Research on interactive response strategy of power demand-side resources participating in power grid

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Abstract. At present, it is difficult to cope with the increasingly severe power supply and demand situation and large-scale renewable energy grid connection demand only relying on generation side dispatching mode adjustment. With the deepening development of energy Internet, new demand side resources such as distributed generation, energy storage and electric vehicles are gradually exploited, and their value is more prominent. In order to adapt to the impact of large-scale renewable energy grid connected operation on the security and stability of power grid, it is necessary to comprehensively sort out the types of power demand side resources and study their participation in the interactive response strategy of power grid, so as to effectively ensure the safe and stable operation of power grid.

1. Introduction

As the largest power energy producer and consumer in the world, China attaches great importance to the development and utilization of clean energy. Among them, wind, light and water power generation capacity and investment occupy the first place in the world. However, wind, light and other renewable energy power generation has randomness and volatility, large-scale grid operation will bring serious impact on the stable operation of the grid[1-2]. The traditional power grid regulation is to track the load through the generator output. When the power grid operation is greatly impacted, it is difficult to meet the increasing demand of clean energy grid connection and give full play to the environmental benefits of clean energy if only relying on the generation side dispatching mode adjustment. At that time, it can be effectively controlled by load shedding or calling demand side resources. Using demand side resources can effectively reduce the capacity of load shedding, reduce the social costs brought about by load shedding, and even can replace part of the high-cost and rapid regulation of power generation resources, making the power grid operation control more economic[3].

Under the energy Internet, the concept of demand response can be extended to the substitution and conversion of different energy carriers on the load side, and the support form of consumed energy can be changed, and the energy demand of end users can be adjusted[4-6]. With the continuous development of energy Internet, more and more demand side resources are mined out. Power demand side resources no longer only include load resources, but also include distributed generation, electric vehicles, energy storage and virtual power plants. With the increasing of demand side resources, its implementation and invocation methods become more complex. Different demand side resources have different characteristics, and the effects of participating in power grid regulation are also different. Demand side response resources are an effective way to alleviate the increasing peak valley difference in China.
2. **Power demand side resource classification**

In the traditional sense, the demand side response resources are only limited to the load side, which refers to some controllable load resources. According to the scheduling mode, it can be divided into two categories: schedulable demand side resources and non schedulable demand side resources. The schedulable demand side resources have greater flexibility, which can reduce the load according to the requirements of the power grid. For example, the load of large industrial users can change the production plan according to the incentive signals issued by the power grid, so as to transfer the power consumption period and reduce the load. The non schedulable demand side resources can not be fully deployed according to the grid demand. Taking the residential electricity load as an example, the user's electricity consumption behavior is relatively fixed and difficult to transfer, so it can only further tap its response depth.

With the development of the energy Internet, the power demand side resources are gradually diversified, not only including loads, but also small power supply, electric vehicles and energy storage facilities. Therefore, from the perspective of the characteristics of demand side resources, this paper divides the power demand side resources into three categories: source resources, charging resources and source load dual resources.

![Power demand side resource classification](image)

3. **Demand response strategy of distributed generation**

The small distributed generation in users belongs to a kind of load reduction and transfer. On the one hand, these small household distributed power generation mainly based on solar energy can supply power for the household electrical equipment, thus reducing the amount of electricity purchased from the grid by the user's family, and realizing the goal of load reduction; on the other hand, the surplus energy generated by the small household distributed power can be stored in the energy storage device, and released when needed Electric energy, so as to achieve the purpose of load transfer.

For the household small-scale distributed generation participating in demand response, the strategy is to maximize the local utilization of distributed energy. Through the transfer of residents' load, the load working time is adjusted from the peak period to the period when the distributed generation is not consumed, so as to reduce the amount of electricity purchased by residents from the grid and avoid the negative impact caused by the reverse injection of its output into the grid.

4. **Demand response strategy of industrial electricity**

The power consumption of large industrial users belongs to translatable load, which is a kind of load that shifts the power consumption curve of industrial load in the period acceptable to users due to the
requirements of production process or process. When participating in the demand response, such users can change the production time of each process and adjust the production time to realize the translation of power load, thus achieving the purpose of peak shaving and valley filling. Moreover, due to the large proportion of power consumption load of large industrial power users, these users can participate in demand side response projects in the form of load control, such as joining the energy management contract project, carrying out interruptible load control in the power equipment of enterprises, and implementing special pricing mechanism.

In the current electricity market environment, it is difficult for decentralized small users to actively participate in the power demand response due to the influence of many factors such as small capacity and difficulty in accessing the Internet. Compared with the decentralized small users, the industrial users' power load is larger, the distribution is more regular, and the time of power consumption can be adjusted to participate in the demand response, which can bring greater benefits, which makes the industrial users can participate in the power demand response projects well. For industrial users, they can participate in price based demand response and incentive demand response by adjusting and reducing electricity load. When industrial users participate in price type demand response, they mainly adjust the production plan according to the level of real-time electricity price, and choose to produce in the low price period at night. When industrial users participate in incentive demand response, they will calculate whether the demand response income and the saved electricity cost are higher than the income from normal production products. When the current one is higher than the latter, industrial users will participate in the power demand response projects well.

5. Demand response strategy of commercial buildings

For the power consumption of commercial buildings, the adjustable conditions of various electrical equipment are divided into high response, medium response and low response. Low response load means that the load is not regulated during this period, which is regarded as rigid load, such as lighting and other equipment; medium response load can only reduce the load that can not be interrupted or transferred, which is regarded as the load that can be reduced, such as air conditioning, cold storage and other equipment; high response load is regarded as directly controllable load, and load reduction plan is implemented in peak load period, such as some lighting systems and air conditioning. For the medium response load, which can reduce the load, we can encourage the users to reduce the use time of high-power electrical equipment in the peak period of electricity consumption, or adjust the power of the electrical equipment appropriately; for the high response load, that is, the load can be directly controlled, and these loads can be directly shut down during the peak period of power consumption, so as to realize the load quickly.

Commercial users usually can only participate in incentive demand response, because the electricity consumption time and load demand of commercial building users are relatively fixed, it is difficult to produce load transfer effect, so they can only increase or decrease power load demand. In other words, by signing an agreement with the power system in advance, when the response demand is generated, the electricity behavior is suitable for the requirements of the system and the revenue from participating in the demand response is obtained. When commercial users participate in demand by reducing electricity load, demand response benefits also include reduced electricity cost.

6. Demand response strategy of residential electricity

The electrical load of residential users can be divided into two types: rigid load and controllable load. Rigid electrical load refers to the electrical load of equipment, such as lighting, refrigerator, computer and other household appliances, which will affect the life of users by adjusting or interrupting power consumption. The electrical load of this kind of equipment is not suitable to participate in the demand response, so it is not affected by the electricity price. However, the electricity consumption time and law of air conditioning, water heater, washing machine, dishwasher and other equipment are related to the living habits of residents, which is relatively stable. In the user-defined use period, the power consumption time can be adjusted or the power consumption of each period can be adjusted. The load
of such equipment can be regarded as the controllable electrical load of residential users. Under certain constraints, the power consumption time or power of such equipment can be adjusted according to the electricity price signal, and participate in the demand response project of power sales companies. For such controllable loads, such as washing machines, dishwashers. when participating in demand response, the load shifting can be realized by changing the power consumption time. For such controllable load, such as air conditioning, electric water heater, regenerative electric heating, the load can be appropriately reduced without affecting the comfort and functionality.

Although the power consumption of individual residential users is small, due to the concentration of residential users

7. Conclusion
Based on the source load characteristics of power demand side resources, this paper considers the power demand side resources such as distributed generation, industrial load, commercial load, residential load, energy storage, electric vehicles, micro grid, and divides them into three categories: source resources, load resources and source load dual resources. On this basis, it analyzes all kinds of power demand side resources from the perspective of transferable quantity and reduction. It can provide important reference for power grid enterprises when they use demand side resources, and can enhance users' understanding of the comprehensive value of power demand side resources, so as to promote the development of China's power demand response.

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