Research on the Source of Subsidies Funds for Power Demand Response

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Abstract. With the upgrading of residents' consumption and the continuous improvement of electrification level, Henan's power consumption has maintained rapid growth. There is a shortage of power supply under the constraints of time, structure, and environmental protection. The implementation of power demand response can smooth peak loads, promote supply and demand balance and operational efficiency. The basis for the successful implementation of power demand response is to have a stable and full source of subsidy funds. The feasibility of three subsidy sources of demand response under the current business model is discussed in order to provide useful reference for provincial power grid enterprises to organize and carry out demand response work.

Keywords: Power Demand Response; Response Characteristics; Potential Evaluation; Subsidy Funds.

1. Introduction
In recent years, the cooling load of Henan's power grid has increased rapidly, but the load peak duration is relatively short, and the pressure to maintain the balance of power supply and demand is increasing. The power demand response (DR) can be implemented to increase the user-side regulation capability of the power system and alleviate the gap in power supply and demand. The lack of long-term, stable and sufficient funds largely limited the development of DR project. The financing channels of DR proposed in literature [3] can be referred to, but it cannot be directly applied in Henan Province. Based on the actual situation and policy documents of Henan province, this paper proposes three alternative funding sources suitable for the current stage.

2. Implement Cost Estimates on Demand Response
The implementation cost of demand response is mainly compensation capital expenditure. According to the latest compensation standard and the response target of 5% of the annual maximum load, it is assumed that ten demand responses are organized in a year, and the implementation cost of demand response from 2019 to 2025 is calculated.
| Table 1. Subsidy Standard of Demand Response in Henan Province in 2019 |
|---------------------------------------------------------------|
| **Response Category** | **Response Duration (T, minute)** | **Subsidy Price (Yuan/kW·Each)** |
| Contract demand response | $60 \leq T \leq 120$ | 6 |
| | $T > 120$ | 9 |
| Real-time demand response | $30 \leq T \leq 60$ | 12 |
| | $60 < T \leq 120$ | 18 |

| Table 2. Annual Implementation Cost of 5% Maximum Load Response Target |
|---------------------------------------------------------------|
| **Unit:** 10000 Yuan |
| **Year** | 2019 | 2020 | 2022 | 2025 |
| 5% Maximum Load | 9485 | 19078 | 44045 | 57021 |

Therefore, in order to achieve the demand response target of 5% of the annual maximum load and respond ten times a year, under the existing compensation standards, the implementation cost will be 570 million yuan in 2025. If the 5% maximum load (5.2 million kilowatts) reduced by demand response in 2025 is met by investment in power generation and transmission equipment, according to the construction standard of 16250 yuan per kilowatt, 84.5 billion yuan will be required for power and power grid supporting investment. The saved investment is regarded as the economic benefit of implementing the demand response, and the cost-benefit ratio of the demand response is 148.2. From the aspect of users, 10.4 billion yuan of power grid investment will be saved every year during the 14th Five-Year Plan period, and 5.88 billion yuan for each year will be saved for users participating in market transactions through the reduction of transmission and distribution prices.

3. Research on the Source of Subsidy Funds

The successful implementation of electricity demand response is based on a stable and abundant subsidy funding source, and three funding source alternatives are proposed for the current phase.

3.1. Peak-Hour Price Increase Scheme based on Revenue-Expenditure Balance

The plan is for industrial users of 315kVA and above in the province to increase prices during the following periods:\(^1\): from 10:00 to 14:00 in the afternoon peak period and 18:00 to 22:00 in the evening peak period, from 15 July to 15 August. The specific amount of price increase is calculated as follows:

3.1.1. Forecast of Power Quantity Implemented at Peak Price. Industrial electricity consumption accounts for more than 60% of the total electricity consumption in society, and the growth rates of the two have relatively consistent changes. By comparing the growth rate of total electricity consumption and industrial electricity consumption from 2015 to 2018, it can be judged that the growth rate of industrial electricity consumption is about 2% lower than that of the entire society. Based on the prediction of the growth rate of electricity consumption in the whole society, the growth rate of industrial electricity consumption from 2019 to 2025 is predicted by analogy. Based on the average daily peak period of large industrial electricity sales in July and August 2018, the electricity base of peak price increase is predicted.

| Table 3. Power Quantity Implemented at Peak Price between 2019 to 2025 |
|---------------------------------------------------------------|
| **Unit:** 10000 kW·h |
| **Year** | 2019 | 2020 | 2022 | 2025 |
| Power Quantity | 288982 | 304074 | 330656 | 372467 |
3.1.2. Calculation of Electricity Unit Price Increase during Peak Hours. The annual response implementation cost is shared equally to the peak electricity base, and the amount of price increase per unit electricity is calculated.

Table 4. Calculation of Price Increase per unit Electricity during the Peak Period from 2019 to 2025

|      | 2019 | 2020 | 2022 | 2025 |
|------|------|------|------|------|
| Peak Shaving5% | 0.033 | 0.066 | 0.152 | 0.197 |

Therefore, in order to achieve the demand response target of 5% of the annual maximum load and respond ten times a year, under the existing compensation standards, the price increase per unit electricity during the peak period in 2025 is 0.197 yuan / kW·h.

3.2. Included Power Supply Cost Dredging through Transmission and Distribution Price

Included power supply cost through the transmission and distribution price is a source of subsidy funds proposed by the government document. Combining the spirit of the national document "Measures for the Supervision and Examination of Costs of Transmission and Distribution Prices (Trial)" and "Provincial Grid Transmission and Distribution Prices (Trial)", the feasibility of this method is studied.

The subsidy funds for implementing power demand response shall be included into the permitted cost among other expenses in the operation and maintenance fee. Among them, the permitted cost is composed of depreciation cost and operation and maintenance cost, distinguishing the permitted cost of base period and the permitted cost of new (reduced) supervision period.

3.2.1. Channeling Feasibility through Electricity Transmission and Distribution Price in the Second Supervision Period. In the second regulatory period (2020-2022), the approval period of the approved cost in the base period is 2016-2018, during which no relevant costs are incurred due to the implementation of power demand response. In 2018, Henan implemented the first electricity demand response pilot program, and the cost of that year has been solved through surplus electricity generation funds of the province.

The increased (decreased) permitted cost in the second supervision period refers to the reasonable increase or decrease in the permitted cost of power grid enterprises in the year before the beginning of the supervision period and during the supervision cycle (2019-2022). The newly-increased allowable cost is converted through a certain ratio based on the part of the planned new grid investment during the period that can be included in the original value of fixed assets. Therefore, the subsidy costs that may be expected to occur from 2019 to 2022 cannot be included in the additional permitted costs during the second regulatory period.

In summary, the subsidy costs that are expected to occur from 2019 to 2022 cannot be channeled through the transmission and distribution price of the second regulatory period.

3.2.2. Feasibility of Dredging Transmission and Distribution Prices through the Third Supervision Period. The approval period for the permitted cost of the base period for the third regulatory period (2023-2025) is 2019-2021, and the actual electricity demand response subsidies incurred in these three years can be included in the permitted cost of the base period.

In summary, the actual electricity demand response subsidy funds that occurred from 2019 to 2021 can be channeled through the third regulatory period (2023 to 2025). By analogy, the actual electricity demand response subsidy funds that occur from 2022 to 2024 can be channeled through the fourth regulatory period (2026 to 2028).
3.2.3. *Impact on Power Transmission and Distribution Prices.* Transmission and distribution price increment = average value of permitted cost increments in the base period * (1 + value-added tax rate) / average value of electricity sales

Take the actual electricity demand response subsidy funds that occurred from 2019 to 2021 through the third regulatory period (2023 to 2025) as an example.

**Table 5. 2019-2021 Demand Response Subsidy Funds**

| Unit: 10000 Yuan | 2019 | 2020 | 2021 | 3 Year’s Average |
|------------------|------|------|------|------------------|
| Peak Shaving 5%  | 9485 | 19078| 40287| 22950            |

**Table 6. Forecast of Electricity Sales in Henan Province in 2025**

| Unit: 100 million kWh | 2019 | 2020 | 2021 | Average Annual Growth Rate | 2022 | 2025 | Average Annual Growth Rate |
|-----------------------|------|------|------|-----------------------------|------|------|----------------------------|
| Company Electricity Sales | 2865 | 3460 | 4100 | 6.5%                        |      |      | 5.9%                       |

When the demand response target from 2019 to 2021 reaches 5% of the annual maximum load and responds ten times a year, the transmission and distribution price of the third regulatory period will increase by 0.6674 yuan/1000kW·h. If the peak electricity demand is met by investing in the construction of power sources and grids, the grid investment part will increase the transmission and distribution price of the third supervision period by 30 yuan/1000kW·h. In a comprehensive comparison, the implementation of demand response can reduce the transmission and distribution price of 29.33 yuan/1000kW·h.

3.3. *The province’s Excess Power Generation Balance Fund*

Funds for the implementation of the demand response pilot in Henan in 2018 came from the province's excess power generation funds. The implementation background is as follows: the demand response work has just started the pilot, the source of compensation funds has not been straightened out, and the demand response scale during the pilot period is small, and the demand for compensation funds is still small, so it is temporarily disbursed from this fund.

From a long-term perspective, continuing to use demand response compensation funds from the province’s excess power generation balance funds may have the following problems: Firstly, the sources of surplus funds are not sustainable. The Provincial Development and Reform Commission optimizes and adjusts the basic power generation plan year by year based on the annual electricity demand, unit energy saving and emission reduction. The excess power generation capacity of enterprises will gradually decrease under the constraints of the current assessment policy, and the total amount of excess power generation funds has a decreasing trend. Secondly, the surplus funds have other uses. According to the *Reply of Henan Provincial Development and Reform Commission on the Implementation of Preferential Policies for Big Data Centers* (Yufagai Energy Letter [2019] No. 10), the funds subsidized by the policy of the data center are also temporarily spent from the surplus funds of the province's excess electricity generation. Thirdly, the mechanism for using funds is not smooth. For the peak-hour price increase scheme, funds come from large industrial users who use electricity during peak hours to compensate users who use less electricity during peak hours. In order to smooth the peak load, this kind of "transfer payment" is reasonable. For the excess power generation balance funds, the funds come from the assessment of the basic power generation plan of
the generator sets, but they are used to compensate users for participating in the peak shaving of the power grid. The source of funds and the use of funds are poorly correlated.

4. Conclusion
The cost of implementing power demand response subsidies in Henan in 2025 is 570 million yuan. Considering that the subsidy funds come from the increase in peak hours, the amount of increase in unit electricity is 0.197 yuan/kW·h. Considering that the actual electricity demand response subsidy funds in 2019-2021 will be channeled through the third regulatory period (2023-2025) transmission and distribution price, the third regulatory period will increase the transmission and distribution price by 0.6674 yuan/1000kW·h. Compared with investing in the construction of power sources and power grids to meet peak demand for electricity, the implementation of demand response can reduce the transmission and distribution price by 29.33 yuan/1000kW·h.

With the increase in user participation, equipment automation, demand-side bidding, and the emergence of ancillary service markets, the cost of subsidies for implementing demand response will be gradually reduced until it is resolved through marketization, the implementation effect will also expand from alleviating the power supply and demand gap to providing auxiliary services for the system, promoting the consumption of renewable energy, improving the level of smart power consumption, and playing a greater role in improving the level of refined energy and power management and the flexibility of grid operation.

References
[1] Yunwei Shen, et al. Demand Response Cost-Benefit Analysis and Financing Channels under the Background of New Electricity Reform [J]. Power Automation Equipment, 2017, 37(9):124-130.
[2] Bin Li, et al. Analysis and Prospects of Key Issues in China’s Large-scale Demand Response [J]. Grid Technology, 2019, 43(2):694-704.
[3] Yi Ding, et al. Design of Business Model and Market Framework for Active Response to Power Demand Side [J]. Automation of Electric Power Systems, 2017, 41(14):1-9.
[4] Wei Yang, et al. Research Plan for Guangdong Power Market Demand Side Response Transaction Mechanism [J]. Guangdong Electric Power, 2017, 30(5): 25-34.