Research on User Load Configuration Combination Method Based on Demand Side Management and Computer Software Analysis

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Abstract. With the continuous development of economy, China's power load increases rapidly every year, which leads to the traditional generation side investment has been difficult to meet people's daily needs. Therefore, demand side management (hereinafter referred to as DSM) has become the main power supply method based on user demand, which can regulate the power system by stimulating demand side resources. At present, DSM has been difficult to meet the actual load form analysis, which needs to be analyzed based on big data technology. With the growth of power grid data, we can classify the power load according to the difference of power users. With the diversification of power consumption types, the shape of load curve (hereinafter referred to as LC) in China will become more and more complex, which requires us to study the combination method of user load patterns. Firstly, this paper analyzes the related concepts. Then, this paper analyzes the basic model of DSM. Finally, this paper proposes a combined identification model of load configuration.

Keywords: DSM, Computer Software, User Load, Load Form Combination Method

1. Introduction

Power load is easily affected by many factors, such as holidays, weather, temperature, etc. Therefore, the research on the demand side of users will have more variable load patterns. At the same time, there will be great differences between different users [1]. With the increasing demand of power load, the traditional scheme of increasing generation side investment has been unable to meet the demand of market economy, which requires power grid load management based on DSM. In recent years, demand response of DSM has become an important direction of power grid reform in the future, which will adjust peak load by stimulating the load resources of demand side users [2]. At present, China's power grid is still dominated by orderly power consumption, which leads to a variety of problems in power load management. For example, by reducing the peak load demand, the grid can meet the overall demand, which indeed reduces customer satisfaction. In order to analyze the load patterns of power users more effectively, we can classify the difference of power consumption forms, which will provide users with appropriate DSM means [3]. User load characteristic analysis is to...
analyze the difference of various characteristics of different types of power users, such as load size, power consumption characteristic track, etc., which will identify different types of power consumption and their mutual relationship [4].

2. Related concepts

2.1. The LC

LC is the curve formed by the change of active load with time in power system, which is classified according to time span, such as daily LC, monthly LC and annual LC. LC is a curve that changes with time, which can weaken the influence of load growth and other factors. The continuous LC is a curve that arranges the load value (hereinafter referred to as LV) in the order of duration, which can reflect the duration of different load levels. Through the continuous LC, we can reflect the annual electricity demand [5].

2.2. Classification of load characteristic index

According to the time span, we can divide into daily load characteristic index, monthly load characteristic index and annual load characteristic index, which can vividly reflect the fluctuation of LC characteristics with time, which requires peak valley (hereinafter referred to as PV) treatment [6]. The classification of load characteristic index is shown in Table 1.

| Daily LC characteristics | Monthly LC characteristics | Annual LC characteristics |
|--------------------------|----------------------------|---------------------------|
| 1. Daily maximum load    | 1. Monthly maximum load    | 1. Annual minimum load    |
| 2. Daily minimum load    | 2. Monthly minimum load    | 2. Annual maximum load    |
| 1. Average daily load    | 1. Monthly average daily load | 1. Annual average daily load |
| 1. Daily PV difference   | 1. Monthly maximum PV difference | 1. Annual maximum PV difference |
| 2. Monthly average PV difference | 2. Annual average PV difference |
| 1. Daily PV ratio        | 1. Monthly maximum PV ratio | 1. Annual maximum PV ratio |
| 2. Monthly average PV ratio | 2. Annual average PV ratio |
| 1. Daily load rate       | 1. Monthly load rate       | 1. Annual load rate       |
| 2. Daily minimum load rate | 2. Monthly average daily load rate | 2. Annual average daily load rate |
| 3. Monthly minimum load rate | 3. Seasonal unbalanced coefficient |
| 1. Daily LC              | 1. /                       | 1. Annual average minimum daily load rate |
|                          |                            | 2. Annual LC              |
|                          |                            | 3. Annual continuous LC   |

3. Load management optimization method based on DSM

3.1. Peak shifting

Peak staggering is a method for power grid to adjust its own power consumption period according to the characteristics of users' power load, which can stagger the peak period of power consumption and the peak period of power system consumption [7]. By changing the period of low power consumption, we can enhance the stability of power system operation, which will reduce the load of power system in peak period. The method of time interval peak shifting has strong limitation, which is generally used
in users with obvious load PV difference\cite{7}. When the difference between peak and valley is small, the practicability of staggering peak is not strong \cite{8}. The principle of peak shifting is shown in Figure 1.

Figure 1. The principle of staggered peak time

When the peak period of user power consumption is consistent with the peak period of power system, the peak shifting method can be used for user load, which will meet the requirements of Formula 1 and formula 2.

\[
\begin{align*}
P_i(t) &= P_i(t + \Delta t_i), t + \Delta t_i \leq 24; \\
P_i(t) &= P_i(t + \Delta t_i - 24), t + \Delta t_i > 24; \\
\end{align*}
\]

(1)

\[
\begin{align*}
P_i(t) &= P_i(t-\Delta t_i), t-\Delta t_i \geq 0; \\
P_i(t) &= P_i(t-\Delta t_i + 24), t + \Delta t_i < 0; \\
\end{align*}
\]

(2)

Among them, $P_i(t)$ is the LV of each time period before peak staggering is implemented by the user, $P_i(t)$ is the LV of each time period after peak staggering in the implementation period, and $\Delta t_i$ is the time size of peak shifting. Formula 1 indicates that the user runs the PV period ahead of time, and formula 2 indicates that the user postpones the PV period.

3.2. Shifting peak to fill valley

Peak shifting and valley filling is a method to urge users to adjust part of the peak period to the low period as much as possible, which will reduce the PV load of the power system. The traditional peak load management method is to limit users' power consumption, which will greatly affect the normal power consumption of users \cite{9}. Through the implementation of peak load shifting and valley filling, we can guide users to reduce electricity consumption, which will reduce the impact of users on normal power consumption. The schematic diagram of peak shifting and valley filling is shown in Figure 2.
3.3. **Peak clipping**

Peak shaving is equivalent to interrupting load, which is a DSM method after mutual consultation. Peak shaving will reduce the total power consumption of users, which requires mutual consultation between users and power grid. By the way that the total amount of peak shaving is applied by users independently, the impact of peak shaving on users can be reduced [10].

4. **Research on user load configuration combination method**

4.1. **User load extraction principle**

The power grid needs to extract the daily load of typical users effectively, which will be of great significance for load classification. It is difficult to represent the daily load by the load of a certain day. At the same time, the power consumption habits of different users are inconsistent, which will lead to the unreasonable load extraction of different users at different times. Therefore, we must extract the user's daily correspondence by clustering method, which can be visualized by computer software. Through FCM algorithm, we can classify the daily load data of users for one year, which will obtain the daily load data of cluster center. In this paper, the LC is drawn up based on a user's 24 point load per year, as shown in Figure 3. As shown in Figure 3, the type 2 load contains the most days. Therefore, this paper selects the cluster center of type 2 LC as the representative daily load of the user.

![Figure 2. Schematic diagram of peak shifting and valley filling](image)

**Figure 2.** Schematic diagram of peak shifting and valley filling

![Figure 3. User daily load extraction](image)

**Figure 3.** User daily load extraction
4.2. Identification model of load configuration combination

In view of the limitations of the existing methods, this paper proposes a clustering load morphological analysis method. The flow chart is shown in Figure 4.

![Flow chart of combination method based on user load form](image)

Figure 4. Flow chart of combination method based on user load form

5. Conclusion

Using real-time temperature acquisition combined with neural network can provide more possibilities for future research. How to use this method to extract power load effectively to deal with the future active distribution network is also the direction of this paper in the future. In the stage of distribution network planning, we need to optimize the load distribution and optimization scheme according to the fluctuation characteristics and variation rules of each user's load, which will achieve the purpose of peak load cutting and valley filling and load balancing. In this way, we can improve the economic benefits of power grid operation.

References

[1] Huang Yuteng, Hou Fang, Zhou Qin, Fu Bo, Guo Xinxin. A method of customer load pattern combination analysis for DSM [J]. Power system protection and control, 2013, 41 (13): 20-25.

[2] Huang Yuteng. Load form analysis and load management optimization [D]. Zhejiang University, 2013.

[3] Jia Huimin. Hierarchical clustering method combining hierarchical clustering and bi-directional pinch for load forecasting [J]. Power grid technology, 2017, 31 (23): 33-36.

[4] Li Xinran. Classification and synthesis method of power consumption industry based on user daily LC [J]. Power system automation, 2010, 34 (10): 56-61.

[5] Ma Ming. Optimal combination of power load and its application in urban power grid transformation [J]. Power grid and clean energy, 2014, 30 (8): 37-42.

[6] Peng Xiangang. Intelligent recognition method of customer power consumption pattern based on cluster analysis [J]. Power system protection and control, 2014, 42 (19): 68-73.

[7] Song Yiyang. Power load pattern extraction method based on cloud model and fuzzy clustering
[8] Wang Xinghua, Chen zhuoyou, Peng Xiangang. A method of load pattern combination identification based on bi level cluster analysis [J]. Power grid technology, 2016,40 (05): 1495-1501.

[9] Xie Zhenzhen, Yang Xiu, Zhang Peng, Xu Lei. Short term load forecasting method based on information theory and hybrid clustering analysis [J]. Electrical measurement and instrumentation, 2017,54 (19): 67-72.

[10] Zhu Jinzhou, Zhang Yan, Hua Yueshen, pan Zhijun. Optimal combination and application of power load based on Markov chain [J]. Power grid technology, 2016,40 (08): 2437-2444.