Evaluation of Adjustable Load Potential of Industrial and Commercial Users Based on Power Demand Response

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Abstract. In order to reduce the peak load in the period of power shortage through power demand side response, it is necessary to evaluate the peak cutting potential of major industries in this region. Based on electricity information acquisition system and big data mining analysis technology, this paper proposes a peak-clipping potential assessment method and process for power demand side response based on the characteristics of different industries, and evaluates and ranks the peak-clipping potential of 17 major industries in Henan Province. The evaluation method and results provide a theoretical basis for studying and judging the peak cutting scale and target in advance.

Keywords: Henan Province, Power Demand Side Response, Peak Clipping Potential Assessment

1. Introduction
Electricity demand-side response refers to when the electricity market price is significantly increased (decreased) or there is a risk to the safety and reliability of the system, the electricity user changes the inherent electricity consumption mode according to price signals or incentive measures to reduce (increase) electricity consumption, thereby promoting electricity supply and demand balance, maintain system reliability and improve system operation efficiency.

In recent years, during the summer peak period of Henan power grid, power supply is tight in some areas. It is necessary to guide power users to reduce peak load during peak power consumption through power demand side response to ensure the balance of power supply and demand under slight power shortages. Due to the differences of production technology and flow, load characteristics of different industries are not the same, peak cutting capacity is different. Through peak clipping potential assessment, users with strong response ability and large scale can be targeted to ensure the smooth implementation of demand response through targeted publicity and focus, and it is possible to assess the total peak clipping scale of an area and help to develop a reasonable annual response plan.

2. Peak Clipping Potential Assessment Method of Power Demand Response
The data and process needed to evaluate peak clipping potential of a large industrial user in a region are introduced. By evaluating the peak clipping potential of each large industrial user in this region, the peak clipping potential of the large industrial user in this region is obtained after summarizing. The
evaluation is not limited to industrial enterprises, but can be applied to commercial, construction, residential and other users, or even an industry.

2.1. Required Basic Data

① Load data of 96 points of the maximum daily load in the region in the previous year (collection cycle of 15 minutes)

② The 96-point daily power transfer data of all large industrial users with an operating capacity of 315 KVA and above in the month of demand response implementation.

2.2. Specific Evaluation Process

① Determine the implementation month of demand response. The power demand side response is generally implemented in the period when the load supply is the most intense and there may be a power supply gap, so the month is chosen where the maximum load day is located.

② Determine the implementation period of the requirements response. Demand-side response, as a market-based means of user-side participation in peak regulation, aims to solve the power balance under the condition of slight power gap. Relevant documents require that the annual maximum power load of about 3% of the demand side should be established gradually through the demand response. Therefore, more than 97% of the maximum load is selected as the demand response implementation period. At this stage, the user's electricity load constitutes the peak load of 3% in this area.

③ Selection of typical days. In order to make the research conclusion more general, the working days with the load rate closest to the average monthly load rate of the demand response implementation and without abnormal distortion of the load curve were selected.

④ Typical daily load characteristic analysis. The average daily load rate $\lambda_i$ of each large industrial user in the region on a typical day and the average load rate of the demand response period $\Gamma_i$ are statistically analysed. Where, the average daily load rate $\lambda_i = \text{average daily load}/\text{maximum daily load}$; Average load rate in the demand response period $\Gamma_i = \text{average load in the response period}/\text{maximum load in the response period}$.

According to the principle of "who lifts the peak, who responds", if "$\lambda_i > \Gamma_i$" is met, it indicates that the power load level in the demand response period is higher than the average power consumption level of the day. At this time, the load in this period constitutes the peak load of the day, has the responsibility of peak clipping, and meets the conditions for participating in the power demand side response.

⑤ Assessment of peak clipping potential of enterprises. The response potential calculation model of enterprise users meeting the response conditions is as follows:

$$R_i = L_{i,max} \ast (1 - \Gamma_i)$$

Where, $R_i$ represents the response potential of the $i$-th enterprise user who meets the response conditions in the region, $L_{i,max}$ represents the maximum load of the $i$-th enterprise user who meets the response conditions in the demand response period, and $\Gamma_i$ represents the average load rate of the $i$-th enterprise user who meets the response conditions in the demand response period.

⑥ Determination of response potential for the region. Sum up the response potential $R_i$ of all enterprise users that meet the response conditions in this region, and the scale interval obtained is the power demand-side response potential $R$ of this region. Where, the response potential $R = \sum_{i=1}^{m} R_i$, and $m$ is the number of industrial users that meet the response conditions in this region.
3. Principle of Industry Selection

Industrial users are preferred to participate in the power demand side response for the following reasons: firstly, the load constitutes a large proportion. The power load of the secondary industry accounts for about 40% of the provincial power load. In 2019, for example, the proportion of primary industry, secondary industry, tertiary industry and the life composition of urban and rural residents in the heavy load is 3.3%, 34.4%, 25%, and 37.3%. Secondly, there is a certain basis for regulation. Under the premise of not affecting the normal production capacity, the general power load adjustment capacity of an industrial enterprise is about 5-20% of the maximum power load of the enterprise. Thirdly, it is sensitive to price signals. Based on the consideration of production cost, industrial enterprises are more sensitive to electricity price signals. Under appropriate incentive conditions, they have a high enthusiasm to participate in power demand side response.

Priority should be given to assessing peak clipping potential of large electricity users. Based on the difference of industrial structure, the load of users and the scale of electricity consumption are quite different in different regions. From the point of view of electricity consumption, selecting users with large electricity consumption to conduct peak clipping potential assessment can quickly assess the approximate scale of peak clipping in a region, avoid the high cost and low efficiency of large-scale investigation, and help to improve the pertinency and feasibility of follow-up work.

Therefore, the evaluation method in the following paper focuses on the evaluation of peak clipping potential. Based on the different evaluation objects or the availability of data, the method is applicable to micro enterprises, medium industries and macro regions. At the same time, the study selected the top 17 industries in terms of electricity consumption in 2019, most of which are in the industrial category.

4. Potential Assessment of Demand-Side Response Peak Clipping in Major Industries in Henan Province

After the peak clipping potential assessment is completed and arranged in descending order according to response scale $R_i^*$, the industry priority that is suitable to participate in the peak clipping response of power demand side can be obtained. In the subsequent response invitation stage, the response invitation can be sent within a limited range according to the priority order based on the size of the peak clipping target, so as to ensure the smooth and controllable implementation process.

Table 1. Peak-Clipping Potential and Prioritization of 17 Major Industries

| No. | Industry Categories                                      | $\lambda_i$ | Maximum Load in Response Period | $R_i$ | $R_i^*$ |
|-----|---------------------------------------------------------|-------------|---------------------------------|-------|--------|
| 1   | Ferrous metal smelting and calendering industry         | 0.897       | 209.43                          | 0.899 | 21.15  |
| 2   | Non-metallic mineral products industry                  | 0.893       | 168.86                          | 0.944 | 9.46   |
| 3   | Nonferrous metal smelting and rolling processing industry| 0.973       | 469.82                          | 0.987 | 6.11   |
| 4   | The mining industry                                    | 0.89        | 68.97                           | 0.94  | 4.14   |
| 5   | Manufacturing of chemical raw materials and chemical products | 0.968       | 234.99                          | 0.991 | 2.11   |
| 6   | Plastics and rubber products                           | 0.886       | 15.64                           | 0.936 | 1      |
| 7   | Other manufacturing industries                         | 0.902       | 11.27                           | 0.931 | 0.78   |
| 8   | Transportation, electrical, electronic equipment         | 0.914       | 14.09                           | 0.961 | 0.55   |
| 9   | Metal products industry                                | 0.615       | 2.41                            | 0.778 | 0.54   |
| 10  | Petroleum processing industry                          | 0.714       | 3.75                            | 0.885 | 0.43   |
| 11  | Paper and paper products industry                       | 0.966       | 14.59                           | 0.971 | 0.42   |
| 12  | Business, accommodation and catering                   | 0.628       | 0.95                            | 0.774 | 0.21   |
| 13  | The construction industry                              | 0.559       | 0.84                            | 0.751 | 0.21   |
| 14  | Textile industry                                       | 0.969       | 7.83                            | 0.984 | 0.13   |
| 15  | Timber processing industry                             | 0.67        | 0.18                            | 0.826 | 0.03   |
| 16  | General and special equipment manufacturing industry    | 0.734       | 0.64                            | 0.694 | 0      |
| 17  | Pharmaceutical manufacturing industry                   | 0.844       | 1.38                            | 0.711 | 0      |
5. Conclusions and Suggestions

5.1. Analysis Conclusion

① Based on the analysis of load characteristics in typical days and response periods, a simple and easy method to measure the peak-shaving potential of users' power demand side response is proposed. This method can preliminarily determine whether users are raising the load during the demand response period (peak power consumption), and can be used to participate in the preliminary screening of power demand side response applications. Not all users are suitable for participating in power demand side response.

② This paper analyses the regulating capacity of typical industries in the demand response period, and ranks the priority of industries participating in demand response according to the actual production characteristics and power consumption scale. The industry has peak shaving potential in different degrees, and the top five industries in response capacity are successively: ferrous metal smelting and rolling processing industry, non-metallic mineral products industry, non-ferrous metal smelting and rolling processing industry, mining industry, chemical raw materials and chemical products manufacturing industry.

5.2. Related Suggestions

① Preliminary screening is recommended for the application submitted by users to participate in power demand side response. For the enterprises whose average load is less than the average load of a typical day in the response period, the potential scale of their participation in peak clipping can be evaluated to be zero, and the response invitation is no longer required, so as to reduce the workload of response effect evaluation in the later period.

② According to the characteristics of industrial structure and energy use in this region, it is suggested that the industry priority order participating in demand response should be used to lock in key enterprises and key users, improve the pertinence of previous research and contract signing, and ensure the smooth implementation of power demand side response in this region.

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