

Power Industry Restructuring in China

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Abstract— China power industry is on the way to a deregulated electricity market since the industry restructuring in 2002. The integrated generation and transmission has been regrouped into five independent generation companies and two grid companies. The regional grid companies act as the system operators and exchange centers for the regional electricity markets. The customer side is still regulated by the government. In this paper, we will introduce the situation of China power industry restructuring. Some issues will be discussed for the current regional electricity markets, such as, electricity price policy, renewable energy policy, investment and planning issues.

Index Terms— electricity market, electricity price, planning, renewable energy, power industry restructuring.

I. INTRODUCTION

RESTRUCTURING and reform of the traditional integrated power industry has been started all over the world for more than 10 years. In various deregulated power systems, the market structures, the degree of privatization and the sequence of reform stages are different. China has started the process of power industry restructuring since the late 1990s. In this paper, we will introduce the current situation of China power industry reform and will focus on the following issues: market structure, electricity price policy, investment and planning, renewable energy in the new market.

II. CHINA POWER INDUSTRY STRUCTURE AND ITS RESTRUCTURING

China has been experiencing significant economic growth since 1980s. The electricity consumption increased more than three times due to the booming market and manufacture industry. At the end of 2004, the installed capacity in China has reached 440GW, and the annual generation has reached 2180TWh. Both installed capacity and generation are ranked the second highest in the world. Within the 440GW, the proportions of thermal units, hydro station, nuclear and wind power are 73.7%, 24.5%, 1.6% and 0.17 %, respectively [1].

A. Power Industry Restructuring

In February 2002, the State Department issued the Power Industry Structure Reformation Program. The program includes three main points: 1) Restructure state-owned

generation assets, and establish several independent generation companies; 2) Restructure transmission assets, and establish two grid companies; 3) Establish State Electricity Regulatory Commission (SERC) to monitor and regulate the electricity markets.

On the 29th of December 2002, two grid companies, State Grid Company and South China Grid Company were established. The State Grid Company has five subsidiary regional grid companies. They are North China Regional Grid, North East China Regional Grid, Central China Regional Grid, East China Regional Grid and North West China Regional Grid. The geographical areas of the regional grids are shown in Figure 1.



Fig. 1. China Regional Grids

On the same day, five independent generation companies were established. They are:

- China Huaneng Group,
- China Datang Corporation,
- China Huadian Corporation,
- China Guodian Corporation, and
- China Power Investment Corporation.

The installed capacities of the five generation companies are given in Table I. Each of the five generation groups have a certain amount of share of any local market [2]. After the restructuring of generation assets, the State Grid and South China Grid own 24.5GW generation capacity, of which, 15.9GW capacity is used for frequency regulation and load following to ensure the reliable system operation [1].

The installed capacities owned directly by the two grid companies and all regional grid companies in 2004 are given in Table II. The total generations of all grids in February 2005 are given in Table III [3].

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TABLE I
INSTALLED CAPACITIES OF THE FIVE GENERATION COMPANIES IN 2002

	Capacity (Gwh)
China Huaneng Group	40.98
China Datang Co.	4.95
China Huadian Co.	8.64
China Guodian Co.	29.30
China Power Investment Co.	27.96

TABLE II
INSTALLED CAPACITY IN EACH GRID COMPANY AT THE END OF 2004

		Thermal Capacity (GW)	Hydro Capacity (GW)	Total Installed Capacity (GW)
State Grid	Own by State Grid	9.8	2.1	7.7
	North China Grid	77	74.5	2.5
	North East Grid	41.5	35.9	5.6
	East China Grid	78	64.4	11.6
	Central China Grid	65.4	41.9	23.5
	North West Grid	27.1	18.8	8.3
South China Grid				80.3

TABLE III
GENERATIONS OF ALL GRID COMPANIES IN FEBRUARY OF 2005

	Generation (Twh)	Increase Rate (%)
North China Regional Grid	32.6	5.67
North East Regional Grid	15.4	2.21
East China Regional Grid	30.3	1.62
Central China Regional Grid	22.9	6.45
North West Regional Grid	10.2	13.7
South China Grid	17.5	1.16

B. Regional Electricity Markets

The structure of China electricity market is a regional electricity market based on regional grids. The first regional market, North East electricity market, started generation auctions in January 2004. Four months later, East China regional market started its market operation [4]. The market participants of a regional electricity market are power system operation and exchange center, grid company, the five generation companies and local provincial generation companies. The regional regulator commissions monitor and regulate the operation of regional markets. At the current stage, the system operation and exchange center is the single buyer of the market. The market settlement mode is Pay-as-bid. Single buyer model has been used in many countries as a transition stage toward competitive market.

In the energy markets, generators provide long-term offers and short-term offers in the auction market. Long-term offers include annual transaction offers and monthly transaction offers. Short-term day-ahead spot market will be established in the next stage of the regional markets.

Ancillary services, such as reserve, frequency regulation and voltage support, are provided by some hydro plants owned by the grid companies. Some compensation mechanisms have been applied for the ancillary services provided by the units owned by the generation companies.

The mid-term goals of China regional electricity markets are: establish ancillary service markets; run day-ahead spot markets; consider unit emission criteria in the auction

markets; start bilateral contract markets and generation right markets. The long-term goals are: open customer-side markets, establish financial markets, such as, futures, forward and option markets.

III. ELECTRICITY PRICE POLICY

The electricity price policy plays an important role in China power industry reformation. In May 2005, the National Development and Reformation Commission (NDRC) issued three regulations about electricity prices, Generation Price Regulation, Transmission and Distribution Price Regulation, and Customer Electricity Price Regulation [5].

A. Generation Price

Generation price is composed by capacity price and energy price. Energy price represents the variable costs of a power plant. The price is obtained by competition through regional auction markets. It is the price for a certain amount of power during a time period. Generators can submit 3-segment offers or 5-segment offers depending on the market regulations. In some regional markets, the regional grid company provides a reference energy price for each provincial generation company.

Capacity price represents the fixed costs of a power plant. It can be calculated as following:

$$\text{capacity price} = \text{capacity payment} / \text{installed capacity.}$$

Capacity price is determined by the installed capacity of the plant and the capacity payment, which is decided by the NDRC from time to time according to the power supply and demand of the time. The purpose of utilizing capacity price is to guarantee the basic benefits for power plants. The ratio of capacity price and energy price can reflect the degree of competition in a market. The higher percentage the energy price in a generation price, the higher competitive level the market is. In one of the regional markets, the capacity price vs. energy price can roughly be 1: (2~3).

Electricity price reformation in one of the core parts of power system deregulation. Price reformation will be accomplished gradually in a longer term in China. The current two-part generation price is a transition pricing mechanism towards completely competitive electricity market.

B. Transmission and Distribution Price

In the Transmission and Distribution Price Regulation issued by NDRC, the T&D price is composed by transmission price, ancillary service price, and special service price. Transmission price covers the network expansion and maintenance costs. Ancillary service fee is paid for the regional grid companies for their provision of ancillary services, such as, reserve, frequency control, voltage control, black start, *etc.* Grid companies use grid-owned units to provide such ancillary services. The special service prices are charged to market participants that require special services from the grid company. Such as, connect to the network, build a transmission line for a special project, *etc.*

The transmission and distribution prices are decided by the

government and NDRC.

C. Customer Price

Electricity price for customer is regulated and decided by NDRC. Customer prices can be classified into three categories: residential customer price, industry customer price and agriculture customer price.

D. Electricity Price Interlink with Coal Price

Most areas of China have experienced a high increase of electricity consumption in 2003, and one third of the provinces are suffering power shortages [2]. In some areas, electricity demands are higher than power supplies. System operators sometimes have to shed load to balance the power demands. On the other hand, the fossil-fuel price goes up dramatically at the time. Around 74% of installed capacities in China are fossil-fuel thermal plants. The high coal price limited the profits of power plants to the maximum extend.

In April 2005, NDRC announced a scheme to interlink electricity prices with coal prices. According to NDRC, customer side electricity prices can be adjusted with the change of coal prices. A few months later, the customer electricity prices in all provinces have increased from 0.95 to 3.99 cents (Chinese Cent) per kWh. The average electricity price of the whole country has increased 2.52 Cents per kWh [6]. This price increase is around 5%.

On the other hand, generation prices all over the country are also adjusted with the increased coal price. The generation prices of all provincial power companies increased from 0.33 to 3.1 cents per kWh. Other Independent Power Producers (IPPs) followed provincial power companies and increased their generation prices to keep up with the coal price increase [7].

At the current stage of power system restructuring, government and NDRC are on a leading position regulating electricity prices. Both transmission & distribution price and customer side electricity price are determined by the government and NDRC. Only generation prices can be partly decided by auction market.

IV. RENEWABLE ENERGY POLICY

In China power system, coal-fired thermal power plants dominate the electric power generations (around 74%). The generation costs and the electricity prices rely on coal prices to a certain extent. With the coal prices continuously going up in 2004 and 2005, the profits of most generation companies drop down. On the other hand, hydro generations are around 24% of the total generations. Renewable energy generation sources are not more than 1% of the total generations. The current renewable energy sources are mostly small-scale wind turbines. The slow development of renewable energy was due to the lack of market regulations and pricing mechanisms for high-cost renewable energy entering electricity markets.

In February 2005, the Renewable Energy Act was issued by NDRC. The Act indicates that the renewable energy generation is encouraged by the government. The detailed

regulations of the Act will be forced in January 2006. A proper renewable energy policy and a reasonable pricing mechanism would facilitate the development of renewable energy sources in China power system.

The renewable energy generations currently used in China are mainly solar energy and wind energy. The solar energy generation production has reached 230MW in 2005. Some of the solar energy generations are installed at the remote areas. In Shenzhen, a photovoltaic power station of 860kW has been interconnected to the transmission grid. It is estimated that the total solar generation production could reach 500MW in 2010.

The total installed capacity of wind power in 2005 is 500MW. Besides this, the wind turbine capacity is going up at an annual increase rate of 40%. The capacity is expected to reach 100GW in 2020, which will be around 10% of the total installed capacity of that year. Wind power and solar energy generations are the potential new generation sources in the future China power industry.

One of the factors that limit the development of renewable energy is the high production cost. The cost of renewable energy is much higher than that of the regular coal-fired generation. In China, the cost of small hydro generation is around 1.2 times of the cost of thermal generation; the cost of biomass generation is about 1.5 times, the cost of wind power is about 1.7 times, and the cost of photovoltaic generation is about 11-18 times [8]. The average generation price for traditional thermal sources is around ¥0.5/kWh, the cost of wind power is usually around ¥0.8/kWh and the cost of solar energy could be more than ¥5/kWh. Besides the high cost of renewable energy, the uncertainty of the renewable energy pricing mechanisms and the unclear of renewable energy policy also raised the investment risk. Investors are hesitated to invest in renewable energy generation unless they can see the benefits.

The Renewable Energy Act and its regulations provide detailed rules about interconnecting renewable energy units to the grids and the detailed generation prices for various types of renewable energy.

In the new regulations, renewable energy generation price is composed by two parts: government regulating price plus market auction price. The wind power generation price decided by the government is expected to be the fossil-fuel generation price plus ¥0.25 per kWh. The generation prices for photovoltaic might be classified into two categories: ¥3.2/kWh for those located at open areas and ¥3.4/kWh for those located in buildings. The prices for other renewable energies, such as biomass energy, are also stated in the regulations [1]. The government authorized renewable energy generation prices will insure the companies recover their generation costs and the return rate of investment.

To facilitate renewable energy generations, the government authorized some regulations as well as the regulating prices. In the Act, it has been explicitly stated that the future renewable energy policy will be a quota system. The grid companies must sign purchase contracts with renewable

generation companies and buy all the contracted renewable energy generations in their grids as well as providing transmission services. On the customer side, the large customers are compulsory to pay for the shares of the renewable energy allocated to them. The future regulations might fix a required proportion of the renewable energy in a grid. On the other hand, some preferential policies will be issued to encourage generation companies developing renewable energy sources. For examples, some perquisites might be provided for renewable energy, some funds are founded especially for renewable energy, providing tax reduction or low interest loan, etc.

In Shanghai, the government has started to execute the regulations on special generation prices and purchase prices for Green Power. The residential customers are required to buy Green Power at least 120kWh per year.

V. INVESTMENT AND PLANNING

The electricity consumption in China is keeping on increasing in recent years. The total consumption in 2004 is 2.17PWh, which is a 15% increase of 2003. In 2005, the consumption increases for another 10% and reaches 2.4PWh. On the generation supply side, 50GW new generation capacity is installed in 2004, and 70GW new generation capacity is installed in 2005. However, it is still not easy for all investors to enter the market of generation investment. The five independent generation companies and local government owned generation companies play the dominant roles in generation investment, although the individual investors and overseas investors hope can hold a share in the investment market.

A. Investment

After the power industry restructuring, transmission and distribution are regulated by government. The generation side is deregulated, and independent power companies are able to participant generation side markets. Each generation investment project will be examined and discussed by the government before it is approved.

Currently, the state-owned generation assets are around 90%, and the other 10% are owned by private investors and overseas investors. Of the 90% state-owned assents, 35% are owned by the five generation companies (including the 40GW approved in 2004), and the other 65% are owned by the local government generation companies [9].

The generation investors in China are mainly in five categories:

- The former state-owned five generation companies.
- Some other state-owned companies.
- Local government owned generation companies. They own around 55GW capacities in total.
- Overseas investors. They own 37GW in total.
- Other private investors.

In the new generation investment projects, the state-owned generation companies still occupy a large share. For example,

the 40GW generation capacities approved in 2004 are mostly invested by the five generation companies.

1) Overseas investment

At the end of 1980s, electrical consumption demands increase dramatically. To attract oversea capital investments to China generation market, China government has provided very high rate of return for overseas generation investments. The annual rate of return was as high as 15% - 20%. In some provinces, the local governments sign long-term contracts with investors. The contracts guarantee the generators can get fixed generation prices for a number of years. More than 30 overseas companies invested power plants in China. In 1997, their total capacity ever reached 14.5% of the total installed capacity of the country. In 1999, the government started to abolish the fixed high rate of return. Some of the investors don't see the high profits any more and withdrew their investment from the market. The overseas generation investment reduced from 14.5% of 1997 to 7.5% of 2002.

B. Power System Planning

In the traditional integrated power system, planning is performed centrally. For some years, the power system planning has been under a situation that generation planning always leads transmission planning.

After the restructuring of power industry, the integrated power system has been separated into some generation companies, and some grid companies. Who will perform power system planning is still not clear. State Grid Company has the most possibility being authorized by the government to perform transmission network planning for the whole country grid. Each regional grid company is responsible for its' own regional grid expansion and planning. Generation companies are responsible for generation expansions. Where and what size to invest new generations are decided by the government and the State Grid Company. Generation companies bid for building new generation capacities. The government and NDRC examine and approve all the expansion projects.

VI. CHALLENGES

There are some issues need to be emphasized in the development of China power industry after the system restructuring [10].

- The structure of generation sources is not yet fully optimized. The proportion of fossil-fired generation sources is much higher compare to other clean renewable energy generation sources.
- The high proportion of generations relying on coals makes the electricity prices affected by coal prices significantly.
- The transmission network expansion and planning are lagging the generation expansion. How to perform generation planning and transmission planning after unbundled generation and transmission is an emerging issue.

The challenges to the industry and government in the

restructured power system are from some sides. From the investment side, efficient policies would facilitate the investment in renewable energy sources and optimizing the generation source structure. From the planning side, generation planning and transmission planning coordination is a big challenge for the unbundled system. An authorized body for power system planning might be a good option to solve the problem. From the development side, the current single-buyer regional electricity market is still a transient stage towards the competitive electricity market. Electricity market models in all countries and areas are various. Find the best electricity market model for China power system will be one of the goals for the future China power industry.

VII. CONCLUSIONS

In this paper, we introduced the regional electricity markets after the restructuring of China power industry in 2002. Some issues in the new market environment have been raised and discussed. The issues are electricity price, renewable energy, planning issues, *etc.*

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IX. BIOGRAPHIES

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