



中国电力圆桌
POWER SECTOR ROUNDTABLE



Policy Brief

Electricity Wholesale Markets: US Experience and Recommendations for China

Power Sector Roundtable Working Group

November 2017

Power Sector Roundtable (PSR)

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1

Introduction

Document #9, which launched China's current power sector reform effort in March 2015, calls for reform efforts to be focused on five basic principles:

- Security and reliability (坚持安全可靠)
- Market-oriented reform (坚持市场化改革)
- Protection of consumers (particularly small and agricultural) (坚持保障民生)
- Energy savings and emissions reduction (坚持节能减排)
- Rational (scientific) regulation (坚持科学监管)

Here, we look at international experience with market-oriented reform, and discuss ways in which it might be relevant to China's efforts. We look briefly at the various market-related policy documents issued in the wake of Document #9 and suggest that electricity sector marketization in China could be better focused on the following basic things:

- Operating (dispatching) existing resources efficiently and flexibly on an hour-by-hour and minute-by-minute basis. This is necessary to integrate renewable resources, minimize system costs and emissions, and maintain reliability.
- Rationalizing the way that generators are paid in order to support that efficient and flexible operation.
- Sending the right price signals to guide new investment and for retirement of excess capacity.

First, we take a look at the long-standing problems associated with China's approach to on-grid pricing and generation output planning, turn to a brief look at reform efforts post-Document #9, examine some important ideas from international experience, and then conclude with a discussion of suggestions for policymakers.

The Status Quo: Wholesale Pricing Before Document #9

Consider the approach to wholesale pricing in China in place before Document #9 and now under reform. There are several issues associated with that pre-Doc-
#9 approach.

- Compensation for coal-fired generators was traditionally set by the National Development and Reform Commission (NDRC), together with provincial-level officials, in the form of fixed yuan-per-kWh on-grid prices.
- These on-grid prices were reviewed annually but, in practice, there was little fluctuation from year to year.
- Meanwhile, under the status quo, annual output planning allocated hours of operation to coal-fired generators.

This approach arose in the 1980s. There have been various attempts at reform before the current round of power sector reform, and some provinces have departed significantly from this pre-Doc-#9 approach. Still, it's worth considering this notion of the pre-Doc-#9 approach—even if it is a rough caricature—in order to illuminate some of the fundamental challenges at hand.

This pre-Doc-#9 approach to pricing and hourly output planning has been a root cause of several significant problems that the country's power sector faces today.

First, under the pre-Doc-#9 approach, prices were adjusted only sluggishly to reflect changing economic conditions or shifts in the government's overall policy goals. In recent years, wholesale prices have overcompensated investment in coal-fired capacity by failing to adjust in the face of weakening demand growth and declining coal prices. This overcompensation has exacerbated the problem of excess coal-fired capacity.¹

Second, the pre-Doc-#9 approach resulted in inefficiency and unnecessary emissions. On-grid pricing failed to offer adequate incentives to these generators to operate efficiently in the context of the overall power system. Less efficient coal-fired plants should, in an efficient system, operate less than their more efficient counterparts and should only be dispatched in hours when the demand for electricity is high. However, the pre-Doc-#9 approach left coal-fired generators hungry for hours of operation, and with reason to oppose any move toward a more rational approach to dispatch.

¹ A significant portion of current coal-fired capacity is now simply not needed, meaning that if generators were operated according to merit order, some power plants would likely not run at all.

Third, the pre-Documant #9 approach failed to encourage various resources that can provide flexibility to the system (e.g., demand response, gas-fired units, or energy storage) to do so, presenting an obstacle to the government's goals to make progress with renewable energy integration.²

Before taking a look at the efforts following from Document #9 to reform the status quo in China, we first turn to a brief examination of international experience, with a focus on the United States.

2. For more details, see: Dupuy, M., Kahrl, F., and Xuan, W. (2016). Issues in China Power Sector Reform: Generator Dispatch. Beijing, China: The Regulatory Assistance Project. Retrieved from: <http://www.raonline.org/knowledge-center/issues-in-china-power-sector-reform-generator-dispatch/>; Dupuy, M., and Wang, X. (2016) China's String of New Policies Addressing Renewable Energy Curtailment: An Update. Renewable Energy World. Retrieved from: <http://www.renewableenergyworld.com/articles/2016/04/china-s-string-of-new-policies-addressing-renewable-energy-curtailment-an-update.html>; and Regulatory Assistance Project (2015) Integrating Renewables: Opportunities to Create More Flexibility in Power System Operations [blog post]. Retrieved from: <http://www.raonline.org/blog/integrating-renewables-opportunities-to-create-more-flexibility-in-power-system-operations/>

Practice in the United States

There is much to be learned from the progress and mistakes in other countries. There have been numerous rounds of reforms in various countries and there continue to be vigorous debates about the details of market design. In this sense, electricity markets are still works in progress around the world. Despite this ongoing and complex debate over market design, and despite differences in models seen across the United States, European Union, and other places, it is worth emphasizing that there is a significant degree of consensus in the United States and the European Union on some basic principles regarding what markets are supposed to do. In particular, there is consensus that markets should be designed to support the following fundamental outcomes:

- Guide efficient system operations. All market models are concerned with ensuring efficient use, on a day-by-day and hour-by-hour basis, of available generation resources (and, increasingly, also demand-side resources) in a least-cost manner. This includes the principle of economic dispatch, under which the power sector dispatcher, on an hour-by-hour basis, chooses the resources with the lowest operational cost (and ideally also the lowest emissions), whenever possible.
- Guide rational investment and retirement of generators and other resources. Markets should send price signals to help stimulate investments in the “right” resources (that is, the most cost-effective resources available to support policy objectives for reliability and emissions reduction). Similarly, markets should send signals to rationally retire excess and unneeded capacity, including dirty and inefficient power plants that are not in line with policy objectives. In recent years, much discussion has been focused on how to ensure investment in non-generation resources, such as storage and demand-side management, can be considered on a level playing field with traditional power plants.
- Provide rational compensation for generation owners (and, again, for non-generation resources). This idea is in support of the first two principles so that generators have adequate incentives to operate efficiently and flexibly—and also to invest in and retire facilities in a rational way.

In addition, there is broad agreement that markets are tools and should be designed to meet government policy objectives, including policy goals for efficiency, emissions, and reliability. When markets are not delivering outcomes in line with policy objectives, it is necessary to adjust the details of market rules and regulations.

There is also agreement that markets cannot meet these goals alone, and need to be closely coordinated with various planning processes—including planning processes for transmission and demand-side resources.³

³ See article on “Power Sector Planning” in this series of papers.

At this point, we'll narrow our focus and will briefly review the experience from parts of the United States that have implemented restructured electricity markets beginning in the mid-1990s. At this time, utilities in the East, Midwest, and California divested their generation (at least partially) and joined wholesale electricity markets that extend across multiple states. These markets are oriented around independent system operators (ISOs) or regional transmission organizations (RTOs), two terms with practically the same meaning: they are independent (voluntary) organizations that operate the short-term markets and have functional control of the transmission system in order to ensure real-time coordination of electricity supply with demand. ISOs/RTOs do not own generation or transmission assets.

In a series of regulations beginning in 1996, the US Federal Energy Regulatory Commission (FERC) specified various criteria and requirements, together known as “open access” policy, including:

- Regulations governing charges imposed by transmission owners for use of their transmission network assets.
- Requirements for utilities to separate their transmission and generation businesses, and to file open access transmission tariffs, under which they agree to provide nondiscriminatory transmission service. Transmission owners turn over control of their systems in exchange for these federally-approved tariffs that allow for recovery of costs plus a return on investment. The transmission system must be operated in an open manner, so that it is accessible to any generator that wants to use it.
- The principle that each ISO/RTO is responsible for both operation of a competitive, efficient, and transparent market and operation of the system in accordance with trading rules. This includes the concept of economic dispatch. These principles were designed to ensure least-cost and fair operation of the system.
- Requirements that ISOs/RTOs take a leading role in open and transparent regional transmission planning with an objective of promoting adequate competition.

Each ISO/RTO conducts a day-ahead market for each operating hour of the following day. The lowest bids are accepted—subject to security constraints—which results in a provisional dispatch order. Each ISO/RTO also operates real-time markets, which support dispatch and financial settlement on a 15-minute or less time interval. These real-time markets play an important role in balancing the system, reflecting real-time fluctuations in generation (due, for example, to changing weather conditions), transmission constraints, and demand. In addition, each ISO/RTO operates markets and incentive mechanisms to support the provision of ancillary services, which play a crucial role in supporting system flexibility.

Together, these day-ahead, real-time, and ancillary service mechanisms (which are, together, loosely defined as the “spot market” in the terminology typically used in China) have, or at least approach, some important characteristics:

- Prices fluctuate day-by-day and minute-by-minute with demand, supply, and transmission conditions. Where there is adequate competition—something that must be ensured through careful regulatory oversight—competitive bids reflect the operating costs of generators. Generating units are committed and dispatched in a “merit order” according to these bids.
- These fluctuating prices allow for a business model for “peaking” resources to only operate in a limited number of hours every year, earning revenue to cover at least some of annual capital costs—as well as operating costs—in the hours when their services are most needed.⁴
- As in any market, when these prices are high, new generation (and other resources) have an incentive to enter the market; when they are low, the least efficient resources close down.
- Ancillary services provided by generators (and by storage and demand-side resources) are rationally compensated for their contributions.

This simplified description of the workings and crucial functions of spot markets in the United States perhaps obscures the difficult and ongoing challenges of ensuring that the markets actually work in practice.⁵ Regulators, policymakers, and the ISOs/RTOs put considerable effort into overseeing the markets and adjusting various details. For example, electricity spot markets are susceptible to temporary bouts of inadequate competition and much effort is put into monitoring markets and mitigating the scope for market power.

The growth of variable generation (wind and solar) has had important implications for market design in the ISOs/RTOs. Supporting and integrating these variable resources requires system flexibility. Flexible resources can respond to system needs by ramping up, ramping down, and turning on and off quickly and often. If resources cannot respond quickly to system needs, customers will pay the price in higher operating costs and lower reliability. Various ISOs/RTOs have been pursuing a number of efforts to change market rules and regulations in order to promote flexibility. These include measures to:⁶

- Extract flexibility out of existing generation
- Plan for and develop increased investment in transmission
- Implement better variable generation forecasting

4 In Texas' ERCOT ISO (an “energy-only” market), generators must recover all of their capital costs in this fashion. Other ISOs/RTOs feature various types of “capacity mechanisms.” This is a subject of much debate in the United States and will be the subject of subsequent papers.

5 For more detail, see Hurlbut, D., Zhou, E., Porter, K., Arent, D. (2015). ‘Renewables-Friendly’ Grid Development Strategies: Experience in the United States, Potential Lessons for China. Golden, CO: National Renewable Energy Laboratory. Retrieved from: www.nrel.gov/docs/fy16osti/64940.pdf.

6 For some examples in each of these areas, see section 2.6 of RAP (2014). Low-Carbon Power Sector Regulation: International Experience from Brazil, Europe, and the United States. Beijing, China: Regulatory Assistance Project. Retrieved from: <http://www.raponline.org/knowledge-center/low-carbon-power-sector-regulation-international-experience-from-brazil-europe-and-the-united-states/>.

- Promote demand response
- Enlarge balancing areas
- Allow storage to participate in markets.

Coordinating market design with electricity sector planning is another major challenge. In the parts of the United States where ISOs/RTOs exist, the responsibility for generation planning is generally dispersed among several entities—state energy offices, system operators, and generators themselves—and implementation of the plans is largely a matter of market design. In particular, periodic resource adequacy planning and market monitoring analyses overseen by the independent system operators (but conducted in a routine manner, typically by independent experts) are used to assess the performance of markets. In addition to analyzing market performance, such reviews help judge whether the markets are cost-effectively delivering the right kind of resources to ensure reliability, and whether the markets are meeting other policy goals (such as for clean energy). If deficiencies are found, then the experts conducting the analyses will recommend changes in market rules and regulations. In this way, planning and markets work together (although the process is not always smooth).

4

The Path of Reform in China After Document #9

Document #9 laid out a brief, but high-level, blueprint for dealing with these problems, including the unwinding (liberalization) of the practice of annual output planning, and calling for the design of market mechanisms to promote competition. To date, reform efforts in the wake of Document #9 have focused on the implementation of competitive mechanisms for medium-to-long-term (MLT) contracts between generators and demand-side entities—growing from direct trading pilots that have been running in certain provinces for several years—along with a scaling-back of planned allocations of generator operating hours (that is, gradually liberalized generation planning).⁷

Meanwhile, the Five-Year Plan for Electricity formally commits to implementing a spot market pilot by 2018 with national rollout by 2020; several provinces have already been selected for spot market pilots. However, little detail has been offered publicly regarding plans for spot market design and implementation. While integration of the MLT markets with the new spot markets is expected, little guidance has been issued regarding how that is to be done as well.

There are two main issues worth emphasizing here, in light of international experience. First, it is essential to devote adequate attention to promoting the system flexibility needed to integrate renewable energy. The current annual MLT contracts are somewhat similar to the contracts that generators received (and in many places still receive) under annual output planning.⁸ That is, annual allocation of hours is being gradually replaced by annual contracts that also specify a number of hours that the generator in question will operate. The practice under the pre-Document #9 approach of treating these contracts as physical (rather than financial), and dispatching according to these annual contracts, has long been a key issue contributing to system inflexibility. Recent policy documents regarding MLT contracting do not clearly and adequately address this problem, and in fact may entrench inflexible dispatch practices.⁹ This problem could also hamper efficient operation of any spot market approach to dispatch that may be implemented in the future. Meanwhile, the spot market itself should—if well designed—be an important mechanism to support flexibility.

Second, market reform so far has perhaps been excessively focused on reducing prices for industrial end users. These end users have clamored for price reductions and in much of the public discussion market reform is typically framed in terms of “hongli” (dividends) for large users. It is true that, given large and growing overcapacity of coal-fired generation, there is a strong argument for reducing and rationalizing compensation to coal-fired generators. However, the case for reducing retail prices (particularly with regard to heavy industry) is much less

7 See 中发9号文件配套文件二《关于推进电力市场建设的实施意见》和国家能源局《电力中长期交易基本规则（暂行）》。

8 To date, contracts are largely annual, although there is scope for monthly contracts. There is also scope for contracts with specified load curves.

9 See National Energy Administration “Basic Regulations for Electricity Medium-and-Long Term Trading” 《电力中长期交易基本规则（暂行）》 (Document 2784), December 2018. According to this document, the dispatch centers will be closely involved with the details of annual and monthly contracts from the time of signing, and will operate the system according to these contracts.

clear. Ideally, retail prices (or, more specifically, power sector revenue) should reflect the actual costs of electricity production, including the social costs of emissions. The national carbon trading scheme and efforts to tax other types of emissions may eventually play a significant role in ensuring that retail electricity prices reflect the social cost of emissions, but those emissions pricing mechanisms will take some time to strengthen and implement in a comprehensive fashion. In the meantime, there is a risk that excessive reduction in retail electricity prices will undermine emissions and air quality goals, not to mention the government's goals regarding rebalancing the economy away from heavy industry. Policymakers have acknowledged these downsides associated with decreasing retail prices, and have outlined useful steps including measures to strengthen differential pricing and limit inefficient generators and end users from participating in markets.

5

Mapping a Path for Market Reform in China

In a previous section, we looked at some fundamental areas of consensus regarding market design in other countries. We recommend that these principles also guide market design in China. This, in turn, will support the vision for the power sector laid out in Document #9.

The 13th Five-Year Plan for Electricity clearly commits to the implementation of spot markets by 2020 (with various pilots in operation by 2018), which will operate in conjunction with MLT contracting. This is a reasonable path, but the details and timeline will be very challenging. Here are several considerations:

Getting the details of market design and regulation right will be very challenging, particularly given the ambitious timeline for fully functioning spot markets. The discussion of US ISO/RTO spot markets in the previous section presented a simplified overview in order to highlight the key principles. In practice, market design involves the establishment of very detailed rules and procedures that take time to develop. Ensuring that the different aspects of day-ahead, real-time, and ancillary service market mechanisms work together in a manner that supports reliability and policy goals for costs and emissions is no small task. This requires high levels of transparency regarding the market design process and power system data.¹⁰ It also requires clear institutional responsibility to coordinate across issues of pricing, operations, planning, environmental regulation, and demand-side management. These areas of responsibility are currently somewhat dispersed within the NDRC and National Energy Administration (NEA), and across other central and provincial agencies.

Given generation overcapacity, a competitive electricity market will tend to offer low wholesale prices, sending clear signals for excess capacity to close down. This would be a major political challenge in any country and, indeed, many countries have struggled to deal with excess capacity problems that are smaller in relative size than China's. Policymakers may feel that it is difficult, for political reasons, to avoid measures to protect unneeded coal generators—although this will likely lead to inefficient outcomes in terms of reliability, costs, and emissions.

At the same time, it is important to avoid irrational reductions in prices faced by end users. Ideally, retail prices (or, more specifically, power sector revenue) should reflect the actual costs of electricity production, including the social costs of emissions. Emissions pricing will eventually play this role, but until the national emissions trading system is mature it is worth being cautious about reductions in prices faced by end users—particularly inefficient industrial end users. To this end, it would be worthwhile to strengthen differential pricing and strengthen limits on inefficient end users from participation in the MLT.

¹⁰ See also the article in this series titled "Governance and Regulation."

It will be a challenge to ensure that spot market bids from generators reflect the cost of operation for each generator, and thus are able to guide economic dispatch. Part of this will, again, be a matter of getting the right rules and procedures in place to govern market bidding. Another difficulty will be to ensure adequate competition. This is a particular concern in light of recent moves to consolidate generation companies. As noted in the previous section, spot markets are susceptible to periods in which individual generators are able to game the market, which can result in excess costs for consumers, reliability problems, and unnecessary emissions. Even occasional opportunities for individual generators to game the system can cause significant problems—and these episodes can happen even in the context of general overcapacity.

It may be worth considering (at least as an interim measure) conducting spot markets on the basis of estimations of each generator's operating costs if adequate market competition is elusive.¹¹ Even in a competitive spot market, it will be necessary for some authority (perhaps the dispatch centers or a new market monitor regulatory agency) to be given the authority to regularly collect data and estimate each generator's operating costs. This will be necessary in order to 1) ensure that the market is behaving properly and decide what adjustments are needed to market design; and 2) mitigate market power.

Promoting adequate system flexibility to support integration of renewable energy will remain a major challenge. Spot market design will need to include careful attention to compensation mechanisms for ancillary services and compensation for the costs experienced by generators of flexible operation; rules to allow demand response and storage resources to participate in markets; unifying (or at least linking) spot markets across provincial boundaries;¹² and measures to differentiate market prices across geographic regions in order to better incentivize efficient placement of generators.

Currently, the spot market pilots in China are being developed on a province-by-province basis. It would be useful to consider integrating these pilots right from the beginning. For example, the Southern Grid spot market pilot calls for a spot market to be implemented first in Guangdong, with a regional market to be implemented later. Instead, the Southern Grid regional market could be designed as a regional integration spot market right from the outset. Such integration will help foster renewable integration and reduce system costs.¹³

The recently evolving framework for MLT, as it has been set out in policy documents and various provincial pilots so far, may end up being more of a hindrance to system flexibility than a benefit. As it currently stands, it appears to reflect a series of compromises along the path of liberalizing the generator output plan. Various forms of MLT contracting are necessary in any electricity market, but broadly speaking these can take the form of financial

11 See discussion of dispatch in Brazil: Dupuy, M., Allen, R., Kahrl, F., Crossley, D., Porter, K., Weston, R., and James, C. (2014). Low-Carbon Power Sector Regulation: International Experience from Brazil, Europe, and the United States. Beijing, China: The Regulatory Assistance Project. Retrieved from (in English): <http://raponline.org/document/download/id/7432> and in Chinese: <http://www.raponline.org/document/download/id/7482>

12 The recently-announced cross-provincial spot market for surplus renewable energy appears as though it may be a promising step.

13 See also the article in this series titled "Renewable Energy Integration."

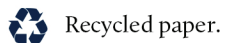
contracts. Care needs to be taken to avoid an approach where dispatch is unnecessarily constrained by year-in-advance contracting decisions. Instead, the spot market should guide dispatch (subject to current reliability conditions and constraints) and MLT contracts should be largely the business of generators and demand-side entities in the interest of hedging their exposure to short-term prices.

Expert Discussion

A panel of experts from Chinese institutions was convened on July 21, 2017, to review this paper. The experts drew attention to several additional issues, including:

- Financial vs. physical contracting.
- Capacity market mechanisms vs. energy-only markets.
- Lessons from a comparison of US and Australian market models.
- The complexity of identifying factors contributing to renewable curtailment in China.
- Measures to assure transparency of markets (and market operations) in the United States.

These issues will be integrated into the Roundtable workstream and discussed in more detail in follow-on papers.



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