Regulation of Market Power in Australia and Its Implications for the China's Electricity Market

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Abstract. This paper aims to conduct an in-depth investigation into the regulatory mechanisms governing the exercise of market power in the Australian electricity market and to explore the implications of these mechanisms for the regulation of the Chinese electricity market. Firstly, an analysis of the legal framework for electricity market regulation in Australia is presented, encompassing the registration of market participants and the establishment of regulatory bodies. Furthermore, the paper delves into the constraints on market power exercise by examining price controls and behavioral indicators of market participants. It introduces the steps involved in the regulation of market power forms in Australia and, in conjunction with practical operational examples, analyzes their effectiveness and challenges in ensuring fair market competition and preventing market abuses. Finally, drawing insights from the Australian case study, the paper presents implications for the regulation of China's electricity market. These implications are aimed at addressing market competition, enhancing regulatory efficiency, and promoting the sustainable development of the market.

Keywords: electric market power; market power regulation ; pre-regulation ; generating units.

1 Introduction

Market power also known as market dominance, market authority, and market control, is defined by U.S. antitrust regulatory agencies as the "ability of a supplier to raise prices above competitive levels and maintain those prices for a period profitably." In the electricity market, the exercise of market power by market participants can lead to issues such as price distortions, harm to consumer interests, and market inefficiency. Therefore, the regulation of market power is an important mechanism for ensuring fair competition and maintaining market order in the electricity market.

The Australian electricity market adopts an open competitive market model with diverse energy sources and comprehensive market power regulation. Its primary objectives include promoting the development of sustainable energy, ensuring supply reliability, and maintaining fair and transparent pricing. [1] describes the regulatory mechanisms in the Australian market,

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discusses assessment indicators, and evaluation methods. Regarding the identification of market power exercise, market bidding behavior is considered a significant factor influencing market clearing prices. [2-3] analyze market power exercise issues between trading prices and trading portfolios based on historical operational data from Australia, providing insights for market mechanism design and regulation. [4-5] discuss the impact of market supply and demand changes on the behavior of power generation companies, analyzing the effects of reducing the market share of power generation companies on market power. [6] focuses on the uncertainty of market clearing prices in the Australian electricity market, analyzing the impact of price fluctuations on market and environmental behavior by power generation companies. [7] further analyzes the intrinsic connections between market clearing prices and their impact on market behavior and risk management of market participants.

While market bidding behavior affects market clearing prices, it does not necessarily represent the subjective intentions of market participants. [8] explores the reasons for rising electricity prices in Australia and examines the influence of rising generation costs on unit market bidding behavior.

Additionally, financial markets are considered essential factors in eliminating market power. [9-10] analyze the impact of medium- and long-term contracts on market prices and market bidding behavior in Australia. [11] discusses the operational mechanisms of Australia's financial markets and analyzes their impact on market bidding behavior and risk mitigation.

Currently, China is in the process of establishing provincial electricity markets and gradually advancing toward a unified national electricity market. Exploring Australia's successful regulatory experiences and how to apply them to China's electricity market will provide valuable insights into China's market regulatory reform and enhancing market efficiency.

Based on the above analysis, this paper introduces the characteristics of the Australian electricity market, discusses market power monitoring and mitigation methods based on market clearing prices. Additionally, it provides a detailed overview of market power regulation in Australia in cases where cost information of market participants is lacking. This analysis is combined with the operational regulatory practices in the Australian electricity market in 2022 to evaluate the effectiveness of market regulation. Finally, considering the context of China's electricity market development, the paper offers relevant recommendations.

2 Electricity Market and Market Power Regulation

Australia's electricity market [1] is divided into three power systems: the southeastern, western, and northern regions. Among them, the National Electricity Market (NEM) in the southeastern region, covering more than 80% of the population, is primarily dominated by thermal power generation. The NEM is a centralized market, with a focus on the "day-ahead dispatch + real-time balancing" market, and it uses a scarcity pricing mechanism to address issues related to generation adequacy and system reliability.

The Australian market regulatory authorities consist of the Australian Energy Market Operator (AEMO), the Australian Energy Market Commission (AEMC), and the Australian Competition and Consumer Commission (ACCC). AEMO is an independent agency responsible for coordinating and regulating the national electricity market in Australia. Its

responsibilities include balancing electricity supply and demand, enforcing market rules, managing the operation and planning of the electricity system, and more. AEMC is an independent body responsible for developing and amending the energy market rules in Australia, with the goal of promoting market efficiency, competition, and economic benefits while ensuring fairness and transparency in the rules. ACCC is responsible for regulating issues related to monopolistic behavior, unfair competition, market manipulation, and other concerns in market transactions.

Starting from July 1, 2022, Australia has set a spot market price cap at 15,500 Australian dollars per megawatt-hour (MWh) and a floor price at negative 1,000 Australian dollars per MWh. The higher market price cap, to some extent, ensures the reliable supply of long-term electricity capacity. However, it places limited constraints on unilateral exercise of market power by market participants. Therefore, there is still a need to strengthen the identification of market power exercise behaviors by market participants during the real-time market clearing process to ensure market operational efficiency and fair competition.

Depending on the method of market power exercise, regulatory indicators in Australia can be classified as physical withholding, economic withholding, and re-bidding. Physical withholding involves market participants deliberately reducing their unit capacity supply. Economic withholding occurs when market participants submit prices that deviate from their actual costs. Re-bidding refers to market participants changing their submitted generation quantities and unit bid parameters after the trading submission period but before real-time generation dispatch. Through these behaviors, market participants engage in capacity withholding, resulting in the replacement of capacity that was originally supposed to generate power with higher-priced units, which in turn raises the marginal clearing price, allowing them to earn excess profits.

3 Market Power Regulation Process

3.1 Traditional Market Power Regulation

To further identify the exercise of market power by generation units, the United States and China's electricity markets often employ market power monitoring and mitigation methods based on market clearing prices [12]. If the weighted average price from the day-ahead market clearing of generation units exceeds the market power detection reference price, regulatory actions are taken. When market power fails the detection, specific generation units are selected for regulation. Their day-ahead market bids are replaced with cost-based prices, and the market clearing is reorganized.

The pre-regulation mechanism refers to evaluating whether the trigger conditions are met based on the average price from the day-ahead spot market after the formal market clearing. If the conditions are met, the regulatory capacity is calculated for oligopolistic units with potential market power. Their capacity bid curves are then replaced with cost-based curves, and a new market clearing is performed based on the adjusted bids.

Regulatory authorities set a reference price to trigger the pre-regulation mechanism. After the day-ahead market clearing, the weighted average market clearing price is calculated, and it is determined whether it exceeds the reference price. If it is higher than the reference price, the

trigger conditions are activated. The demand regulatory capacity for oligopolistic units with potential market power is calculated, and their corresponding capacity bids are replaced with cost-based bids.

The cost-based bid for each unit is the sum of its cost-based generation cost (including taxes) and a reasonable profit, where the reasonable profit rate (π) varies with supply and demand conditions in each period. The cost-based bid is calculated as follows:

$$P_{t,j}^{REF,DA} = C_j \times \left(1 + \pi_{t,DA}\right) \tag{1}$$

$P_{t,j}^{REF,DA}$ represents the cost-based bid of generation entity *j* in period *t*, C_j denotes the cost-based generation cost of generation entity *j*, and $\pi_{t,DA}$ stands for the reasonable profit rate in period *t*.

The reference price $P^{REF,DA}$ for triggering the pre-regulation mechanism is calculated based on the clearing results of generation entities and their cost-based bids.

$$P^{REF,DA} = \frac{\sum_{t,j} Q_{t,j} \times P_{t,j}^{REF,DA}}{\sum_{t,j} Q_{t,j}} \tag{2}$$

Where, $Q_{t,j}$ represents the cleared generation output for generation entity *j* in period *t*.

Based on the actual market operation, a new "virtual oligopoly" is defined as a set of N maximum generation entities, and their residual supply index is calculated, with regulation applied to their bidding capacity.

The specific implementation steps of the pre-regulation mechanism are as follows:

Calculate the residual supply index ρ_j^{RSI} for each generation entity (generation group):

$$\rho_j^{RSI} = \frac{S_0 - S_j}{D_0} \tag{3}$$

ρ_j^{RSI} is the residual supply index for the generation entity, S_0 represents the total generation capacity of all eligible generation entities, S_j is the generation capacity of generation entity j, and D_0 is the total market demand for the target trading period.

For any generation entity (generation group) *j*, if $\rho_j^{RSI} < \rho_0^{RSI}$, it indicates that the residual supply index for generation entity *j* exceeds the threshold. If $\rho_j^{RSI} \geqslant \rho_0^{RSI}$, it means that the residual supply index for generation entity *j* is qualified. Here, ρ_0^{RSI} represents the threshold value for the residual supply index.

For the generation entity (generation group) *j* with an exceeded residual supply index, the excess threshold capacity S_j^{CBC} is calculated:

$$S_j^{CBC} = \left(\frac{S_0}{D_0} - \rho_0^{RSI} \right) \times D_0 \tag{4}$$

Where $\frac{S_0}{D_0}$ represents the overall market supply-to-demand ratio for the target trading period.

The portion of generation capacity of generation entity j that exceeds the critical capacity S_j^{CBC} is referred to as the controlled capacity S_j^{RBC}:

$$S_j^{RBC} = S_j - S_j^{CBC} = S_j + D_0 \times \rho_0^{RSI} - S_0 \tag{5}$$

All generating units of generation entities (generation groups) that exceed the critical capacity for residual supply index are sorted in descending order based on their unit prices. Their unit prices are replaced with the benchmark cost prices until the controlled capacity requirement is satisfied.

Based on the revised unit prices for controlled generation entities (generation groups), the day-ahead market is re-cleared. Using the day-ahead market clearing results, the benchmark price $P^{REF,DA}$ and the day-ahead market clearing average price $\overline{P}^{DA}$ are recalculated. If $\overline{P}^{DA} \le P^{REF,DA}$, the pre-market regulatory process is concluded, and the day-ahead market clearing results are used as the basis for market settlement. If $\overline{P}^{DA} > P^{REF,DA}$, the pre-market regulation for virtual oligopolies is conducted, the steps of pre-market regulation calculation for virtual oligopolies are similar to those for generation entities and are not further elaborated here.

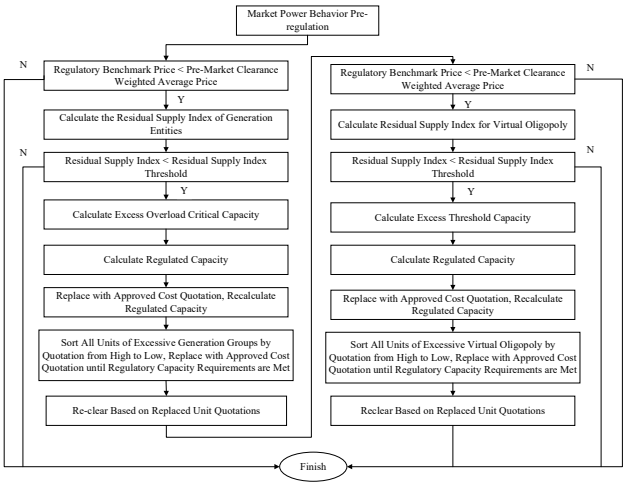

Fig.1. The process of market power behavior pre-regulation

3.2 The Innovations of Australian Market Regulation

Due to rising fuel costs and the large-scale integration of renewable energy sources, the Australian Energy Regulator (AER) has encountered difficulties in accurately obtaining cost information from market participants. This has posed challenges for identifying market power

exercise behavior based on market clearing prices. To address this issue, AER has implemented a regulatory benchmark price based on market data to assess market competitiveness.

The specific steps for market power regulation based on market data are as follows: (a) utilize clearing prices under different historical supply and demand conditions as a basis; (b) identify the periods where market clearing prices are higher than the expected prices by fitting the market surplus capacity-price relationship under various proportions of new energy output; (c) calculate the bidding capacity of units for the corresponding periods.

$$SC_{st} = C_{st} - L_{st} \tag{6}$$

SC_{st} denotes the bid capacity, C_{st} denotes the effective generation capacity.

Taking into account regional power import and export, the bid capacity for the respective period t can be expressed as follows:

$$SC_{st} = \left(C_{st} - L_{st}\right) + \left(N_{s't\to st} + \tilde{N}_{s't\to st}\right) \tag{7}$$

$N_{s't\to st}$ denotes the regional power injection, $\tilde{N}_{s't\to st}$ denotes the regional power withdrawal.

Once high-price clearing periods are identified, based on the fitted results of the remaining capacity-price relationship, the potential incentive revenue for market participants' retention behavior RWC_{it} under established medium to long-term contracts is estimated.

$$RWC_{it} = \Delta p_t \cdot \left(Q_{it} - 10\right) \tag{8}$$

Δp_t denotes the price increase for retaining an additional 10MW by a generating unit at time *t*, Q_{it} denotes the output of the generating unit.

Finally, a comparative analysis is conducted on the bidding behavior of market participants when the estimated potential incentive revenue is significant.

$$QP_{it} = \sum_{J} \frac{q_{ijt}}{Q_{it}} \cdot p_{ijt} \tag{9}$$

$$QPI_{it} = QP_{it} - \overline{QP} \tag{10}$$

QP_{it} denotes the quantity-weighted offer price, *j* represents the price tranche, q_{ijt} , p_{ijt} denotes the offer quantity and price per tranche, Q_{it} denotes the total offer quantity for the generating unit. QPI_{it} represents the weighted average increase in offer price for the generating unit, Q_{it} represents the weighted average offer price for the generating unit under typical scenarios.

4. 2022 Market Regulation in Australia

In 2022, AER employed the method to assess and analyze electricity behaviors in its wholesale electricity market [13], resulting in the following conclusions.

Due to rising fuel costs, market participants had an increased incentive to submit high-priced bids. The growing annual output of renewable energy in Australia has squeezed the electricity production space for traditional coal-fired power companies. Coupled with the rapid increase

in fuel costs, market participants' marginal cost of electricity production increased, making it challenging for them to recover their production costs. This was especially pronounced when renewable energy output was low, as coal-fired power companies needed to recover their fixed costs in a shorter operational timeframe, increasing their willingness to submit high-priced bids to gain excess profits.

The motivation to raise bids decreased as the proportion of long-term contracts grew. The analysis of market behaviors under different proportions of long-term contracts showed that market participants exhibited weaker motivations to exert market power when operating under long-term financial contract models. This was because the fluctuations in spot prices had limited impact on the revenue of contracted capacity.

The motivation to exert market power increased when market participants revised their bids. While AER required market participants to provide reasons when revising their bids, it could not prevent them from trying to change capacity from lower to higher prices. This behavior significantly contributed to high-priced market clearing outcomes.

In summary, the motivation for Australian market participants to submit high-priced bids increased in the context of high coal prices. This characteristic was particularly pronounced within the bid revision mechanism. Based on this, we conducted an analysis of the relationship between high-priced market clearing and the exercise of market power, as shown in Fig 2.

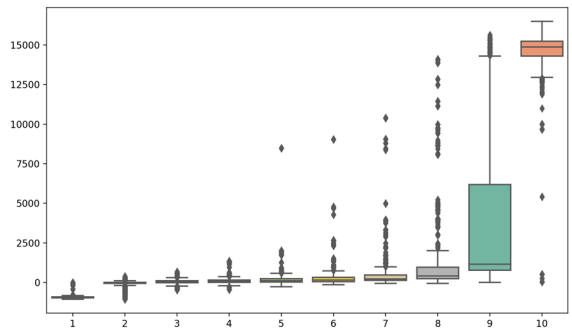

Fig.2. The relationship between bids and high price

Fig.2. illustrates that the ten segments of bids in Australia from July to December 2022 were generally concentrated. With the exception of the ninth segment, the range distribution and evolution trends of market participants' bids were mostly consistent for both concentrated and discrete areas. The price range for segments 1-8 was relatively low, mainly because in low capacity periods and due to the impact of early long-term contracts, market participants preferred to submit low bids to secure more cleared electricity. The ninth segment had a pronounced discrete characteristic, with a few market participants submitting bids close to the maximum limit of 15,500 Australian dollars per MWh. This behavior was mainly driven by the scarcity pricing mechanism, which encouraged market participants to compete for high-priced clearing opportunities based on market supply and demand. Bids in the tenth segment were generally distributed below the maximum limit of 15,500 Australian dollars per MWh and followed a consistent pattern.

These results indicate that Australian market participants' bidding behavior exhibited certain similarities, and some market participants may have the potential to exert market power by bidding high prices. However, the 2022 AER market regulation report stated: "Considering the factors driving market participant bidding behavior and their impact, the similarity of bids and high-priced bidding behavior cannot be used as the basis for determining market power, but this behavior still needs to be monitored and analyzed in conjunction with subsequent market operational conditions." This conclusion was drawn because, under the influence of rising renewable energy output and fuel cost increases, market participants faced pressure to recover their fixed costs and manage variable costs. Their bid similarity and high-price bidding were considerations for cost recovery, and market participants did not obtain excess profits. Therefore, it could not be recognized as an exercise of market power.

5. Implications for Market Regulation in China

First, perfect the market regulatory system. Australia's market regulatory bodies are independently divided but collaborate effectively to fulfill their responsibilities. AER provides comprehensive market reports and data, including information about market participant behaviors, market prices, supply and demand situations, market power regulation mechanisms, market efficiency, and competition. This transparency in information disclosure enhances market transparency, prevents market manipulation and the abuse of market power, boosts the confidence of market participants, and promotes the healthy development of the market.

Second, strengthen the connection between market restrictive mechanism and market power supervision. Australia's experience shows that increasing the proportion of long-term contracts and lowering the spot price cap can discourage market participants from exerting market power. In China, market power regulation is still in its early stages, and the motivation for market participants to exercise market power can be mitigated by enhancing mechanisms like setting reasonable proportions for long-term contracts, price caps, and implementing capacity compensation mechanisms, thereby offering multiple channels for market participants to receive revenue and preventing the abuse of market power.

Third, Reasonably define the difference between the reasonable profit of market participants and the exercise of market power.. AER considers that bid similarity and spot prices above marginal costs are not necessarily indicators of market power when viewed in the context of cost recovery by market participants. With coal prices remaining high in China over the past few years and the capacity compensation mechanism still in its early stages, market participants may face limited means to manage their costs. Therefore, when determining the exercise of market power, it is crucial to consider both long-term and short-term cost recovery, to encourage businesses to achieve normal operational returns, and to ensure the long-term reliability of power capacity.

6. Conclusions

This paper delves into the experience of market power regulation in Australia and analyzes the insights that this experience provides for the Chinese electricity market. Market power is a ubiquitous challenge in electricity markets, and Australia's market power regulation

mechanisms offer effective tools to prevent market power issues. These tools include the establishment of clear and responsible market regulatory agencies, the reasonable setting of market price limits, and the continuous enhancement of form-based market power analysis, which all aimed at safeguarding fair market competition and the rights of consumers. Furthermore, the market rules and transparency in the Australian electricity market are crucial for the stable operation of the market and the confidence of its participants. This also offers a key lesson for the reform of China's electricity market, emphasizing the importance of establishing clear market rules and enhancing market transparency to attract more participants and promote market development. By drawing from Australia's experience in market power regulation, China can establish a more competitive and sustainable electricity market, contributing to economic sustainability and environmental improvement.

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