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EDITED BY
Bin Zhou,
Hunan University, China

REVIEWED BY
Yan Zhang,
Guangdong University of Finance and Economics, China
Xiurong Zhang,
Beihang University, China

*CORRESPONDENCE
Kaitao Yang,
yangkaitao@cau.edu.cn

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Opinions on unbalanced funds in China's electricity market

Jianing Zhu[1], Hao Yin[1], Yan Ma[1], Bo Sui[1], Mei Wang[1] and Kaitao Yang[2]*

[1]Henan Power Exchange Center Co., Ltd., Zhengzhou, Henan, China, [2]College of Information and Electrical Engineering, China Agricultural University, Beijing, China

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Introduction

In 2017, the construction of the spot market was started under the new round reform of China's electricity market. Eight provinces (i.e., Shanxi, Zhejiang, Guangdong, Sichuan, West Inner Mongolia, Shandong, Fujian, and Gansu) were selected by the National Development and Reform Commission (NDRC) as the first batch of spot market trial operation areas (Cai et al., 2020). After that, each province conducted multiple rounds of continuous settlement trial operations. Unbalanced funds are inevitable in the process of the transaction and settlement in the electricity market. Various provinces have also experienced the problem of unbalanced funds during the settlement period. The power grid company does not profit or lose from the market. If the spot market does not apportion the unbalanced funds reasonable, there will produce enormous unbalanced funds in the sustaining operation of the market. When the gap between revenue and expenditure of the power grid company is in the red, the power grid company needs to pay this part of the cost, and then recover the cost from the market entities that generate this part of the unbalanced funds. Therefore, various market entities may obtain extra profits or bear losses from the market in an active or passive situation, which is not in line with the principle of fairness and justice in the market economy and is not conducive to the long-term and healthy development of the spot market. For example, from 16 May 2020 to 19 May 2020 during the trial operation of the spot market in Shandong Province, the unbalanced funds in the third continuous settlement were generated as high as 95.08 million RMB (Fu et al., 2022). This phenomenon has aroused the extensive attention of experts in the industry and has not been effectively solved so far. Therefore, exploring the causes and the solutions of unbalanced funds has an important significance.

Unbalanced funds in foreign electricity markets (Dannecker, 2015; The European Network of Transmission System Operators for Electricity, 2021) generally include settlement deviation fees, metering deviation fees, rounding fees, costs and fines due to company bankruptcy or other reasons (Long et al., 2019; He et al., 2021). These unbalanced funds are usually small. China's economic system includes both a command economic system in which the government determines the allocation of resources and a market economic system in which resources are allocated by buyers and sellers. These two jointly decide the particularity of China's electricity market. Therefore, in addition to the above-mentioned fees such as rounding fees. Unbalanced funds in China's electricity market also include planned unbalanced funds, congestion costs, compensation costs, deviation recovery fees etc. At

present, the problem of unbalanced funds in China's electricity market is generally believed to be caused by the dual-track operation of China's command and market economic system (Cui et al., 2021; Liu et al., 2021). It is also the only way to go through the reform process of electricity marketization. In the study of the problem of unbalanced funds, Wu et al. (2020a) believed that there were three kinds of settlement modes in the spot market based on the command and market economic system, and analyzed the settlement problem of unbalanced funds caused by the command economy. Gong et al. (2021) argued that government-mandated contracts can directly affect unbalanced funds. Based on the load forecasting techniques and spot electricity prices, a contract decomposition method was proposed. This method can ensure the fairness of contract decomposition and reduce the unbalanced funds by introducing a fairness coefficient. According to China's two dual-track operation modes of decoupling mode and coupling mode in the spot market. Wu et al. (2020b) considered that the coupling mode is more in line with the Chinese electricity market, and studied the settlement mechanism of the spot market and medium and long-term market based on this mode. Xu et al. (2021) established an agent-based model of the real-time balanced market considering unbalanced costs, and proposed methods such as the mechanism of unbalanced electricity price to reduce unbalanced funds. Based on the balance settlement mechanism of China's electricity market, Wu et al. (2020c) designed a balancing market clearing model for wind power participation. According to the market settlement rules, Lu et al. (2021) proposed to reduce the deviation settlement cost by controlling the energy storage equipment, thereby improving the operation efficiency of the retailer in the spot market. At present, scholars have carried out extensive research on unbalanced funds. However, many studies focused on how to reduce or allocate unbalanced funds. There is still a lack of relevant research on how to analyze the solution to the dual-track unbalanced funds based on the actual settlement rules of transactions in the spot market trial operation provinces.

Unbalanced funds

The remaining funds or arrears that are generated during the operation of the electricity market are often referred to as unbalanced funds. These funds usually cannot find the exact beneficiary. The generation mechanism of various unbalanced funds is different, which can generally be summarized as the mismatch between the electric quantity and prices on the power generation side (PGS) and the power consumption side (PCS). The trading rules in various pilot provinces are not identical, and there is no uniform definition of unbalanced funds. Each pilot province has also included all types of expenses into the category of unbalanced funds management. On the basis of the actual situation of China's electricity market, the unbalanced funds can be divided into dual-track unbalanced funds, congestion costs, compensation costs, deviation recovery fees, assessment fees (Yu et al., 2020; Li et al., 2021) etc. Considering that the latter types of funds are different from the dual-track unbalanced funds and are all reflected in the market settlement, this article collectively refers to them as settlement unbalanced funds. The reason for dual-track unbalanced funds in China's electricity market is shown in Figure 1.

In China's dual-track electricity market with command and market, the generators on the PGS are divided into market-oriented power sources and priority power generation sources. Electricity users are divided into market-oriented users and priority electricity purchasers. Priority electricity purchasers refer to agricultural users and other small users who purchase electricity depend on power grid companies. All of them do not directly participate in the spot market. The liberalization proportion of the market scale on the PGS and the PCS is inconsistent. The electricity between priority electricity production and priority electricity purchasers is generally not equal. If the actual electricity usage of priority electricity purchasers is greater than the medium and long-term contract, the grid company needs to buy the market power and sell it to priority electricity purchasers. On the contrary, the grid company needs to buy scheduled contract energy and sell it to the market users. To achieve the balance of power grid electricity, it is necessary to adjust the units to achieve power balance. Under the command economy, the units with adjustment ability can provide adjustment ability for free. But under the market economy, market-oriented units are guided by price signals in the market. They are under no obligation to provide adjustment services for others free of charge. If generator units continue to provide balancing services for priority purchase and priority generation, they need to receive corresponding fees, but non-market users do not pay these fees. All of the above reasons will lead to the unbalance of revenue and expenditure in the system during the settlement process, and the resulting unbalanced funds are called dual-track unbalanced funds.

In addition to the dual-track unbalanced funds, there are several other types of unbalanced fees in the electricity market. Such as congestion costs, compensation costs, deviation recovery fees, assessment fees, and other fees. Although there are many types of these fees, they account for a small proportion of the unbalanced funds. These fees all lead to an unbalance in the overall revenue and expenditure of the system, and we collectively refer to them as settlement unbalance funds. The settlement unbalanced funds are closely related to the settlement rules of the electricity market.

Discussion

The dual-track operation mechanism of command and market is a major feature in China. This is also the transit point for China's electricity market to transform from a command economic system to a market economy system. At present, the reform of the electricity market in China has stepped into the acceleration period, and whether the problem of

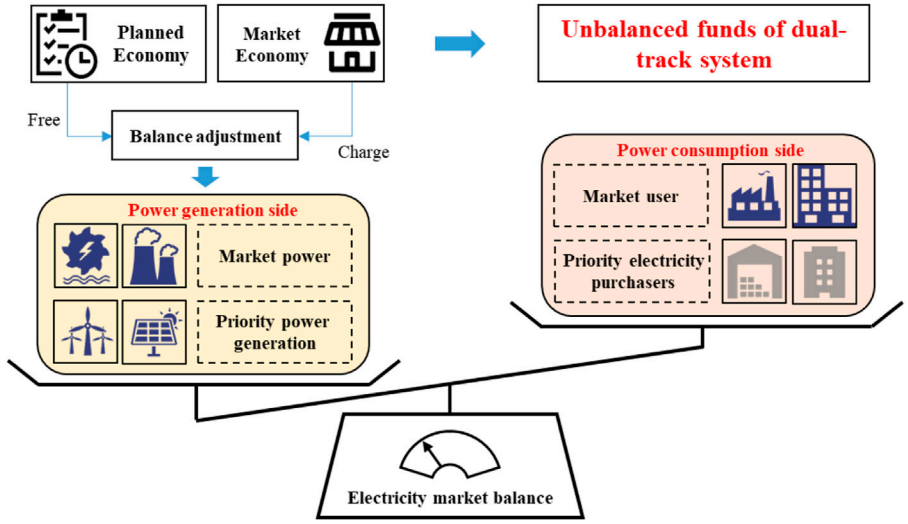

FIGURE 1
The unbalanced funds of dual-track system.

unbalanced funds can be properly resolved will also be one of the key factors for the success of the construction. This study will give some advice on how to solve the problem of unbalanced funds from the aspects of market mechanism and technical methods.

Market mechanism

The settlement mechanism of the electricity market should be further improved. Each pilot province should establish flexible and diverse market settlement methods according to its actual situation. For example, a settlement method in Guangdong Province is the decoupling of the planned electricity and the market electricity. This settlement method matches the priority power generation output curve according to the electricity consumption curve of the priority electricity purchase users. This method can reduce the unbalanced electricity in each period in the settlement, thereby reducing the dual-track unbalanced funds. Another example is the West Inner Mongolia electricity market. They change the "dual-track system" into a "single-track system," allowing all market players on the PGS and PCS to participate in the electricity market on an equal footing. This helps them eliminate the risk of unbalanced funds. In addition, the fixed contract mechanism of Singapore and the self-dispatching mechanism of the PJM electricity market also provide another way of thinking for the settlement of unbalanced funds in China's electricity market.

Based on the regulation of "who benefits, who bears," the source of unbalanced funds should be clarified, and a fair and reasonable mechanism for the apportionment and return of unbalanced funds should be established. Whoever generates the unbalanced funds and who benefits from them should bear the burden. For example, the calculation and apportionment method of unbalanced funds was clearly stipulated in the settlement rules of the electricity spot market in Gansu Province. On the basis of the ratio of the electricity consumption of the monthly non-spot market user and the spot market user, the unbalanced funds of the regional price difference are apportioned on the PGS and the PCS.

The policies of priority electricity generation and priority electricity consumption should be gradually integrated and connected with the market mechanism. Gradually realize the non-market electricity directly participate in the market, such as inter-provincial electricity, renewable energy and nuclear power. Through capacity guarantee mechanism replace the reduced base electricity. Steady push forwards the reform of the electricity market. The dual-track unbalanced funds are mainly affected by the fluctuation of the base electricity. Therefore, promoting the direct participation of non-market electricity in the market can effectively reduce the dual-track unbalanced funds, and the capacity guarantee mechanism can ensure a stable supply of base electricity. In 2021, the NDRC issued a notice about deepening the market reform of net prices for coal-fired power generation. The notice stipulates that all coal-fired power should participate in the electricity market by principle. This reduces the unbalanced funds to a certain extent.

Technical method

Grid transmission capacity needs to be further improved. The essence of congestion cost is the cost of transmission congestion due to insufficient grid transmission capacity. Therefore, by improving the power transmission capacity of

the power grid, or adopting congestion management methods such as the re-dispatch method and transaction reduction method, the occurrence of network congestion can be reduced. All of these methods can reduce the unbalanced funds in settlement caused by transmission congestion to a certain extent.

Medium and long-term electricity transactions need to be carried out with curves, and the accuracy of medium and long-term load forecasting needs to be improved. When conducting electricity transactions, market players should independently agree on the power load curve or the formation method of it, to guarantee the power load curves on the PGS are in line with the power load curves on the PCS. In this way, medium and long-term contracts can be delivered timely and completely, thereby reducing the deviation of the actual power generation and power consumption of market entities from the contract decomposition curve, and reducing the unbalanced funds during the settlement period generated by the deviation of electricity.

Author contributions

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Conflict of interest

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