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Electricity Market Creation in China: Policy Options from Political Economics Perspective

Ni Lei ¹, Lanyun Chen ^{2,*}, Chuanwang Sun ^{2,*} and Yuan Tao ³

¹ School of Public Administration, Faculty of Economics and Management, East China Normal University, Shanghai 200062, China; nlei@dem.ecnu.edu.cn

² China Center for Energy Economics Research, School of Economics, Xiamen University, Xiamen 361005, China

³ School of Economics, Xiamen University, Xiamen 361005, China; taoyuan@stu.xmu.edu.cn

* Correspondence: chenlanyun@stu.xmu.edu.cn (L.C.); scw@xmu.edu.cn (C.S.); Tel.: +86-59-2218-6076 (C.S.); Fax: +86-59-2218-6075 (C.S.)

Received: 25 February 2018; Accepted: 4 May 2018; Published: 8 May 2018



Abstract: In 2015, a new round reform of the marketization for the electricity sales in China is launched. This paper investigates the policy selection for this reform in China, from the perspective of political economics. We analyze the policy selection of the 2015 reform from two aspects of market structure and pricing mechanism. According to the policy of the 2015 reform, China's power industry is of great potential to develop the market structures of "integration of generation and retail services while integrating transmission and distribution" versus "integration of generation, distribution and retail services while independent of transmission". Those two market structures have advantages on competition efficiency and political practicability. For the pricing mechanisms, the power exchange market of China can take bilateral contracts for the long-term trading and double-sided auctions for the short-term trading, as well as for the spot market. In addition, electricity financial market can be set up as a supplement for the power exchange market, which is of potential contribution to manage the risk and discover the effective price. The 2015, reform assigns two state-owned grid companies the responsibility of the demand side management. The intelligent system to improve the information management of energy consumption can be established. Utilization of renewable energy is also emphasized in the 2015 reform for energy sustainability in China. Effective policy instruments, such as the efficient subsidy policy, an independent exchange market, and a quota system, for the promotion of renewable energy utilization, can be implemented.

Keywords: power industry reform; political economics; market structure; pricing mechanism

1. Introduction

In the last century, the power industry of most countries was monopolized by state-owned companies and regulated by governments. From the 1980s, restructured reforms of the power industry were first launched in the United Kingdom and some Latin American countries, and achieved momentum in 1990s [1,2]. The major purposes of the restructure were to reduce electricity prices through competition, provide consumers with more sufficient and reliable services, and create more commercial opportunities for private capitals [1]. In order to break the monopolization and ensure the sustainability of energy development, China's government started the first-round reform of the power industry in 2002 (the 2002 reform), and the second-round reform in 2015 (the 2015 reform) [3–5].

The reforms of the power industry in different countries were various, due to the diverse economic, political, and social contexts. For example, the United Kingdom transformed the power sector from the Pool (short for Power Pool) schema to the NETA (short for New Electricity Trading

Arrangements) schema, and then to the BETTA (short for British Electricity Trading and Transmission) schema. It adopted the market structure of “integration of generation, distribution and retail services while independent of transmission” [6]. Australia employed the market structure of “integration of transmission and distribution while integrating generation and retail services” [7]. France implemented the management system of vertical integration. However, the generation, transmission, distribution, and retail sections of the EDF (short for Electricite De France) are accounted for separately. Independent retail firms are set up to enhance the competition [8]. China’s power industry was perfectly monopolized by the State Power Corporation, which was a government department and state-owned company before the 2002 reform. However, the 2002 reform separated the generation plants from grid companies, but failed to establish a competitive pricing mechanism in China’s power industry. Hence, the 2015 reform expected to liberalize the power market by building a fairly competitive market and setting up a rational pricing mechanism. In other words, the reform of the power industry in China is from state-owned monopolization to market-oriented competition, which concerns not only the economic benefits, but also the political issues.

The motivation of this paper is to investigate the policy selection for the marketization of the electricity sales reform (the 2015 reform) in China, from the perspective of political economics. On one hand, the power production chain involves a number of participants including the generation plants, the transmission firms, the dispatch centers, the retailers, and the end users. All the participants expect to maximize their own profits, while the government implements appropriate policy instruments to coordinate the benefits among them, taking the whole social welfare into consideration. On the other hand, the state-owned grid companies became dominants of the power market, and the electricity price was dominated by NDRC (short for National Development and Reform Commission) to a large extent after the 2002 reform in China. As a result, China’s power market was lack of fair competition and a rational pricing mechanism, which led to the low efficiency of resource allocation in the power industry [9]. Therefore, the 2015 reform of China is a process that the government removes its power from the market and acts as a supervisor, rather than a direct participant, in the power market. This reform is proposed to liberalize the power exchange gradually, and to build fairly competitive power market.

Different from previous studies, the innovation of our research is to discuss the policy selection of the 2015 reform from two aspects: market structure and pricing mechanism. Transformation of the market structure in China’s power industry is investigated from the perspectives of price components, competition efficiency, and political practicability. Pricing mechanism of China’s power industry is proposed to change from fixed pricing to market-oriented pricing, since the 2015 reform. The issues about how the price changes and the effects participants may exert on the price are discussed to analyze the pricing mechanism. The remaining sections of the paper are as follows: Section 2 briefly describes achievements and failures of the 2002 reform, and then introduces the 2015 reform. Section 3 analyzes the market structure of the 2015 reform. Section 4 discusses the pricing mechanism of the 2015 reform. Section 5 carries out the further discussion on the role transformation of two state-owned grid companies and the promotion of renewable energy utilization in the 2015 reform. Section 6 is the conclusion.

2. The Reforms of the Power Industry in China

The first-round reform of the power industry in China was launched in 2002. It completed certain achievements but did not fulfill a rational pricing mechanism of China’s power industry. Therefore, in 2015, the second-round reform was carried out in order to lower the administrative effects in the power exchange, and to form a fairly competitive power market in China. This section will introduce the achievements as well as the failures of the 2002 reform, and the major contents of the 2015 reform.

2.1. The 2002 Reform of the Power Industry in China

Before the first-round reform of the power industry in 2002, China's power industry was dominated by the State Power Corporation. The government departments regulated the operation of power system and decided the electricity price, forming a perfect monopoly mode for China's power industry at that time. For the purpose of breaking the monopolization and improving the market efficiency of the power industry, China launched the first-round reform of the power industry in 2002.

The major achievement of the 2002 reform was separating the power industry into the power generation section and the power grid section, which changed the market structure of the power industry in China [10]. Specifically, five big state-owned power generation corporations were constructed by the 2002 reform, and became dominants of the generation section. They are China Guodian Corporation, China Huaneng Group, China Datang Corporation, China Huadian Corporation, and State Power Investment Corporation. Meanwhile, the power grid section was separated into two grid companies: SGCC (short for State Grid Corporation of China) and CSG (short for China Southern Power Grid Company Limited). CSG takes in charge of the power grid operation for five provinces: Guangdong, Guangxi, Yunnan, Guizhou, and Hainan. SGCC is responsible for the power grid operation of remaining provinces.

However, the 2002 reform did not fulfill the key goal of the pricing mechanism reform in the power industry of China. According to the original plan of the 2002 reform, the power generation enterprises sell the electricity at the on-grid price to grid companies, and then grid companies sell the electricity to end users at the electricity price. There would be competition within the power generation section and negotiation between generation enterprises and grid companies. However, five big power generation enterprises and two state-owned grid companies dominated the power market, which led to the unfair competition. As a result, the power market could not realize the market-oriented pricing mechanism. The on-grid price was dominated by NDRC (short for National Development and Reform Commission), and the electricity price was controlled by NDRC in terms of different utilities, such as agricultural use, industrial use, residential use, and so on. The transmission and distribution price and the government funds show the gap between the on-grid price and the electricity price.

The occasion of the reform in 2002 was not appropriate, and the failure of fulfilling the expected goal of marketization reform can be attributed to some reasons. Firstly, the power supply in China experienced shortages and redundancies alternatively at the same time, which means the power supply could be surplus in most of the years but insufficient in the others. The maximum power demand–supply gap in China accounted for more than 10% of the maximum load in 2004, while the massive power shortages occurred simultaneously throughout 26 provinces in China. In addition, there were 19 provinces in 2008 and 24 provinces in 2011 suffering from the power shortages [11,12]. Under the pressure of power shortages, expanding power capacity to ensure electricity supply should be placed as the first priority, rather than the marketization reform [13,14]. Secondly, the prices of coal fluctuated remarkably. The growth rate of the coal price was 30% from 2004 to 2005 and around 50% from 2007 to 2008 [15,16]. Coal-based power accounted for about 75% of the total power supply in China. As a result, in order to prevent the electricity prices from soaring due to the dramatic price fluctuation of the coal, the marketization reform was suspended [12,16,17]. Thirdly, some natural disasters, such as the snowstorm in 2008, challenged the reliable power supply and the reform process. Due to the inappropriate timing, the power grid companies should put the electricity supply in the first place, rather than carrying on the power pricing reform. In addition, the government's supervision and promotion in the 2002 reform was not as strong as expected. Thus, grid companies were developed rapidly to dominate the power market, which prevented the marketization reform. In other words, the reform launched in 2002 was not thorough and completed.

Several reforming initiatives were not conducted effectively in China's power industry during the period of the 2002 reform. Firstly, the pricing mechanism was still distorted. The prices of the power industry were dominated by the government on the basis of the historical prices instead of the generation costs [18,19]. Therefore, the condition of supply and demand could not affect the

prices, and the power resources could not be allocated efficiently [9]. Secondly, the effective way of stimulating renewable energy to enter into the power grids was still restricted. Due to instability and uncertainty of the power supply from renewable energy, grid companies preferred the coal-fired power on grid. Thirdly, two state-owned grid companies expanded overwhelmingly after the 2002 reform unexpectedly, and the government was unable to balance the interests of all parties with the result that monopolization was maintained or even increased [14]. Therefore, the second-round reform of the power industry was necessary and launched in 2015.

2.2. The Second-Round Reform of the Power Industry in China

The rapid development and expansion of industries, with an average growth rate of 9.83% from 2002 to 2015, has led to a sharp rise in power consumption in China, [20]. After the growth rate slowing down in those years, China has formed a huge power market of 5.55 trillion kWh, ranking the first in the world (see Figure 1). The distribution section, the transmission section and the retail section are affiliated to two state-owned grid companies, SGCC and CSG (see Figure 2). In this paper, G represents the power generation enterprise, T represents the power transmission company, D represents the power distribution firm, R represents the power retailer, and C represents the power consumer. GR indicates an enterprise that owns the business of power generation and retail services. TDR indicates an enterprise that owns the business of power generation, transmission and retail services. TD and DR are abbreviations, similar to above.

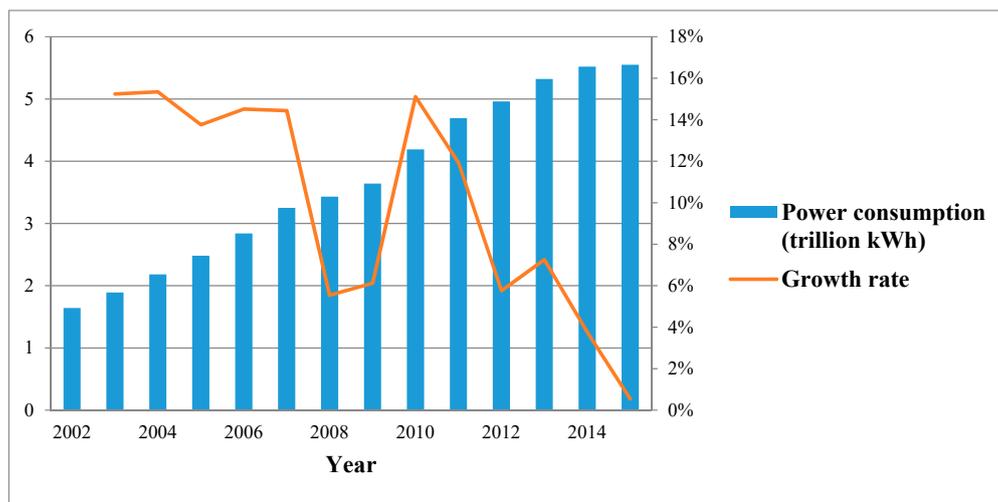


Figure 1. The power consumption and the growth rate of China from 2002 to 2015. (The data source is China Electricity Council.)

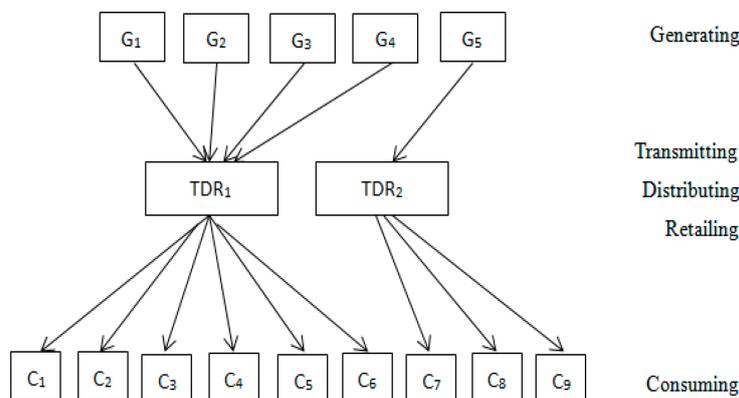


Figure 2. The market structure of the power industry in China before the 2015 reform.

The year of 2015 is an appropriate opportunity for the reform of the power industry in China. Reasons are listed as follows. Firstly, the power supply in China is redundant around 2015 [21,22]. Due to the surplus power supply and the low demand of coal, the coal price decreased 30% in 2015 (the data source is ASKCI Consulting). Low coal price would not exert extreme impact on the power price to hinder the reform process. Secondly, monopolization of the two state-owned grid companies results in that China's power industry had a distorted price mechanism, due to a lack of competition. The super power of the state-owned grid companies also challenges the reform. Those issues of monopolization attract public and political attention, and they are expected to be addressed through the reform. Thus, the occasion of the 2015 reform is appropriate.

The main objective of the 2015 reform is the deregulation of the electricity sales in China's power industry. The first stage of this reform is to deregulate the generation section and the retail section, while the transmission section and the distribution section are still dominated by two state-owned grid firms for the sake of the stable and safe power supply. Afterwards, the 2015 reform will extend the deregulation to the distribution section as well.

Firstly, the 2015 reform aims at establishing a competitive trading mechanism between generators and large users, or between generators and retailers, which can be regarded as an extension of the DPLU (short for Direct Purchase of Large Users) policy. DPLU policy indicates that a large user can purchase the power directly from generation enterprises, and the transaction price is market-oriented, rather than government-dominated. In this case, the electricity price is constituted by the transaction price, the transmission and distribution price, and the government funds (see Table 1). In 2004, the trials of DPLU policy were launched over 24 provinces. Different trials have different conditions for large users. Usually, large users are supposed to satisfy the qualifications—the annual electricity consumption is more than 100 million kWh, and the voltage level should be higher than 100 kV. Partial industrial and commercial users are large users in China.

Table 1. The components of the electricity price in the 2015 reform.

Components	Price Maker	Fee Collector
The transaction price	Decided by the negotiation between generators and large users or between generators and retailers.	Earned by generators.
The transmission and distribution price	Dominated by National Development and Reform Commission (NDRC).	Earned by grid companies.
The government funds	Dominated by NDRC.	Earned by the government.
The electricity price	Sum up the transaction price, the transmission and distribution price, and the government funds.	Paid by large users or consumers.

Secondly, other consumers who do not satisfy the qualifications of large users have to purchase the power according to the price mode before the 2015 reform, such as agricultural use, residential use, and so on. The price mode before the 2015 reform is constituted by the on-grid price, the transmission and distribution price, and the government funds, where the on-grid price and the transmission and distribution price are dominated by NDRC. The 2015 reform proposes an alternative way for the electricity consumers to purchase power. They can authorize retailers to buy the electricity directly from power generation plants through uniform trading centers instead of from the state-owned grid companies, which is exactly the extension of DPLU policy. The components of the electricity price are shown as Table 1. Therefore, retailers and uniform trading centers are encouraged to set up in the power exchange market. Consumers can choose the way they purchase the electricity.

Thirdly, the 2015 reform plans to release the distribution section to the private capitals gradually. Meanwhile, it will deregulate the power generation planning to the market-oriented mechanism, except for public coordination.

Fourthly, promotion of renewable energy utilization is emphasized in the 2015 reform, which is of great significance for the energy sustainability in China.

The highlights of the 2015 reform are to establish principal market players, build a rational pricing mechanism, and create a fairly competitive power market. On the one hand, China's government takes the responsibility of supervision and promotion on the 2015 reform. It is of essential significance to guarantee the reliable, stable, and safe power supply as the power industry is a foundation industry in a national economy. On the other hand, this reform is propelled step by step. It is not proposed to liberate all sections of the power industry immediately. Specifically, liberalization of the distribution section is for the new enterprises, but not for the existing grid companies. The marketization of pricing mechanism is for the transaction price, not for the transmission and distribution price. Generally, the pace of the 2015 reform is moderate and reasonable.

3. Market Structure of the 2015 Reform

There are several representative schemas of the market structure implemented world widely (see Table 2). At the first stage of the 2015 reform in China's power industry, competition is introduced into the generation and the retail sections, while the transmission and the distribution sections are mainly regulated. Uniform trading centers for the transactions between generators and retailers, or between generators and large users, are established. In order to ensure sufficient power supply, some large users start or increase investing in the generation section to own certain generation assets after the 2015 reform. Meanwhile, generation enterprises can set up retail firms, as well. In this case, China's power industry tends to develop the schema of "integration of generation and retail services while integrating transmission and distribution" in the 2015 reform.

Table 2. Representative schemas of market structure.

Schema	Representative Country
Integration of distribution, transmission, distribution, and retail services	Japan [23], France [8]
Integration of generation, distribution and retail services while independent of transmission	UK [24]
Integration of distribution and retail services while independent of generation and transmission	India [25], Brazil [2]
Integration of generation and retail services while independent of distribution and transmission	New Zealand [26]
Integration of transmission and distribution while independent of generation and retail services	Canada [27]
Integration of generation and retail while integrating distribution and transmission	Australia [7]

At the second stage of the 2015 reform in China's power industry, the distribution section is open to the private capitals gradually and the power generation planning except for the public coordination can be marketization [28,29]. In this situation, China's power industry can develop the schema of "integration of generation, distribution and retail services while independent of transmission" as well. Hence, we discuss these two schemas, "integration of generation and retail services while integrating transmission and distribution" versus "integration of generation, distribution, and retail services while independent of transmission", in this section.

3.1. Schema 1: Integration of Generation and Retail Services while Integrating Transmission and Distribution

Figure 3 shows how the power flows through the whole production chain of the power industry under Schema 1. By applying Schema 1 in China, transmission and distribution are integrated and monopolized by two state-owned grid companies (TD). It is in consistency with the moderate pace of the 2015 reform at the first stage, which is politically practicable. Two state-owned grid companies have the responsibility to collect the fees of the distribution and transmission, while the price of

the distribution and transmission is dominated by NDRC. Large users can invest in generation enterprises or the generators can set up the retail services to form GR firms. All the transactions should be conducted through the uniform trading centers, rather than inside GR firms. GR firms should account for the business of generation and retail services, respectively. The transaction price is decided by the negotiation between generators and retailers, or between generators and large users. The electricity price is constituted by the transaction price, the transmission and distribution price, and the government funds.

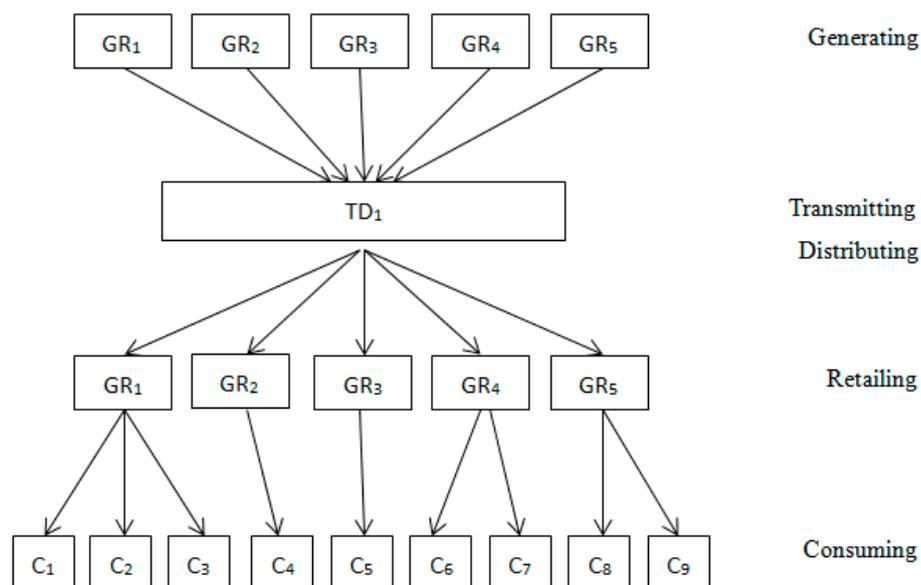


Figure 3. Schema 1: integration of generation and retail services while integrating transmission and distribution.

From the perspective of competition efficiency, Schema 1 can benefit several participants in the power exchange market. Firstly, GR firms can be substantially beneficial. Those firms that integrate generation and retail services can gain a great advantage in the competition. By the statistics from Guangdong Power Exchange Center, the top ten retail firms in Guangdong occupy almost 91% of the power exchange market from March to September of 2016, and nine of them have their own generation assets. The advantages of the power capacity from the upstream, the comprehensive information, and the sufficient capitals, make GR firms competitive in the power exchange market. Secondly, as for the end users, they are able to purchase electricity at a lower price, since the electricity price can be decreased through the competitive pricing mechanism. According to the Annual Report of Guangdong Power Market 2017, large commercial and industrial users of Guangdong gained a benefit of 5.86 billion CNY (6.75 CNY = 1 US dollar in 2017 approximately) from the decrease in electricity price. Thirdly, due to the competitive pricing mechanism between the generation section and the retail section, the transmission and distribution price dominated by NDRC becomes more reasonable and more transparent.

However, Schema 1 shows some shortages, inevitably. First of all, the distribution section is not released to private capitals, so the efficiency of the distribution section cannot be improved. In addition, the existing big generation enterprises are almost all state-owned in China. It is difficult for the private capitals without generation assets to enter the power exchange market. Finally, the management and supervision costs are very high, due to the separate accounting for the independent sections of generation and retail.

3.2. Schema 2: Integration of Generation, Distribution and Retail Services while Independent of Transmission

According to the further process of the 2015 reform, competition will be introduced into the distribution section, and the generation section can be partially privatized. Hence, the market structure may transform to “Integration of generation, distribution and retail services while independent of transmission” (see Figure 4). In Schema 2, the transmission section is monopolized by two state-owned grid companies (T), and regulated by the government. It is corresponded with by the natural property of monopolization in the transmission section. That is, GR firms, DR firms, and GDR firms are encouraged to found. Each section of the integration should be accounted separately. Power grids are open to all retailers under fairly strict supervision. The projects of GDR firms are approved in some provinces during the process of the 2015 reform, which shows the tendency of Schema 2 in China. For example, in 2016, the distributed energy project of Shenzhen Low Carbon City is approved to develop the business of distribution and retail services. It is the first project integrating generation, distribution, and retail services since the 2015 reform in China.

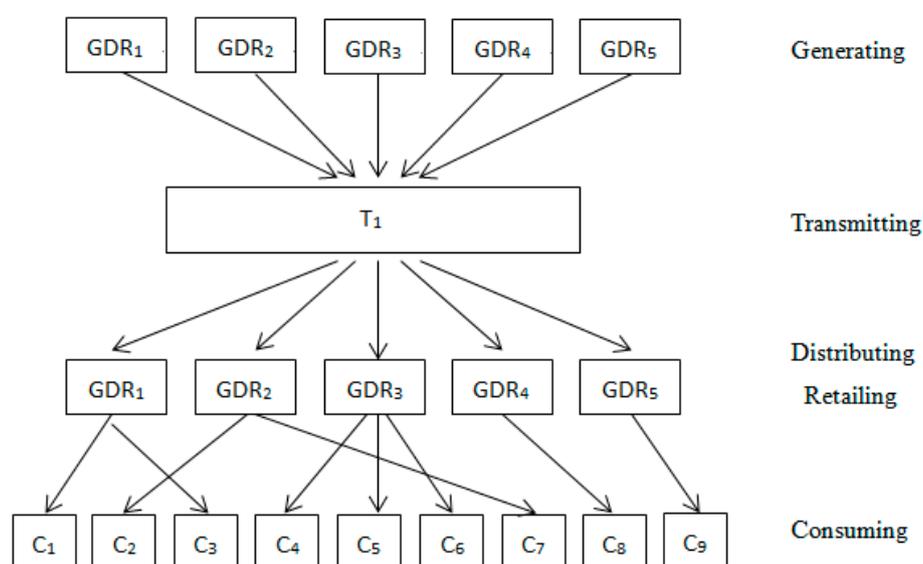


Figure 4. Schema 2: Integration of generation, distribution and retail services while independent of transmission.

Schema 2 can be achieved through two steps. The first step is to set up independent retail firms by grid companies. At the same time, generation enterprises and other private capitals are allowed to invest in the new distribution assets. The second step is to make generation assets and distribution assets which are state-owned partially privatized, so that the power exchange market could be further liberalized. In this case, GDR firms can be formed in diverse ways, and competition will be brought in among GDR firms.

Compared with Schema 1 (see Table 3), Schema 2 allows grid companies to enter the retail section. It is able to reduce the protest from grid companies against the reform, which promotes the reform efficiency and the political practicability of Schema 2. Schema 2 shows potential advantages from the perspective of competition efficiency. Firstly, Schema 2 releases the distribution section to private capitals. It is of great potential to improve the distribution efficiency. Secondly, the form of GDR firms can prevent the power exchange market from excessive competition. The benefit–cost ratio of Schema 2 is higher, as integrating companies can achieve advantages through internalization [29]. However, Schema 2 has some drawbacks. First of all, Schema 2 is more likely to create super power corporations, which will cause a higher risk of monopolization and a higher cost of supervision. Besides, Schema 2 also brings about higher expenses of separating the distribution section from the transmission section. Finally, coordination of the grid planning under Schema 2 is challenging and expensive.

Table 3. Comparison between Schema 1 and Schema 2.

Schemas	Advantages	Disadvantages
Schema 1 Integration of generation and retail services while integrating transmission and distribution.	GR firms can be substantially beneficial due to their advantages in competition.	The distribution section is not open to the private capitals.
	Customers can gain benefits from the reduction in the electricity price due to the competitive pricing mechanism.	The private capitals without generation assets are difficult to enter into the power exchange market.
	The transmission and distribution price become more reasonable and more transparent.	The management and supervision costs are high as the integrating firms should account the business of each section separately.
Schema 2 Integration of generation, distribution and retail services while independent of transmission.	It is able to reduce the protest form grid companies against the reform as they are allowed to enter the retail market.	It is highly likely to create monopolization by the super power companies of integrating generation, distribution and retail services.
	The distribution efficiency can be improved as the distribution section is open to private capitals.	The costs of separating the distribution section from the transmission section are high.
	The form of GDR firms can prevent the power market from excessive competition.	Coordination of the grid planning under this schema is challenging and expensive.

4. Pricing Mechanisms

There are three principal pricing mechanisms in the power exchange market: bilateral contracts, single-sided auctions, and double-sided auctions. The consumers cannot participate in the pricing procedure in single-sided auctions, which makes generation enterprises the dominant in the auctions [30,31]. Thus, generation enterprises can manipulate the transaction price for the sake of their own profits [24,32]. In 2017, the power quantity transacted by single-sided auctions only accounts for 7% of the power exchange market in China, while the power quantities transacted by bilateral contracts and double-sided auctions occupy 72% and 19%, respectively (the data source is JOINERGY). Taking the disadvantage of single-sided auctions into consideration, the power exchange market of China mainly implements bilateral contracts for long-term trading, while double-sided auctions are for implemented for short-term trading. Therefore, this section will discuss the pricing mechanisms of bilateral contracts and double-sided auctions. The comparison of pricing mechanisms between bilateral contracts and double-sided auctions is provided in Table 4.

4.1. Pricing Mechanism 1: Bilateral Contracts

Large users (C) and retailers (R) can negotiate the quantity, the price, and the loading curve of the electricity with generators (G) directly, and then they form the preliminary bilateral contracts. After that, the transactions should be reported to the uniform trading centers and confirmed by relevant administrative departments (see Figure 5). In general, the pricing mechanism of bilateral contracts is suitable for the forward power exchange, whose periods can last for weeks, months, or even years [33]. The pricing mechanism of bilateral contracts has several advantages. On the one hand, relationship between supply and demand can affect the price since the transaction price is decided by bilateral negotiation. In this case, the effective price can guarantee the fairly competitive market mechanism and reduce the administrative effect on the power exchange market. On the other hand, the long-term bilateral contract can prevent the electricity price from fluctuating violently as it stabilizes the market risk for both sides [1,30].

Table 4. Comparison between bilateral contracts and double-sided auctions.

Pricing Mechanisms	Advantages	Disadvantages
Bilateral contracts	1. The transaction price is generated by bilateral negotiation, which can reflect the relationship between supply and demand.	1. The deals are determined by the long-term confidential contracts, which are not transparent enough.
	2. Bilateral contracts can prevent the electricity price from fluctuating violently as long-term contracts can stabilize the market risk.	2. The existing integrating firms are so powerful in the market that new generation enterprises and new retail firms find it difficult to participate in the power exchange.
Double-sided auctions		3. Costs for management and supervision of the power exchange market are high.
	1. The transaction price is generated from the direct trading by both sides, which can reflect the relationship between supply and demand.	1. Management and supervision of the transactions by double-sided auctions are difficult and expensive, as different provinces have diverse bidding rules.
	2. Retailers have the competitive advantages of their professional skills and auction strategies.	2. The electricity price may fluctuate violently, and the market is risky as the price reacts sensitively to the market.
		3. Large users without professional bidding strategies are in an unfavorable situation of the power exchange market.

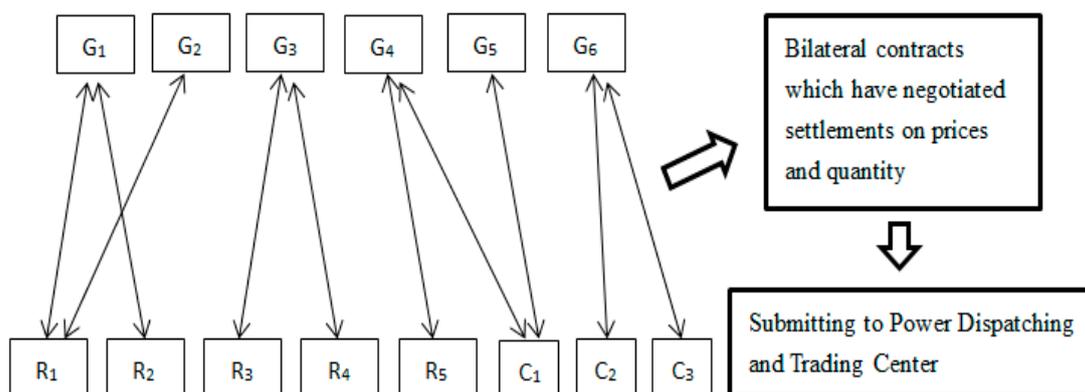


Figure 5. Pricing mechanism 1: Bilateral contracts.

However, the pricing mechanism of bilateral contracts has some disadvantages [34,35]. Firstly, the deals are made by the long-term confidential contracts, which are not transparent enough. Secondly, the integrating firms dominate the market, causing the fact that it is difficult for new generation enterprises and new retail firms to enter the power exchange market. Specifically, it is hard for new generation enterprises to gain a share of the power exchange market as those integrating firms prefer to receive power supply from their own generation plants. For new retail firms without generation assets, it is not easy to gain reliable power supply as well. Thirdly, large generation enterprises have strong power in the market. The government faces a challenge in preventing the abuse of market power, and spends much money on supervision.

The pricing mechanism of bilateral contracts is widely implemented in China during the 2015 reform. Large users, retailers, and generators participate in the pricing negotiation to decrease the electricity price. Many provinces adopt the pricing mechanism of bilateral contracts, such as Guangxi, Chongqing, and Gansu. Most of them achieve a reduction in the electricity price for the industrial and commercial uses. For instance, in 2017, the power expense of the industrial and commercial large users in Guangxi decreased by 3.9 billion CNY due to the lower electricity price (the data source is JOINERGY).

4.2. Pricing Mechanism 2: Double-Sided Auctions

In the double-sided auction, potential sellers submit their supply quantities and the ask prices while potential buyers submit their demand quantities and the bidding prices to the uniform trading centers in a sealed bid format. After that, an aggregated supplier curve and an aggregated customer curve are formed. Market clearing price is determined by the intersection of two aggregated curves. All buyers winning the auction pay the clearing price for per unit power, and all sellers winning the auction are paid the clearing price for per unit power [36,37]. The pricing mechanism 2 is usually regarded as spot exchange, which can be used for a short-term trading of days, hours, or even minutes before the electricity is dispatched [33]. However, double-sided auctions are implemented for monthly power exchange in a few provinces of China under the process of the 2015 reform.

There are various bidding rules and market clearing mechanisms in different provinces of China. In this case, management and supervision of transactions by double-sided auctions are difficult and expensive. Regarding to the bidding rules, we take Guangdong as an example for the reason that Guangdong is one of a few provinces in China that adopt double-sided auctions, and it takes the fastest process of the 2015 reform, which has the highest percentage with 17.36% of China's power exchange market in 2017 (the data source is JOINERGY). Guangdong applies the indirect bidding. Generators submit the price of the gap between the generation cost and the benchmark on-grid price. Retailers or large users submit the price of the gap between the electricity price and the benchmark electricity price. The price difference is the gap between the price generators submitted and the price retailers or large users submitted. The deal will fail if the price difference is positive, while the deal can be made if the price difference is negative or zero. The smaller absolute value of the price difference has the priority to win the bidding. After the bidding quantities of the consumers and the suppliers are confirmed, the transaction prices are determined by a return mechanism by the Basic Rules of Guangdong Power Exchange published in 2016. In general, a smaller absolute value of the price difference suggests that generators are less willing to reduce the price.

The double-sided auction in Guangdong is a direct transaction between supply and demand sides. There are two features of this pricing mechanism. Firstly, the transaction price can react sensitively to the market, which indicates the electricity price may fluctuate violently and the market risks are high. The transactions by double-sided auctions in Guangdong demonstrate that generators are less willing to reduce the prices accompanying, with an increase in the quantities of transacted power. Overall, the quantity of power exchange over months in 2017 shows an upward trend, while the absolute value of average clearing price difference demonstrates a decreasing tendency (see Figure 6). Secondly, this pricing mechanism requires auction strategies so that retailers benefit substantially due to their professional skills [38]. There are 62 generators, 11 large users, and 136 retailers making the deals successfully in the power exchange market of Guangdong in 2017. Those 136 retailers represent 4562 end users, and the number of retailers in Guangdong continues to increase under the implementation of double-sided auctions (the data source is Qianzhan Industry Research Institute). Large users without professional bidding strategies are in an unfavorable situation of the power exchange market, and more customers tend to authorize retail firms to participate in double-sided auctions.

Guangdong is one of a few provinces that implement the double-sided auctions in the power exchange market. However, it adopts double-sided auctions for monthly exchange not for spot exchange. In 2017, 72.37% of the power exchange in Guangdong is conducted by bilateral contracts, with the remaining power exchange conducted by double-sided auctions. Guangdong is representative in the pricing mechanisms that China's power exchange market mostly implements, currently. That is, the power exchange markets of different provinces in China mainly adopt bilateral contracts for the yearly contracts and double-sided auctions for the monthly contracts. Double-sided auctions for spot exchange remain to be promoted. Therefore, we suggest that the power exchange market can take bilateral contracts for the long-term trading and double-sided auctions for the spot exchange. The long-term bilateral contracts become the principal mechanism of transactions in China's power exchange market as it builds a rational pricing mechanism and prevents the market risks [39]. Large

users can choose to trade with either generators or authorize retailers. The spot market of double-sided auctions can conduct both day-ahead transactions and in-time transactions which enables for balancing of the power exchange market. Since retailers have advantages on professional auction strategies, more large users would like to authorize retailers to participate in double-sided auctions, instead of participating in auctions by themselves. In addition, futures and options for the electricity financial market can be set up as a supplement for the power exchange market, which is helpful for managing the market risks and discovering the effective prices.

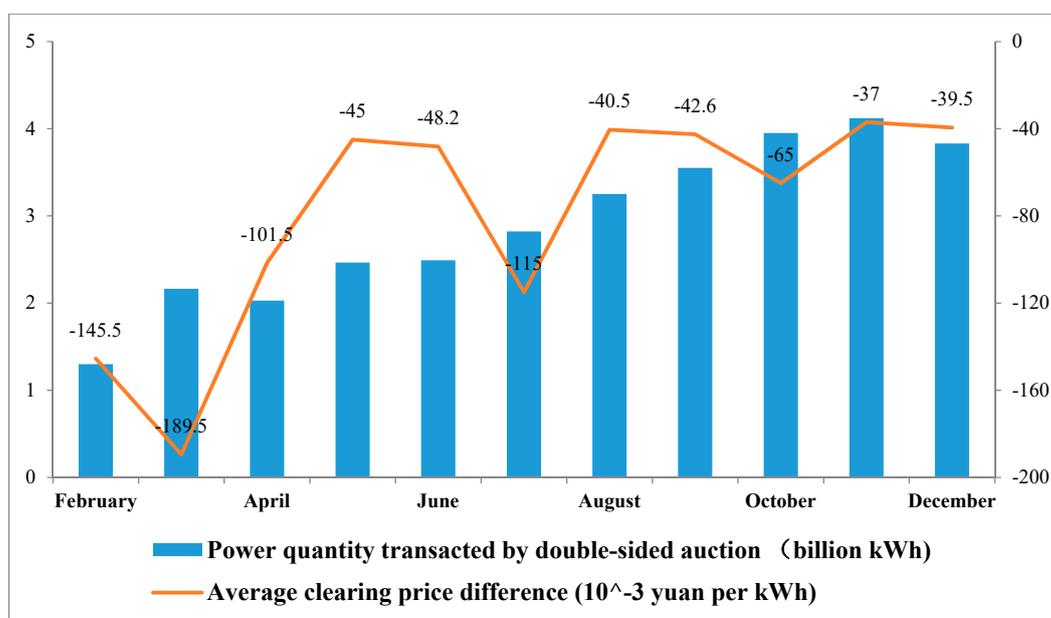


Figure 6. The power quantity transacted by double-sided auctions and the average clearing price difference of 2017 in Guangdong. (The data source is Qianzhan Industry Research Institute.)

5. Further Discussion

This section will discuss the role of two state-owned grid companies and the promotion of renewable energy utilization in the 2015 reform.

5.1. The Role of Two State-Owned Grid Companies

The 2015 reform brings about the repositioning of two state-owned grid companies. Before the 2015 reform, CSG and SGCC earned the gap between the on-grid price and the electricity price. They are so powerful in the market that they could enlarge the gap to achieve much higher profits. However, the 2015 reform changes their operation and profit mode. Under the 2015 reform, their major income is the transmission and distribution price, which is dominated by the NDRC. In other words, the income of grid companies is fixed. Moreover, the 2015 reform assigns two state-owned grid companies the responsibility of the demand side management [40]. Therefore, grid companies should develop the intelligent system to promote information management of consumers. Subsequently, grid companies and retailers can provide the consumers, especially the large industrial users, with effective suggestions to improve energy efficiency in terms of energy management programs, such as Energy Performance Contracting. Energy Performance Contracting is a contract that energy service companies offer energy consumers an energy saving program with specific energy saving targets and methods.

5.2. The Promotion of Renewable Energy Utilization

The promotion of renewable energy generation faces challenges. On the one hand, grid companies prefer the coal-fired power on grid, due to instability and uncertainty of the power supply from

renewable energy. On the other hand, the on-grid prices of renewable energy are higher than that of coal-fired power, which makes the electricity from renewable energy is more costly. Specifically, in 2016, the on-grid prices of photovoltaic generation are from 0.80 CNY per kWh (6.64 CNY = 1 US dollar in 2016 approximately) to 1.05 CNY per kWh in different regions, and the on-grid prices of wind power generation are from 0.47 CNY per kWh to 0.60 CNY per kWh. By contrast, the on-grid prices of coal-fired power generation are from 0.2773 CNY per kWh to 0.3729 CNY per kWh (the data source of on-grid prices is JOINERGY).

In the 2015 reform, an aim to increase renewable energy generation is particularly emphasized. A series of policies to compensate the generation and ensure the on-grid priority of renewable energy is implemented. For example, the renewable energy companies are encouraged to participate in the power market transactions directly, and the trans-provincial and transregional transmissions from the abundant renewable energy province are supported. The 2015 reform also improves the power services to make great efforts to develop the renewable energy generation, such as the peak load compensation mechanism, government purchase guarantee of renewable energy, and the regulations of bilateral consultation or market bidding.

As a next step, further effective policy instruments for the promotion of renewable energy generation can be adopted as well, such as setting up an independent exchange market for renewable energy generation [20] and allocating a quota for renewable energy generation in the electricity dispatch. In other words, the 2015 reform provides the new opportunity of improvement of renewable energy utilization and enhances the significance of energy sustainability in China.

6. Conclusions

The 2015 reform of China is a process that the government removes its power from the market and acts as a supervisor, rather than a direct participant, in the power exchange. It carries out a series of policy instruments to liberalize the power market gradually, and build a fairly competitive market. According to the policy of the 2015 reform, we analyze two schemas of the potential market structures, "Integration of generation and retail services while integrating transmission and distribution" (Schema 1) versus "Integration of generation, distribution and retail services while independent of transmission" (Schema 2). Those two schemas have the advantages of efficient competition and political practicability. Schema 2 has a higher benefit–cost ratio, but it is more likely to create super-power companies, which may cause the monopolization in the power market.

As for the pricing mechanism, bilateral contracts have been widely adopted in China, while double-sided auctions have been implemented only in a few provinces. For the future development of the 2015 reform in China, we suggest that the power exchange market can take the mechanism of bilateral contracts for the long-term trading and the double-sided auctions, in particular, not only for a monthly trading, but also for a spot market. Meanwhile, the futures and options for electricity financial market can be set up gradually. Electricity financial market, serving as a supplement for the power exchange market, is of potential contribution to manage the risk and discover the effective price for the China's power industry.

By the repositioning in the 2015 reform, two state-owned grid companies should promote the demand side management. Two state-owned grid companies could develop an intelligent system to improve the information management of energy consumption. Subsequently, grid companies and retailers can provide effective energy saving programs for consumers, particularly for the large industrial users. The promotion of renewable energy utilization is also emphasized in the 2015 reform for the energy sustainability in China. Effective policy instruments, such as efficient subsidy policy, an independent exchange market, and a quota system, for the promotion of renewable energy utilization, can be implemented.

Author Contributions: All authors contributed to the model construction. N.L. provided the core idea. L.C. revised the manuscript. C.S. helped to check the entire manuscript and wrote the policy recommendations. Y.T. helped to outline the manuscript.

Funding: This research was funded by [the National Natural Science Foundation of China] grant number [71673230 and 71303199].

Conflicts of Interest: The authors declare no conflicts of interest.

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