



2023 China Power Outlook: 20 Key Trends for Power Market Players



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Yujing Liu et al., *2023 China Power Outlook: 20 Key Trends for Power Market Players*, RMI, 2023, <https://rmi.org/insight/2023-china-power-outlook-key-trends-for-power-market-players/>.

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Executive Summary: Amid a Global Energy Crisis and Daunting Challenges, China's Power Market Reform Forges Ahead

In the past 20 years, the reform of China's power system and market has seen several breakthroughs. The *Notice of the State Council on the Power Industry Reform Plan (Document No. 5)*, released in 2002, broke the vertical integration of the power system, separating generation businesses from the grid companies. *Opinions of the CPC Central Committee and the State Council on Further Deepening the Reform of the Electric Power System (Document No. 9)* and a series of supporting documents released in 2015 further introduced competition in the wholesale, distribution, and retail businesses — paving the way for nationwide pilots of medium- to long-term (M2L) transactions and large-scale spot markets.

In September 2020, China announced its targets of reaching peak carbon emissions by 2030 and achieving carbon neutrality by 2060 — twin goals now referred to as “Dual Carbon.” Since then, policies and markets in various industries and fields have been evolving toward these goals. The power sector plays a critical role in reaching these targets. The power sector is the largest emitter of CO₂ in China, responsible for about 40% of annual emissions. The development and utilization of low-carbon power generation technologies can accelerate the transition to a low-carbon economy. At the same time, transformation of other sectors such as industry, transportation, and construction depends on end-use electrification. Thus, promoting the development of low-carbon electricity will help move the entire society toward the Dual Carbon goals.

To achieve Dual Carbon in the power sector requires not only technological innovation, but also market reform. In October 2021, the Communist Party of China Central Committee and the State Council issued *Opinions on Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy*, which is the top-level “1+N” policy plan for achieving the Dual Carbon targets. The document emphasizes the need to strictly control fossil fuel energy consumption and aggressively develop nonfossil energy. It also calls for further comprehensive market reforms of the power system and improvement of the power pricing mechanism, and support for large-scale development of renewable energy and energy storage technologies.

Under the guidance of the Dual Carbon top-level design, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) jointly issued the *Guiding Opinions on Accelerating the Construction of a National Unified Power Market System* in January 2022, to promote the establishment of the New Power System — one that is suited for China with expanded capacity for renewable energy consumption.

The document emphasizes the transformation of the energy structure and market mechanisms that support a New Power System with a high degree of penetration by renewables. It sets clear goals and direction for reform during the 14th Five-Year Plan (2021–25) and 15th Five-Year Plan (2026–30) periods: to

establish a national unified power market system that fits the New Power System by 2030. Development of the power market is essential to meeting the Dual Carbon goals.

Looking back at the power reform process, it becomes clear that reform is about adjusting anchor points and seeking a balance among multiple goals. Reform is not only about introducing competition, improving efficiency, and optimizing resource allocation, but also about increasing the penetration rate of zero-carbon electricity while ensuring low-carbon, stable operation of the power system. Indeed, as the penetration rate of renewables generation continues to increase globally, the issue of stability has become a worldwide concern.

After the global energy crisis and domestic seasonal power shortages between 2021 and 2022, the importance and urgency of renewable energy have come into clear focus. While Europe leads the world in penetration of renewables and marketization of its power system, it is pursuing further power market reforms to encourage more renewable power generation and greater flexibility of its power system in the face of the energy crisis. Further reforms are aimed at providing more protection for electricity consumers and local manufacturers while meeting climate commitments.

The coming years are a crucial time for China to peak its carbon emissions and promote power market reform: First, some provinces are still in the initial stages of short-term trading markets, such as spot markets and ancillary services markets. They will require further consolidation in order to operate smoothly. Second, long-term transactions, such as renewable multiyear contracts, still lack the stability as investments to attract capital on a large scale. Therefore, there is ample room for improvement in this area. Third, the coordination of multilevel markets, cross-regional dispatching, and trading presents challenges to establishing a national unified power market by 2025. It is imperative to break down administrative barriers and optimize resource allocation. We anticipate that these areas will undergo intensive reforms in the next few years.

RMI has been closely observing the reform of China's power market. In the past year, we published *Power Market and Pricing Mechanism Reform in China: A Vital Step toward Zero-Carbon Electricity Growth and New Power System*. The report focused on the goal of finalizing a unified national power market system by 2030 that fits the New Power System. It explored electricity pricing mechanisms that are suitable for China and the growth of zero-carbon generation. We also examined, at the provincial level, Qinghai's goal of building a zero-carbon power system by 2030 in our report *Northwestern China Power System Decarbonization: Moving toward Zero-Carbon in Qinghai Province*. These reports focus on longer-term solutions and address the trends in power market reform. They provide a comprehensive suite of analyses of specific conditions and challenges faced by the power industry.

Beginning this year, we will expand our coverage to include shorter time frames by providing annual reviews and outlook reports to answer the question: what will happen next in China's power market reform? This report aims to provide readers who are interested in China's power marketization process with comprehensive and in-depth insights while supporting the development of the power market and the New Power System. The various sections of this report will analyze the power market's components, including the electricity market, ancillary services market, capacity market, and transmission and distribution (T&D) pricing. We will examine recent market developments and provide an outlook on power marketization in the next one to three years (see Exhibit ES1).

Exhibit ES1: 20 key trends for China’s power market reform in 2023–25

Electricity market	M2L market	The M2L market will usher in more market players, maintain a high trading ratio, and see rapid growth in total trading volume.
		Coal-fired power will continue to play a role as a price cornerstone in the long run, but the pricing mechanism will gradually transition as the power structure changes.
		There will be increased operating risk of coal-fired units associated with prioritized dispatch power sources.
		Multiyear contracts are expected to become the primary risk control instruments for renewables projects.
	Spot market	Time-segmented M2L trading will be further promoted as an essential means of connecting with the spot market.
		Spot market development accelerated in 2022, and the provincial-level market will be fully established during the 14th Five-Year Plan period.
		The spot market price cap and floor will gradually be deregulated, but its role in transmitting M2L prices will remain limited.
		Interprovincial and regional spot markets are still in their early stages, but they hold great potential for promoting the consumption of renewables and breaking down provincial price barriers.
	Retail market	Energy storage has taken the first step in participating in the spot market, but it may have a difficult time reaching projected profits.
		As industrial and commercial users fully enter the market and grid agents gradually exit from electricity procurement, power retail companies are poised to capture a larger share of the market.
In the short term, generation-integrated retail companies will maintain their advantage; however, risk control and customer service are keys to long-term success.		
Ancillary services market	Power retail packages are now being designed with greater differentiation to better meet customers’ risk preferences for price fluctuations.	
	The updated “Dual Rules” add ancillary services suited to development of renewables to the New Power System.	
	Peak regulation may phase out, as frequency regulation and reserve ancillary services turn to marketization, with compensation mechanisms for other ancillary services optimized.	
	The costs for ancillary services are passed downstream in the power system.	
Capacity market	While the ancillary services market presents opportunities for novel energy storage systems, it remains challenging for them to become the primary source of revenue.	
	Capacity mechanisms currently exist only in Shandong and Guangdong, but are expected to roll out more broadly.	
T&D pricing	The regulated capacity payment will be China’s primary capacity mechanism in the near future.	
	Energy storage may again be included in the cost audit for transmission network; the decline in T&D tariffs may halt.	
		The lack of user load and administrative support has slowed the progress of distribution grid expansion (DGE) in China.

Note: “Dual Rules” refers to the revised versions of the Regulations on Power Plant Grid Connection and Grid Operations and the Regulation on Power System Ancillary Services Operations by the NEA.

General Roadmap for Power Market Reform and Recent Progress

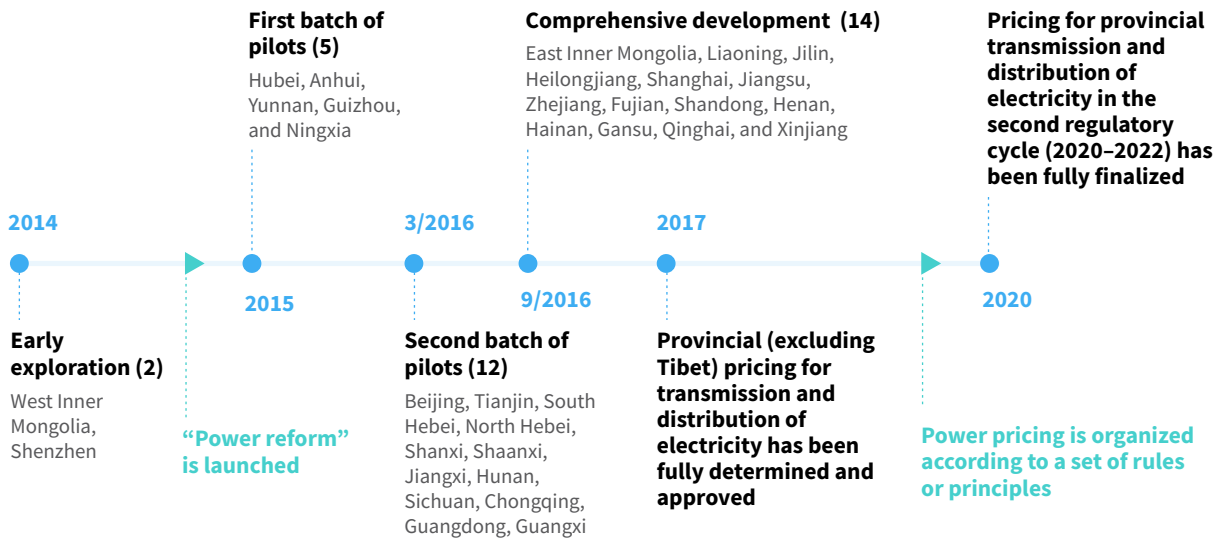
Power market reform is the core of China's power system reform. The first round of reform in 2002 enabled the separation of the power grid and power generation — leading to the formation of two power grid companies, five major power generation groups, and several minor ones. In 2015, the second round of reform was launched to improve the power pricing mechanism and establish a market-oriented power trading system. Over the past eight years, power pricing and market reform have made significant progress, providing a strong foundation for development of a national unified power market system and the New Power System.

“Regulating the middle and liberalizing the two ends”: Formulating the transmission and distribution tariff and redesigning the power pricing model

Before 2015, China applied a regulated tariff system, namely the “feed-in tariff plus catalog tariff” system. The administrative authorities set both the feed-in tariff for power generators — paid by the grid to power plants — and the catalog tariff charged by the grid to consumers. The price difference between the catalog and the feed-in tariff was the revenue for grid companies.

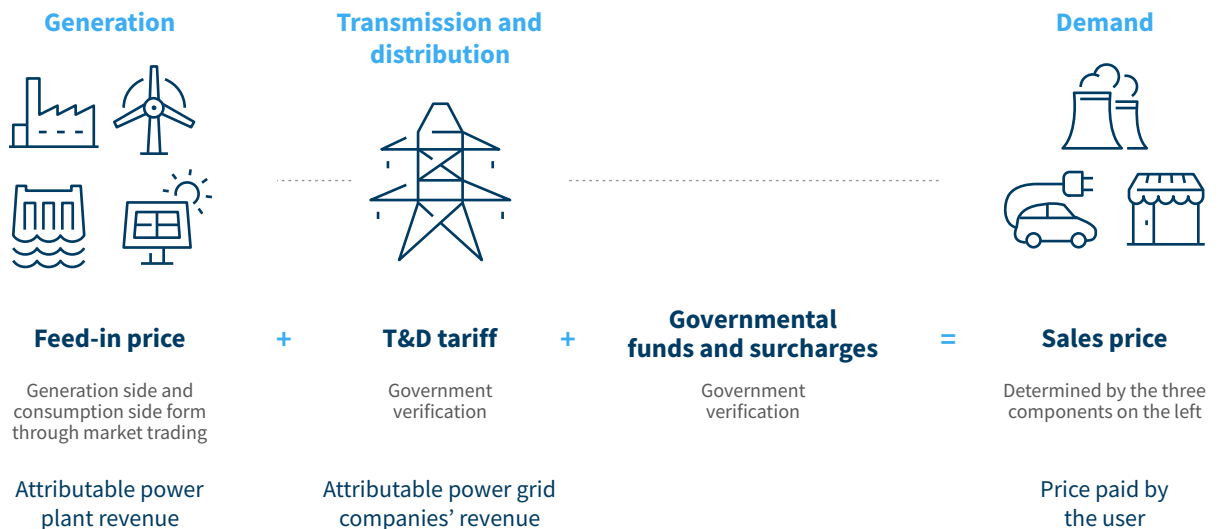
In 2015, under a strategy of “regulating the middle and liberalizing the two ends,” China began to set regulated transmission and distribution (T&D) tariffs for power grid companies. This T&D tariff reform was rolled out in three batches (see Exhibit 1). The calculation of the new T&D tariff was based on permitted cost, permitted revenue, and tax. With the T&D tariff set, the new means of calculating electricity prices for industrial and commercial consumers in China became “feed-in price + T&D tariff + government funds and surcharges = sales price” (see Exhibit 2). In addition, distribution grid expansion (DGE) reform was carried out, with the aim of introducing private investment for the construction and operation of incremental distribution networks. Through competition and innovation, the reform is intended to improve power supply services for users.

Exhibit 1: Chronology of price reform for transmission and distribution of power



Source: RMI

Exhibit 2: "Cost plus reasonable profit" model for industrial and commercial power pricing



Source: RMI

Five steps for provincial power market development

The provincial power grid is the basic unit for power system balance in China. Therefore, the provincial power market is a critical component of market development. The general idea for power market development in China is a “provincial plus interprovincial” structure, where the provincial market construction is the first mover.

The provincial power market cannot be formed overnight. It first needs to make a smooth transition from the planned dispatch to the market-based dispatch, and then add trading products to achieve comprehensive coverage of power system functions. To date, China has taken five main steps to develop the provincial power market (see Exhibit 3).

Exhibit 3: Key components and development of provincial power markets in China

Electrical energy	Medium- to long-term transactions	From trades spanning multiple days to multiple years, electricity transactions primarily take place on an annual and monthly basis.
	Spot market	Including day-ahead and real-time electricity transactions, there are two batches and a total of 14 provincial pilots, and plans for national expansion are under development.
Ancillary services	Peak regulation service market	Intra-day peak regulation is gradually transitioning toward the spot market and the regulating capacity market.
	Ancillary services (except for ramping)	Targeting ancillary services such as frequency regulation, reserve capacity, reactive power compensation, flexible ramping, and rotating inertia.
Capacity	Capacity mechanism/ capacity market	Maintaining system adequacy, incentivizing available generation capacity, and improving the resilience of power supply.

Source: RMI

1. Medium- to long-term (M2L) transactions

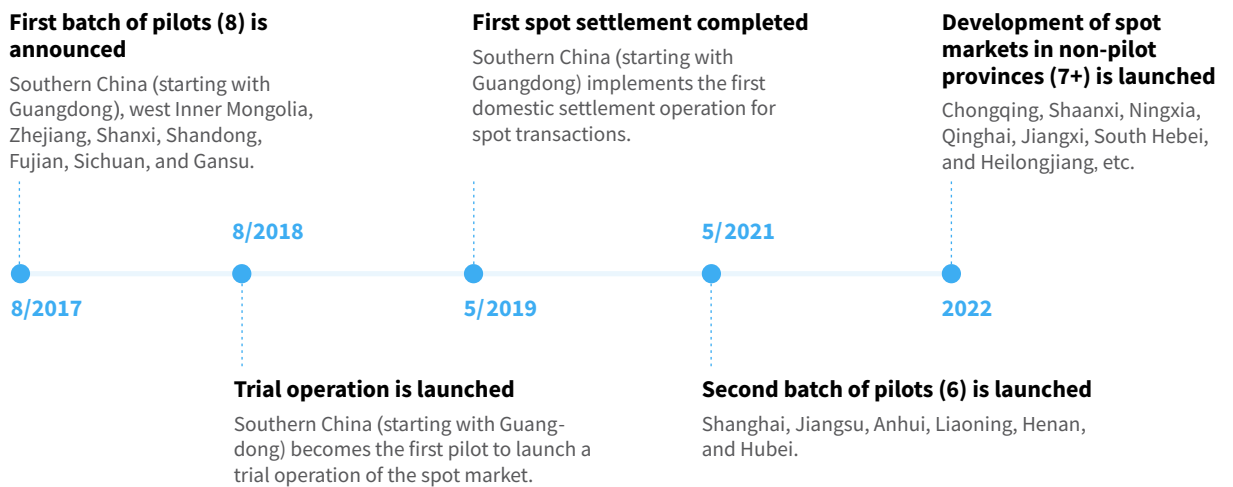
M2L transaction refers to electricity transactions with a multiday to multiyear time frame and is the initial step of power market reform. The transactions are made between the power generators and the consumers, usually through bilateral negotiations or centralized bidding. More than 90% of the market-based electricity trading volume is made through M2L transactions. At present, M2L transactions are mainly annual and monthly: at the end of each month or year, power generators and consumers trade on electricity for the following month or year. In some provinces, a small number of multiday, weekly, or multiyear transactions are being tested.

M2L transactions inherit some features of the planned electricity dispatch era, and as such help provide a bridge from the planned dispatch system to the market system. For example, the M2L and planned dispatch both heavily rely on trading or planning on an annual basis. Annual and monthly M2L transactions provide power generators and consumers with a relatively stable long-term price, which serves as a hedge against short-term power price fluctuations.

2. Spot market

The spot market refers to electricity trading between generators and consumers on the day-ahead and intra-day scales, usually settled on a 15-minute basis with 96 units per day. The spot market is the basis for discovering the real-time value of electric energy. Theoretically, the spot-market price and fluctuations provide a reference for the M2L transaction prices. China launched the first batch of eight provincial spot market pilots in 2017 and a second batch of six pilots in 2021, and spot markets are now in development in most provinces (see Exhibit 4).

Exhibit 4: Spot market development



Source: RMI

3. Peak regulation service market

The peak regulation market is considered a part of the ancillary services market. It was the first traded product among all ancillary services. Peak regulation service is mainly traded among power generators, where dispatchable units — usually thermal power generators — compete to regulate (adjust downward) the output of generating units on a daily basis to hedge against the volatility of renewable energy generation, thus promoting a higher penetration of renewable energy.

The peak regulation service market is China-specific: a stand-alone peak regulation market is generally not a feature of international power market practice, which realizes the corresponding function through the spot market. In China, the peak regulation market has assumed part of the function of the spot market until the latter is developed. With the establishment and expansion of the spot market, the peak regulation market is replaced by the spot market and a flexible capacity market, with the latter aiming to provide a healthy compensation mechanism to stimulate the deep ramping retrofit of the thermal power units.

4. Ancillary services market (excluding peak regulation)

Ancillary services refers to the operations required to maintain a safe and stable grid and ensure power quality, as well as electricity production, transmission, and consumption. Paid ancillary services mainly include frequency regulation (automatic generation control), reserve, reactive power management, black start, etc. Pricing varies among provinces and products, depending on physical characteristics and geographical features. At present, frequency regulation is the main product traded on the provincial ancillary services market and is mainly traded among power generators.

5. Capacity compensation mechanism or capacity market

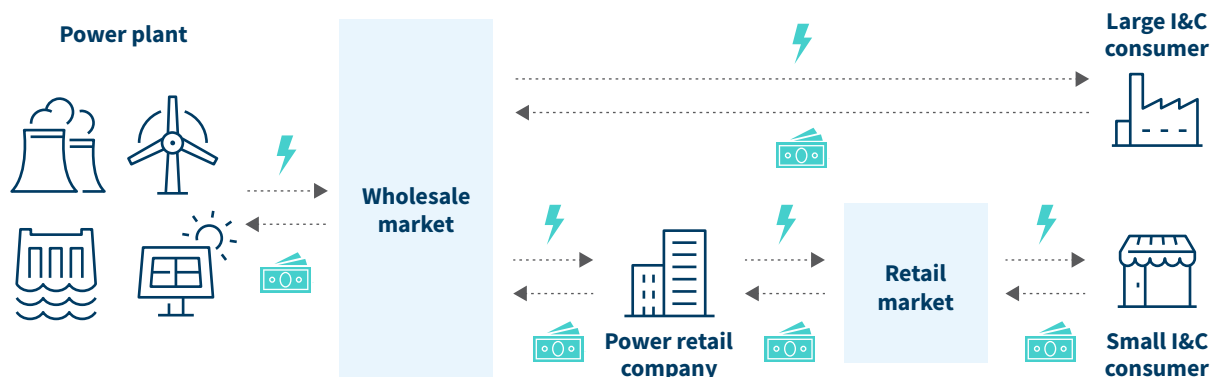
The capacity compensation mechanism or capacity market is a trading product designed to ensure adequate power from the system. In international practice, this service is usually provided by the power producers and purchased by consumers. As the names imply, unlike the traditional way of settling revenues on the basis of electricity output, capacity compensation mechanisms and capacity markets usually settle revenues on the basis of effective capacity, regardless of the actual generation output status.

More participants: Setting up both wholesale and retail markets

Power market reform is designed to fully deregulate electricity generation and consumption for all industrial and commercial (I&C) players. I&C electricity consumption accounts for about 80% of the national total, so a significant portion of power generation and a greater variety and number of power generators will need to participate in market transactions. New energy, hydropower, nuclear power, and other nonfossil-fired power generators will enter the market.

The M2L and spot markets, through which the generators and consumers trade electricity, can be further divided into a wholesale power market and a retail power market, depending on the scale (voltage level and electricity consumption) of the I&C consumers (see Exhibit 5). The wholesale market is designed for large consumers, while the retail power market is primarily designed for small consumers.

Exhibit 5: Wholesale and retail power markets



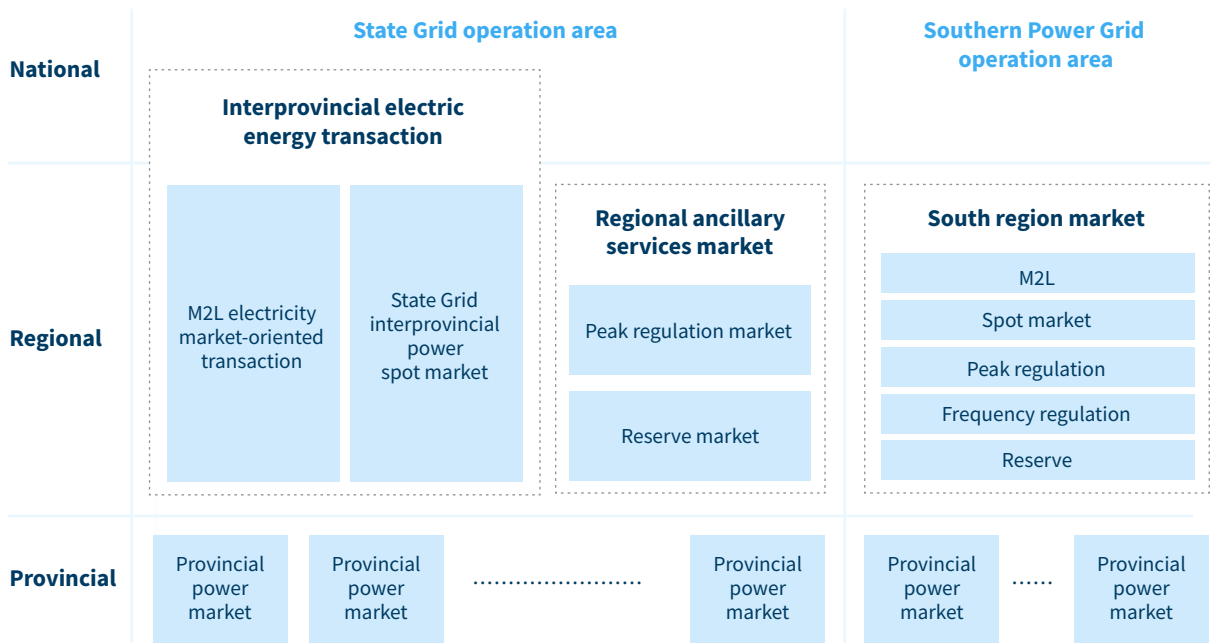
Source: RMI

In the wholesale power market, large power users and power retail companies are buyers and power generators are sellers. Smaller power users must trade with power retail companies in the retail market. Development of both wholesale and retail electricity markets has been an important component of China's power market reform since 2015. Of the two, the wholesale power market has progressed much faster and is more mature.

Power is distributed over a broader area: Interprovincial and regional power markets

On top of the provincial power market, interprovincial power exchange is becoming more active with the growth of renewable energy and ultra-high-voltage transmission infrastructure. Markets for interprovincial power transactions are steadily developing. At present, interprovincial power trading mainly includes electricity trading and ancillary services trading (see Exhibit 6).

Exhibit 6: Interprovincial power market structure



Note: China's State Grid serves all mainland China provinces except Western Inner Mongolia, Guangdong, Guangxi, Yunnan, Guizhou, and Hainan. The Southern Power Grid includes Guangdong, Guangxi, Yunnan, Guizhou, and Hainan.

Source: RMI

Electricity trading is in two main forms: M2L and spot trading. M2L transactions usually reflect the national plans for interprovincial and inter-regional power transmission or agreements between provincial governments. Spot market practices include interprovincial transactions based on the remaining interprovincial transmission capacity (within the State Grid operating area) and integrated regional spot market transactions (within the Southern Grid operating area). Most interprovincial electricity transactions occur between the provincial grid companies, while a small number of transactions are direct transactions between electricity users and power generators.

Interprovincial ancillary services (AS) markets are mainly organized on a regional basis. Currently, peak regulation and reserves are the main products in most regional AS markets. In the Southern Power Grid, there is also an effort underway to operate a regional frequency regulation market.

Major focuses of power market reform in 2021 and 2022

From 2021 to 2022, China's power market reform process made substantial progress in light of the "Dual Carbon" target announcement and the global energy crisis.

Overarching market design

The *Guiding Opinions on Accelerating the Construction of a National Unified Power Market System* announced plans to initially build a national unified power market system by 2025 and finalize it by 2030. Among the 2030 goals of the system are adoption of the New Power System, coordinated operation of multilevel markets, and full participation of new energy in market transactions. The market is expected to further optimize the allocation of power resources in the country.

M2L and spot markets

The *Notice on Further Deepening the Market Reform of Feed-In Tariffs for Coal-Fired Power Generation* promotes full market participation for coal-fired power generators and I&C consumers and expands the upper and lower limits of power transaction price. The *Notice on Accelerating the Construction of the Power Spot Market* promotes the expansion and acceleration of provincial spot market development. The first batch of eight pilot provinces has performed a long-term continuous trial operation, the second batch of six pilot provinces has started trial operations, and several nonpilot provinces have announced rules or started trial operations. The State Grid released *Interprovincial Power Spot Market Rules (Trial)*, and the interprovincial spot market has started a continuous trial run with settlement.

Ancillary services markets

The new version of *Regulations on Grid-Connected Electric Power Operation and Measures for Electric Power Ancillary Services Management*, also known as "Dual Rules," were released. The rules reflect the requirements of the New Power System and allow new AS products, new AS providers/entities, and new mechanisms for AS cash flow. The document also serves as high-level guidance and a reference for the AS markets.

Green power trading

China carried out the first batch of direct green power transactions in September 2021. In 2022, the *Implementation Rules for Green Power Trading on the Beijing Power Exchange and the Rules for Green Power Trading in the Southern Region (Trial)* were released and implemented. The rules lay the foundation for regular green power trading.

Energy storage participation

The *Opinions on Further Improving the Pricing Mechanism of Pumped-Hydro Storage* and the *Notice on Further Promoting the Participation of New Energy Storage and its Dispatch in the Power Market* clarify the pricing mechanism for pumped-hydro storage and new energy storage facilities, in the effort to promote participation of various types of energy storage methods in power market transactions.

The following chapters will review recent market progress in detail and provide an outlook on development over the next one to three years.

Outlook for the power market in 2023-25

By 2025, China aims to have established a national unified power market system. Under this macro goal, the main trends in China's power market development from 2023 to 2025 include:

M2L transactions

The trading volume of M2L power transactions will remain high, and coal-fired power will continue to play a critical role in determining market prices. The number of market participants is expected to increase, with some prioritized dispatch power generation sources gradually entering the market.ⁱ Furthermore, time-segmented M2L transactions will be further promoted, and multiyear contracts are expected to make significant progress.

Spot market

The provincial spot market is expected to be fully established during the 14th Five-Year Plan period, when the interprovincial/regional spot market is expected to be initiated. Restrictions on bid and clearance prices in the spot market will gradually ease. As time-segmented long-term trading is further improved, spot prices will be more effectively integrated into long-term electricity trading. Additionally, energy storage entities will engage in trial trades and evaluate trades in the spot market. The actual income level for novel energy storage systems entering the spot market remains uncertain for now.

ⁱ Prioritized dispatch is an effective way to ensure the security procurement of clean energy, such as wind and solar power generation, and to ensure clean energy such as nuclear power and large-scale hydropower operate at full capacity according to the base load, while also ensuring safe operation. Prioritized dispatch also promotes the stable operation of regulation power sources such as peak regulation and frequency regulation.

Retail market

Electricity retailers are expected to face a larger market as more users enter the market and power grid purchases are withdrawn. Different electricity retailers will offer more diverse retail packages, creating a more competitive market. In the near term, integrated electricity sales companies are expected to maintain their advantage.

Ancillary services market

The design of the ancillary services market will continue to reflect the needs of the New Power System development. This will involve expanding transaction varieties, supplies, and cost-sharing entities. Peak regulation service is expected to be integrated with the spot market, and frequency regulation and backup services will be developed in a market-oriented manner. Reactive power and other new ancillary services are expected to be compensated at a fixed rate.

Capacity mechanisms

Provinces with higher renewables penetration and more mature spot markets are expected to promote capacity mechanisms. The pricing mechanism is expected to be mainly based on administrative pricing but may evolve toward fine-tuned pricing that matches time slots.

T&D pricing

Transmission and distribution pricing is expected to have limited price reduction. New directions such as generation-grid-load-storage integration and microgrids will be new ways to develop DGE.

We hope this report will provide valuable insight on the process of power system reform and market reform in China, and help stakeholders to better understand and participate in the emerging and fast-evolving electric power market.



Medium- to Long-Term (M2L) Transactions

The M2L market will usher in more market players, maintain a high trading ratio, and see rapid growth in total trading volume

With the advance of marketization, more prioritized dispatch power generation and I&C users will gradually enter the energy market. With more tradable power entering the electricity market, M2L power trading volume will maintain steady growth and become the leading force in the market. During the 2023 electricity M2L contract signing window, the government continues to require the total volume of electricity purchased through M2L contracts by market-based power users to be higher than 90% of the previous year's electricity consumption.¹ The total contracted electricity supply from coal-fired power generation enterprises should be no less than 90% of the actual electricity generated in the previous year.

Lowering the barriers to entry and facilitating inclusion of all types of players in the market are important to stimulating the power market. China proposed establishment of a national unified power market in 2022, with emphasis on the cultivation of diverse and competitive market players. Currently, China's main participants in the power market are coal power companies, large I&C users, and power traders. More entities are expected to enter in the future:

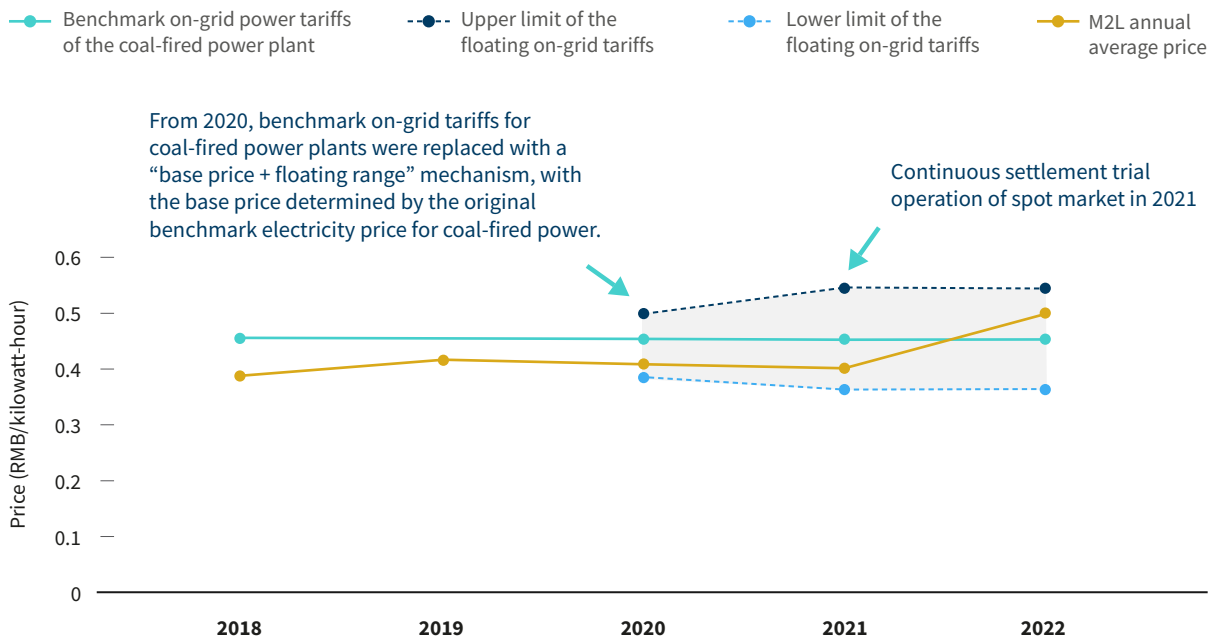
- **Generation:** All existing coal power plants have entered the power market, and some renewables, hydropower, and nuclear power plants have also participated in the market. In the next step, all kinds of power sources will be gradually introduced to the market, and the prioritized dispatch power generation will progressively be settled through the M2L power transactions or contracts for difference. Moreover, renewables — especially wind power, solar photovoltaic (PV), and other novel power sources — should accelerate their participation in the market.
- **Consumption:** Currently, large-scale I&C users participate in the power market through direct purchase or power retailers while small users still largely depend on power grid agents to purchase and sell electricity. In accordance with policy requirements, operational users will gradually be allowed to fully participate in the market. State and social capital will continue to enter the electricity retail business, leading to a more diversified retailing pool which will result in more effective competition. Small and medium-sized I&C users represented by grid enterprises will gradually transition to market-oriented power retail companies. To accelerate the marketization, all regions require users who have directly participated in market transactions and previously purchased electricity through grid companies to have their prices set at 1.5 times the grid company's purchase price.

Looking ahead, new entities will enter and play an important role in the power market. With the addition of market entities such as demand-side flexible load resources, energy storage, distributed energy, and renewable energy vehicles — gradually participating in time-segmented M2L transactions or spot markets — the flexibility of demand-side resources will be fully unleashed.

Coal-fired power will continue to play a role as a price cornerstone in the long run, but the pricing mechanism will gradually transition as the power structure changes

Even though China's nonfossil energy installed capacity has exceeded 50%, coal power still accounts for the bulk of electricity generation by volume, and in 2022 the proportion of coal power in China's electricity output was about 58%.² Therefore, the current price of coal power is the key factor in determining the average electricity cost. All provincial-level regions have introduced coal benchmark pricing based on the average coal power generation cost (see Exhibit 7 for an example). Renewable power pricing will use the coal benchmark pricing as a reference, making coal power cost the cornerstone of China's electricity price.

Exhibit 7: Benchmark pricing, M2L price range, and average price of coal power in Guangdong



Source: Guangdong Development and Reform Commission; Guangdong Power Exchange Center; RMI

The role of coal power prices as a cornerstone is mainly reflected in M2L transactions, which are based on annual contracts. In the long run, due to China's coal-dominated energy resource legacy, coal power is not yet replaceable, which means that China's coal-dominated power structure has yet to change. Coal power prices will remain the pricing cornerstone in the long run, but the mechanism is undergoing subtle changes — e.g., whether the benchmark price of coal power will be adjusted, whether the proportion of high energy-consuming users will exceed 20%, and the proportion of electricity output:

- **Pricing for coal power will become more flexible.** With increasing fluctuations in coal prices, China will gradually remove the upper and lower limits on the M2L floating prices of coal power. Therefore, the spot prices will not be subject to such limits. The floating limits for M2L prices are expected to gradually increase in the coming three to five years, and the M2L prices and spot prices will fully converge. This will tie the price of coal power with coal prices, and the coal power price will gradually disappear as the benchmark price.
- **Pricing in the spot market will have a significant impact on the M2L prices.** The spot market will accurately reflect the real-time price of electricity and electricity supply and demand. The average price in the spot market will progressively become a reference for the M2L trading prices. As China's power structure changes, various power sources — especially renewables — will have a significant impact on electricity prices during certain periods in a day. Take Shandong Province as an example: as the proportion of solar PV power has increased, the “duck curve effect” in the province has become more apparent, and electricity prices are significantly lower at noon than at other times.ⁱⁱ When the time-of-use curve is applied in M2L trading, the phenomenon mentioned above in the spot market will affect the M2L pricing. It is likely that electricity prices at noon will see a significant decrease in M2L contracts when the time-of-use curve is in effect.
- **In the long run, the electricity price will be determined by the competition between the integrated cost of renewables and of coal power (including carbon cost).** On the one hand, the larger-scale development of renewables and their increasing share in the power market will compete with coal power, making coal-fired power not the sole price-setting unit. On the other hand, with the accelerated establishment of the carbon market, the competitiveness of coal power with the added carbon costs will decline, potentially leading to a greater competitive advantage for renewables. In the spot market, during the period when the proportion of renewables generation is high, pricing will be completely determined by renewables. In M2L contracts, the average electricity price will reflect the combination of the costs of renewables, coal power, and carbon. The cornerstone role of coal power prices in the power market will change, and pricing will be determined jointly by renewables and coal power. Based on the current development of renewables and the marketization trend, joint pricing is expected to begin to take shape by 2030.

ii “Duck curve” refers to a phenomenon that there is a significant drop in demand in the grid during the middle of the day when solar power generation is at its peak, and a corresponding increase in demand in the grid during the evening hours when solar power generation decreases.

Increased operating risk of coal-fired units associated with prioritized dispatch power sources

When it comes to prioritized dispatch power sources such as renewables, nuclear power, and biomass, entering the market means competing with coal-fired units, which entails risks to revenue. In China's power market, long-term transactions are mainly based on annual and monthly contracts, and multiyear contracts are rarely used. This mechanism reflects a bias toward fossil fuel power generation. For generation units with high variable costs such as fuel and carbon emissions, annual and monthly contracts are beneficial for transferring the fluctuations in variable costs. Multiyear contracts, on the other hand, lack a flexible adjustment mechanism, so fluctuations in variable costs cannot be passed on by power generators. However, for renewables with little or no variable costs and high up-front investment costs, locking in multiyear prices in advance ensures a healthy revenue flow that helps recover the high up-front costs.

In Xinjiang, Inner Mongolia, Shanxi, and other renewables-rich provinces and regions, power generation that exceeds the guaranteed purchase volume has already begun trading in the power market.ⁱⁱⁱ China has laid out requirements for renewables to participate in power market trade on a larger scale as renewables capacity grows. According to the *Guiding Opinions on Accelerating the Construction of a National Unified Power Market System*, renewable power generators are required to sign longer-term M2L contracts and are expected to fully participate in the power market by 2030.

In response to this requirement, some provinces and regions have introduced measures to incrementally increase the participation of renewables in the market. For instance, according to the *Notice on the Improvement of the Region's Renewables Pricing Mechanism* from the Xinjiang Development and Reform Commission, all electricity generated by renewable parity projects commissioned in 2021 will be traded in the power market, with the actual transaction price being the weighted average price of each period. In several provincial-level spot market pilots, such as those in Shandong, Shanxi, Gansu, and western Inner Mongolia (an area known as Mengxi), renewables are required to participate in spot market trading.

The entry of renewables into the power market means that the business model, which focuses on “guaranteed volume and price” (to protect the consumption and benchmark feed-in tariff), will change, leading to a significant increase in business risks. The main risks associated with renewables entering the market are as follows:

The first challenge is locking in prices for a period long enough to recover initial investment for renewables. Because coal-fired power generation still dominates in most provinces, the pricing of renewable energy is usually anchored to the annual average trading price of coal-fired power, the price of which is based on thermal coal. However, there is no multiyear futures market for coal, which means that the price of coal-fired power and renewable energy can only be fixed for one year and that renewable energy cannot lock in revenue in advance to ensure coverage of initial investment costs.

The second risk is that the variable nature of renewables will result in “price undercutting.” Renewables generation can cause a rapid drop in electricity prices during periods of surplus power, particularly

ⁱⁱⁱ Guaranteed purchase volume is based on the minimum guaranteed annual utilization hours of renewables.

in regions with a high proportion of solar PV power. The surplus of PV and wind power will result in fierce competition between renewables plants during generation periods, making it difficult to obtain high electricity prices in both the M2L and spot markets. This issue is especially serious for solar PV; according to preliminary statistics, the average price of solar PV entering the State Grid interprovincial spot market in 2022 was about RMB 0.2 per kilowatt-hour (kWh),³ significantly lower than the benchmark price for coal power.

Third, whether in the long term or on spot markets, the stochastic volatility of renewables has caused difficulties in pricing strategies and deviation management. Renewables have poor predictability and adjustability, and precise prediction of output is essential for formulating long-term and spot market trading strategies. Otherwise, inappropriate quantity and price declaration may result in deviation losses. In the M2L market, power deviation caused by the inaccurate output prediction requires renewables to pay for the losses according to deviation assessment. In the spot market, fulfilling the deviation electricity quantity according to the spot price may lead to significant losses. Accurate prediction of output is critical to mitigating these risks and requires sophisticated algorithms and advanced technologies.

The integration of renewables into the power market has shattered the conventional and relatively stable business model. Prior investment decisions and asset evaluation methods suitable for conventional power units may no longer be viable. Consequently, renewables companies must reformulate their financial and asset valuation models, shifting from predictable income models to those factoring in more uncertainty. Such a transition makes investment decisions for new projects and evaluation of assets for existing projects more challenging.



Multiyear contracts are expected to become the primary Risk-Control instruments for renewables projects

In the *Notice on Excellence in the 2023 M2L Contracts Signing*, China's energy authorities began to encourage market entities to sign M2L contracts lasting more than one year, requiring them to explore mechanisms for better tuning the prices of long-term contracts. In cases where there is a significant deviation between the long-term contract and the actual market price, market entities will be encouraged to negotiate and adjust the contract execution price on an equal basis.

In the first batch of green power trading in September 2021, a number of foreign companies including BASF, Covestro, and Schneider as well as domestic technology companies signed multiyear power purchase agreements. Global Data Solutions Limited (GDS), as a representative of power users in this national green electricity trading pilot, signed a green electricity cooperation framework agreement with China General Nuclear Power New Energy Investment (Shenzhen) Company (CGNPC). The agreement stipulates that GDS will purchase green electricity from CGNPC for a total amount of not less than 2 billion kWh over a 10-year period. In May 2022, BASF's industrial park in Zhanjiang, Guangdong province, signed China's first 25-year fixed-price renewable power purchase agreement with Brookfield, priced at the levelized cost of electricity (LCOE) of the renewables projects under development and construction.

In general, factors such as future thermal coal prices, the rate of decline in renewable energy costs, and green equity price trends can help buyers and sellers determine the choice of contract period and pricing method. In the past two years, we have observed that the multiyear contracts have yet to be standardized. This reflects the diversity of market participants' needs and risk preferences, as well as the lack of consistency in how various market players evaluate the above factors. We have observed three key phenomena:

- The risks associated with multiyear contracts mainly stem from fuel price fluctuations. For fossil fuel power plants, signing a multiyear contract without a flexible price adjustment mechanism may result in significant loss due to extreme price peaks in fuel markets. However, for variable renewable energy (VRE) sources such as wind and solar power, which have very low fuel costs, this risk does not exist. On the consumer side, multiyear contracts ensure a stable supply of electricity, helping to counter the risks of energy shortages and price increases. Although locking in long-term prices means that contracted electricity volumes cannot benefit from any cost reductions brought about by technological advancements in renewable energy, waiting for cost reductions is not always the best strategy for companies that have made incremental green power usage commitments. Therefore, their hesitation will not hinder the short-term development of renewable multiyear contracts.
- The pricing method of LCOE, which covers the entire life cycle of renewable energy projects, is still not widely understood and accepted. Although this method aligns better with the investment and operational characteristics of renewable projects, the proportion of contracts signed using this method remains low, and it is generally more familiar to multinational power users. Local industrial and commercial users, on the other hand, are generally unfamiliar with this pricing method. As the cost of renewable energy continues to decrease, and more green power purchasers need to sign contracts with new projects and meet additional requirements, we anticipate that the LCOE pricing method will gradually gain more acceptance among market participants.

- Currently, long-term contracts commonly require supplementary off-site contracts or agreements. Although standardized long-term contracts within trading centers are generally simple, buyers and sellers often need to sign additional agreements off-site to agree on more customized terms such as trading methods, price adjustment mechanisms, and risk-sharing arrangements. As the use of long-term contracts continues to grow, we anticipate that standardized contracts within trading centers will be further improved to better meet the growing demand. As a result, long-term contracts are expected to gradually transition from off-site to on-site.



Time-segmented M2L trading will be further promoted as an essential means of connecting with the spot market

Due to the real-time balancing characteristic of power generation, the value of electricity varies depending on the time of day. M2L contracts are not organized for real-time trading, so the value of electricity in different periods is mainly reflected by time-phased power and price curves. However, due to the limitations in the current national spot market mechanism, many provinces have not yet adopted time-segmented M2L transactions. Under the conventional M2L transactions without time segments, parties to the contract only agree on the total amount of electricity and a single price during the contract period. When executed, the power generation curve is broken down by the trading and dispatching center according to certain rules subject to local, municipal, or provincial rulings, and all electricity is dispatched at the same price under the same long-term contract.

There are many drawbacks to M2L transactions without time segments: First, a single price cannot accurately reflect the time-specific value of electricity, so it fails to encourage adjustment of both power generation and consumption based on price signals. Second, M2L transactions without time segments do not contribute to the overall balance of electricity. The balance of the contracts is still managed by the grid. If the transactions are time-segmented, the use curve of the demand side and the generation curve of the supply side should match to a certain degree, which promotes the overall balance of the power market. Therefore, it is essential to tailor time segments in the M2L contracts according to the time-value of electricity reflected in the spot market. Some progress has been made in this regard on M2L transactions in Shanxi and Guangdong.

Box 1: Time-Segmented M2L Transactions Practices in Two Provinces

Shanxi

In 2022, Shanxi carried out time-segmented M2L transactions, dividing daily M2L contracts into 24 time slots by hour, with the electricity in each time slot the subject of a transaction. It is equivalent to opening 24 submarkets every day. The 24 submarkets do not interfere with one another, and each submarket individually handles power trading between the power generation side and the demand side. Collectively, the 24 transactions form a steplike M2L trading curve.

Time-segmented trading in Shanxi is mainly organized in the form of centralized bidding and rolling matching on an annual, quarterly, monthly, 10-day, and daily basis. The centralized bidding transaction is conducted by each market player independently declaring the purchase and sale of electricity volume and prices. After the declaration deadline, a unified marginal clearing is conducted to form a unified clearing price for that period. Rolling matching trading is carried out after the centralized bidding transaction. Using the centralized bidding price as a reference, market players independently make declaration. In both forms, the power generation side and the power consumption side can buy or sell power and freely adjust the contracted power for each period according to their needs.

Guangdong

In December 2022, the Guangdong Power Trading Center issued the *Implementation Plan for Guangdong Power Time-Segmented M2L Trading* to promote the implementation of time-segmented M2L trading.

In annual transactions, Guangdong has added peak, flat, and valley time-of-use centralized competitive trading. The centralized competitive trading is organized monthly, totaling 36 segments for a year. The annual transaction volume is broken down according to weighted monthly, daily, and hourly volume.

In monthly M2L transactions, bilateral negotiation, listing trading, and centralized competitive trading are conducted. The mechanism for bilateral negotiation and listing trading remains unchanged, but monthly centralized competitive trading is now adopting a 24-hour segmented trading format. The monthly transaction volume is broken down based on weighted daily and hourly volume.

With the accelerated promotion of the provincial spot market, there will be a growing connection between time-segmented M2L transactions and the spot market. Relevant government documents on M2L trading call for further expansion of time-segmented trading and increased volume. Bilateral negotiation, centralized trading (including competitive bidding, rolling match trading, and listing trading) and other types of M2L trading forms will be flexibly conducted in time-segmented transactions — yearly, quarterly, monthly, etc. In the future, bilateral negotiations are expected to be the main means of annual and quarterly time-segmented trading, while centralized bidding will be the main form of monthly time-segmented trading. Provinces with the necessary conditions will further refine time-segmented trading to within a month, achieving scheduled market openings by weekly or 10-day intervals, thereby seamlessly integrating with the spot market.

Spot Market

Spot market development accelerated in 2022, and the provincial-level market will be fully established during the 14th Five-Year Plan period

In 2022, the Chinese government stepped up its efforts to promote the spot market. In February, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) issued the *Notice on Accelerating the Construction of the Power Spot Market*, which stated that through a phased approach, the spot market would eventually be active in all provinces. The first batch of pilots began a continuous trial operation of the spot market in 2022, according to the notice, while the second batch was to start trial operation before the end of June 2022. Other regions were required to submit their plans for the spot market in the first quarter of 2022 and were expected to enter the trial operation in 2023.

On November 25, the NEA began gathering public comment on the *Basic Rules of Electricity Spot Market (Draft for Comments)*, which was based on insights gained from spot market pilots. The document outlines the fundamental regulations for intraprovincial and interprovincial spot markets and establishes a basic framework for the operation of spot markets in each province and region. By doing so, it creates an environment conducive to development of the spot market from its current pilot phase to nationwide implementation.

The implementation of the spot market in pilot provinces (and designated cities and districts) has yielded results, although progress has varied (see Exhibit 8). Among the first batch of provincial pilots, eight pilot regions have successfully entered long-term, continuous trial operation of the spot market, as required. Those provinces and regions, including Shanxi, Shandong, Guangdong, Gansu, and western Inner Mongolia, have demonstrated the effectiveness of the spot market. The second batch — Henan, Liaoning, Jiangsu, Anhui, Hubei, and Shanghai — has started trial operation of the spot market.

Exhibit 8: Progress and characteristics of selected pilot provincial spot markets

Batch	Province/ region	Progress	Highlights
First	Shandong	Long-term continuous trial operation	Renewable generators participate in the market by bidding volume only and acting as price takers. Novel energy storage system* participates in the market as an independent entity, placing volume and price bundle bids. These systems profit by capitalizing on the fluctuating electricity prices in the spot market. In Shandong, a capacity compensation mechanism is in place, which allows new energy storage systems to receive payment for their available capacity.
First	Shanxi	Long-term continuous trial operation in 2022	Renewables participate in the spot market by bidding volume only, and the virtual power plants respond to demand by participating in the spot market on an experimental basis.
First	West Inner Mongolia	Long-term continuous trial operation from June 2022	Renewables enter the spot market by bidding both price and volume. Day-ahead market pre-clearance is not yet settled, and real-time market clearing is settled. The market is divided into two separate price zones, and the users' weighted average price is used to determine the benchmark zonal settlement price.
First	Guangdong	Long-term continuous trial operation in 2022	Includes day-ahead market and real-time market; spot electricity and ancillary services are currently cleared separately.
Second	Jiangsu	Completed three running simulations and three settlement trial operations in 2022	During trial operation, the average daily volume of spot market electricity cleared was approximately 1 billion kWh, with the highest electricity price reaching RMB 1.5/kWh and the lowest electricity price at RMB 0.1/kWh.
Second	Henan	Completed the first short-term settlement trial operation in November 2022	The total volume of electricity cleared was 3.6 billion kWh, with an average trading price higher than the M2L trading price.
Second	Hubei	Completed the first short-term settlement trial operation in November 2022	On average, the electricity volume cleared daily on the spot market was 406 million kWh. Clearing prices were higher during the morning and evening peak load and lower during the midday shoulder load. This variation reflects the different power supply and demand relationship at different times in different regions.

*Novel energy storage system refers to all types of energy storage except for pumped-hydro storage.

Source: Provincial energy bureaus; RMI

Looking to the future, the national unified spot market will gradually improve. In terms of scope, there will be a coordinated operation of the inter- and intraprovincial tiers.

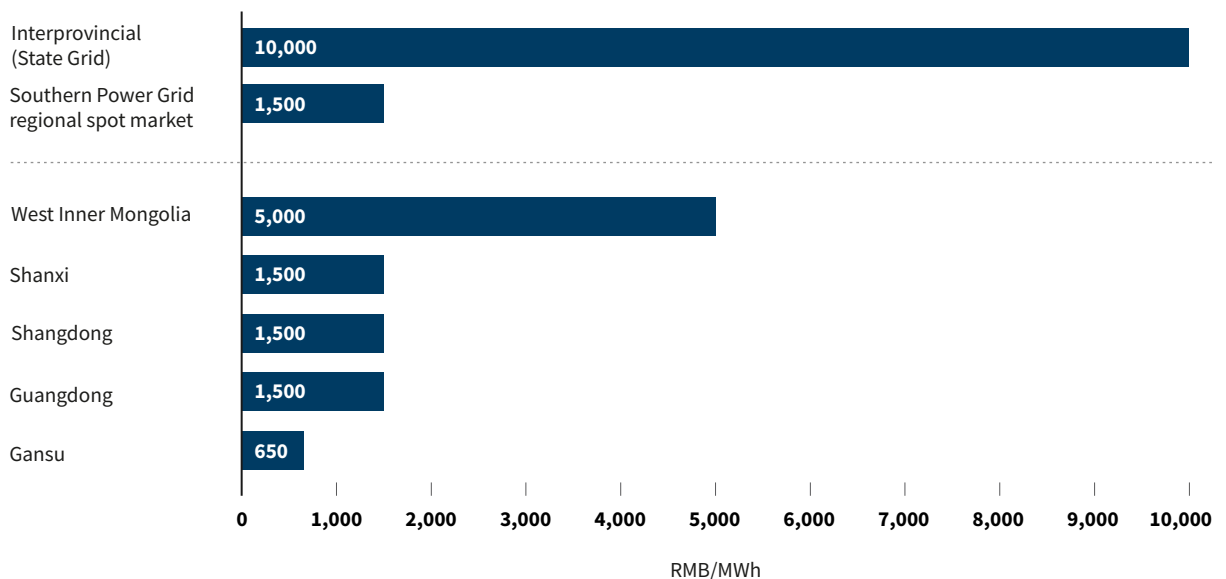
Interprovincial electricity price barriers will be lifted, and the price signals provided by the spot market will promote the optimal allocation of electricity resources nationwide. The provincial spot market will largely adopt a full quantity clearing mode, which will lead to the formation of a three-level market structure (day-ahead, intra-day, and real-time). The spot market will provide a more sophisticated mechanism for the balance of electricity and price discovery. The participating entities will be more diverse, and a greater proportion of preferential generating sources such as renewable energy, nuclear power, and hydropower will enter the electricity market. Small-scale industrial and commercial users, distributed energy storage, distributed photovoltaics, electric vehicles, and other entities will gradually participate in spot market transactions, leading to a significant increase in trading activity.



The spot market price cap and floor will gradually be deregulated, but its role in conducting M2L prices will remain limited

During the early development of the spot market, China set a price cap (see Exhibit 9) to prevent abuse of the power market — such as withholding power generation capacity during periods of shortage. Additionally, this measure aimed to address unexpected events that could disrupt fuel supply or require urgent maintenance, such as extreme weather or emergencies, and trigger extreme price volatility.

Exhibit 9: Domestic spot markets bid cap in 2022



Source: Provincial power trading centers; RMI

Overall — except for the interprovincial markets of State Grid and western Inner Mongolia — the spot market price cap in China is low compared with the caps in Europe and the United States. The main reason for the difference is that the pricing mechanisms are different. China's price cap is set based on the marginal cost of the highest possible unit, while in Europe and the United States the price cap is based on opportunity cost.

The price cap can help prevent power generators from abusing their market power by raising prices, and it can reduce the risk of price volatility for consumers. However, it weakens the spot market's role in price discovery and resource allocation, which suppresses the incentive for long-term investment, and makes it harder for new players, like virtual power plants and energy storage, to enter the market. As the market matures, China is expected to gradually deregulate the price cap and floor of the spot market. With the gradual increase in renewables penetration, the challenge of balancing power generation and consumption will also grow. This objective requires that the spot market play a more significant role in price discovery. However, it is likely that the price cap in China will continue to be relatively low by international standards.

In theory, even if about 90% of the electricity volume is locked in prices through M2L contracts, the spot market still holds significance in determining the market price of electricity. The provincial-level spot market, which adopts the full-volume-clearance mode, effectively discovers the electricity price. Using the spot market's settlement mechanism, the M2L transaction price will align with the spot market, which is an effective way of avoiding M2L contract risk. Therefore, the discovered electricity price and hourly price pattern in the spot market will impact the contract price of M2L transactions. With the gradual opening up of time-segmented M2L transactions and price restrictions in the next few years, the role of the spot market in price discovery will be more pronounced.

The spot market's current pricing function is restricted by a policy that limits prices in M2L transactions and the lack of widespread time-of-use trading. Despite the spot market's importance in the discovery of electricity prices, the limit on prices in M2L transactions restricts its ability to set prices effectively, causing distortions in electricity prices.

As shown in Exhibit 10, the annual average price of electricity in spot markets in Guangdong, Gansu, and western Inner Mongolia has risen by more than 20% relative to the benchmark coal-fired power price. During a period of tight electricity supply — including July, August, and September — the spot market price is more than 10% higher than the annual average. However, the spot market's prices cannot be entirely conducted to M2L markets due to the 20% upper and lower fluctuation limits. This limits the spot market's ability to fulfill its pricing function.

Moreover, in the current stage, where time-of-use trading is not yet widely promoted, the price distribution pattern discovered by the spot market (such as the duck curve brought about by solar PV) is also difficult to reflect in the M2L market. As a result, the spot market's role in balancing power supply and demand and promoting the participation of flexible resources in regulation is not significant.



Exhibit 10: Spot market prices in some of China's provinces in 2022

Province	Annual average price (RMB/MWh)	Annual minimum price (RMB/MWh)	Annual maximum price (RMB/MWh)	Benchmark coal generation price (RMB/MWh)	Upward ratio of spot average price to benchmark coal generation price	Average intra-day peak-valley price gap (RMB/MWh)
Guangdong	556.59	0	1,481	453	22.87%	195.4
Shanxi	389.27	0	1,500	332	17.25%	504.8
Shandong	366.52	-100	1,500	394.9	-7.19%	415.3
Gansu-East*	428.1	0	800	297.8	43.75%	219.9
Gansu-West**	366.23	0	800	297.8	22.98%	268.8
West Inner Mongolia (East Huhhot-Baotou)	451.64	-0.8	1,891	282.9	59.65%	536.9
West Inner Mongolia (West Huhhot-Baotou)	457.97	-70.86	1,785	282.9	61.88%	548.3
Interprovincial	631.94	34.89	6,015	-	-	-

* Gansu-East refers to the area east of the Yellow River in Gansu, including Tianshui, Pingliang, Longnan, and Lanzhou.

** Gansu-West refers to the area west of the Yellow River in Gansu, including Jiuquan, Zhangye, Wuwei, Jinchang, and Jiayuguan.

Source: Lambda; RMI

Interprovincial and regional spot markets are still in their early stages, but they hold great potential for promoting renewables and breaking down provincial price barriers

In November 2021, State Grid released the *Interprovincial Power Spot Trading Rules (Trial)*, proposing a unified market operating at two levels for intraprovincial and interprovincial spot markets. The interprovincial spot market utilizes an incremental electricity clearance mode, which differs from the full-volume-clearance mode used in provincial spot markets. This mode takes advantage of the residual interprovincial channels to trade additional electricity on top of M2L contracted volume, optimizing the complementary nature of interprovincial power resources. In 2022, interprovincial transaction data showed that except for the period of tight power supply in the Southwest during the summer, the proportion of renewable energy transactions reached about 90% each month. This effectively promoted the optimized consumption of renewable energy across a wider geographical area.

In 2022, State Grid launched a trial operation of interprovincial spot market settlements, with participation of more than 6,000 power generation companies. The cumulative traded electricity volume reached 27.8 billion kWh for the year, with a maximum daily transaction volume of 319 million kWh and an average settlement price of RMB 0.87/kWh.⁴ During the peak summer period, persistent high temperatures, increased electricity demand, and a severe shortage of hydropower generation resulted in power shortages in many provinces in southwestern, central, and eastern China. The demand for electricity in the interprovincial spot market increased significantly, while the sending provinces had reduced electricity to export due to supply pressure. This led to a supply shortage in the interprovincial market, and spot market prices rose sharply. In the third quarter, the average interprovincial transaction price reached RMB 1.3/kWh, and the highest electricity price exceeded RMB 6/kWh.⁵

Unlike the State Grid operating area, the Southern Grid region implements interprovincial power trading through an integrated regional power market. The regional spot market is a crucial element in the regional power market system. In July 2022, the Southern Grid regional spot market began operating with the participation of three provinces — Yunnan, Guizhou, and Guangdong — and successfully conducted the first interprovincial spot trading in the southern region, involving more than 157 power plants and users. Power generation entities set an upper price limit of RMB 1,500/MWh.⁶ From September to October, the Southern Grid regional spot market achieved coordinated operation with Guangdong's intraprovincial spot market, and from November to December, Guangxi and Hainan provinces were added to the Southern Grid regional spot market's operating scope.

Despite the sharp surge in interprovincial electricity prices, the regional spot market played an effective role in balancing electricity supply and demand. During the peak summer period of 2022, the maximum load of interprovincial transactions of the State Grid reached 19,000 MW,⁷ effectively supporting the provinces suffering power shortages. Furthermore, interprovincial transactions facilitated the flow of provincial electricity prices, reflecting the temporal and spatial value of electricity. The intra-day electricity price curve exhibited a clear single peak and single valley, and a significant seasonal difference was observed within the year, providing a comprehensive price signal for the optimization of electricity resources throughout the network. While interprovincial transactions increased the purchasing costs of the receiving provinces, this was necessary for ensuring efficient allocation of electricity resources.

Energy storage has taken the first step in participating in the spot market, but it may have a difficult time reaching projected profits

National policies are encouraging new market players, such as energy storage companies, to participate in spot market trading. In 2022, independent energy storage companies began participating in spot market trading in Shandong and Shanxi. In the Shandong market, energy storage relies on price arbitrage in the spot market and capacity compensation as main sources of revenue. According to the Shandong Power Trading Center, a total of eight energy storage companies with a combined storage capacity of 712 MW/1,504 MWh participated in spot market trading in 2022, with the total traded volume exceeding 200 million kWh. However, the income from energy storage participating in spot market trading was significantly lower than the theoretically calculated value, due to three main factors:

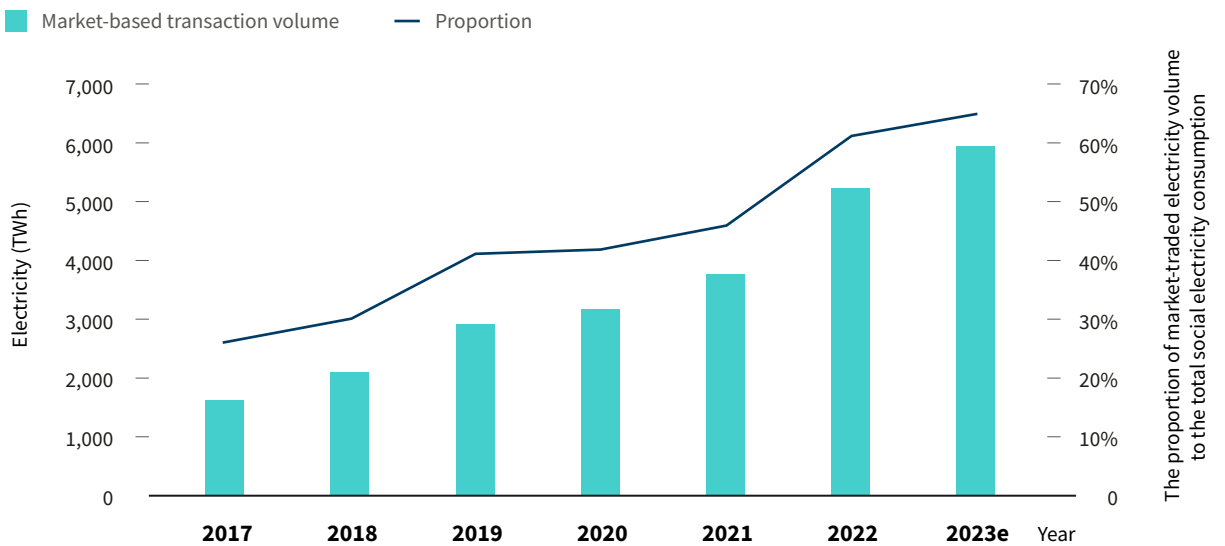
- **Predicting peak and valley electricity prices is challenging in the spot market.** The fluctuations of intra-day electricity price peaks and valleys are significant, making it hard to anticipate the high and low values of electricity prices in advance. Formulating accurate operation strategies for novel energy storage systems is challenging. Improper setting of the charging and discharging price thresholds for energy storage on a given day may lead to inability to charge and discharge at the optimal electricity price, resulting in low or no profit. Moreover, with the increase in energy storage assets in the future, the intra-day load curve will be further smoothed, further compressing the intra-day electricity price gap and limiting the profit margin of energy storage.
- **The average peak-to-valley price gap is not significantly higher than the energy storage LCOE.** As shown in Exhibit 10, the annual peak-to-valley average price gap in Shandong province is only slightly over RMB 0.4/kWh. According to our field research, LCOE of intermediate lithium iron phosphate battery is currently the lowest, ranging from RMB 0.45/kWh to RMB 0.65/kWh, and the annual peak-to-valley average price gap in other provinces is not significantly higher either. In addition, peak pricing occurs for only a brief period in a day, and not all the energy storages are able to discharge at peak hours. The competition and randomness in earning the peak hour pricing increase uncertainty around the profit margin for energy storage providers.
- **It is difficult to implement the “dual charge and discharge” strategy.** In the era of tiered electricity pricing, user-side energy storage generally adopts the “dual charge and discharge” mode — charging during the late off-peak period and discharging during the early peak period, and charging during the afternoon flat period and discharging during the late peak period. This enables energy storage providers to increase profits and accelerate the recovery of costs. However, the rapid development of renewables, especially solar PV, has changed the time distribution of peak and valley periods. Many provinces have already shown a clear “duck curve” pattern, with low prices during the day and high prices at night in the spot market. As a result, typical days only allow for “single charge and discharge,” which will prolong cost recovery for energy storage. With the larger-scale development of solar PV in the future, single charge and discharge within a day will become the long-term operating mode.

Retail market

As industrial and commercial users fully enter the market and grid agents gradually exit from electricity procurement, power retail companies are poised to capture a larger share of the market

Following the release of the NDRC's *Notice on Further Deepening the Market-Oriented Reform of Coal-Fired Power Generation On-Grid Electricity Prices*, I&C users are gradually entering the power market and driving up the volume of market transactions. In 2023, we expect the volume of market transactions to increase by 14% year-on-year, reaching approximately 6,000 TWh. This will represent 65% of the total social electricity consumption, continuing to set records (see Exhibit 11).

Exhibit 11: Market-based transactions and proportion of total volume, 2017–23



Source: China Electricity Council; RMI

Most of the electricity traded in the market is bought through individual power retail companies or grid-owned power retail companies. Only a small portion of large industrial users still opt to directly purchase electricity in the wholesale market. In 2023, we predict that these three types of electricity transactions — through individual power retail companies, grid-owned power retail companies, and large industrial users — will account for approximately 40%, 20%, and 5% of the total electricity consumption, respectively.

We anticipate that the proportion of electricity purchased through individual power retail companies will continue to increase. Many small and medium-sized I&C enterprises will still choose grid-owned power retail companies. This group encompasses a vast number of users, despite relatively low levels of electricity consumption per entity. We believe that, in light of current reforms, these users will gradually shift their purchase from grid-owned power retail companies to individual power retail companies. We expect the transition to be complete by 2025. We also expect that as the market rules continue to evolve, some large industrial users may turn to professional individual power retail companies to meet their electricity requirements.



In the short term, generation-integrated retail companies will continue to maintain their advantage; however, risk control and customer service are key to long-term success

Despite the expected benefits of further expansion of agency procurement by power retailers, they will also face stricter regulation. Stimulated by attractive power market reforms, the number of power retailers has increased dramatically — from 559 in May 2016 to 5,410 at the end of 2022. However, due to the constraints of the power marketization process, many power retailers have not carried out substantial business.

In November 2021, the NDRC and the NEA issued the *Management Measures for Power Retailing Companies*, which place more emphasis on risk management. The policy requires power retail companies that have not conducted sales in any administrative region for three consecutive years to withdraw from the market and establish performance bonds and insurance systems.

Strengthening the management of power sales companies on the basis of financial strength, risk resistance, and creditworthiness results in a shake-up of the industry. In August 2022, nearly 45% of power retail companies in Guangdong, a total of 266, were forced to delist for various reasons, including failure to conduct business for three years — an indication of the major changes occurring in China's power retail industry. Additionally, according to the Beijing Power Exchange website, multiple power retail businesses closed in 2022. As of the end of 2021, 4,989 power retail companies were operating in various power trading centers nationwide, and this number has since declined to around 4,000.

In addition to stricter regulation, power retailers are facing increasing competition. As the spot market is promoted, power retailers are under pressure to reduce their operating costs, improve price forecasting and risk management, and compete for customers with lower electricity prices and better services. The business model based on earning price differences through intermediaries will become unsustainable. The retail business is expected to become more specialized and quality oriented. Retailers with strong market risk management and customer service capabilities will thrive, while those relying solely on earning price differences will gradually fade away.

At present, there are various types of power retail companies, including subsidiaries of state-owned energy enterprises, local state-owned enterprises, and listed companies. Due to their inherent advantages in power supply, technology, and customer networks, state-owned (or state-controlled) power generation enterprises play a significant role in the power retail market. They have an integrated model of power generation and retail that enhances the overall efficiency of their companies. According to national annual electricity data, Huaneng International and GD Power Development Retail Company have revenues exceeding RMB 100 billion, ranking first by revenue among power retail companies.

Although other power generation groups are not part of the RMB 100 billion revenue club, their provincial subsidiaries also rank high in the local retail volume. For example, in Jiangsu province, power retail companies China Resources, China Energy Group, Datang, State Power Grid, and State Power Investment Corporation are among the top 10 in retail volume.

As the spot market continues to evolve and risk management requirements become more stringent, power retail companies are expected to expand beyond the one-dimensional retail model and explore

value-added services. These services, which are likely to become a primary source of profit growth for the industry, include: fully understanding the load characteristics of users; enhancing the complementarity of electricity consumption curves among these users; and developing spot market pricing strategies to better hedge against electricity price fluctuations and reduce user-side power purchase costs. Additionally, effective management and utilization of flexible resources on the user side — such as distributed energy storage and electric vehicles — could enable companies to establish virtual power plants, participate in spot market transactions, and respond to demand fluctuations in order to generate additional revenue.

Power retailers can enhance their market position by expanding services such as digitalized energy management, equipment operation and maintenance, and providing distributed energy construction planning for users. However, providing these value-added services will require power retail companies to develop a deep understanding of user needs and highly specialized professional capabilities.



Power retail packages are now being designed with greater differentiation to better meet customers' risk preferences for price fluctuations

To enhance their competitiveness, power retailers design various packages based on the preferences of users. In Zhejiang province, for example, retail power packages include fixed-price packages, proportional-split packages, and price-linkage packages.

- **Fixed-price package:** The power retailer and customer agree on a fixed settlement price in this type of package, which effectively eliminates price risk for customers. When the wholesale market prices change, customers do not need to bear price increases nor benefit from price drops. This package offers customers the lowest risk of electricity price fluctuations.
- **Proportional-split package:** The power retailer and the retail user agree on a base price and sharing ratio, which means they share profits and risks based on the monthly transaction average price. The package allows electricity customers to manage their price risks effectively. When wholesale market prices change, the customer and the retailer share the profit and risk according to the agreed sharing ratio. The proportion of risk and benefit can be adjusted separately, offering users a moderate risk of electricity price fluctuations.
- **Price-linkage package:** The power retailer and the customer agree on a flexible fee that directly links to the market price. This package carries a higher risk of electricity price fluctuations for users.

With the development of the spot market, price fluctuations in the wholesale market have become more significant. The growing pricing risk should not be ignored. In the future, power retailers' package designs will better reflect price risks, providing various packages based on users' risk preferences. One important consideration in pricing is the risk premium, which refers to the additional cost users pay to power retailers to avoid price shocks. Fixed-price packages allow users to avoid price fluctuation risks, so the risk premium represents an increase of average pricing. In contrast, price-linkage packages effectively transmit spot market price signals to users, promoting user-side demand management. This package model is encouraged by policies and does not require payment of a risk premium. The proportional split package enables risk sharing, and users pay a certain risk premium based on the risk proportion borne by the power retailer.

Ancillary Services Market

The updated Dual Rules add ancillary services suited to development of renewables to the New Power System

In March 2021, China proposed development of the New Power System to address the power balance and grid operation safety issues arising from increasing renewables penetration. A comprehensive ancillary services compensation mechanism and an ancillary services market trading mechanism are essential components of the New Power System. At the end of 2021, the NEA released revised versions of the *Regulations on Power Plant Grid Connection and Grid Operations and the Regulation on Power System Ancillary Services Operations* (hereinafter referred to as the Dual Rules), which were first issued in 2006.

The revision of the Dual Rules expands the types of ancillary services for the power grid, approves more market entities to provide ancillary services, establishes a market-based services compensation mechanism, and provides a fair cost-sharing framework. After the announcement of the Dual Rules in 2022, the southern, eastern, northern, and northwestern regional grids revised their implementation rules for ancillary services.

With the significant increase in the penetration by renewables in the power system, the demand for traditional ancillary services, such as frequency regulation, has increased, as well as demand for new types of ancillary services. The fluctuation of power output by renewables may cause serious imbalances in power generation and consumption during certain periods of the day, such as the rapid decrease of solar PV output at dusk, resulting in insufficient generation in the power grid.

As new energy increasingly replaces conventional synchronous power sources on a large scale, the proportion of power electronic devices connected to the grid will further increase, which will reduce the synchronous rotational inertia of the power grid and cause a decrease in frequency stability. Therefore, it is necessary to establish inertia ancillary service types to support high-penetration periods of new energy and encourage entities with rotational inertia to operate on the grid as much as possible to provide a rapid response to changes in system frequency.

Peak regulation may phase out, as frequency regulation and reserve ancillary services turn to marketization, with compensation mechanisms for other ancillary services optimized

Ancillary services are purchased and settled in two forms in the market: one is through a fixed compensation determined according to the regional Dual Rules, and the other through the market. Currently, market-oriented transactions for ancillary services are limited, and fixed compensation is still the major means of settlement. However, as power market reforms progress, settlement for ancillary services will gradually shift to market-based transactions.

Peak regulation will gradually merge with the spot market

Peak regulation is currently a major type of ancillary services, compensated by fixed price. It is in operation in northern and southern regional grids, as well as Hunan, Fujian, Qinghai, Tibet, and Gansu provinces. To encourage market entities to upgrade their ramping capabilities, the northern regional grid and Gansu markets have adopted two trading methods: one based on capacity (according to ramping ability) and the other based on volume (according to the opportunity cost of selling electricity while providing ramping services).

The principle of setting up the peak regulation market is to discover the value of electricity in different time slots, which overlaps with the function of the spot market. Therefore, the merger of the peak regulation market and the spot market is inevitable. The updated Dual Rules proposes that “during the operation of the spot market, there will be no peak regulation market running in parallel.” In the *Spot Market Basic Rulings*, the NEA also calls for “strengthen[ing] the integration of the spot market and the peak regulation market.” As the spot market pilot progresses, peak regulation will be phased out. Based on the development of the spot market pilot so far, peak regulation in the first batch of pilot areas is expected to be integrated with the spot market before 2024, and the second batch in 2025.

Marketization of frequency regulation, reserve, and other ancillary services is accelerating

In 2022, various regions accelerated the marketization of ancillary services. Except for peak regulation, frequency regulation and reserve services have already undergone marketization. Some regions (e.g., Guangdong) have established independent ancillary services markets to incentivize the participation of demand-side flexibility resources in providing ancillary services.

Marketization of secondary frequency regulation has advanced further than other ancillary services. Frequency regulation refers to the service provided by the market entity to adjust its active output to restore the frequency of the power system that has deviated from the target frequency. This is accomplished through speed control and automatic power control systems. Under the original rules governing frequency regulation market, primary frequency regulation is generally uncompensated, and secondary frequency regulation (Automatic Generation Control and Automatic Power Control) is compensated. Among various types of ancillary services, secondary frequency regulation has gone further

in marketization. The southern regional grid and provinces such as Shanxi, Jiangsu, Fujian, Anhui, and Chongqing have launched secondary frequency regulation markets. The frequency regulation market is applicable to all types of market entities. The dispatch of the service is generally determined based on the overall frequency regulation performance of the entities. Among the entities, electrochemical energy storage has obvious frequency regulation advantages due to its fast response time, while new energy sources such as wind and solar have weaker performance.

Some regions have attempted to set up compensation mechanisms for primary frequency regulation.

With the increase in renewables penetration, the risk of frequency fluctuation in the power system increases. To better utilize the rapid adjustment function of primary frequency regulation, the southern grid and the eastern regional grid have set up compensation mechanisms according to the volume of theoretical power adjustment integral. For example, primary frequency regulation with a theoretical power adjustment integral lower than 70% of the plant's maximum output is still treated as an uncompensated adjustment, while that greater than 70% is a compensated adjustment — effectively incentivizing power units to participate in primary frequency regulation. In 2021, Shanxi conducted primary frequency regulation transactions, with trades on a daily basis and primary frequency regulation pricing of RMB 5–10 per megawatt-hour (MW). Since flywheel energy storage has an absolute advantage in primary frequency regulation in terms of rate of adjustment, it is the main means of primary frequency regulation.

The development of the regional reserve ancillary services market is accelerating. Reserve refers to the ancillary services provided by an entity to increase power output in response to dispatch instructions when there is an electricity shortage, ensuring reliable power in the grid. Based on the physical characteristics of China's power grid, using regional reserve markets is more economical, in that various provincial grids within the same region can share the reserve resources. Novel energy storage with adjustable capacity and conventional power sources such as coal and hydropower can all participate in the reserve market. In 2022, the central and southern regional grids accelerated the development of interprovincial reserve ancillary services markets.

The interprovincial reserve market of the central regional grid is structured in two layers: day-ahead and intra-day. During day-ahead trading, the provincial power dispatching agencies of the service buyers announce the reserve demand curve for the following day, the service sellers provide a quote according to the available reserves, and the reserve transaction is cleared at marginal quantity and price. Intra-day trading is based on the service buyers' declaration of incremental demand for the day. To prevent price fluctuations during the transaction, a limit is imposed on the declared price. The tentative reserve electricity price quote cannot exceed 1.2 times the provincial-level electricity retail price, and the reserve capacity price quote cannot exceed RMB 100 per megawatt-hour (MWh).

In the southern regional grid, the interprovincial reserve capacity market employs a system of day-ahead clearance and intra-day adjustment. On the day of operation, based on the interprovincial trading results in the day-ahead market, the southern regional grid organizes interprovincial reserve capacity adjustment according to the balance and the reserve capacity status of each province on that day, and the adjustment is disclosed afterward. The upper limit of the reserve price quote is RMB 50/MWh, and the lower limit is RMB 0/MWh.

Moment-of-inertia, ramping-up, and reactive-power services continue to be compensated, but their future paths differ

The updated Dual Rules now officially include moment-of-inertia and ramping-up services. The southern and northern regional grids have implemented moment-of-inertia compensation since 2022, while ramping-up services have not yet been initiated. The eastern and northwestern regional grids have launched moment-of-inertia and ramping-up services. As renewables continue to expand, it is anticipated that all regional grids will introduce these services by 2025. Ramping-up and moment-of-inertia services lend themselves to marketization and will gradually enter the market over time.

Because renewables lack reactive power and voltage-support capabilities, demand for reactive power is expected to continue rising. Therefore, it is essential to optimize the compensation mechanism for reactive power. One characteristic of reactive power is that the service provider needs to be proximate to the demand to maintain the local balance, so reactive power compensation is not a good fit for marketization.

Box 2: Demand-Response Ancillary Services

As the difficulty of balancing supply and demand in the power system increases, the need for demand-response participation in ancillary services is also growing. However, in general ancillary services markets, the bidding cap limits the incentive for demand-side resources to provide ancillary services. Additionally, due to their small size, demand-side resources have difficulty responding to dispatch instructions. In April 2022, the Guangdong Power Trading Center issued the *Guangdong Provincial Market-based Demand Response Implementation Rules (Trial)* mandating higher prices and load aggregation to encourage demand-side resources to participate.

The Guangdong demand-response market has the following characteristics: First, it significantly expands the coverage of response entities to include direct-controlled virtual power plants (above 10 MW) and non-direct-controlled virtual power plants (above 0.3 MW) with direct-control capabilities. Second, it mainly targets the peak shaving function of demand response, which can best reflect the role of demand response in improving the safety of the power system and reducing overlapping investments. Third, it sets up three tiers of settlement — months (half a year or a year), weeks, and days — based on the capacity or electricity volume. The settlement mechanism establishes a long-term, stable income to attract demand response resources investments and stimulates demand response resources through instant bidding.

Meanwhile, Jiangsu has also put in the practice of user-side adjustable load participation in the ancillary services market. Shandong, Zhejiang, Hunan, and other provinces have implemented demand-response practices but have not formed continuously operating market mechanisms. As the scarcity of flexible resources in the power system becomes more apparent, the degree of marketization of demand response will increase.

The costs for ancillary services are passed downstream in the power system

In 2022, various regions allowed more entities to provide ancillary services, including renewables, novel energy storage systems, interruptible loads of industrial and commercial users, virtual power plants, and electric vehicle charging networks. If they can respond to power dispatching instructions, these new entities can participate in ancillary service regulation.

The expansion of participating entities can effectively mobilize flexible resources on the load side, significantly reducing the overall cost of ancillary services. However, different types of ancillary services will still have different requirements for participating entities: peak shaving services (before being integrated into the spot market) are suitable for conventional power sources, novel energy storage, and controllable loads; frequency regulation services are suitable for conventional power sources, novel energy storages, and renewables with compatible regulation equipment; ramping-up services are suitable for conventional power sources and novel energy storage; and moment-of-inertia services are suitable for conventional synchronous power sources, flywheels storage, and compressed air energy storage.

Box 3: Ancillary Services Entities In Various Regions

In the southern region, wind power (greater than 10 MW), solar PV (greater than 10 MW), novel energy storages (10 MW lasts for one hour or more), and direct controllable loads (not less than 30 MW, maximum adjustment capacity not less than 10 MW, and adjustment duration not less than one hour) have all been included for participation in ancillary services.

In the eastern and northern regions, ancillary services have been expanded to include hydro, thermal, nuclear power, privately owned power plants, pumped-hydro storage, wind power, solar PV, and concentrated solar power generation facilities with a voltage level of 35 kilovolts (kV).

In the past, the cost of ancillary services was shouldered by the generation side, based on the principle of “rewarding the good and punishing the bad.” However, the rewards and penalties on individual generation units did not accurately reflect the scarcity of ancillary services, making it difficult to incentivize power generation companies to participate in ancillary services, and even more difficult to mobilize additional resources to participate in regulation. The updated Dual Rules establishes a market-oriented ancillary services compensation mechanism and an ancillary service cost-sharing mechanism for power users, with the cost of ancillary services listed separately in electricity bills.

When distributing the costs of ancillary services, it is important for each region and province to carefully consider a fair and reasonable allocation among the different stakeholders. In the southern region, the ramping-up compensation costs mainly caused by the rapid drop in renewables’ output are shared by renewables generation companies based on the predicted deviation ratio. The peak-shaving compensation costs for direct controllable loads are shared by market-oriented power users based on their monthly

electricity consumption, while compensation costs of other services are shared equally between the generation side and market-oriented power users.

In the eastern region, power generation companies, novel energy storage entities, and power users share the responsibility for the safe operation of the power grid, including frequency regulation, voltage control, reserve, and moment of inertia. The cost of ancillary services that have been designated as free should not be charged, and those already compensated should not be repeat charged. The cost of ancillary services for specific entities should be borne by those entities.



While the ancillary services market presents opportunities for novel energy storage, it remains challenging for them to become the primary source of revenue

In 2022, the Southern Power Grid and other jurisdictions including Chongqing, Qinghai, Hunan, and Henan have issued policies to support novel energy storage entities participating in the ancillary services market. In Guangdong province, novel energy storage entities participating in peak regulation can receive compensation of RMB 0.792/kWh; in Guangxi, those participating in peak shaving receive compensation of about RMB 0.396/kWh; and in Chongqing, novel energy storage entities participating in the frequency regulation market have a bid range of RMB 6–15/MW and can also receive capacity compensation at about RMB 3/MW in day-ahead trading and RMB 10/MW in intra-day trading.

Market-oriented distribution of ancillary service costs to users partially addresses the shortcomings of business models associated with novel energy storage. For example, electrochemical energy storage (aka battery storage) has excellent frequency regulation and ramping capabilities, and can generate revenue through the ancillary services market or fixed compensation. There are electrochemical energy storage power stations earning revenue in the frequency regulation markets in Shanxi and Guangdong. According to the NEA's analysis, ancillary services costs may account for more than 3% of the total electricity bill for end users.

However, ancillary services can only be a partial source of income for novel energy storage entities. For one thing, the demand for ancillary services is not linearly related to electricity consumption, and the market size is limited. In addition, there is fierce competition in the ancillary services market itself; the entry of low-investment resources such as controllable loads and flexible retrofitting of thermal power plants poses a significant substitution risk for novel energy storage. The competitiveness of novel energy storage in the ancillary services market depends on continued improvement of the technology and decrease in cost.

Capacity Mechanisms

Capacity mechanisms currently exist only in Shandong and Guangdong, but are expected to roll out more broadly

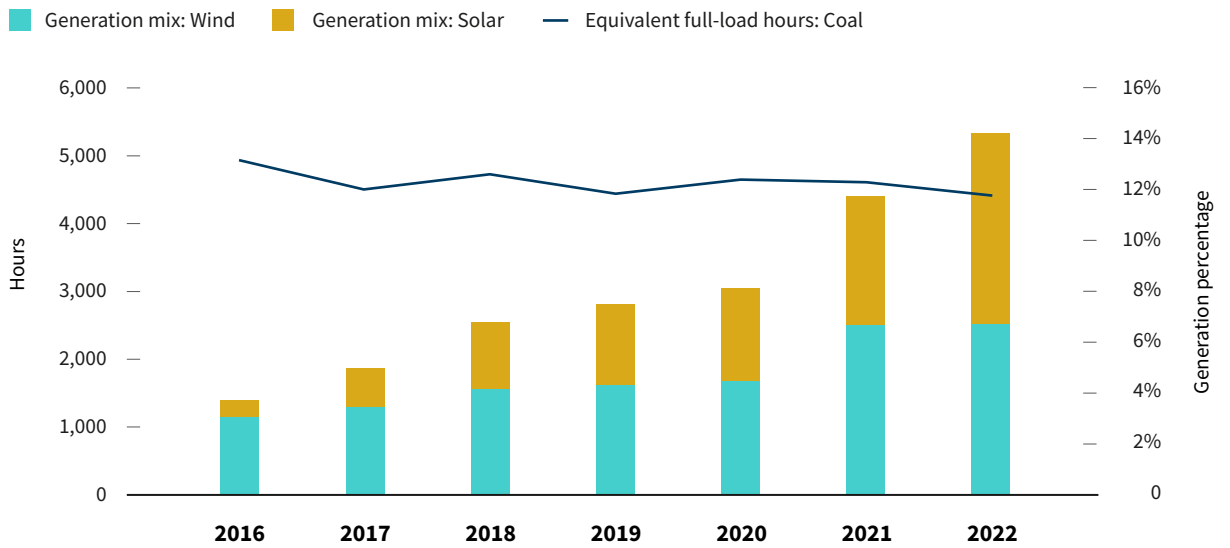
Shandong and Guangdong, which were in the first batch of spot market pilot provinces, took the lead in establishing capacity mechanisms to ensure power system adequacy. In both provinces, the mechanisms involve collecting a fixed-capacity fee from the user side according to the electricity consumption and then apportioning the capacity fee to the generator side according to the effective capacity. As shown in Exhibit 14 (page 49), on the generator side, Guangdong's capacity compensations are limited to thermal power units, while in Shandong, energy storage and renewables are also compensated based on their effective capacity. On the user side, Shandong charges the capacity fee for the total electricity consumption of I&C users, while Guangdong charges the capacity fee only for the monthly excess electricity consumption over M2L contracts of electricity retailers.

Similar capacity mechanisms are expected to roll out in other provinces, especially those where the spot markets are under continuous trial operation and where there is a large presence of renewables. Given the rapid growth of renewables with near-zero marginal cost, some generation units with high marginal costs are having difficulty competing in the spot market — meaning that either they need extra revenue to recover their fixed costs, or they must exit the market. Therefore, promoting capacity mechanisms in China is to supplement the spot market — with the aim of compensating the generation units, making them economically viable so they remain in the market and ramp up during power shortages.

In Shandong, for example (see Exhibit 12, next page), coal power capacity dropped by 6.2% between 2016 and 2020. Furthermore, after Shandong started the continuous spot market trial operation in 2021, where all coal power and renewables generation units entered the market, the equivalent full-load hours of coal power continued to decrease in 2022. The first version of the capacity compensation mechanism was proposed in April 2020, and an updated version was released at the end of 2022.

In general, such capacity compensations allow (old) coal plants with high marginal costs to recover basic expenses and choose to shut down or maintain minimum generation during nonpeak hours/seasons, and to start up or ramp up amid tight power supply and demand to guarantee the security of the power supply.

Exhibit 12: Comparison of coal and renewable generation in Shandong, 2016-22



Source: China Electricity Council; RMI

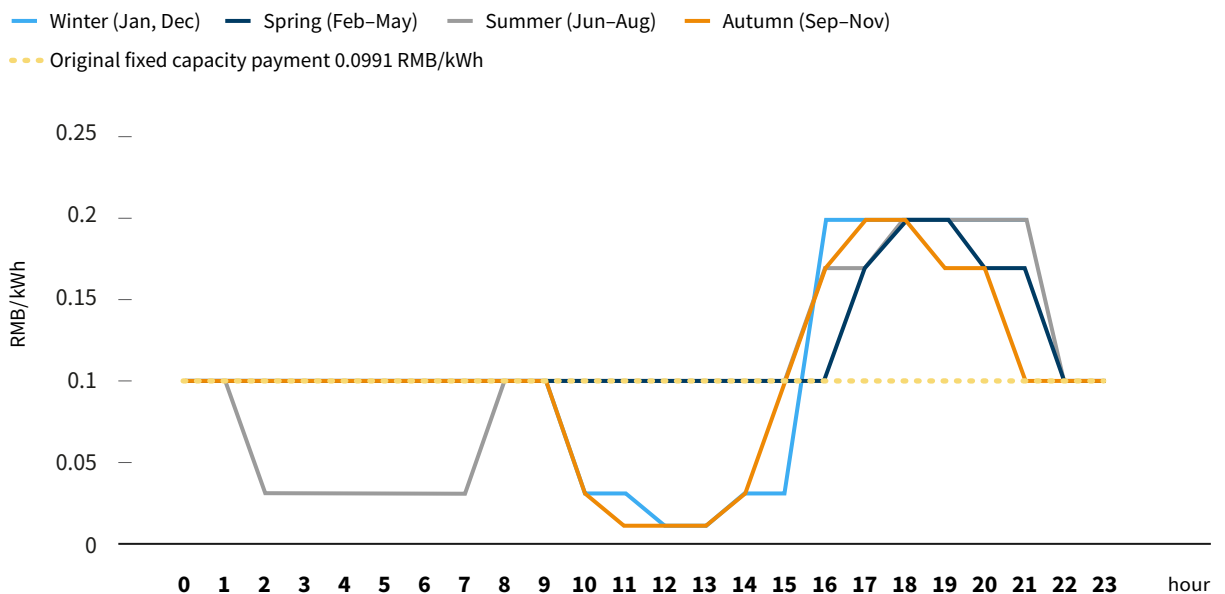


The regulated capacity payment will be China's primary capacity mechanism in the near future

During the 14th Five-Year Plan period, more provinces are likely to adopt the regulated capacity payment. Based on international experience, more complex and auction-based capacity mechanisms should be introduced only after the electricity market is mature, to keep the market accessible to participants. The capacity mechanism in the Chinese context will focus more on cost recovery for existing generation resources as a means of maintaining system adequacy rather than incentivizing new capacity investment. Because investment in new projects — coal, natural gas, and hydroelectric power plants, etc. — is still guided and approved by China's provincial and national governments, there is no need to use market-based capacity mechanisms to provide investment signals. Given the recent power shortages in some regions, the rollout of capacity payment with regulated tariffs is an easy-to-implement approach that promises to help the power system meet demand.

Specifically, capacity payments will be calculated with reference to the fixed cost of generation resources providing system adequacy and will be further refined for time-of-use. In 2020, Shandong set the fixed-capacity payment from C&I users at RMB 0.0991/kWh (tax included) based on the fixed cost of the existing thermal power plants and electricity consumption. From 2023 onward, Shandong introduced a seasonal and time-based capacity payment based on historical supply and demand (see Exhibit 13). The purpose of this move is to incentivize the user-side flexibility for peak shaving/shifting and valley filling and ease supply-demand tightness. The peak-valley periods and rate coefficients to the capacity payment baseline are expected to be adjusted on an annual basis according to the price signals from the provincial spot market.

Exhibit 13: Comparison of the time-of-use capacity payment (from 2023) and the original fixed-capacity payment in Shandong



Source: State Grid Shandong Electric Power Company; RMI

In the 2030s, after the electricity market is mature and renewables have been integrated on a large scale, the capacity mechanism could be changed to a more economically efficient model such as the capacity auction.

BOX 4: Development Trends in the Regulation Capacity Market

Except for the Shandong and Guangdong capacity mechanisms, the mechanisms listed in Exhibit 14 belong to the category of the flexible capacity ancillary service market.

Understanding the background and purpose of these mechanisms is helpful to understanding the trajectory of China’s power market reform. The Coal Power Flexible Capacity Market trialed in Yunnan is a market-based solution to bail out coal power plants in an environment of high coal prices and declining coal power utilization hours. In addition, it provides a means for renewables to meet the policy target of integrating energy storage. As the leading regions for renewables development, North China, Gansu, and Northwest China, have faced the problems of high renewables curtailment rates in recent years, the introduction of peak regulation or flexible capacity markets aims to promote the deep ramping retrofit of thermal power plants and the investment of flexible resources.

Unlike the capacity mechanisms in Shandong and Guangdong, the flexible capacity ancillary service market addresses the ramping-down capacities of system resources. Therefore, this mechanism is likely to be further rolled out in regions where renewables play a large role in the power mix and the deep ramping retrofit of thermal power plants is lagging.

Exhibit 14: Comparison of six capacity mechanisms and flexible capacity ancillary services markets in China

Region and policy release date	“Capacity” mechanism name	Purpose	Market entity	Transaction method and pricing mechanism
Capacity mechanisms				
Shandong, 4/2020 (first edition) / 11/2022 (latest edition)	Power spot market capacity compensation tariff	Facilitating generators to recover fixed costs	Sellers: Thermal power plants, energy storage, wind power, solar PV Buyers: All C&I users	Buyers: Total electricity consumption is charged for capacity compensation Sellers: Compensation allocation based on the effective capacity Shandong approves the peak-valley periods and rate coefficients of time-of-use capacity payment and the current capacity compensation baseline as RMB 0.0991/kWh (tax included)

Region and policy release date	“Capacity” mechanism name	Purpose	Market entity	Transaction method and pricing mechanism
Guangdong, 11/2020	Power market capacity compensation tariff	Facilitating generators in the electricity market to recover fixed costs and ensure the long-term system adequacy of the power system	Sellers: Coal and gas power plants Buyers: Electricity retailers	Buyers: The monthly excess electricity consumption over M2L contracts is charged for capacity compensation Sellers: Compensation allocation based on the effective capacity Guangdong Energy Administration approves the compensation level
Flexible capacity ancillary services markets				
Yunnan, 12/2022 (trial implementation)	Coal power flexible capacity market	Facilitates cost recovery of coal power enterprises and provides a means for renewables to integrate energy storage	Sellers: Anthracite and bituminous coal power plants Buyers: Wind power, solar PV	Negotiation between sellers and buyers Yunnan approved the current price range of RMB 220/kW/year \pm 30%
North China Power Grid (Beijing, Tianjin, and Tangshan), 10/2021	Peak regulation capacity market	Promote the deep ramping retrofit of thermal power and the integration of renewables	Sellers: Thermal power plants Buyers: Wind power, solar PV, thermal power plants that do not win the bid	Market operators: Set the peak regulation or flexible capacity demand for the next trading interval; approve the sellers’ bid price cap and floor Sellers: Unilaterally bid, marginal pricing method
Gansu, 9/2022 (Draft for comments)	Peak regulation capacity market	Compensate the investment cost of thermal power deep ramping retrofit and grid-side energy storage	Sellers: Thermal power plants, grid-side energy storage Buyers: Wind power, solar PV, hydropower, thermal power plants that do not win the bid, C&I users	Buyers: Cost allocation by electricity generation/consumption
Northwest Power Grid, 11/2022 (Draft for comments)	Flexible capacity market	Promote the investment of flexibility resource and facilitate the integration of renewables	Sellers: Thermal power plants, energy storage, adjustable load Buyers: Wind power, solar PV, thermal power plants that do not win the bid, C&I users	

Note: By the end of 2022, six provinces or regions in China had launched certain power market mechanisms that contain the word “capacity.” Based on the analysis of their purpose and operation, some mechanisms are out of the scope of capacity mechanisms. Therefore, this report divides the six mechanisms into two categories: capacity mechanisms and flexible capacity ancillary services markets.

Source: Shandong Provincial Development and Reform Commission; State Grid Shandong Electric Power Company and Shandong Electric Power Trading Center; Guangdong Provincial Energy Administration and Southern Supervision Bureau of the National Energy Administration; Gansu Energy Supervision Office; Yunnan Provincial Development and Reform Commission; National Energy Administration North China Supervision Bureau; Northwest Regulatory Bureau of the National Energy Administration; RMI

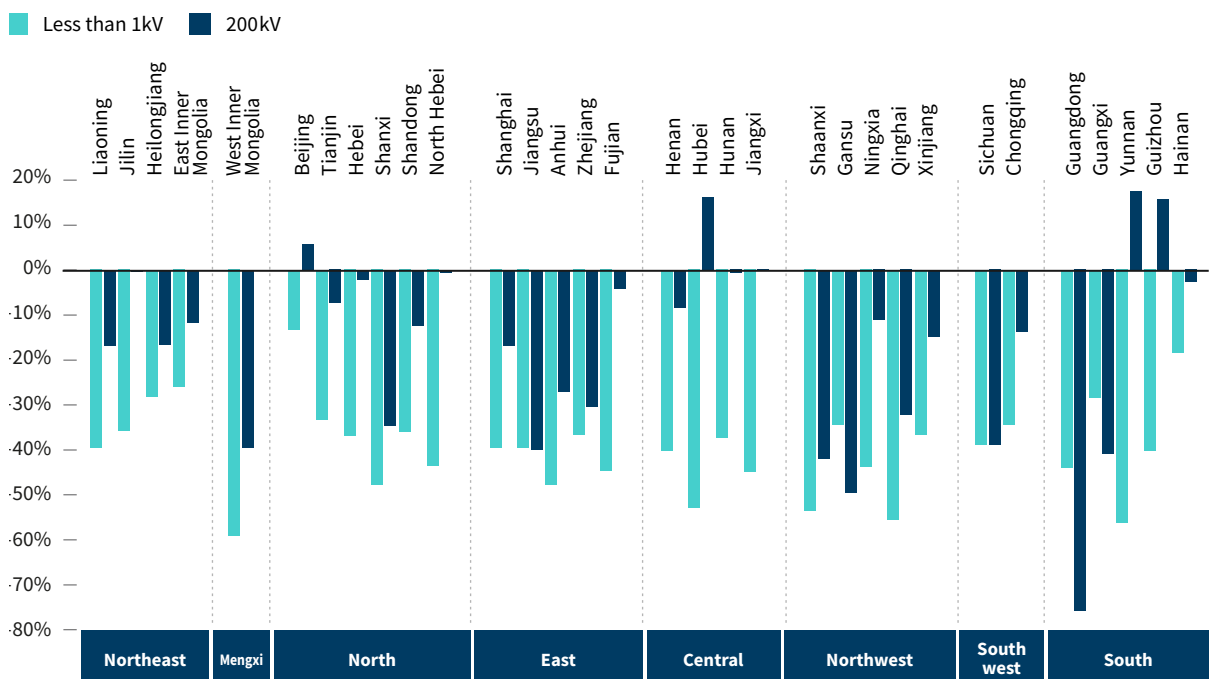
Transmission and Distribution (T&D) Tariff Mechanism

Energy storage may be included in the cost audit for transmission network; the decline in T&D tariffs may halt

Since the release of Document No. 9, the T&D tariff is no longer based on a fixed rate but adjusted according to the principle of “permitted cost plus reasonable profit,” and is specified at various voltage levels, with a recurring tariff assessment every three years. Comparing the second assessment cycle (2020–22) with the first cycle (2017–19) shows a significant decline in the tariffs nationwide. The T&D tariffs for general industrial and commercial use under 1 kV, for example, have declined more than 10% in every province, and 30% or more in the provinces of eastern, central, northwestern, and southwestern China. The tariff reduction in the second cycle is consistent with the national downward trend of electricity prices in 2018 and 2019.

The Report on the Work of the Government for 2018 and 2019 both proposed lowering average electricity prices for general industrial and commercial use by 10% and made specific mention in 2018 of reducing power grid charges and T&D tariffs. The percentage change of T&D tariffs between the two assessment cycles is shown in Exhibit 15.

Exhibit 15: Summary of T&D tariff adjustments



Source: NDRC

This year, the cost audit for provincial T&D tariffs enters the third assessment cycle (2023–25), and the new rates have not yet been announced as of early May 2023. Whether energy storage assets should be included in the accounting of T&D costs will be one of the factors affecting the new rates. According to the principle of “permitted cost plus reasonable profit,” changes in costs will directly affect the level of T&D tariffs. Based on recent policies, the capacity charges of pumped-hydro storage and grid-side energy storage may be incorporated into the T&D cost audit,^{iv} and the decline in T&D tariffs may not last.

- In May 2019, the NDRC issued *Method for the Audit of Transmission and Distribution Costs*, which stated that pumped-hydro storage and grid-side energy storage should not be included in the T&D cost audit. At the end of 2019, the State Grid — the largest investor in pumped-hydro storage and novel energy storage — postponed relevant investments.
- In April 2021, a new policy was released which defined capacity charges for pumped-hydro storage. The government-defined capacity charges corresponding to pumped-hydro storage, including those to be built in the next three years, will be paid by power grid enterprises and included in the provincial T&D tariffs. Miscalculated capacity charges of this T&D tariff assessment cycle will be passed on to the next cycle. Since then, the State Grid not only restarted pumped-hydro storage investments, but also announced that it will actively promote the construction of pumped-hydro storage power stations and peak-shaving gas-fired power plants.⁹
- The turning point for novel energy storage came in 2022 when the NDRC issued a policy document proposing to explore the inclusion of the capacity charges of the grid-side energy storage facilities in T&D tariff.⁹

iv Grid-side energy storage refers to energy storage facilities that store excess electricity during low-demand periods and release it during peak-demand periods, replacing traditional peaking regulation to improve the stability and reliability of the power grid. Typically, grid-side energy storage is equipped with inverters to ensure that the energy storage facility can put out sufficient power.

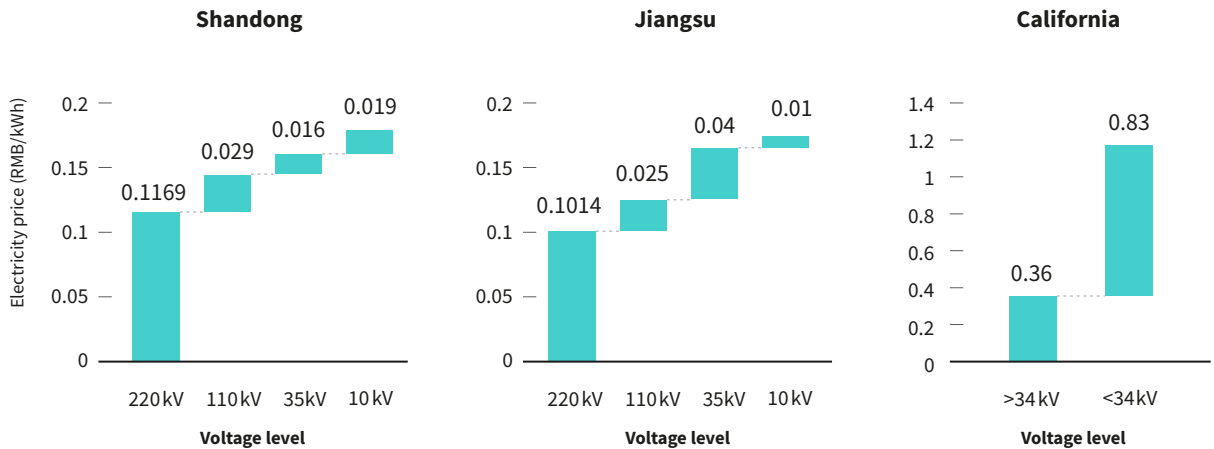
The lack of user load and administrative support has slowed the progress of distribution grid expansion (DGE) in China

DGE refers to the incremental distribution grid that meets power distribution needs and planning requirements. The main purpose of promoting DGE is to introduce social capital from non-state-owned power grid companies into distribution network assets, in order to bolster competition and distribution services. The NDRC and the NEA have announced five batches of 483 DGE pilot projects in China; however, most of the announced pilots are not new investment projects, but rather the conversion of existing distribution networks to DGE.

Progress on most pilot projects has been slower than expected, but a few projects have progressed quickly. These fast-progressing projects had favorable conditions and received strong administrative support before being put into operation. These projects, all controlled by private enterprises rather than state-owned grid companies, started with well-defined service areas and promising user loads. In addition, provincial institutions, such as the Provincial Development and Reform Commission, have facilitated key aspects of project application, planning, ownership confirmation, and determination of operating entities — critical support for project implementation. We believe that the overall progress of DGE is less than expected mainly for several reasons:

- The majority of pilot projects that have progressed more slowly than expected lack a well-defined service area and promising user loads. Some projects lacked experience in power grid operation and did not plan for service coverage and users when applying for the DGE project. In addition, the service area for new DGE projects is still underdeveloped, and they require a long waiting period for quality users and loads to gradually settle in.
- There is a lack of support from local governments. The entry of DGE into the power distribution market will inevitably change current power transmission and distribution patterns, and resistance from existing operators can retard the progress of DGE. Strong support from local governments can significantly reduce the administrative difficulty of the pilot projects. The support of local departments in key areas such as project application, project planning, owner confirmation, and the determination of the operating body helps accelerate the progress of the pilot projects.
- The revenue of distribution network operations is relatively low within the current power transmission and distribution pricing mechanism, and there is not yet a mature business model to support sustained investment in distribution network operations. At present, China's power transmission and distribution system does not isolate distribution prices from the overall T&D tariffs. The pricing of distribution is regulated to not exceed the tariff difference between different voltage levels set by the provincial power grid, and the current tariff difference does not reflect the actual cost of distribution operations. As shown in Exhibit 16 (next page), the tariff difference between voltage levels in Shandong and Jiangsu is small, and the distribution tariff (110 kV and below) is far lower than the transmission tariff (above 110 kV). This varies from international practices. The distribution tariff in the US state of California, for instance, is about 2.5 times higher than the transmission tariff. The NDRC has issued guidelines on adjusting local distribution tariffs for provincial power grids and DGE to reflect the actual cost. The guidelines propose that “provincial price regulatory authorities may apply to the State Council price regulatory authorities for adjusting the structure of provincial power grid transmission and distribution tariff according to the actual circumstances.”¹⁰ However, provincial or municipal governments have not yet released any specific adjustment plans.

Exhibit 16: T&D tariff breakdown (RMB/kWh)



Note: According to the Management Measures for Orderly Opening-Up of the Distribution Network Business, the distribution network in China generally refers to a voltage level of 110 kV and below, while 110 kV and above is considered the transmission network. In California, the transmission price (>34 kV) is 5.17 cents/kWh, and the distribution price (<34 kV) is 12 cents/kWh, which in the exhibit are converted to RMB at the current exchange rate of RMB 6.9/US\$1.

Source: NDRC; PG&E; RMI

DGE is one of the key components of the 2015 power sector reform in China, but its development has been slow compared with the development of M2L transactions and spot markets. Achieving large-scale development of incremental distribution will require strengthening the understanding and professionalism of DGE stakeholders in the distribution network business, gaining greater local government support, and improving the definition and pricing mechanisms in the distribution network. In the short term, the DGE will remain focused mainly on cultivation and incubation, and still lacks conditions for large-scale development.

In recent years, various other pilot projects have been launched in China, such as microgrids and integrated generation, transmission, and load systems. Microgrids focus on optimizing user-side resources, including power generation, energy storage, and flexible loads to reduce reliance on the public power grid and lower supply costs. Integrated generation, transmission, and load systems are mainly concentrated in provinces with abundant renewable resources and aim to coordinate the collaborative development of renewables, grid, and industries. They take the responsibility of autonomous peak-shaving and cooperating with dispatching of the public power grid. These pilots may offer new channels for the development and reform of distribution business, temporarily avoiding the difficulties of DGE reform.

Endnotes

- 1 *Notice on Excel in the 2023 Electricity M2L Contracts Signing*, National Development and Reform Commission, National Energy Administration, December 2022, https://www.ndrc.gov.cn/xwdt/tzgg/202212/t20221222_1343757.html.
- 2 *2022 National Power Industry Statistical Bulletin*, China Electricity Council, 2023.
- 3 Dayan Sun, “Operation and Practice of the Interprovincial Power Spot Market,” *Global Energy Interconnection Journal*, March 16, 2023, https://mp.weixin.qq.com/s/j1juXX7pyp_97amYRYVeg.
- 4 Sun, “Operation and Practice,” 2023.
- 5 “Monthly Report on Electricity Spot Prices,” *Lambda*, October 2022, <https://mp.weixin.qq.com/s/k7l0dHggKqVtYnLJO-HoKw>.
- 6 “The Southern Regional Power Market Launches Trial Operation, Promoting Inter-Regional and Interprovincial Electricity Spot Trading,” State-Owned Assets Supervision and Administration Commission of the State Council, *Weixin*, July 23, 2022, https://mp.weixin.qq.com/s/EsWuB1ZWNawGCo__GkLYbA.
- 7 *Annual Report on Power Sales Industry 2022*, Beijixing Shoudian, March 2023.
- 8 *Carbon Peak and Carbon Neutrality Action Plan*, State Grid, March 2021, <http://www.sasac.gov.cn/n2588025/n2588124/c17342704/content.html>.
- 9 *Notice on Further Promoting the Participation of Novel Energy Storage in the Power Market and Dispatching and Utilization*, NDRC, June 2022, https://www.ndrc.gov.cn/xxgk/zcfb/tz/202206/t20220607_1326854.html.
- 10 *Guiding Opinions on Formulating Distribution Tariff of Local Power Grid and DGE Network*, NDRC, February 2021, <https://www.ndrc.gov.cn/xxgk/zcfb/ghxwj/202002/W020200205376754617616.pdf>.

Yujing Liu et al., 2023 China Power Outlook: 20 Key Trends for Power Market Players, 2023, <https://rmi.org/insight/2023-china-power-outlook-key-trends-for-power-market-players/>.

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