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OECD Reviews of Regulatory Reform: China
Defining the Boundary between the Market and the State

Chapter 6

Power Sector Reform

The continued success of rapid economic growth in the People's Republic of China – and the accompanying economic reforms – will depend in no small measure on the continued growth of the electricity sector. With the aim of improving the commercial and technical performance of the sector, the Chinese government has undertaken a series of reforms in the electricity sector. These include the now standard reform strategy of separating the assets and operations of generation from those of transmission and distribution. This chapter describes the challenges, both politically and economically, of implementing this strategy. The aim of this chapter is to examine the progress of reforms and to evaluate the outlook for continuing the reform of China's power sector in light of developments in energy markets in recent years, both within China and around the world. The chapter concludes that given the current situation in China, the introduction of widespread competition in generation runs a number of risks and that competitive markets should only be introduced gradually. It further suggests that a period of several years could be used constructively to build up the institutional framework for later competition, and a range of instruments other than competitive markets could be employed to address urgent priorities relating to system security, security of supply, sector efficiency and the environment.

Introduction

The continued success of rapid economic growth in the People's Republic of China and the accompanying economic reforms will depend in no small measure on the continued growth of the electricity sector. With the aim of improving the commercial and technical performance of the sector, since the late 1990s the Chinese government has undertaken a series of reforms in the electricity sector, including the now-standard reform strategy of separating the assets and operations of generation from those of transmission and distribution. The contemplated outcome includes a generation sector characterised by independent enterprises competing among each other for access to the transmission grid – and so for customers, with liberalised wholesale prices that both ensure that the most efficient generation assets are called into production, and provide a return to the owners of those assets.

However, it is not at all clear how realistic or likely this contemplated outcome is, either politically or economically. Politically, the Chinese government has so far been unwilling to allow either wholesale or retail electricity prices to increase in line with increases in costs. Economically, certain aspects of the electricity sector are not likely to change quickly, especially the heavy dependence on coal generation and the limited interregional transmission capacity. These constraints may render generation competition difficult to implement, unpredictable in its impact, volatile, and ineffectual at achieving the goals of restructuring.

This chapter updates and builds on an earlier report on China's power sector by the International Energy Agency (International Energy Agency, 2006). The aim of this chapter is to examine the progress of reforms and to evaluate the outlook for continuing the reform of China's power sector in light of developments in energy markets in recent years, both within China and around the world. The chapter will begin with a review of the motivations and context for the major reforms undertaken in the period 2002-04, before detailing the nature of these reforms. The sections that follow will examine developments in China's power sector since that time and re-evaluate the original and current reform strategies given these recent developments and the experience of power sector reform around the world in recent years.

The context of the reforms in 2002-04

Proposals to reform China's electrical power sector emerged during the 1990s in response to two sets of drivers, international and domestic. Governments around the world were drawing up and implementing plans to progressively liberate most sectors of the economy from direct state control and introduce market forces. These plans covered utility companies, including the electrical power industry. At the same time, China's government was driving through a rapid transition from tight state control to increasing market orientation across much of the domestic economy. As a result, government

strategies for the development of the country's power sector were influenced by international ideologies and experiences, as well as by domestic priorities.

International context

The growing desire to remove government from the operational management of most sectors of the economy arose in the 1980s from a change in perception of the role of government and its ability to manage industries effectively for the benefit of the country. Economic theories highlighted the tendency of politicians to maximise votes, of bureaucrats to pursue their own interests, and of governments to lack the ability to monitor and control the enterprises they owned. At the heart of the proposed reform process lay the need to remove government interference from industry, to provide commercial incentives for managers, and to remove or reduce the burden of non-commercial obligations placed on the companies. It was believed that the profit motive, private ownership and competition were key to maximising the economic benefits of sector reform. In particular, competition was believed to be critical for stimulating technical and management innovation, for driving improvements in technical and economic efficiency, for reducing or at least constraining prices, and for providing consumer choice.

All of these arguments could be and were applied equally to the electrical power sector and other industries (Helm *et al.*, 1988; Jaccard, 1995). Indeed, in some countries the need to reform the power sector was particularly pressing. Economic growth and development required a rapid and sustained expansion of the power industry to supply electricity to all sectors of the economy and to all households. Yet many national power industries were bankrupt, with high costs and low revenues; they required large subsidies and were unable to maintain the existing systems, let alone invest in new capacity. As a consequence, power sector reform tended to be driven by a combination of two primary objectives: to improve efficiency and reduce costs through competition, and to attract investment in new capacity, including from overseas. The relative importance of these two priorities varied between countries.

The transformation of the power industry from a vertically integrated monopoly to a competitive market requires a change, from command and control systems dominated by vertical relations to a network of horizontal relations defined by contracts. This in turn requires new systems to constrain potentially high transaction costs relating to dispatch, investment, settlement and safety, as well as new approaches to regulation, in particular for those parts of the electricity supply chain not open to competition.

A sequential approach to reform can be represented by four models (Hunt and Shuttleworth, 1996). The power sectors in most developing countries resemble the first two described below, while those in countries that have vigorously pursued power sector reforms tend to resemble one of the second two.

Model 1 comprises one or more vertically integrated monopolies, in which construction and dispatch are planned within the company. In such systems the government may face great difficulties when trying to enhance efficiency. As a result, either the customer or the government pays for the inefficiencies of the monopolist, unless the company is commercialised and prices are carefully regulated. In this model independent power producers (IPPs) may sell to the power company under a power purchase agreement (PPA) and individual utilities may trade power with each other.

Model 2 involves the development of a moderate degree of competition in generation, providing some incentive for generators to improve their performance. In order for this to happen, the generating companies must be separated from the rest of the utility and sell their power to a purchasing agency. This purchasing agency chooses, on the basis of cost, from among different generators to supply electricity and sells it either to the grid at a regulated wholesale tariff or directly to large consumers.

In this model the generators have PPAs that contain incentives for efficiency and investment. These agreements comprise a capacity or availability payment to cover fixed costs and an energy charge to cover variable costs. The power stations will be dispatched on the basis of variable cost, which requires constant cost monitoring in order to drive through efficiency gains, as well as links to fuel price. Competition is achieved through competitive bidding for the construction and operation of power plants.

Though the incentives for efficiency enhancement are only moderate here, this model has the advantage that the government retains significant authority over the sector to impose social obligations and to address objectives relating to technology or fuel.

Full wholesale competition in generation is introduced in Model 3. The distribution companies buy directly from the generators and the transmission grids are open to all buyers and sellers of power. Electricity is traded in a spot market or pool, based on bids made on an hourly or half-hourly basis.

A separate tariff is imposed on transmission. While this model places much clearer incentives on the generating companies, especially if they have been privatised, it leaves the regulator with a number of challenges relating to the market power of generating companies and to stranded costs. At the same time, the government's ability to impose social obligations and to determine technology and fuel is curtailed in comparison to Models 1 and 2.

Model 4 takes reform one step further and involves competition in retail for all consumers. This in turn requires the separation of the retail function from distribution, and the removal of entry barriers to the retail function. Challenges concerning stranded assets, social obligations and technology control are greater.

Experience around the world has shown that reform of the power sector carries considerable risks. These include the potential for interest groups to distort the reform process for their own benefit, continued interference by government in the operation of the industry, and abuse of market power by players in the industry.

These and other risks have their roots both in the design of the reform itself and in the structures and systems for regulating the industry during and after reform. Of these two, the structures and systems for regulation are of the greater importance. As the United Kingdom experience has shown, a flawed reform process can, to a greater or lesser extent, be remedied by an effective regulator (Helm, 2003).

The key responsibilities of an electricity regulator lie in economic regulation, though they may also be obliged to address environmental and social concerns. The main tasks relate to the implementation of the reform strategy, to investment decisions, to pricing in the non-competitive parts of the industry, and to monitoring the behaviour of players in those parts of the market open to competition.

The regulatory agency has to balance the interests of the government, the industry and the consumers, and must be, as far as possible, independent of the government and of

the industry. It needs the authority to obtain information from companies, the capacity and expertise to analyse this information, and the power to make and implement decisions, however unpopular with one or more parties (Foster, 1992; Bishop *et al.*, 1994; International Energy Agency, 2001). Though the establishment of such regulatory agencies has proved possible in developed countries, the structures and systems of governments in many developing countries and the reluctance of government departments to yield power have resulted in regulatory agencies that lack the capacity or the authority to carry out their functions effectively. In such circumstances, the weaknesses of the regulatory agency may undermine the entire reform process.

The domestic context in China

The reform of China's power sector in the 1990s was directly affected by this evolving understanding of the reform process around the world, especially in international financial organisations such as the World Bank. However, the desire to reform the power sector was part of a much deeper plan to reform the entire economy and to restructure all the state-owned enterprises, which in earlier decades had dominated the national economy.

The key elements of industrial reform included diversification of enterprise ownership, increasing autonomy and commercialisation of enterprise management, and the gradual alignment of prices with market forces. The government progressively removed itself from both the operational management of the industries and from the financing of their investments. These and other reforms were implemented incrementally, often with local experiments. Though the reform process started in the early 1980s, the most radical steps were taken during the 1990s: there were also reforms to the banking sector, the launch of domestic stock markets, and the establishment of new accounting rules, as well as growing foreign involvement in China's economy both through direct investment and through local and international stock markets (Chiu and Lewis, 2006).

The structural reforms were particularly pronounced in 1998. That year saw the abolition of a number of industrial ministries, the creation of new state companies, and the restructuring and commercialisation of existing state-owned enterprises. The energy sector was completely transformed by these changes (Andrews-Speed, 2004).

During the 1990s the primary objectives of China's government in reforming the power sector were to increase the quantity and quality of power supply in order to support economic growth; to raise technical and commercial performance and thus constrain costs in the industry; and to pass the benefits of these cost reductions to the consumer (Li, 1997; Shao *et al.*, 1997). As was the case with other industrial sectors, these reforms were directed at industry structure and at pricing (Xu, 2002; Andrews-Speed, 2004). The main ideas were outlined in the Electric Power Law, which came into effect in 1995.

Before 1997, the Ministry of Electric Power acted as policy maker, regulator and enterprise manager for most of China's power industry. Under the ministry the provincial power bureaus held monopoly control over transmission, distribution and supply within their respective areas. Some of these bureaus were consolidated into regional power groups for the purpose of inter-province transmission of power. In 1997, the State Power Corporation of China was established to take over the enterprise management functions from the ministry. The provincial and lower-level bureaus were renamed companies.

The year 1998 saw the abolition of the Ministry of Electric Power and the transfer of its government functions to the SETC. From 1998 to 2002 a number of measures were taken to

reorganise the State Power Corporation, to corporatise the subsidiary provincial power companies, to implement a limited separation of generating assets from transmission and distribution, and to embark on experimental "market" trials in a number of provinces.

In the early 1990s foreign participation was seen as vital to ensure that investment in generation reached a sufficiently high level. Until this time most foreign funds flowing to the power sector had come from international financial organisations, such as the World Bank and the Asian Development Bank. Between 1994 and 1997 the government issued a number of regulations intended to encourage foreign direct investment by private sector.

Electricity tariffs had already been undergoing reform for several years. Since 1986 the tariff paid to power generators had been based on a "new price for new power" policy that provided significantly higher tariffs for new plants in order to provide those plants with the revenue to pay off their debts. These new and higher prices applied to plants constructed between 1986 and 1992 that did not use central government funds, and to all plants built after 1992. This scheme was successful in encouraging investment but provided no incentive for investors to reduce their costs or to seek more favourable financing terms.

During the 1990s the numbers of parties investing in power generation multiplied, as did the numbers of plants. The "new price for new power" policy evolved into a system in which most offtake prices were set by the government, usually by the provincial pricing bureau, with final approval from the State Pricing Bureau. The price was based on the age, efficiency, fuel, location and type of power generated (peak or off-peak).

The government introduced a new policy in 1998, known as the "operating period tariff". This approach sought to base the tariff on the expected lifetime of the plant, rather than on the debt repayment period. The lifetimes were set at 20 years for fossil fuel plants and 30 years for hydro-electricity. The assumed return on equity was set at 2-3% above the long-term bank lending rate, and the costs of each plant were benchmarked against plants of similar types of fuel, age and unit size. The objective of this approach was to control and lower the capital cost of new plants and place the responsibility for negotiating suitable financing terms on the project sponsors.

Beginning in 1999 bidding by power generators was carried out on an experimental basis in four regions of China: Shanghai, Shandong Province, Zhejiang Province and in the northeast (Jilin, Heilongjiang and Liaoning Provinces). Though the detailed rules varied from case to case, a number of common features ran across all the experiments. Only a small percentage of total available power was bid into the "pool" and tariffs were capped.

Despite these progressive changes to wholesale tariffs, the system for setting consumer prices changed little during the 1990s. The Catalogue system for consumer tariffs started in the 1960s as a method of giving preferential treatment to heavy industry, chemical plants, agriculture and irrigation, both in terms of allocation of power and the price of power. It has evolved to comprise eight main categories of consumer with three voltage classifications, making 24 basic categories. The Catalogue forms the basis of end-user tariffs throughout China. Each of the categories is assigned a Catalogue price which forms the starting point for calculation of the final price. To this price are added a range of charges and fees to reach the final end-user price.

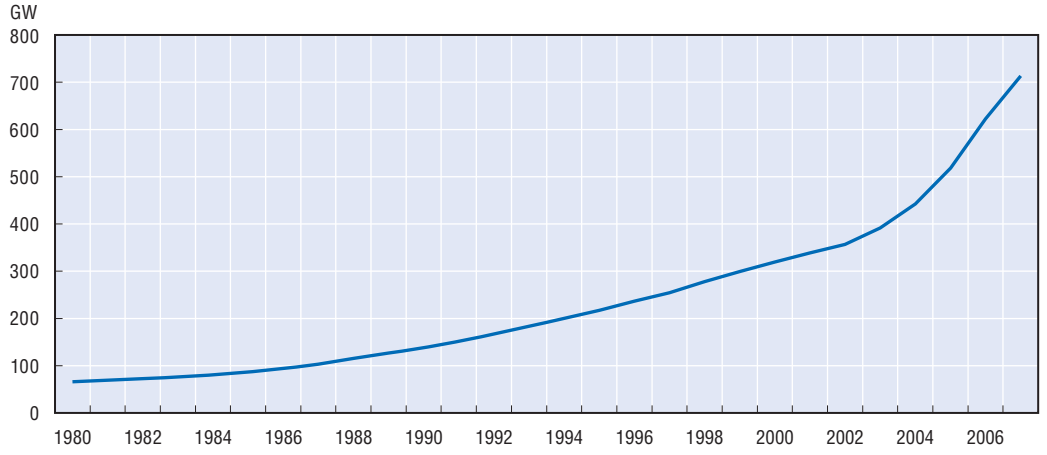
Lack of a change to the way consumer prices were set did not prevent the government from raising these prices in order to allow the power industry to recoup its costs and to encourage energy efficiency. Prices in 1997 were set at levels 40-50% higher than those for 1995, at a time when inflation was running at about 10% p.a. This reflected a real

increase of 15-25% over a two-year period, except for household consumers who were protected with a price increase equivalent to inflation (Andrews-Speed, 2004).

The desire to protect individuals from high energy prices was and continues to be a constant consideration in government policy. A further social dimension to its strategy for the power industry was the need to extend access to electricity to as many rural households as possible and to protect these users from unfairly high levels of tariffs (Shao *et al.*, 1997).

The success of these measures can be seen in a number of improvements from the late 1980s to the late 1990s. First, the generating capacity of the industry grew at a spectacular rate, from 100 GW in 1987 to 200 GW in 1994 and 300 GW by 1999 (Figure 6.1). Second, the proportion of central government investment in the power sector declined as the role of local governments and enterprises grew and progressively more of the central government funds came from banks rather than directly from the government itself (Xu, 2002). Finally, great progress was made in providing access to electricity to rural communities. By the year 2008, only about 30 million people lacked electricity supply, just over 2% of the total population – a remarkable achievement for a developing country.

Figure 6.1. **Installed power generation capacity in China, 1980-2007**



Source: Energy Information Administration, 2008.

The rate of increase of demand for energy in China declined sharply in 1997 on account of the Asian financial crisis, and a surplus of generating capacity emerged as a result. This enhanced the perception that continued reform of the power sector was indeed feasible, for competition in power generation should only be introduced when a surplus of capacity exists. Thus the government continued to formulate plans for further restructuring of the industry and the introduction of competitive markets in generation.

Reforms to China power sector, 2002 to 2004

By 2002 the government was ready to embark on the next stage of reform of the power sector and in March of that year the State Council published the key elements of the proposed reforms (State Council, 2002). The plan followed most of the ideas that had been

proposed by the World Bank and other external advisers, and comprised three main elements:

- The restructuring of the State Power Corporation into five generating companies, two grid companies and a number of service companies.
- The immediate establishment of a State Electricity Regulatory Commission under the State Council to formulate market rules and to regulate the developing markets.
- A new approach to power pricing and the development of competitive markets for power generation across 5-6 separate regions of China, with participation of most major power plants in this competition by the end of 2005.

In addition to these major reform measures, the government introduced other changes to state institutions.

Industry restructuring

The separation of generation from transmission and distribution was the most important component of the restructuring of the State Power Corporation. The generating assets of the State Power Corporation were unbundled from the grid and, together with those of the pre-existing Huaneng Group, were assigned to five companies whose sole business was to be power generation:

- The China Huaneng Power Group.
- The China Datang Corporation.
- The China Huadian Corporation.
- The China Guodian Corporation.
- The China Power Investment Corporation.

The redistribution of generating assets to the five new companies was carried out in such a way that no single company held more than 20% of the generating capacity in one of the planned regional power markets. Immediately after the restructuring, each of the five generating companies owned about 20 GW of generating capacity, though through their majority ownership of consortia the amount of capacity each company controlled was higher, ranging between 30 GW and 38 GW.

Though each company started with an equivalent total generating capacity, the structure of this capacity varied depending on the previous histories of the entities forming the core of the new companies. Datang retained its strength in the north of China, near the coal supplies; Huaneng was strong along the east coast; and Huadian was well represented in Shandong Province. Datang had the lowest proportion of hydro-electricity, while China Power Investment, at 30%, had the highest. China Power Investment was the only one of the five with significant nuclear capacity, and Guodian was an important player in wind power.

The transmission and distribution assets of the State Power Corporation were divided between two new companies. The State Grid Corporation was to own and control the majority of the regional grids in the country, as well as the interregional transmission lines. The Southern China Power Grid Company took over the assets in the far south of the country, in Yunnan, Guizhou, Guangxi, Guangdong and Hainan. The two new grid companies were required to progressively sell off most of the generating capacity that had been previously assigned to the transmission and distribution subsidiaries of the State Power Corporation.

Although these five new generating companies were created from the pre-existing State Power Corporation, they, together with the two new grid companies, only owned about 40% of the generation capacity across the country. The remaining generating capacity was owned by a wide range of industrial and financial enterprises. These players formed consortia to own and operate individual plants, with or without the involvement of one of the new large five generating companies. Some of these players were state-owned at national level, such as the Three Gorges Dam Corporation, the Shenhua Group, the China Nuclear Power Corporation, and the State Investment and Development Company. Most participants in these consortia were owned at local rather than at national levels, and some had been partially floated on one or more stock exchanges.

Likewise, the two new grid companies did not own the entire transmission and distribution network. Some of the grids were owned by the local governments and other entities. For example, the State Grid Corporation owned about 75% of the transmission and distribution lines in its service area and about 88% of the transformers.

Despite the radical nature of the restructuring, it did not include two steps that form part of most programmes of sector reform. Distribution was not separated from transmission, and the function of dispatch was not separated from grid ownership. The state dispatching centre within the State Grid Corporation remained responsible for dispatching the interregional transmission lines and facilities, and regional dispatching centres within each regional grid subsidiary continued to be responsible for dispatch within the region.

Restructuring of regulatory agencies

The period 2002-05 was marked by a series of reforms to the structure and function of government agencies charged with oversight of the electrical power industry. The result was an increase in the number of agencies responsible for regulating the electricity industry, a redistribution of functions, and the creation of some new functions.

The most important of these measures was the creation of the State Electricity Regulatory Commission (SERC) in November 2002. SERC reported directly to the State Council and was charged with wide-ranging responsibilities relating to both strategy and regulation. It was to become the major source of proposals for the development of power markets and for further reforms to the power sector. At the same time it was responsible for the routine technical regulation of the operations of the power industry, including both technical and environmental standards, as well as for collecting data. With respect to economic regulation, its powers were deliberately limited. SERC could investigate "irregular" or anti-competitive behaviour in the power markets and could help to resolve disputes, but was empowered only to make proposals relating to tariffs and then to supervise implementation of the agreed tariffs. Ultimate authority for all electricity tariffs remained with the Pricing Department of the National Development and Reform Commission (NDRC), the successor to the previous State Development and Planning Commission (SDPC).

In addition to a head office in Beijing, SERC established offices in each of the six grids and in eleven additional cities.

Two further agencies were created in March 2003: the Energy Bureau and the State-owned Asset Supervision and Administration Commission (SASAC). The Energy Bureau was created within the NDRC. This brought together many, but not all, of the energy

functions that had been scattered across the previous SDPC and State Economic and Trade Commission. The functions of the Energy Bureau included formulating policy, drawing up plans for sector reform and development, and managing the strategic oil stocks. It was also charged with routine oversight of the country's energy sector, including the approval of major investments (Downs, 2006). The Energy Bureau continued the NDRC's traditional role of approving major construction projects, including power stations and transmission lines. Despite the importance of pricing to the energy sector, it was the Pricing Department, not the Energy Bureau, that retained control of energy prices.

It soon became clear that the Energy Bureau, with a staff of less than thirty, could not possibly fulfil its mandate. Two years later, in 2005, the government set up an Energy Leading Group within the State Council, supported by a State Energy Office. The role of this Leading Group was to set strategic directions and to improve policy co-ordination (Downs, 2006; Rosen and Hauser, 2007).

SASAC was established with the role of executing the functions of government as a shareholder in state corporations; it executes this function at central, provincial and municipal levels. It has authority to approve a wide range of actions by the relevant corporations, including the appointment and removal of directors and senior managers, plans for restructuring or public listing, mergers and acquisitions, and asset disposals.

In addition to these changes, the status and resources of the agency charged with environmental regulation, the State Environmental Protection Agency (SEPA), were enhanced in 2003. This expansion gave the agency greater administrative capacity to monitor and investigate the environmental consequences of large construction projects. SEPA thus became more capable of evaluating proposed power construction projects and the environmental behaviour of power plants, in order to enhance their power to ensure compliance with the relevant laws and regulations.

Among these institutional reforms, the one potentially most significant for the power sector was the establishment of SERC as an industry-specific regulatory agency reporting directly to the State Council. The only other equivalent body within China's central government was the China Securities Regulatory Commission. SERC's most important task in the reform process was to make proposals on price changes and on the introduction of markets for power generation. As a consequence the State Council, the NDRC and SERC issued a number of documents during the years 2003 to 2005 that set forth the key elements of central government strategy for these two critical next steps for power sector reform.

Price reform and market development

Proposals for price reform over 2003-05 took two forms: strategic proposals for substantial reform of the approach to electricity pricing and for the introduction of competitive markets in generation, and short-term measures to address specific concerns relating to coal.

Strategic proposals for price reform

In 2003 the State Council issued the "Scheme for Power Price Reform", (State Council, 2003) which outlined a strategy to overhaul the current tariff system for the electrical power sector and to develop competitive markets for generation and retail. This was

followed by a further notice issued by the NDRC in March 2005, which described these plans in some detail (National Development and Reform Commission, 2005)

The strategy foresaw the creation of three separate sets of tariffs, for generation, transmission and distribution, and retail, with the eventual separation of transmission and distribution tariffs.

The wholesale generation tariff would have two parts: a capacity payment and an energy fee. The capacity payment would be determined by government, while the energy fee would be set by market competition in regional pools. A formula was provided for the calculation of capacity payments which included depreciation and financing costs. The nature of the market and the bidding rules were not specified, but were to be determined separately for each regional market. Bilateral sales from generators to large consumers were to be permitted.

Coal, oil, natural gas, nuclear and hydro-electric power stations would participate in the market competition. Wind, geothermal and other new and renewable forms of energy would not, and would be subject to separate rules. Foreign-invested power plants approved and constructed before 1994 that had signed power purchase agreements or that had received other forms of government undertaking would be obliged to renegotiate these arrangements.

A tariff for transmission and distribution would be set on the basis of cost recovery, reasonable profit and tax liability. Initially the "postage stamp" approach would be used, by which the tariffs in a region are shared according to the capacity of the user or producer. A specific service tariff would be set separately and would include a connection fee. Formulas were provided for the calculation of permitted profit and capital cost.

The Catalogues were to be retained for end-user pricing, but the number of categories would be reduced to three: residential, agricultural, and all industrial and commercial users. The first two categories would be subject to a single tariff, and the third category to a two-part tariff for users with a transformer capacity of 100 kVA (kilo volt ampere) or greater, or a capacity of 100 kW or more. A range of new tariffs would be introduced where appropriate, including peak and off-peak, dry and wet season, high reliability and interruptibility.

The Pricing Department of the NDRC was to retain responsibility for setting or regulating end-user prices as well as wholesale prices prior to the introduction of competitive bidding. This agency would also retain responsibility for transmission tariffs until such time as distribution was separated from transmission. From that time on, provincial pricing departments would be responsible for distribution tariffs.

Market development

SERC set out its vision for the establishment of regional power markets in 2003. A document entitled "Guidelines for Establishing Regional Power Markets" (State Electricity Regulatory Commission, 2003) described the objectives, the main models and the main trading types in the planned regional markets. By the end of 2005 or early in 2006 six regional power markets would be established with regulatory systems and institutions in place. A majority of generation companies would bid to be dispatched, and qualified large end-consumers (including independent supply companies) could directly purchase electricity from generators.

The first trials of the new markets were held in northeast China and east China. The northeast China power market was put into a monthly bidding simulation in January 2004. It initially adopted a one-part price model with 15% of total electricity bid into the market. Following the recommendation of NDRC, the market changed to a two-part price model (a capacity payment and an energy fee) with all electricity bid into the regional power market. At the beginning, only those generators with capacity of 100 MW or above (excluding co-generators and self-serviced generators) were allowed to participate in the pool. During the simulation period, only the bidding system was put into operation and there was no actual settlement. The east China power market was put into monthly bidding simulation in May 2004, again without actual dispatch and settlement.

Both these pilot markets took the form of a mandatory pool with a single buyer. Bidding to the pool was compulsory for qualified generators which, in the case of east China, covered coal-fired plants with capacities of 100 MW or greater. The grid company was the single buyer. Trading arrangements were dominated by contract trade, and supplemented with trading in the spot market. The trading types included yearly contracts, monthly bidding contracts, day-ahead bidding and real-time balancing. Monthly bidding and day-ahead bidding were operated in the regional trading centre with all the coal-fired units of capacity of 100 MW or above participating. The provincial dispatching centre was responsible for scheduling the implementation of the annual contracts and for real-time balancing to control the provincial power system.

Further trials were launched in south China in 2005. Unlike the pilot programmes in northeast and east China, this simulation programme had the intention to stimulate a greater degree of competition. Two characteristics distinguished it from the earlier pilot programmes. First, it engaged not only multiple sellers, but also multiple buyers in the market. The programme required grid companies from four provinces (Guangdong, Guangxi, Yunnan and Guizhou) to participate in the market, and these grid companies competed with each other for power purchase. Second, the programme separated the dispatch function from the market operator.

The development of these pilot regional markets faced a number of challenges. The varying levels of economic development in different provinces in same region made it difficult to implement a unified pricing system, because the poorer provinces were not able to afford a higher price. Allegations emerged that grid companies were favouring their own generators. The weakness of inter-provincial transmission capacity led to grid congestion. Finally, the growing shortages of power rendered these pilot markets irrelevant and all these trials were abandoned (Zhang *et al*., 2005; Wang, 2007).

In anticipation of actual implementation of power markets, the government sought to bring a greater degree of order to prices offered to generators and at the same time improve incentives for efficiency. The new approach was described in a document issued by the NDRC in April 2004 (National Development and Reform Commission, 2004). New plants in the same region and using the same fuel were to receive the same price, and the prices paid to existing plants were to be gradually brought into line with these regional average levels. Further, coal-fired plants that installed and operated desulphurisation equipment would receive a higher price, set at a national level.

Measures concerning coal

Coal is the primary source of energy for almost 80% of electricity generated in China, and therefore its pricing has a direct bearing on the financial health of the electricity industry. Since 1994 a large proportion of the nation's coal output has been sold through wholesale markets, and prices in coastal provinces are at close to international levels. Despite this "liberalisation", coal continued to be sold to large power stations at subsidised prices. The SDPC (later NDRC) ran an annual meeting at the end of each year at which the principal producers, transporters and consumers of coal reached agreement, under SDPC guidance, on coal prices for the following year (Thomson, 2003).

The rapid rise of coal prices during 2003 and 2004 put a great strain on power-generating companies and on their relationship with coal producers. To solve this problem the NDRC agreed to allow the price of coal for power stations to be set by market forces and announced, in December 2004, a new scheme to link wholesale power prices to coal prices. The link was defined by a formula that included coal digestion ratio, standard coal consumption and the calorific value of the coal. The scheme provided for approximately 70% of any rise in coal price to be passed through to the grid. A change in coal price of 5% or more would trigger an immediate adjustment of wholesale prices. Lesser changes of coal price would be addressed in six-monthly reviews.

Progress and significance

The measures drawn up over 2002-04 marked fresh determination on the part of the government to push ahead with the reform and liberalisation of the electricity sector. The State Power Corporation was unbundled, generation was separated from transmission, and an entirely new regulatory agency, SERC, was created. Pilot markets for power generation were run. Yet, much remained unchanged. The NDRC retained authority over both pricing and project approval, and the proposals for power pricing and markets for power generation were shelved in 2005 on account of the growing shortages of electrical power across the country.

As a result, the industry saw a change of structure but with little change in the way that electricity was bought and sold or in the way the industry was regulated. In some ways China's power industry resembled Model 2, with a purchasing agency (the grid companies) buying power from the newly unbundled generating companies – except that the processes for purchasing this power were neither transparent nor predictable, nor were they underpinned by contracts.

The ensuing years, from 2005 to 2008, were marked by stagnation in the reform process, while the power companies focused their attention on increasing the capacity of the industry to satisfy the rapidly rising demand (Figure 6.1 above) and the government sought to enhance its control over the industry. Though few substantial reforms were implemented during this period, the power sector continued to change in a number of ways. These changes, discussed in the next section, will necessarily affect the way in which further reform can be implemented.

Key trends and changes in China's power sector, 2004-08

The five-year period from 2004 to 2008 was characterised by a dramatic increase in demand for all forms of energy across China, including for electrical power. The resulting shortages of energy caused both the government and the power industry to switch their

attention from sector reform to security of supply, and in particular to investing in new generation and transmission capacity. At the same time, in order to address the energy shortages, the government introduced a number of policies to enhance energy efficiency in all sectors of the economy.

In the international arena two further trends were affecting the government's approach to energy policy. First, prices for energy and other raw materials were rising, exacerbating concerns relating to growing import dependence on oil and gas and contributing to a rise in domestic inflation. Secondly, the growing consumption of energy within China was taking the country to the top of the league table of emitters of greenhouse gases. As a consequence, pressures on China were mounting to take steps to limit these emissions.

For these reasons, as China's government seeks to restart the stalled reform of the power sector, it is faced with a policy context that has changed significantly since the late 1990s and early 2000s, when the reform strategy was first drawn up. The aim of this section is to examine the changes that have taken place in China's power sector since the reforms of 2002-04 were implemented; that will provide the basis for an evaluation of the options for further reform in the following section. This section starts with a description of how the power industry responded to the challenge of rising energy demand, before examining how the policy environment has changed and how the government has responded to these changes. It concludes by identifying the key features and changes in the regulatory structures and systems during this period.

Surging energy demand

During the four years from the end of 2002 to the end of 2007 primary energy consumption in China grew by a total of 80% (BP, 2008), equivalent to an average of 16% per year. Demand for electricity grew at a similar rate. Total power output doubled from about 1 600 TWh (Terawatt-hour) in 2002 to about 3 200 TWh in 2007. This sudden growth of demand created an immediate shortage of electrical power, for a ban that had been placed on the construction of large new power stations in 1999 was lifted only in 2002. Thus the consumption statistics underestimate the actual level of demand during this period, as many provinces across China suffered power shortages, especially in the hot summer months. The growth of demand was greatest in the industrial sector, whose share of national electricity consumption rose from 73% to 75% from 2002 to 2006. Demand in the urban and residential sectors also saw strong growth (State Electricity Regulatory Commission, 2008a).

In order to attempt to satisfy the rising demand for electricity, power companies of all types across the country embarked on a massive campaign to invest in new generation capacity (Table 6.1). Given the time and resources required to construct so many power stations, the quantity of additional capacity becoming available grew steadily each year until 2006, when a total of 104 GW of new capacity was commissioned. The aggregate generating capacity of China's powers sector doubled, from 356 GW at the end of 2002 to 713 GW at the end of 2007 (Table 6.1).

The further rise of coal consumption

This growth of generation capacity was characterised by two trends, one unfavourable and the other favourable. The unfavourable trend was the rise in the proportion of coal-fired power stations in the total generating capacity (Tables 6.2 and 6.3). This arose from

Table 6.1. **National power investment in 2002-06**

Year	2002	2003	2004	2005	2006
Growth of GDP (%)	9.10	10.00	10.10	10.40	11.10
Total investment (billion Yuan)	229.692	289.443	328.489	475.422	522.784
Growth (%)	18.12	26.10	13.49	44.73	9.96
Elasticity of investment growth	1.99	2.60	1.34	4.30	0.90
Power sources investment (billion Yuan)	74.743	188.043	204.756	322.806	312.209
Growth (%)	14.25	151.59	8.89	57.65	–3.28
Power grids investment (billion Yuan)	150.748	101.400	123.733	152.615	210.575
Growth (%)	43.88	–32.74	22.02	23.34	37.98
Total capacity (GW)	356.5709	391.4078	442.3873	517.1848	622
Net increase (GW)	18.084	34.8369	50.9795	74.7975	104.8152
Growth (%)	5.34	9.77	13.02	16.91	20.27

Source: State Electricity Regulatory Commission, 2008a.

Table 6.2. **Fuel mix for power sources, 2002-06**

Year	Hydropower			Thermal power			Nuclear power		
	Capacity (MW)	Growth (%)	Share (%)	Capacity (MW)	Growth (%)	Share (%)	Capacity (MW)	Growth (%)	Share (%)
2002	86 074	3.70	24.14	265 547	4.95	74.47	4 586	102.2	1.29
2003	94 896	10.25	24.24	289 771	9.12	74.03	6 364	38.77	1.63
2004	105 242	10.90	23.79	329 480	13.70	74.48	7 014	10.21	1.59
2005	117 388	11.54	22.70	391 376	18.78	75.67	7 014	0	1.36
2006	128 570	9.52	20.67	484 050	23.68	77.82	7 014	0	1.18

Source: State Electricity Regulatory Commission, 2008a.

Table 6.3. **Fuel consumption for power generation, 2002-06**

Year	Standard coal		Raw coal		Oil		Gas	
	Consumption (Mt)	Growth (%)	Consumption (Mt)	Growth (%)	Consumption (Mt)	Growth (%)	Consumption (10^{T2} m^3)	Growth (%)
2002	472.9008	12.16	655.9455	13.81	10.8912	6.48	21.438	16.76
2003	550.4206	16.32	765.4312	16.69	13.2199	21.38	31.657	47.67
2004	624.6809	13.49	895.1227	16.94	13.8650	4.88	80.681	154.86
2005	694.3816	11.16	1 009.0721	12.73	12.7700	–7.90	124.274	54.03
2006	792.7356	14.16	1 182.4107	17.18	9.9366	–22.19	71.392	–42.55

Source: State Electricity Regulatory Commission, 2008a.

two factors. First, coal has long been the major feedstock of the country's power stations and domestic reserves of coal are plentiful. Second, the time and cost involved to build a coal-fired plant is significantly less than for the other preferred fuel, which is hydropower. The alternative fuels were not suitable for such a large expansion of capacity for a variety of reasons: natural gas was not available in sufficient quantities; oil was becoming increasingly expensive and, though its use in power generation did surge in 2003 and 2004, the government was seeking to reduce its application; and the renewable energy industry in China lacked the capacity to deliver such a vast capacity in such a short time.

The favourable trend was the substantial improvement in the nature of the coal-fired stations being constructed with respect to both scale and technology (Table 6.4). A majority of new plants were 600 MW or larger, and between 2002 and 2006 the proportion of plants

Table 6.4. **Composition of capacity of thermal and hydro units nationwide, 2002-06**

Item			2002	2003	2004	2005	2006
Thermal power	100 MW and above	Number of units	855	931	1 026	1 174	1 393
		Capacity (MW)	190 761	208 818	236 184	277 989	358 748
		Proportion to thermal total (%)	71.84	72.06	72.69	72.37	74.11
	200 MW and above	Number of units	519	554	612	708	880
		Capacity (MW)	152 015	164 120	186 440	221 230	295 420
		Proportion to thermal total (%)	57.34	56.64	57.38	57.59	61.03
	300 MW and above	Number of units	314	342	394	480	635
		Capacity (MW)	110 715	121 180	142 180	174 910	244 410
		Proportion to thermal total (%)	41.69	41.82	43.76	45.53	50.44
Hydropower	40 MW and above	Number of units	361	388	418	452	505
		Capacity (MW)	49 417	55 696	62 151	68 586	74 921
		Proportion hydropower total (%)	57.41	58.69	57.41	58.86	58.21
	200 MW and above	Number of units	94	104	109	125	135
		Capacity (MW)	26 905	32 090	35 790	40 790	43 440
		Proportion hydropower total (%)	31.26	33.82	33.06	35.01	33.79

Source: State Electricity Regulatory Commission, 2008a.

with a size of 300 MW and above rose from 41% to 51%. Many of the new plants incorporated advanced technologies that greatly enhance thermal efficiency and reduce pollution. As of the middle of 2008, 8.2 GW of ultra-supercritical plants were in operation and another 100 GW were under construction. A small number of plants using circulating fluidised bed combustion were also coming into operation (International Energy Agency, in press; State Electricity Regulatory Commission, 2008a).

Less successful has been the application of flue gas desulphurisation technology (FGD), intended to reduce sulphur dioxide emissions. This technology is not new and has been available for many years in China, but its high cost has discouraged its widespread use in power generation. Though the rate of installation in existing plants is about 30% and in new plants about 40%, a relatively low proportion of these plants use the FGD equipment. This is on account of the significant incremental operating costs in comparison to the low tariffs received by power generators, and on account of ineffective environmental regulation (International Energy Agency, in press).

At the same time as the industry has been constructing large and efficient plants, the government has been closing down small and inefficient plants. As part of its energy efficiency strategy, the government aims to decommission 50 GW coal of coal-fired capacity during the period 2006-10. This plan covers all plants less than 50 MW and many older plants up to 200 MW in capacity. At the same time the government has lowered the tariffs for power dispatched from plants with capacities of less than 50 MW as well as from some plants in the size range 100-200 MW. This strategy to enhance overall plant efficiency has been offset in part by the construction of many new plants with capacities under 135 MW, as a result of poor control over the planning and approval process during the construction boom.

These behaviours with respect to investment in and use of coal-fired generation have resulted in a very modest decline of 3% in coal consumption per kWh over 2002-06. They have also led to a continuing rise in total emissions of both dust and sulphur dioxide from the power industry, but a decline in emissions per kWh (Table 6.5). Average utilisation rates

Table 6.5. **Emissions from the power sector, 2002-06**

Year	2002	2003	2004	2005	2006
Net coal consumption (g/kwh)	383	380	376	370	367
Dust emissions of thermal power plants (Mt)	3.24	3.30	3.46	3.60	3.70
Growth of dust emissions (%)	0.62	1.85	4.85	4.05	2.78
Performance in dust emissions (g/kWh)	2.4	2.1	1.9	1.8	1.6
National total SO_2 emissions (Mt)	19.27	21.59	22.55	25.49	25.89
SO_2 emissions of power industry (Mt)	8.20	10.00	12.00	13.00	13.50
Proportion of power industry to total in SO_2 emissions (%)	42.6	46.3	53.2	51	52.1
Performance of power industry in SO_2 emissions (g/kWh)	6.1	6.3	6.6	6.4	5.7

Source: State Electricity Regulatory Commission, 2008a.

for thermal plants rose substantially from 2002 to 2004 as the power shortages grew more intense, before starting to decline from 2005 (Table 6.6).

Table 6.6. **Average utilisation hours of generation equipment in 2002-06**

Year	National		Hydro		Thermal	
	Hours	Growth	Hours	Growth	Hours	Growth
2002	4 860	272	3 289	160	5 272	372
2003	5 245	385	3 239	–50	5 767	495
2004	5 455	210	3 462	223	5 991	224
2005	5 425	–30	3 664	202	5 865	–126
2006	5 221	–204	3 434	–230	5 633	–232

Source: State Electricity Regulatory Commission, 2008a.

The power sector has traditionally been the main user of coal in China's economy, along with other industrial sectors. Yet as the share of coal consumption for non-industrial uses has declined, the share taken by the power sector has increased from 38% in 1998 to 50% today (Thomson, 2003; International Energy Agency, in press). Thus China's power industry and its coal industry have become increasingly interdependent.

Though investment in new coal mine capacity did allow coal production to rise by 75% between 2002 to 2007, from 1 450 million tonnes to 2 520 million tonnes, the power generators faced two sets of challenges. First, the government was constraining their ability to pass the rising price of coal through to the grid companies, as a result of which their profits were reduced. Second, the excess of supply of coal over demand declined after 2003 and the level of net exports of coal fell sharply, so that in some months of 2007 and 2008 the country was a net importer of coal. This struggle to meet the rising demand for coal has been exacerbated by shortages in rail capacity to transport coal from mines to the power stations. These twin pressures of commercial profitability and feedstock supply led to intermittent power shortages in 2008 despite the apparent adequacy of the aggregate generating capacity.

The role of other fuels

While investment in new generating capacity has been directed primarily at coal-fired plant, additional capacity has also been constructed for hydro, nuclear, natural gas and renewables.

China has one of the largest hydrological power resources in the world. Most of these resources are located in the southwest, with 50% in just three provinces and one municipality: Yunnan, Guizhou, Sichuan and Chongqing. Since 2002 an average of 10 GW of new capacity was commissioned each year and by 2007 the total installed capacity was 145 GW. Pump storage has been an important component in the expansion of hydro-electricity in order to supply peak load. At the end of 2007 the total pump storage capacity amounted to 9 000 MW with a further 14 000 under construction (Wang, 2008). Despite this construction programme, the proportion of hydro-electric capacity in China's power sector has gradually fallen from more than 30% in the early 1980s to about 20% in 2007. This decline has been largely due to the more rapid expansion of thermal power capacity. Over 2002-06, the proportion of hydro-electricity to national electricity supply declined from 16.6% to 14.7% (State Electricity Regulatory Commission, 2008a).

The power shortages triggered a resurgence of China's nuclear power industry. As part of ongoing plans, six new units were commissioned between 2002 and 2004, bringing the total capacity to 7 GW, entirely in the southeast of the country. This represented just over 1% of China's total power-generating capacity, but because of the way nuclear power is used, this capacity could contribute nearly 2% of total national electricity supply (State Electricity Regulatory Commission, 2008a).

Five more units totalling more than 4 GW are due to come on stream between 2008 and 2011. The real surge is planned for the following decade, 2010-20, as a further 28 GW is to be built, bringing the total to 40 GW. At least 11 units amounting to more than 12 GW are currently in the planning stage, in Liaoning, Shandong, Fujian, Zhejiang and Guangdong provinces. The balance of about 15 GW to be built before 2020 remains a proposal.

Neither oil nor natural gas contributes substantially to the country's power supply. The use of oil in power generation has declined since 2004 as other sources of electricity have become available and as the government successfully closed down the oil-fired plants on account of the pollution they caused. Though the use of natural gas in the power sector grew until 2004, it then declined as a result of the lack of availability of gas and as a consequence of the policy decision of the government to prioritise the use of gas in domestic and commercial sectors over power generation (State Electricity Regulatory Commission, 2008a; National Development and Reform Commission, 2007a).

Aside from hydro-electricity, wind is the major source of renewable electricity in China. The country has substantial wind resources, mainly located in the coastal southeastern provinces and in the northwest and northeast of the country. As part of the government's strategy to rapidly enhance the proportion of renewables in the energy supply, it has been actively promoting the development of wind power. Installed capacity has doubled each year since 2003. New capacity amounting to 2.6 GW was installed in 2006 and a further 3.4 GW installed in 2007, bringing the total to 6 GW. This gave China the fifth-largest wind power sector in the world, behind India. Wind power accounts for nearly 1% of installed power-generating capacity. In addition to these plants connected to the grid, the country has more than 200 000 stand-alone turbines serving individual households, totalling more than 40 MW (International Energy Agency, 2007a; Martinot and Li, 2007).

One of the long-standing weaknesses in China's power sector has been the shortage of capacity in transmission and distribution. This has resulted in congestion and in the inability to dispatch all generating plant that is available. In this way, investment in new generating capacity may be wasteful. The period 2002 to 2006 saw substantial investment

in the transmission and distribution network; a total of nearly 100 000 km of additional line was created, marking a 50% increase in line length. Most of the expansion was at 500 kV and 220 kV (State Electricity Regulatory Commission, 2008a).

The power companies

All five of the large generating companies established in 2002 took part in the construction of power plants. As a result of construction – and possibly, also of acquisition – all of them have substantially increased their share of equity ownership of generating capacity. Between 2002 and 2006 this share appears to have grown from 30% in 2002 to 40% in 2006. Datang and Huaneng showed the greatest growth, while China Power Investment grew the least (Pitmann and Zhang, 2008).

Partial data on the geographic location of major power plants (Pittman and Zhang, 2008) show that the role of these five companies in the north of the country in 2008 is quite different from in the south. In the large north China market and in the smaller markets of northwest and northeast China, these companies own a substantial proportion of the larger power plants, whereas in the central, south and east China markets their role is diluted by the presence of the Three Gorges Dam – especially in central China – and by a large number of other investors, particularly in the south and east China markets.

All five companies have significant holdings of hydro-electric capacity in southern and central China – notably Datang, traditionally a coal-based company from northern China, with 12 GW. The state grid has been progressively restricted to pump storage capacity, as its other generating plants have been sold off to other companies.

Table 6.7. **Production and business conditions of the five large power generation groups**

Power generation enterprises	Year	Sales revenue		Total profit		Total assets		ROR on net assets	
		Amount (billion Yuan)	Growth (%)	Amount (billion Yuan)	Growth (%)	Amount (billion Yuan)	Growth (%)	Rate (%)	Growth (%)
Huaneng Corp	2003	44.7	/	6.4	/	140.3	/	/	/
	2004	52.8	18.12	6.9	7.81	155.8	11.48	6.25	/
	2005	73.6	39.39	8.1	17.39	226.9	45.64	6.14	–1.76
	2006	84.5	14.81	9.6	18.52	285.6	25.87	6.61	7.65
Datang Corp	2003	33.1	/	2.6	/	110.4	/	/	/
	2004	41.2	24.47	3.0	15.38	139.9	26.72	1.54	/
	2005	55.2	33.98	3.6	20.00	183.0	30.81	1.98	28.57
	2006	70.3	27.36	5.5	52.78	226.6	23.83	3.62	82.83
Huadian Corp	2003	29.9	/	1.0	/	95.7	/	/	/
	2004	35.5	18.73	1.2	20.00	117.9	23.20	0.46	/
	2005	44.1	24.23	1.9	58.33	146.7	24.43	2.57	458.70
	2006	55.6	26.08	3.1	63.16	196.1	33.67	3.32	29.18
Guodian Corp	2003	26.2	/	1.4	/	72.6	/	/	/
	2004	34.5	31.68	2.2	57.14	104.1	43.39	3.60	/
	2005	48.7	41.16	3.2	45.45	132.3	27.09	1.62	–55.00
	2006	58	19.10	4.0	25.00	188.0	42.10	4.16	156.80
China Power Investment Corp	2003	25.7	/	1.5	/	85.3	/	/	/
	2004	28.9	12.45	1.5	0	111.2	30.36	1.70	/
	2005	37.9	31.14	2.0	33.33	138.3	24.37	1.70	0
	2006	48.3	27.44	3.9	95.00	181.2	31.02	4.82	183.53
Total		928.7	/	72.6	/	1 077.5	/	3.35	/

Source: State Electricity Regulatory Commission, 2007a.

This expansion of generating capacity allowed each of the five main generating companies to increase their sales revenue over 2003-06. Each company also succeeded in raising their profits both in absolute terms and in terms of rate of return on net assets (Table 6.7). Recent analysis suggests that this improvement in profitability was driven, at least in part, by significant improvements in the efficiency of the use of key inputs such as labour, fuel and non-fuel materials (Du *et al*., in press). The profits of these generating companies have declined in 2007 and 2008 as coal prices have continued to rise faster than the wholesale electricity price.

The role of foreign investment in China's power sector since 2002 has been relatively small, although the government has long permitted foreign direct investment in power stations with a capacity greater than 300 GW. Official statistics show that actual foreign investment in 2005 was USD 1.8 billion, equivalent to 2.6% of total investment in the power sector. This fell to USD 620 million in 2006 and USD 566 million in 2007 (Ministry of Commerce, 2008). This is a consequence of many factors, including policy ambiguity, legal instability and the low level of tariffs (Wee and Wee, 2003; Andrews-Speed, 2004).

The new policy environment and government responses

The period 2004 to 2008 was a time of significant change in the policy environment for China's energy sector. Since 2003, security of energy supply has been high on the agenda for both domestic and international reasons, and the government has identified energy efficiency and energy conservation as forming the core of its new energy strategy. This contrasts with earlier approaches to energy policy, which had emphasised the production of energy. The new approach has had immediate and significant consequences for the electrical power industry. More recently, concerns relating to climate change have supplemented the drive for energy efficiency. But behind both of these sets of policy objectives lies the long-standing priority of addressing social equity concerns through energy pricing.

Energy security and energy efficiency

The growing shortages of energy drove the government to undertake a thorough review of its energy strategies in 2004. The most authoritative report to be published was that of the Development Research Centre of the State Council. This report identified the following main priorities for China's future energy policy (Development Research Centre, 2004):

- Placing greater emphasis on energy conservation and energy efficiency, especially in industry.
- Integrating environmental priorities into energy policy.
- Maintaining domestic primary energy resources as the main source of energy supply, but improving the management of these resources.
- Enhancing the role of the market within the domestic energy sector.
- Increasing the use of hydro-electricity, renewable energy, nuclear energy and natural gas, in order to reduce reliance on coal.
- Developing alternative transport fuels.
- Constructing emergency oil storage.

At the same time, the NDRC issued its "Medium and Long Term Energy Conservation Plan". The Plan not only demonstrated that energy efficiency and energy conservation did indeed lie at the heart of China's new energy policy, but also set forth specific targets and objectives and identified the key steps to be taken (National Development and Reform Commission, 2004). A revised version of the 1997 Energy Conservation Law was approved in October 2007.

The stated overriding goal of the new strategy was to reduce energy intensity by 20% between 2005 and 2010. This Energy Conservation Plan and subsequent documents have set targets for individual energy-intensive industries such as electrical power generation, steel, nonferrous metals, oil refining, petrochemicals, chemicals, cement and plate glass, as well providing proposals for the technological, process or management improvements needed to achieve these targets. By the same year, 2010, standards for energy-fed appliances are to be raised to international levels, and the systems for policy, regulation and technical support for energy conservation are to be dramatically improved. These priorities were further elaborated in the Five-Year Plan for the period 2006-10 (National Development and Reform Commission, 2007a) and work has been under way since 2006 to draft an Energy Law that will encapsulate the key aims and approaches to China's new energy policy.

A number of detailed regulations have been issued relating to the power sector. The aim is to encourage high-specification generation technologies with large capacities, high efficiency, low water usage and effective environmental controls (International Energy Agency, in press). It is these regulations that have encouraged the construction of the supercritical and ultra-supercritical plants mentioned above. At the same time, small, old and inefficient plans are being closed.

In addition to adjusting the efficiency and cleanliness of national generating capacity through construction and closure, the government has taken steps to adjust the system for the dispatch of power plants. In August 2007 a new trial method for dispatch was announced (National Development and Reform Commission, 2007b), which set out the following order for dispatch:

- Renewable energy.
- Nuclear power.
- Coal-fired co-generation units and those using waste heat.
- Natural gas and gasified coal units.
- Conventional coal-fired units.
- Oil fired plants.

For thermal plants within the same category, the order of dispatch should be on the basis, first, of energy consumption and, second, of pollution levels. Trials were started in late 2007 in five provinces, Henan, Jiangsu, Guangdong, Sichuan and Guizhou. Guizhou was the first to implement the new dispatch method. It is reported that the province saved 592 tons of coal on the first day of the trial, and it is expected that the annual coal saving from the new method could reach 300 000 tonnes and sulphur dioxide (SO_2) emissions could be reduced by 150 000 tons.

More recently, governments at local level have taken active steps to introduce SO_2 emission trading programmes. For example, the Environmental Protection Bureaus in Shandong and Jiangsu issued the programme proposals in late 2007 and early 2008,

respectively. Guangdong and Hong Kong have been working on a plan for a joint trading programme since 2005. This programme was finally launched in early 2007; it aims to reduce SO_2 and nitrogen oxide (NOx) from power plants in both areas.

Climate change

The attitude of China's government to the global environmental impacts of energy use has also changed. Interest in adapting domestic policies to address the challenges of climate change had been rather limited, but late in 2006 the International Energy Agency predicted that China would overtake the USA and become the world's largest emitter of greenhouse gases (GHGs) by 2009. Indeed, at the beginning of July, 2007 the Netherlands Environmental Assessment Agency released the results of its preliminary analysis of the latest energy data; they showed that China had already become the largest emitter of GHGs in 2006.

Partly in response to this growing awareness of China's contribution to current (not historic) GHG emissions, China's State Council approved a national plan to address the challenges posed by climate change at the end of May 2007 (National Development and Reform Commission, 2007d). Ambitious though some of these targets are, most of those relating to energy are consistent with the newly developed energy strategies (Lewis, 2007). Three components of the climate strategy that are of relevance to electrical power are renewable energy, the Clean Development Mechanism (CDM) and carbon capture and storage.

The Renewable Energy Law passed in 2005 marked a new determination by the government to substantially enhance the role of renewables in the national energy supply. This law created, for the first time, a relatively coherent framework for promoting investment in renewable energy. It provided an obligation for grid companies to connect all renewable plants and to purchase all electrical power generated by these plants. Incentives for research and development were also provided in order to encourage the domestic manufacturing of the required technologies.

Despite these positive components, the law did not provide for a fixed and predetermined feed-in tariff (the price paid by the grid to generator). Rather, the tariff is set by competitive bidding. This has resulted in the state-owned power companies driving prices down to levels below what most would estimate to be commercially viable for wind power or other renewables. Private sector investors, both domestic and foreign, have failed to gain significant opportunities (Lema and Ruby, 2007; Li and Ma, 2007).

An added potential incentive for the construction of renewable energy capacity is the Clean Development Mechanism, the instrument established by the Kyoto Protocol to encourage financial support from developed economies for investment in clean energy in developing economies. To date wind power has been the prime beneficiary within the power generation sector of the CDM mechanism in China (IEA, 2007). Administrative obstacles and policy ambiguity have so far prevented rapid implementation for renewable energy within China (Zhang, 2006; Resnier *et al*., 2007).

The years 2007 and 2008 saw the launch of two major initiatives relating to carbon trading. In collaboration with the UNDP, the government established exchanges in Beijing and Shanghai to provide platforms for carbon trading, as well as to collect and publicise relevant information and undertake advisory and consultancy services. The second initiative, called MGD Carbon (Carbon Finance for Achieving Millennium Development

Goals), is intended to establish service centres in poorer parts of the country to enable them to take part in the carbon trading schemes.

Carbon capture and storage (CCS) is likely to become an important part of China's climate change strategy on account of the country's probable long-term dependence on coal as a major source of primary energy, especially in the power sector. Though the need to carry out research into this technology is mentioned in the National Climate Change Programme, no specific commitments or targets have been established. Despite the absence of a clear government strategy, the China Huaneng Group commissioned the country's first carbon capture demonstration plant in July 2008. The project, in collaboration with CSIRO of Australia, extracts carbon dioxide from the emissions of a coal-fired plant and uses this carbon dioxide in the food and drink industry.

Rising prices and social equity concerns

The pricing policies introduced in 1998 have led the power industry to be vulnerable to international markets and dependent on government policy. The price of the main primary energy feedstock, coal, is set by international markets, while the end-user prices for electricity are set by government, and at levels intended to address social equity concerns.

As international prices for coal and crude oil rose over 2002-08, so did domestic prices for the producers of coal and oil. The government allowed coal prices to react to supply and demand, and so border prices for steam coal rose from about USD 40 per tonne in 2004 to USD 110 in July 2008 in line with international prices. Inland, near the areas of production, coal prices were at lower levels but also increased by a similar proportion. The government has sought to constrain the price of coal sold to power stations but otherwise has not directly capped coal prices. Domestic crude oil prices likewise continued to rise as the government allowed them to follow trends in the international markets.

In contrast, in its concern to protect private citizens and, to a lesser extent, industrial and commercial enterprises, the government has proved very reluctant to raise end-user prices for electricity, for oil products and for natural gas. Though consumer prices for most forms of energy were raised at irregular intervals, end-user electricity prices continued to lag behind wholesale electricity prices, and they in turn lagged behind the rise in coal prices. The reluctance to raise energy prices further grew during 2007 with rising inflation.

By March 2008 power shortages were appearing across the country, despite the massive and ongoing investment in new power generation capacity over the previous five years. In part these shortages were caused by the severe winter weather in the southern part of the country. But a further cause was the unwillingness of power generators to operate at a time of rapidly rising coal prices and frozen electricity prices.

In June 2008 China's government could no longer resist the pressure for further substantial tariff adjustments and announced a round of price rises for energy products. From 1 July 2008 wholesale electricity tariffs were allowed to rise by 5%. This increase provided some compensation to the power generators, but the industry argued at the time that a further rise of 50% would be required to match the amount that coal prices had risen by over the previous 12 months.

Evolving systems and institutions for sector regulation

The period from 2004 to March 2008, when the government underwent significant restructuring, was a time of subtle rather than substantial change in the structures and systems for managing the power sector. Despite the dramatic change in the structure of the power industry itself in 2002 and the creation of the State Electricity Regulatory Commission, powers and functions remained with the traditional centre of authority, the NDRC (State Electricity Regulatory Commission, 2007b, 2008b).

The sudden rise in the importance of energy as a national priority saw the top leadership and the State Council becoming more involved in issues relating to energy than before, as was shown by the creation of the Energy Leading Group and its supporting State Energy Office. But the NDRC retained control over most of the key aspects of policy making and regulation in the electricity sector (Table 6.8). Specifically, the NDRC continued to be responsible for formulating energy policy and policy for the power sector, including sector reform. At the same time it held approval authority over pricing, investment, new technologies, and CDM projects.

Though these roles were concentrated in the NDRC, other tasks were dispersed among a number of other government departments such as the State Assets Supervision and Administration Commission (SASAC), the Ministries of Finance and of Science and Technology, the State Administration of Industry and Commerce, and the State Environmental Protection Agency (Table 6.8).

Table 6.8. **Summary of the allocation of government functions relating to the power sector between 2003 and March 2008**

Function	Responsible agency	Participating agency
Energy policy formulation	NDRC (Energy Bureau)	Energy Leading Group State Energy Office
Power sector policy formulation	NDRC (Energy Bureau)	SERC
Power sector planning	NDRC (Energy Bureau)	SERC
Price regulation	NDRC (Price Dept)	SERC
Investment approval	NDRC (Energy Bureau)	
Market entry approval	SERC	
Service obligations and quality	SERC	
Law-enforcement and administration	SERC or Local Economic and Trade Commission	
Demarcation of geographic area of power supply	SERC or Local Economic and Trade Commission	
Approval of new technologies	NDRC	
Approval of CDM projects	NDRC	
Technical and quality standards	NDRC	
Regulation of financial system of enterprise	Ministry of Finance	SERC
Regulation and management of national assets	SASAC	
Environmental regulation and management	SEPA	
Approved scope of enterprise operation	State Administration of Industry and Commerce	
Electrical power standards	Ministry of Science and Technology	
Safety regulation	SERC	
Public service	SERC	

Source: State Electricity Regulatory Commission, 2007b, 2008b.

SERC itself was left with few clear responsibilities except for drawing up proposals for the NDRC, drafting rules of minor importance, and undertaking certain minor regulator

functions. SERC appears to have carried out the former two tasks with great enthusiasm to judge by the large number of documents it has produced since January 2006. However, its capacity to undertake the minor regulatory tasks has been restricted by the shortage of staff and of offices at local level. As a result these functions continue to be carried out by local Economic and Trade Commissions wherever no local office of SERC has been established.

In a report that examined the sources of this failure to change the systems and structures of regulation, SERC (2008b) identified two factors preventing radical change:

- A general lack of understanding within government of the nature of regulation and of the need for change in both the structures and functions of government.
- A lack of a precedent within China to guide the creation of new regulatory systems and structures for the power sector.

To this should be added the apparent unwillingness of the NDRC to relinquish its power over policy, planning, investment or pricing.

Further, SERC (2008b) explained that it was unable to carry out even its present functions adequately, for a number of reasons:

- The inadequacy of existing laws and regulations to provide a framework for effective regulation.
- A shortage of skilled manpower to staff an effective electricity regulatory agency.
- The power of provincial governments to protect the interests of the provincial power industry.
- The ability of the power companies to resist calls for information by SERC.
- A lack of appreciation of the rule of law rather than the rule of authority.

Thus, despite a rearrangement of roles and responsibilities, the long-standing systems of regulation of China's power sector changed little over 2003-08. Authority remained concentrated in the NDRC for the most important regulatory functions, while other functions were highly dispersed. The result was excessive government interference where it was not needed, and inadequate regulation where it was needed (SERC, 2008b). After the fanfare that accompanied the creation of SERC as an "independent regulator", this new agency has been treated as a peripheral advisory body rather than a regulator of critical importance to the development of the sector.

The new government, installed in March 2008, undertook a radical reorganisation of some ministries and agencies, but the energy sector only saw minor changes. The Energy Leading Group was transformed into the National Energy Commission and the Energy Bureau was upgraded and enlarged to become the National Energy Administration (NEA). This new NEA incorporates the previous Energy Bureau and State Energy Office, as well as the nuclear power administration. At its launch in July 2008 the NEA had a staff of 112 in nine departments: energy policy, project planning, project approval, electricity, coal, oil, nuclear power, alternative resources and international co-operation. Though its rank has been raised to vice-ministerial status, the NEA is likely to continue to lack the capacity and authority to fulfil its mandate, not least because it remains within the NDRC and because the Price Department of the NDRC retains control over energy pricing (Downs, 2008; Miller, 2008).

In the same reorganisation the State Environmental Protection Administration (SEPA) was raised in status and re-named the Ministry of Environmental Protection (MEP). This upgrade means that, as a cabinet-level ministry, the MEP can be directly involved in high-profile decision making and has the authority to co-ordinate other cabinet-level ministries in order to address environmental problems. A further possible consequence is that the provincial governments may follow the central government's move and introduce the Environmental Protection Bureaus (EPBs) into their decision-making processes. For example, the Jiangsu provincial government has raised the status of its EPB to that of a Department of Environmental Protection.

It is not yet clear what the impact will be on SERC of the creation of the National Energy Administration and the Ministry of Environmental Protection. Their enhanced status may encourage these agencies to retain authority rather than devolve it to SERC. As of late 2008, the government has made no official statement concerning any adjustment of roles or responsibilities relating to SERC.

Re-evaluation of China's sector reform plans

By 2007 it appeared that the power supply crisis was easing, that a surplus of generating capacity was to be in place by 2008, and that systematic power shortages would disappear. In an effort to revive the process of power sector reform, the State Council issued a document in April 2007 (State Council, 2007) setting out the guidelines for moving forward, based on their original strategy published in 2002 (State Council, 2002).

The aim of this section is to evaluate China's plans and proposals for further power sector reform in light of the developments described above, and in light of likely future trends and developments.

The objectives and approach

As discussed above, the objectives of the Chinese government at the time the power sector reforms were launched in the 1990s were:

- To increase the quantity and quality of power supply.
- To raise the commercial and technical performance of the power industry.
- To pass the cost benefits to end-users in the form of tariff reductions.

The underlying ideas and plans for reform were formulated in the mid- and late-1990s, at a time when energy demand was rising, but at a slower rate than in the early 1990s. At that time the government believed that foreign investment was needed to support the expansion of the power sector and that this investment would be forthcoming. Further, the reform strategy was based on the understanding that the introduction of competition was vital to achieving the government's objectives for the power sector – namely, attracting investment, lowering costs and reducing tariffs.

In this respect, China's government was following the prevailing international wisdom at the time and focusing purely on the economic performance of the electricity industry, in the narrow sense of the word "economic". The government's approach was consistent with its wider industrial policy of progressive commercialisation and privatisation of state-owned companies, and of liberalisation of domestic commodity markets. This strategy for the electricity industry was also compatible with the wider energy policy of raising domestic capacity to produce energy to support economic growth.

A decade or more later, China's own energy policy priorities have changed dramatically, and international understanding of electricity sector reform and regulation has evolved (as will be examined in the next section).

In 2008 China's energy policy has been driven by a combination of short-term and long-term objectives. In the short term, the government has been expending considerable effort to achieve its goal of reducing energy intensity by 20% between 2006 and 2010. Many of these measures have been directed at the power sector, both at the production and at the consumption of electricity. At the same time, a relatively high level of inflation since 2006 has rendered the government reluctant to raise end-user prices for energy, including electricity, especially for households and rural inhabitants.

In the longer term, the government has been progressively adopting strategies that are intended to lead to a more sustainable use of energy, with respect to both energy intensity and environmental impact. These strategies recognise the need to adjust the structure of China's economy away from its dependence on heavy industry, to raise the level of energy efficiency throughout the economy, to diversify the fuel mix and to promote the development of new, clean and renewable sources of energy. Thus recent years have seen a drive to build wind farms and nuclear power plants, to install clean coal technology, and to carry out a trial in carbon capture.

Underlying these short-term and long-term objectives is the expectation that demand for electricity in China will continue to rise rapidly, barring a major economic or political crisis, at an annual rate of 7.5-8.0% between 2005 and 2015, and 4.4-4.9% between 2005 and 2030 (International Energy Agency, 2007a).

This combination of policy priorities is quite different from what existed in the mid- to late-1990s. In particular the drive for energy efficiency throughout the economy, combined with the push for cleaner energy, will have the unavoidable consequence that energy costs rise. Though an efficient and clean electricity sector will yield long-term benefits, investors need incentives to invest in new technologies for generating and using electricity, and end-users need incentives to be efficient.

The challenge of managing the transition to a more sustainable energy system faces not just China but also OECD countries that have a low or negative rate of growth of energy demand. China and other developing countries face the additional challenges of managing this transition with a high rate of growth in demand for electricity, and the need for investment in new generation capacity and in new electricity appliances. At the same time, priorities relating to the macro economy and to social equity also have to be addressed.

Given this new context, it is not clear that the original strategy to introduce competition in generation will address the government's current priorities. The reform steps taken already have yielded some benefits with respect to increasing the quantity and quality of power supply, and raising the commercial and technical performance of the power industry. The third objective from the 1990s, that of passing the cost benefits to end-users in the form of tariff reductions, has not been achieved on account of rising fuel costs, though the government has protected some users from these price rises.

The current priorities for China's energy policy require that strong administrative and economic signals be provided to the producers and the users of energy (United Nations Economic and Social Commission for Asia and the Pacific, 2004; United Nations Economic Commission for Europe, 2005; Energy Charter Secretariat, 2007). These signals should furnish guidance with regard to their investments in infrastructure and appliances and to

their operating behaviours, in order to create a power supply system with adequate capacity and reliability, to maximise energy efficiency, and to minimise environmental impacts. For the electricity industry, these signals would cover issues such as:

- The choice of fuel, technology and location of new power-generating plants.
- The upgrading of existing plants.
- The construction of transmission and distribution networks.
- The operation of the generating plants and of the entire system, including dispatch.
- Investment in appliances using electricity, industrial, commercial and domestic.
- Research into and development of new clean and efficient technologies.

The introduction of competition in generation by itself will not achieve these objectives. Strong complementary measures will be needed. Given the urgency of the capacity, efficiency and environmental challenges facing China, the key question is whether or not the introduction of competition should continue to be the main priority for the future development of the electrical power sector.

In simple terms, two choices face the government:

- To press ahead with the introduction of competition in power generation, taking the industry towards Model 3, and at the same time bring in measures to address the challenges relating to capacity, efficiency and environment.
- Or, to continue to set aside the planned introduction of competition, and to continue implementing measures to address the current strategic priorities, and retain the industry within a Model 2 framework.

For several years it has been widely argued that China's power sector is not ready for the introduction of competition and that a wide range of actions must be undertaken in preparation for competition, but also that many measures can be implemented to address the challenges facing the power sector before the introduction of competition (Andrews-Speed, 2004; International Energy Agency, 2006; State Electricity Regulatory Commission, 2007b, 2008b).

Specific reform measures

The State Council's document of April 2007 (State Council, 2007) reiterated the components of power sector reform stated earlier, namely:

- Continuing the separation of generation from transmission.
- Continuing the separation of ancillary businesses from the main power companies.
- Improving systems for dispatch.
- Creating conditions for the separation of distribution from transmission.
- Improving the power sector in rural areas.
- Increasing the commercialisation and performance of power companies.
- Enhancing reform of electricity pricing.
- Revising relevant laws and regulations.
- Accelerating change in government functions.
- Accelerating the development of power markets.

All but the last of these proposals involve no introduction of direct competition in the sale of electricity. Indeed, these measures can be seen as vital steps in preparing *for* the introduction of competition.

That introduction faces a number of major challenges, irrespective of the changed nature of the energy policy priorities. Foremost among these are long-standing weaknesses in the legal system, in the governing laws and regulations, and in the institutional structures and systems for managing and regulating the power sector (Andrews-Speed, 2004; IEA, 2006; SERC, 2007, 2008).

A number of features of the power industry provide additional challenges. Some of these are long-standing, and others have appeared along with the reforms over the last few years (Pitmann and Zhang, 2008). The transmission system remains fragmented despite ongoing investment; this will constrain sales within the proposed regional wholesale markets, as well as the much-needed trade from the west and north of the country to the south and east. As a result, the wholesale markets are likely to be geographically smaller than intended, and this may allow certain generating companies to achieve undue market influence. The possibility of anti-competitive behaviour will be enhanced if individual companies own both base-load and peak-load plant in the same market, if there is little excess supply and companies can benefit from withholding supply, and if collusion arises between different state-owned companies. Further, the very high proportion of coal in the fuel mix, especially in northern and central China, is likely to render prices highly volatile.

Anti-competitive behaviour can be ameliorated if entry barriers to new, private sector investors are reduced. Unfortunately in China, barriers to private investors, especially foreign investors, have been high with the exception of a period of a few years in the 1990s. The main barriers to private sector investment in power generation in China continue to be (Andrews-Speed, 2004; Pitmann and Zhang, 2008):

- Ambiguity of the policies and plans for the reform of the power sector.
- Ambiguity of the laws and regulations.
- The instability of contracts.
- A system for setting wholesale tariffs that limits financial returns even in cases where power purchase agreements have been signed.
- The complexity of the regulatory system, which requires a high level of transaction costs.
- The abundance of domestic Chinese funds flowing to state-owned investors in power generation, combined with local protectionism.

Though China may not need private sector participation to provide additional capital at present, and although the industry may be able to obtain foreign technology through co-operation with foreign engineering companies, the involvement of domestic and foreign private investors should furnish the advantage of reducing the scope for anti-competitive behaviour by the incumbent players. But these investors will only be attracted to China's wholesale market if the entry barriers listed above are lowered substantially.

Given the high level of entry barriers to date and the specific technical and structural concerns discussed above, a strong case exists that China's power sector is not ready for the introduction of competition in power generation, and that the government should focus its attention on other measures that address its strategic priorities, and on further preparation for wholesale competition.

These steps have been elaborated previously by the International Energy Agency (IEA, 2006). They include those measures identified by the State Council's (2007) document as well as specific proposals drawn up at the time by other government agencies in China, such as SERC and NDRC. The steps proposed by the IEA to build on previous reforms and to prepare for the introduction of competition in power generation are more wide-ranging and in places have a different emphasis from those of the Chinese government.

The IEA's recommendations for specific actions to enhance sector efficiency and environmental performance have many similarities to the ongoing priorities of China's government, for example:

- Improving the dispatch system and the methods for setting wholesale prices, which would allow efficient and clean plants to be rewarded in a transparent manner; the wholesale tariffs would in two parts, one part for fixed costs and the other part for variable costs.
- Improving and enforcing administrative systems and economic incentives to control sulphur dioxide and particle emissions, by obliging companies to fit or retrofit the relevant equipment and to operate it.
- Introducing more rigorous planning systems and licensing rules to more effectively control the scale, technology, fuel and location of a new plant.
- Introducing a system of transmission pricing that encourages appropriate investment by the grid.
- Completely changing the system of end-user pricing to one that is transparent and based on costs, that provides incentives for all electricity consumers to enhance their energy efficiency, and that does not unduly discriminate against the commercial sector.

In addition, the IEA proposed a number of measures that are not explicitly identified in the government's strategy for the power sector, for example:

- Separation of the functions of dispatch from those of management of the grid, through the establishment of an independent system operator.
- Much greater effort to develop and implement systems to promote demand-side management (DSM) throughout all sectors of the economy and across the country. Although the steps needed were identified several years earlier and some measures have already been implemented in a limited manner, much remains to be done (Hu *et al.*, 2005). Particular emphasis could be placed on time-of-day pricing for industrial and commercial consumers.
- A change in the way poorer populations receive subsidies for electricity, by introducing lifeline pricing to replace the current indiscriminate low level of household tariffs.

Regardless of the direction and pace of future sector reform, the framework in which the power industry operates requires substantial improvement in a number of respects (International Energy Agency, 2006). The government needs to set out a clear reform strategy for the power sector, in which roles, responsibilities, goals and risks are identified, and in which the sequencing of measures is well-defined. A single agency must be charged with providing leadership for the reform process, and this agency should possess adequate authority and capacity in order to sustain the momentum and to adjust the reform process as and when required. The government should establish a strong legal foundation for the proposed reforms, including updating laws and regulations. Greater transparency is needed with respect to decision making and information in both the reform process and

the ongoing regulation of the power sector. Finally, the systems of governance of state-owned companies in the power sector need radical improvement to ensure that the reform measures have the greatest chance of yielding the intended benefits in terms of energy efficiency and environmental protection.

Of all the measures proposed by domestic and external agencies (Berrah and Wright, 2002; International Energy Agency, 2006; State Electricity Regulatory Commission, 2007b), the single most important is the development of a regulatory agency with the capacity and the authority to oversee the design and implementation of the reforms and to carry them out. When SERC was established in 2002, the expectation was that it would take on this role, but to date SERC has lacked the capacity and, more importantly, the authority to fulfil these tasks. The authority for the key regulatory tasks still lies with the NDRC, as discussed earlier, and yet the NDRC itself lacks the capacity to carry them out effectively.

Success in the reform process will require SERC to take over responsibility for regulating the market players and preventing anti-competitive behaviour; for overseeing system dispatch and system security; for regulating investment; for promoting energy efficiency and environmental protection; for consumer protection; for collecting and analysing data; and, eventually, for tariff regulation. In addition to the political process of transferring authority, SERC will need greatly enhanced resources in terms of staff numbers and skills, both at central level in Beijing and throughout the country. Further, specific steps will need to be taken to enhance the public image of SERC, so that its roles and responsibilities are clearly understood by the public and by the industry – for a regulatory body of this type is quite new in China.

All these measures comprise a major policy programme without the additional step of introducing competition in generation; they should yield substantial benefits in the short term in respect of electricity supply, total energy consumption and environmental impact.

Implications of recent lessons in OECD and developing countries

The first countries to embark on a radical reform of their electrical power sectors were Chile, the United Kingdom and Norway in the 1980s. As mentioned earlier in this chapter, the ideas behind the reforms and the lessons from the first years of reform in these and other countries provided the framework within which China's government formulated a strategy to reform its own power sector in the late 1990s and early 2000s.

Since the year 2000, two phenomena have stimulated a re-evaluation of the liberalisation strategy in some quarters:

- A number of countries that had embarked on liberalisation, mainly OECD countries, experienced severe blackouts and price volatility in the years 2000-05.
- Many countries face new challenges as they attempt to reconcile their sector liberalisation policies with pressing priorities relating to investment in new capacity and to climate change.

The aim of this section is to examine how events, trends, understanding and policy priority changes in OECD and developing countries in recent years have affected approaches to power sector management and reform, and what relevance these changes have to China. The section starts with a summary of key points from recent reports drawing on the 20 years of reform experience in OECD and developing countries, before addressing lessons from more recent experiences.

General lessons from the reform experience

A general consensus exists that the main aim of power sector reform is to provide a better-quality service as a result of improvements, aimed at supporting economic growth and development, in the quantity and type of investment and in the operating practices within the power sector. At the same time, these measures should reduce the financial burden placed on the government by the power sector, and provide improved and affordable access to electricity supply for the poor (International Energy Agency, 2005a; Besant Jones, 2006).

The extent to which power sector reforms can be declared as having proved "successful" is more contentious. However certain significant benefits can clearly be identified in a number of cases (IEA, 2005a; Besant-Jones, 2006; Nakano and Managi, 2008), for example:

- An improvement in the productive and allocative efficiency of the power sector.
- A greater diversity of fuels and players in the power market.
- A reduction in overcapacity within generation.
- Better co-ordination between market players.
- Lower prices for end-users.
- Greater involvement of consumers in the management of the power sector.

Understanding of the risks involved in power sector reform has improved. The greatest risk is that of power shortages or highly volatile prices, or both, and even consistently high prices. These can arise from a variety of causes, for example abuse of market power, poor operating practices, and inadequate investment in infrastructure arising from inappropriate incentives. In a competitive market, very low prices can create financial problems for certain types of investor; this may be perceived as having strategic importance, for example in the case of nuclear power or renewable energy. The market can thus undermine government strategy. Finally, high prices – while they may be necessary at times to provide incentives for investment – exacerbate energy poverty, and market mechanisms alone rarely provide incentives for the power industry to invest in supplying poor and remote communities.

In order to minimise these risks, great care must be taken in the design of the reform strategy and plans, and in preparing for an implementation of the reforms (IEA, 2005a). Strong involvement is required from government in the development of the strategy; political commitment to reform is needed to ensure the steady progress of reforms; and great efforts have to be made to gain acceptance from all relevant sections of society. The government should take great care to prevent abuse by vested interests at key stages of the reform, especially privatisation.

The government needs to draw up the necessary legislation and market rules, to establish a regulatory agency with as high a degree of independence as is feasible, and to maximise transparency in the policy making and regulatory processes. Active and robust regulation is needed throughout the reform process in order to increase the diversity of players and to prevent market abuses.

The most important determinant of successful reform is the regulatory framework (Besant-Jones and Tenenbaum, 2001; Bacon and Besant-Jones 2002; Besant-Jones 2006; IEA, 2001, 2005a; Jamsb and Pollitt, 2007). In addition to the need for independence from the government and from the power industry, the regulatory agency should have clearly

allocated powers and a high level of credibility throughout society. The actual allocation of powers between government and regulator is quite variable. The most liberalised markets tend to have the most independent regulators with the greatest powers, and the less liberalised markets have regulators more closely tied to government. To be effective, the regulatory agency must be suited to the needs of the reform process and to the national systems and structures of government and public administration. In a large country such as China, effective co-ordination is required between regulators at national level and those at local level, and also between the energy regulators and the environmental regulators.

Power sector reform is a process, not a single action, and it can last for years or decades. While certain goals may be easily identified and while there is general acceptance on the overall sequencing of key actions (*i.e.* Models 1-4), there are no "off-the-shelf" solutions. Each government has to formulate plans that address the context and needs of the power sector in its country at the time (Besant-Jones and Tenenbaum, 2001; Besant-Jones, 2006; IEA, 2005a). Of particular importance are the starting conditions with respect to the geographic size of the country, the size of its power industry, the size of any surplus in generating capacity, the state of its transmission infrastructure, the income level and macroeconomic conditions, and the political and administrative systems.

Regardless of the path of reform chosen, governments should refrain from embarking on power sector reform and the introduction of competitive markets until the key preparatory steps have been taken, especially those relating to laws, rules and regulation. Launching reforms without fulfilling these preconditions greatly reduces the probabilities of success.

A further important lesson from international experience is that the post-liberalisation market rules and regulatory framework require clear priorities and systems for addressing externalities relating to reliability of supply, the environment and social equity (IEA, 2005a). Many governments are only recently realising that they have not paid adequate attention to these issues. In their concern for tangible, short-term economic success, they have forgotten long-term priorities.

Lessons from more recent experiences

The years 2000 to 2005 saw severe blackouts and politically unacceptable price volatility in a number of power markets in some OECD countries, for example the United States, Canada, the United Kingdom, Scandinavia and Italy. At the time, many commentators argued that these events illustrated that the whole idea of power sector reform was fundamentally flawed, and as a result many governments slowed down or suspended the reform process. But more considered analysis showed that these incidents arose principally from failures in the design of markets or from failures in the regulation of the operating markets (Besant-Jones and Tenenbaum, 2001; IEA, 2003, 2005a, b).

The introduction of market forces changes the way investment decisions are made. The design of the market must allow price signals to all participants to be appropriate and timely, and the policy and regulatory framework should be transparent and predictable, especially for investment. Two particular dangers are the unpredictable intervention of government in the market and the setting of price caps. Investors must not fear government intervention and any price caps should be short-lived, otherwise investment is discouraged. Likewise, if prices in the market do rise suddenly, governments should not

panic, for these prices are sending signals to investors to invest in much-needed new capacity.

Government does indeed have a role in monitoring the adequacy of generating and transmission capacity and the nature and levels of investment in new capacity. Likewise, government has a clear responsibility to establish effective legal and regulatory frameworks for transmission system security. Maintaining system security and establishing emergency response measures require government intervention, for the market will not address these issues by itself. System security requires that roles and responsibilities be clearly identified, that a high degree of co-ordination, communication and information exchange be established between all the players, and that the best available technology and the most highly skilled people be employed (IEA, 2005b).

In addition to the challenge of addressing short-term disruptions and price spikes, many governments around the world are now facing two additional challenges, relating to security of supply and the environment. At the root of the problem is that, by definition, the process of liberalisation reduces the ability of governments to influence the market directly unless they put in place additional mechanisms to address such externalities.

In the power sector, security of supply rather than system reliability refers principally to the availability and suitability of generating and transmission capacity, though fuel supply may also be a concern. A number of countries, the United Kingdom for example, are facing an imminent shortfall of generating capacity. This has arisen not so much from demand growth as from a combination of low prices and government policy inaction, which together have delayed appropriate investment in base-load capacity to replace plants that are nearing the end of their life. Though high prices are likely to trigger the required investment, the time lag will be significant, especially if the government decides to support the construction of new nuclear plants.

These experiences show that governments risk losing control of investment policy in highly liberalised markets – whereas some government co-ordination of investment is required, especially if the sector is reliant on large-scale technologies. In contrast, smaller-scale, distributed technologies may respond more rapidly to signals for new investment (Finon *et al.*, 2004).

Both energy security and environmental concerns have forced many governments to pay progressively greater attention to alternative, clean and renewable energies such as wind, marine and solar power, clean coal technologies, carbon capture and storage, and nuclear energy. Though these sources of energy may address the concerns to varying extents, they nearly all have a higher cost than the cheapest available alternative that would be favoured by the market. The government is therefore required to intervene to established transparent and predictable incentives, both administrative and economic, so as to encourage certain types of investment and behaviour. The unavoidable result of successful implementation of such policies will be that energy prices for end-users will rise, in direct opposition to a stated objective of market reform.

Of greater concern is the current state of unpredictability of the policies themselves and of the likelihood of success of certain measures once they are implemented. Governments and supranational authorities such as the European Union and the IPCC are currently undertaking a radical re-think of policies relating to clean and renewable energy as well as nuclear energy, and many aspects of future policy at national and international levels are quite unclear. Given the long lead times and long lifetimes of investments in the

power sector, this lack of clarity is hampering investment in new technology as well as investment in new capacity (International Energy Agency, 2007b).

The slow pace of policy decision-making and of effective implementation of appropriate policies derives in part from very understandable uncertainties as well as from the challenge of addressing the implications of such policies for such factors as energy poverty and national competitiveness. These concerns are exacerbated in some countries by political and intellectual resistance to the introduction of measures that are seen to go against the deeply held belief in the power of market forces. In the case of renewable energy, for example, experience has shown that feed-in tariffs are much more successful at encouraging the rapid expansion of capacity than statutory obligations to buy renewable energy, and yet some governments seem unable to adopt the feed-in tariff for doctrinal reasons (Lipp, 2007; Mitchell, 2008).

Implications for China

The implications of these lessons for China in 2009 are:

- The introduction of competitive markets in the power sector can yield economic benefits, but only under certain conditions.
- The risks are substantial, and significant preparation is required in order to limit these risks to acceptable levels; in particular, measures to establish a robust legal and regulatory framework must be completed before competitive markets are introduced.
- Even if the market reforms yield short-term economic benefits, they may fail to address longer-term objectives relating to system reliability, security of supply and the environment, unless the government designs clear policies and instruments to address these concerns.

China's government faces the choice of whether to press ahead with the introduction of competitive markets in power generation in the near future, as apparently preferred by SERC (Zhang, 2008) or whether to suspend the move towards competitive markets and rather address the current challenges without competitive markets. Two considerations argue for the second, more cautious approach.

First, as discussed in previous sections, China has yet to establish, to the required extent, the necessarily legal and regulatory framework for the risks of failure to be limited to an acceptable level.

Second, and possibly of greater importance, the policy priorities for China's government have changed since the 1990s, as discussed above. Setting aside the economic downturn in the short term, China's demand for electricity is set to increase at a significant rate for the foreseeable future. As coal is likely to remain the fuel of choice, this presents substantial environmental challenges. Excess capacity in generation and transmission is likely to be temporary at best. The key priority for China's government is to promote appropriate investment in new generating and transmission capacity, *i.e.* appropriate in terms of fuel, scale, technology and location. At the same time, the government has to further reinforce its energy-saving measures among electricity users.

Thus in the current situation in China, the introduction of widespread competition in generation runs two sets of risks: first, that the limited economic objectives of competition are not achieved; and second, that the competitive markets undermine the government's

ability to address more pressing objectives relating to security of supply and the environment.

For these reasons it is recommended that the government pursue many of the proposals that SERC and the NDRC have put forward, as well as those of the IEA (2006) outlined earlier, but with the exception of the introduction of competitive markets. A period of several years could be used constructively to build up the institutional framework for later competition, and a range of instruments other than competitive markets could be employed to address urgent priorities relating to system security, security of supply, sector efficiency and the environment.

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