electricity tariffs, foreign currency, exchange rates, and the division of management responsibilities and technical specifications.

[15] A testament to the magnitude of the costs imposed by the approval process is the length to which foreign investors are willing to go in order avoid one component of it — central government approval. For example, an April 1997 joint venture project headed by Panda Energy International structured a \$155 million $2 \times 50$ coal-fired project as four separate joint ventures: one owns the steam and water facilities, a second owns the land and transmission lines, a third owns one of the generating units, and a fourth owns the other generating unit. Although this byzantine set up creates tremendous accounting and administrative burdens, Panda preferred it because it ensured that all of the joint ventures fell below the \$30 million threshold for central government approval (Nordlund, 1997).

market-based structure. The 1995 Electric Power industry Law established a legal basis for this transformation. In January 1997 the central government created the State Power Corporation and in March 1998 it disbanded the MEP. Although in practice this change has been largely superficial — many offices contain essentially the same personnel — in theory, it was meant to facilitate the separation of ownership and regulation, a critical first step towards decentralization and eventually elimination of the state monopoly. In the mean time, however, uncertainty about the timing and content of reform exacerbates risks for foreign investors.

### *3.4.5. Foreign Exchange*

FDI projects need to be able to convert revenue earned in RMB into domestic currency in order to meet debt and profit distribution obligations. As a result, they run two types of risks: price risk and quantity risk. The first is the risk that the RMB will depreciate so that real revenues fall. The second is the risk that sufficient quantities of foreign currency will not be available when needed. Until January 1994, China had an officially pegged exchange rate, and quantity risk was paramount. The elimination of the official exchange rate in 1994 has greatly mitigated this problem.

In January 1994, China instituted a number of related foreign exchange reforms. Until 1994, paying foreign entities in foreign currency was the primary means by which the availability of foreign exchange was guaranteed. This was accomplished via so-called "swap centers". The January 1994 reform prohibited the settling of transactions in foreign currency and eliminated the swap centers. Now, foreign firms must use a network of banks which provide foreign exchange subject to the annual approval of the State Administration of Exchange Control (SAEC). The central government no longer guarantees that sufficient foreign exchange will be available. However, it has stated that infrastructure projects approved by the State Planning Commission will have priority access to foreign exchange. Moreover, investors are able to get "quasi-guarantees" from quasi-official agencies or corporations.

There is general agreement that the recent reforms have reduced foreign exchange risks. Yet, such risks continue to be an important concern for foreign investors since creditors often insist on assurances that foreign exchange will be made available.

### *3.4.6. Electricity pricing*

FDI projects depend critically on electricity prices which are state controlled, generally at below-market levels. Although China's ultimate goal is to have a single market-based price for all users on each power grid by 2000, today a complex system of subsidies remains in place (for a description, see Shao *et al.*, 1997). Pricing depends on the vintage of the power plant and on the type of consumers.[16] In coastal provinces, average prices are 10–15% below long-run marginal cost. In interior provinces, they are 30% or more below marginal cost (IPPQ, 1998 II).

Piecemeal reforms of the pricing system began in 1985. The December 1995 Law on Electric Power codified and extended these reforms. Under this law, FDI plants are free to negotiate prices with power purchasers subject to state approval. According to the central power authority, prices charged by FDI plants should facilitate a reasonable rate of return and are "restrained only by the ability of the consumer to pay" (Petroleum Economist, 1996).

The negotiation of electricity prices is one of the most contentious and problematic aspects of project approval for foreign investors (see e.g., Korski, 1997). Once tariffs are set during the approval process they are generally subject to an annual review at which time adjustments can be made for any generating cost increases. This creates problems for investors because price increases can lag far behind cost increases and because the approval of price increases is not certain. To mitigate this problem, foreign investors have sought to negotiate preapproved formulas for adjusting prices to reflect cost changes. Traditionally, pricing has been the domain of local authorities. Recently, however, central authorities have attempted to usurp this control. This has also created bureaucratic problems for foreign investors.

### *3.4.7. Contract enforcement*

The viability of foreign firms in China depends critically on their ability to enforce business contracts in an environment in which contract law is still in its infancy. Although legal uncertainties affect contracting for construction, fuel supply, labor, and cooperative joint ventures, they are perhaps most daunting for so-called "power purchase contracts".

Power purchase contracts require that the power purchaser — usually a local government-owned power bureau — buy a "minimum take" from the plant for a fixed term at a fixed price schedule. The minimum take, term, and price schedule are all negotiated before plant construction begins based on the plant's projected operating costs. The term of the contract can range from 10 to 30 years.

Perhaps the most serious risk run by FDI power plants is that the power purchaser will not buy the contracted minimum take. During the mid-1990s, the Chinese government maintained that, given electricity shortages, power purchase contract default should never actually occur. Nevertheless, default risk is real, especially in areas

[16] New power plants charge higher prices than old ones. Large industry and agricultural users pay the lowest prices while small industry and commercial users pay the highest (MEP, 1995).

where there is surplus generating capacity and where large economically unstable state-owned industrial enterprises account for a major share of electricity demand (IPPQ, 1998 II). Financiers of FDI ventures often require some type of assurances regarding default. In the past, payments to foreign ventures were often guaranteed by the government. But the central government has made it clear that such guarantees will no longer be available. Exacerbating the problem is the fact that joint venture plants often include power purchasers as a partners, an arrangement that enables foreign investors to obtain favorable contract terms, but limits legal recourse in case of contract default.

*3.4.8. Trade and financing restrictions*

In April 1996, China eliminated foreign investor's exemptions from tariffs and duties on imported generating equipment smaller than 350 MW. Import tariffs of 38% on generating equipment smaller than 350 MW (versus 6% for larger units) create strong incentives to use domestic equipment (Gruettner, 1997).

Generally foreign investors prefer to leverage their equity capital with debt at ratios of at least 4 : 1. This is often problematic in the PRC for two reasons. First, regulations require that investors contribute equity of 20–40% depending on the size of the project (IPPQ, 1998 II). And second, because of the risks discussed above, and because many players in China have limited credit histories, debt financing has been in short supply, especially preferred "limited-recourse" and "non-recourse" loans which restrict creditors' access to revenues other than those generated by the power project.

*3.4.9. Innovative solutions*

Increasingly, investors are finding ways of overcoming institutional impediments to FDI in the Chinese power sector. An example is an October 1996 project agreement for a joint venture between Sithe China Holdings Limited ("Sithe") and two Tangshan government-controlled utility companies to build and operate a $2 \times 50$ MW coal-fired cogeneration plant. Involving US $128.4 million in limited-recourse financing, the project agreement has been heralded as a model for future deals because it employs a number of innovative contractual tools to allocate the risks discussed above (e.g., Starke, 1997).

To minimize contract enforcement and operations risks, Sithe put in place a termination agreement with one of its Chinese partners, Tangshan Power, wherein Tangshan Power must buy out Sithe's interest in the plant in the event of certain adverse circumstances such as failure by government officials to implement the agreed upon tariff formula. The People's Insurance Company of China, the largest state-owned insurance company in China, underwrites Tangshan Power's obligation under the termination agreement. The insurance company also covers political "force majeure" events such as expropriation, war, and restrictions on foreign currency remittance. To reduce construction risk, Sithe negotiated a first-ever fixed-price date-certain engineering, procurement and construction (EPC) turnkey contract with a well-recognized international contractor.[17] To reduce uncertainty about fuel availability, Sithe negotiated a 20 year coal supply contract with one of China's ten largest mines. Finally, to minimize foreign exchange risk, China International Trust Investment Corporation, the largest non-bank financial institution in China, has agreed to use its best endeavors to ensure that the project has access to foreign currency to cover its needs for 20 years.

In addition to the financial and contractual innovations developed by foreign investors, the PRC is experimenting with new procedures to overcome some of the problems that have plagued FDI. Chief among these is competitive bidding for BOT projects (Traditionally, BOT projects like Hopewell's Shajio B in Guangdong are negotiated). The PRC has already approved two BOT projects using a competitive bidding process and tendered packages for others.[18] The power authority's long-term goal is to require competitive bidding for all foreign capital (Tan, 1997). Competitive bidding has several desirable properties: it is relatively transparent; it removes the need for a cap on rates of return as it presumably selects for the lowest return on investment that investors will accept; it greatly streamlines the approval process; it ensures that investors work with sophisticated and professional government personnel; and in general competitively bid projects are "bankable", that is international lenders are willing to provide financing (Turner, 1997b).

## 4. Survey results

In July 1997, we conducted a mail survey of 35 US firms that have developed power projects in China, or that have tried to do so. We focus on US firms because, as discussed in Section 3.3, they are responsible for the lion's share of FDI in operation and under construction in the Chinese power sector. We received responses from 14 companies which between them have experience with 75 projects or project proposals.[19] We asked each company

[17] Under this arrangement, the contractor agrees to build the plant and turn it over to Sithe for a fixed price and to guarantee the plant's completion date and performance.

[18] The two BOT projects that have been approved are (i) a $2 \times 350$ MW second phase of the Laibin coal-fired plant in Guanxi Shuang Autonomous Region tendered in December 1995 and awarded to EDF/GEC-Alsthom in September 1997 and (ii) a $23 \times 50$ MW Changsha coal-fired plant in Hunan Province tendered in April 1997 and awarded to National Power in October 1997.

[19] Our respondents had 13 projects in operation, six under construction, eight awaiting final approval, 23 in the proposal stage, and 25 that had been proposed but were later withdrawn.

to provide general information about FDI in the Chinese power sector and also to provide detailed information about any projects currently in the proposal, construction, or operation stage. We received detailed information on 20 such projects comprising 13 of the 24 FDI projects in China that are in operation and four of the 12 projects that under construction (Tables 6–8). Because the data were provided with the caveat that they remain confidential, we are only able to present summary statistics. Also, to preserve confidentiality, some respondents declined to answer some questions. We indicate response rates for each question below.

### 4.1. Sample plant characteristics

Of our 20 sample plants, 13 are in operation, three are under construction, and four are in planning stages. Not surprisingly, our sample confirms the trends in location, type and size described in Section 3.3. All but one of the operational plants are located coastal regions, while a third of the plants under construction are located in the north. Seven of the 13 plants already in operation are gas- , oil- and diesel-fired plants smaller than 100 MW, while the majority of plants under construction or in planning are larger coal-fired plants (Table 9).

Four of the sample plants are expansions of existing plants. Interestingly, four are peaking plants. This suggests that efforts to mitigate the shortage of such plants have had a significant impact.

Majority control of a cooperative joint venture with a local governmental organization is clearly the most popular contract structure for American FDI. Over two-thirds of our sample plants are cooperative joint ventures. All but one of the remaining plants are equity joint ventures (Table 10). Foreign investors have a controlling interest in 63% of the joint ventures. Those plants for which foreigners do not have a controlling interest tend to be those contracted before regulations prohibiting majority ownership were rescinded. Chinese partners in joint ventures are local governmental organizations, in most cases the local power authority (Table 11). Build-operate-transfer (BOT) contracts have clearly increased in popularity as the central government has promulgated guidelines for BOT and tendered BOT offers. None of the sample plants are build-operate-own (BOO).

Table 9
FDI sample plant type and use of imported equipment

| Type | Operational | | Pre-operational | |
|---|---|---|---|---|
| | Number | Avg. % imp. equipment | Number | Avg. % imp. equipment |
| Coal-fired | 5 | 40 | 5 | 57 |
| Gas-fired | 1 | [a] | 1 | [a] |
| Oil-fired | 6 | 79 | 0 | |
| Hydro | 1 | [a] | 1 | [a] |
| All | 13 | 59 | 7 | 46 |

[a]Omitted to preserve confidentiality ($n = 20$ plants).

Table 10
Contract structure of sample plants

| Type | In operation | | Pre-operation | | |
|---|---|---|---|---|---|
| | BOT | Non-BOT | BOT | Non-BOT | All |
| Cooper. joint venture | 0 | 7 | 3 | 3 | 13 |
| Equity joint venture | 1 | 2 | 2 | 0 | 5 |
| Wholly owned venture | 0 | 0 | 1 | 0 | 1 |
| All | 1 | 9 | 6 | 3 | 19 |

($n = 19$ plants)

Table 11
Types of Chinese partners in joint ventures

| Partner | Number |
|---|---|
| Local power authority (LPA) | 3 |
| Other local govt. agency (OGA) | 7 |
| LPA + OGA | 5 |
| LPA + Construction co. | 1 |
| LPA + OGA + Investment bank | 1 |
| Mining co. | 1 |

($n = 18$ plants)

### 4.2. Sample plant efficiency

We have both subjective and objective data on energy efficiency. We present the subjective data first. A significant proportion of survey respondents believe that FDI plants and imported equipment have the potential to improve energy efficiency. Four of 12 respondents believe that their plant is more efficient than average new wholly owned Chinese plants. Not surprisingly, all four of these plants use advanced generation technologies (we discuss this point in more detail below). But there also seems to be support for the view that FDI plants using imported conventional equipment are superior to new domestic plants using Chinese equipment. Four of 15 respondents believe that the Chinese equipment used in their plants reduces overall energy efficiency. All four of these plants use conventional technologies. We note that given the number of respondents who declined to answer these questions, our findings must be interpreted with caution.[20]

To get an idea of the relative efficiency of FDI plants we compare their heat rates to: (i) Chinese heat rate targets; (ii) heat rates of large Chinese plants built between 1983 and 1993; and (iii) heat rates of US plants built between 1985 and 1995 (Table 4). Since our samples of FDI, Chinese, and American plants are small, and since a third of the 15 FDI plants for which we have heat rate data are pre-operational, these comparisons should be interpreted cautiously. Nevertheless, our results are striking. Perhaps not surprisingly, the sample FDI plant heat rates compare favorably to efficiency targets for all Chinese plants. Six of the seven sample FDI plants with units larger than 50 MW have gross heat rates lower than 2010 target and every one of the eight sample FDI plants with units smaller than 50 MW have gross heat rates lower than the 2000 target. As a result, average gross heat rates for sample plants are well below the most stringent target in every unit size category.

More impressive, the FDI sample plants compare favorably with ten new Chinese plants in the two size categories for which both FDI and Chinese data are available.[21] Using small-sample tests, we are able to reject the null hypothesis that FDI and Chinese sample means are identical at the 5% level.[22]

More impressive still, the FDI sample plants also compare favorably with new US plants in every size category. Using small-sample tests, we are able to reject the null hypothesis that FDI and US sample means are identical for two of the four size categories — 500–600 MW and 0–50 MW — at the 1% level.

The relative efficiency of the 20 FDI sample plants is at least partly due to the fact that seven of them use advanced generation technologies. Four of the small operational plants (unit size $< 125$ MW) employ oil-fired combined cycle gas turbines (CCGT) and one proposed plant employs integrated gasification combined cycle turbines (IGCC). Two of the sample coal-fired plants — a 50 MW plants under construction and a 1200 MW proposed plant — use fluidized bed combustion (FBC) technology. Moreover, in a broad sense, the plants may actually be more efficient than our heat rate data indicate. Five of the sample plants (including one of the advanced generating technology plants) are cogeneration plants.

What accounts for the high percentage of advanced generating and energy-efficiency technologies in our sample? In the case of CCGT and FBC plants, market forces and government pricing policies are probably most important. CCGT is a economical choice for peaking power: it delivers high-energy efficiency despite cycling requirements; entails reasonable capital costs; and can be built relatively quickly. Even though petroleum fuels used in some CCGT plants are more expensive than coal, central authorities allow peaking plants to charge higher prices than base-load plants.[23] High-efficiency combined with fuel flexibility can make FBC competitive despite higher capital costs. However, at this stage in its applied technological development, is doubtful that IGCC could be competitive.[24] While government policy favoring advanced technologies is likely to have played a secondary role for the CCGT and FBC plants, it was probably the primary consideration for cogeneration plants. Many small plants have added cogeneration facilities in order to ensure government approval despite official policies discouraging the building of small plants (Global Private Power, 1998).

The relative efficiency of FDI plants may also be due to their use of imported conventional equipment. Overall, 52% of the equipment used in the sample plants is imported versus 24% for all Chinese plants. Alhough the average percentage of imported equipment for the sample plants is higher for the six advanced technology plants (71%) than for conventional plants (48%) the percentage for the latter is still higher than the percentage for average Chinese plants (Tables 9 and 2).[25]

### *4.3. Institutional factors influencing respondents' equipment, location, and scale choices*

This subsection presents survey data on the extent to which foreign investors' equipment, location, and scale

[20] Additional subjective survey data suggests that FDI plants are not as efficient as they could be. Four of 14 respondents believe that there are significant institutional barriers to energy efficiency. Barriers identified in a follow-on question include pressure to use domestic equipment, over-employment, and dispatch rigidities. Similarly, four of 17 respondents believe that energy efficiency potential was unrealized because of government regulation.

[21] The source of the Chinese data — MEP (1993) — contains heat rate and internal use rate information for 102 Chinese plants that fit the definition "large industrial enterprise". Of these, 33 were built after 1982. Of these, 26 have uniform unit sizes. And of these, 10 have unit sizes that are comparable with those of the FDI sample plants.

[22] In addition, the average percentage of electricity used internally (a measure of efficiency) for the 17 FDI sample plants that provided this data is 5.8% while the average for the 26 Chinese plants built after 1982 for which we have data is 8.2%. A small sample test confirms a significant difference between the sample means at the 1% level.

[23] CCGT plants can also burn low-grade relatively inexpensive petroleum distillates.

[24] The one proposed IGCC plant in our sample something of a special case. It is an add-on to a pre-existing industrial coal-gasification plant, and even then will only be built with multilateral financial support.

[25] Note however that the average percentage of imported equipment is higher for operational plants than for those under construction or in planning. The trend over time away from small gas- and oil-fired units that use a high percentage of imported equipment towards larger coal-fired units that use more domestic equipment probably reflects a number of changes in the institutional climate for investment including the imposition of higher tariffs on imported equipment in 1996.

Table 12
Factors affecting technology and equipment choices: average ranking on a scale of 1 ( = no effect) to 5 ( = very important) and percentage of respondents who ranked each as "most important"

| Factor | Avg. rank | % #1 rankings |
|---|---|---|
| Cost of equipment | 3.6 | 30 |
| Reliability | 3.8 | 10 |
| Energy efficiency | 3.5 | 30 |
| Construction time | 3.3 | 5 |
| Government regs. and incentives | 2.6 | 0 |
| Financing constraint | 2.2 | 0 |
| Environmental concerns | 2.4 | 0 |
| Fuel flexibility | 2.4 | 5 |
| Other[a] | 2.0 | 15 |
| Price of coal | 2.1 | 5 |

($n$ = 20 plants)
[a]Other factors were: (i) "did not select equipment," (ii) "temporary waiver of taxes on imported equipment," and (iii) "taxes on imported equipment".

Table 13
Preference for plant type absent institutional constraints vs. observed choices: percentage of respondents ranking each type as first choice and percentage plants of each type

| Type | % #1 rankings ($n$ = 14 firms) | % observed plants ($n$ = 20 plants) |
|---|---|---|
| Large coal-fired (>600 MW) | 21 | 20 |
| Medium coal-fired (125–600 MW) | 21 | 10 |
| Small coal-fired (<125 MW) | 29 | 20 |
| Gas or oil fired | 21 | 15 |
| Diesel-fired | 0 | 25 |
| Hydro plant | 7 | 10 |
| Renewable plant | 0 | 0 |

Table 14
Factors affecting location decision: average ranking on a scale of 1 ( = no effect) to 5 ( = very important) and percentage of respondents who ranked each "most important"

| Factor | Avg. rank | % #1 rankings |
|---|---|---|
| Local government support | 4.6 | 65 |
| Shortage of electricity in region | 4.0 | 20 |
| Fuel supply | 3.2 | 5 |
| Local infrastructure | 2.8 | 5 |
| Environmental regulations | 2.7 | 0 |
| Other[a] | 1.3 | 5 |

($n$ = 20 plants)
[a]Other factors were: (i) "special economic zone" (ii) "central government support".

choices are driven by institutional factors as opposed to investors' preferences.

### 4.3.1. Equipment

The survey data do not suggest that regulatory and institutional factors have a strong impact on most foreign investors' equipment choices. Respondents ranked cost, reliability, and energy efficiency as the most important determinants of these choices (Table 12). However, the data indicate that regulatory and institutional factors — in particular contracts mandating the use of Chinese-made equipment, and tariffs on imported equipment — were important to some investors.

### 4.3.2. Plant type

The survey data suggest that there may be some institutional biases that affect the types of plants foreign investors build. There are differences between the types of plants that the 14 firms in our sample claimed they would prefer in the absence of institutional constraints and the types of plants they actually built (Table 13). Most striking, not one firm preferred diesel plants yet such plants comprise one quarter of our sample.

The prevalence of diesel-fired plants despite a professed preference for other types of plants probably stems from: the fact that small plants can bypass the convoluted central government approval processes; pressures to build small plants quickly to meet urgent local needs; relatively low risk associated with building small plants and relying on imported equipment; and the availability of diesel versus other types of fuel.

### 4.3.3. Location

Government policies clearly affect foreign investors' location choices. Respondents ranked local government support as the most important factor affecting their location decisions (Table 14). This is not surprising since, as discussed above, all but one of the plants in our sample is a joint venture with a local governmental organization, generally a power bureau.

At the aggregate level, there is not much difference between the regions that firms claimed they would prefer in the absence of institutional constraints, and the regions they actually chose. The populous and industrialized East and South-Central regions are ranked highest and are home to 85% of the sample projects. However, this interpretation is not fully supported by a comparison of individual respondents' rankings with their actual location choices. The two most prolific investors in our sample both rank the Southwest and Northwest regions highly, perhaps owing to shortages of electricity and the availability of coal or natural gas in these regions. Yet these two firms have only one plant in the Southwest and none in the Northwest.

Table 15
Institutional barriers to foreign investment in Chinese power sector: average ranking on a scale of 1 ( = no effect) to 5 ( = severe) and percentage of respondents who ranked each "most important"

| Institutional Barrier | Avg. rank | % #1 rankings |
|---|---|---|
| Ambiguity of relevant laws and regs. | 4.3 | 36 |
| Delay of approval process | 4.3 | 14 |
| Control of rate of return | 4.2 | 7 |
| Credit risk of power purchaser | 3.9 | 7 |
| Enforcement of contracts | 3.8 | 7 |
| Control electricity pricing | 3.7 | 7 |
| Control of foreign exchange | 3.3 | 0 |
| Regulation of ownership | 2.8 | 7 |
| Other factors[a] | 2.0 | 14 |

($n = 14$ firms)
[a] Other factors were: (i) "uncertainty of dispatch and pricing mechanisms" and, (ii) "risk/reward ratio".

### 4.4. *Perceived institutional barriers to FDI in the Chinese power sector*

Our survey contained several sets of questions designed to elicit respondents' perceptions regarding institutional barriers to FDI in the Chinese power sector. Among a list of eight reputed barriers, respondents ranked ambiguity of relevant laws and regulations highest, followed by delay of the approval process, and control of the rate of return (Table 15). Regulation of ownership, foreign exchange and electricity pricing were ranked lowest. Our survey also elicited policy recommendations. Of the 12 responses we received from our 14 sample firms, five had to do with making laws and regulation more clear and complete, and four had to do with instituting competitive contracting and bidding standards.

Respondents concerns about the length of the approval process appear to be well-founded. Although the average length of the approval process for our sample plants was a fairly reasonable 16.5 months, there is striking difference in the length of the process for small and large plants. For plants smaller than 100 MW, the average was just 6.4 months while the average for larger plants was 40 months.[26]

We asked firms in our sample with power projects in other developing countries to compare features of the investment environment in China with those in other countries. Those features that compared least favorably were contract enforcement, government control, and regulatory efficiency (Table 16). Those features that compared most favorably were the transmission and distribution system, infrastructure facilities, and the quality of workers.

Finally, among six factors contributing to project risk, fully two-thirds of our respondents ranked enforcement of the power purchase contract most highly (Table 17).

[26] Sixteen of our 20 sample plants completed the approval process. Of these, ten provided information about the length of the process. Seven of these ten plants were smaller than 100 MW.

Table 16
Features of investment environment in Chinese power sector compared to other LDCs: average ranking on a scale of 1 ( = inferior) to 5 ( = superior)

| Features | Avg. Rank |
|---|---|
| Transmission-distribution. system | 3.4 |
| Infrastructure facilities | 3.4 |
| Quality of workers | 3.4 |
| Convertibility currency | 2.8 |
| Stability government policies | 2.2 |
| Efficiency of regulatory authorities | 2.1 |
| Government control of investment | 2.0 |
| Contract enforcement | 2.0 |

($n = 14$ firms)

Table 17
Factors contributing to project risk: average ranking on a scale of 1 ( = no effect) to 5 ( = very important) and percentage of respondents who ranked each "most important"

| Factor | Avg. rank | % #1 rankings |
|---|---|---|
| Enforcement of power purchase contract | 4.6 | 66 |
| Changes in government policy | 3.7 | 11 |
| Convertibility of currency | 2.6 | 11 |
| Operational failure | 2.9 | 6 |
| Changes in fuel supply | 2.4 | 6 |
| Inflation | 2.1 | 0 |
| Others | 1.2 | 0 |

($n = 18$ plants)

## 5. Conclusion

By way of summary and as a prelude to policy prescriptions, we present brief answers to the four questions posed in the introduction.

*What have been the volume and characteristics of FDI in China's power sector*? To accommodate rapid economic growth, in the early 1990s the Chinese central government set ambitious capacity expansion and energy efficiency targets and actively encouraged FDI. However, the volume FDI in China's power sector will likely fall short of the government's year 2000 capacity expansion target of 18 GW by a substantial margin. It is unlikely that any more than 13.9 GW of FDI capacity will have come on line by 2000, of which approximately 8.9 GW has been contributed by Chinese partners in joint ventures. Given the pace of foreign investment in the mid 1990s, this shortfall would likely have occurred even without the downturn in electricity demand that has resulted from the Asian financial crisis

There has been a marked shift in the characteristics of FDI during the 1990s. FDI plants already in operation tend to be small-scale, gas- and oil-fired, largely imported, and located in the heavily populated and industrialized coastal provinces. However, half of the FDI facilities under construction are large coal-fired plants using primarily domestic equipment, and over 40% are located in the north. Increasingly FDI projects are BOT. The predominant contract structure for FDI is majority control of a cooperative joint venture with a local power authority.

*What has been the impact of FDI on energy efficiency in the power sector*? Our survey data suggest that FDI is having a significant positive impact on energy efficiency. Almost a third of the 20 FDI plants in our sample use advanced efficiency-enhancing generating technologies (CCGT, IGCC, or FBC), and a fifth are cogeneration plants. These high-technology plants not only enhance average efficiency when they come on line, but also have the potential to speed the transfer and diffusion of advanced generating technologies in the future.

*What factors limit the contribution of FDI to energy efficiency in the power sector*? The principal factor that has hampered the contribution of FDI to energy efficiency is an institutional bias in favor of small-scale plants which are generally not as energy efficient as the large-scale plants foreign investors would seem to prefer. This bias stems from: the fact that small plants can bypass the convoluted and costly central government approval and regulatory processes; pressures to build small plants quickly to meet urgent local needs; and the low risk associated with such plants given their limited scale and reliance on imported equipment. The government's new policy of discouraging the building of new small plants and shutting down existing ones as well as a marked shift towards larger plants over time, seems to indicate that this bias is being corrected.

*What factors constrain FDI in the power sector generally*? Our study indicates that the most important institutional barriers to FDI are uncertainty associated with the approval process for FDI projects, electricity sector regulation, and the risk of default on power purchase contracts. Three barriers that received quite a bit of attention in the trade presses in the mid 1990s — foreign exchange risks, electricity pricing, and regulation of ownership — no longer seem to be of paramount concern to foreign investors, indicating that the policy reforms have had a significant impact.

The policy prescriptions that flow from our findings are straightforward. First, if China hopes to significantly boost FDI to meet its long-term capacity expansion and energy efficiency goals, it will have to mitigate the barriers of greatest concern to foreign investors — those regarding contract enforcement, regulation, and project approval. Given that Chinese contract law is still in its infancy, it is probably not realistic to expect dramatic across-the-board improvements in contract enforcement in the short term. However, the central government might consider a targeted effort to strengthen contract enforcement in the power sector. If Sithe's Tangshan power project is truly a bellwether, then foreign investors may have found, in state insurance companies, a means of allocating default risk, albeit one that is untested and potentially costly. Happily, state insurance against default risk presumably creates financial incentives for the central government to enforce power purchase contracts.

With regard to regulation, government officials have mapped out an ambitious strategy for reform. The 1995 Electricity Law, pricing reforms, and efforts to separate ownership and control all represent steps forward. Unfortunately, the pace of regulatory reform is bound to be politically determined.

Perhaps the most promising avenue for improving the institutional climate for FDI in the short term is to codify and streamline the approval process, which by all accounts is unnecessarily time-consuming and arbitrary. Presumably, the principal benefit of the arduous central government approval process is that it enables the central government to maintain some degree of control. But the costs of the process are substantial. It clearly creates a bottleneck that limits the total amount of investment. Moreover, it creates incentives to build relatively inefficient small plants.

While our research indicates that the approval process has slowed the pace of FDI, it also suggests that it has created strong incentives to enhance energy efficiency and transfer advanced generating technologies — the high costs of negotiating the approval process have strengthened incentives to develop projects that receive special consideration from regulatory authorities. Ironically, this implies that if the approval process is reformed, these incentives will be weakened. Therefore, efforts to streamline the approval process should be matched by efforts to strengthen incentives to develop desirable projects.

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