Research on Internal Resource Quality Evaluation and Cascade Utilization Strategy of virtual power plants

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Abstract. With the continuous promotion of power market reform, the trading mode of power market is constantly enriched. In this context, the virtual power plant technology breaks the traditional "source grid load storage" boundary, and realizes the multi-energy complementary and multi-source interaction of the power system, but the resource utilization strategy for the virtual power plant is not enough. Therefore, starting from the composition of virtual power plant, this paper constructs the internal resource quality evaluation system of virtual power plant. Based on the division of resource quality, the cascade utilization strategy of virtual power plant resources is provided. The practical results show that the quality evaluation of internal resources of virtual power plant is helpful to classify the internal resources of virtual power plant, help them realize the cascade utilization of resources, and maximize the economic benefits of virtual power plants.

1. Introduction
At present, China is in an important period of energy transformation. With the continuous breakthrough of technology, the development of new energy is faster and faster, and the scale is also growing. The randomness, intermittence and volatility of renewable energy such as wind energy and solar energy have an increasingly obvious impact on the power grid. In order to support the large-scale and high proportion of renewable energy access to the power grid, fully mobilize the interaction of power system source network load storage resources, and deeply tap the power market potential, virtual power plant technology came into being.

Virtual power plant technology is an effective way to adapt to the rapid development of renewable energy in power system, the rapid growth of re electrification proportion, the continuous increase of production and consumption users, the continuous increase of distributed generation, and the enhancement of demand for friendly interaction between power supply and load. The virtual power plant can monitor the flexible load of central air-conditioning and electric vehicle in real time. It can also automatically adjust and optimize the response quality according to the environmental parameters and the output forecast of distributed energy, so as to reduce the investment in power supply and power grid construction, and realize the win-win situation of users, systems, technologies and business models while creating a good and comfortable living environment.

However, for the main body of virtual power plant, how to evaluate the quality of internal resources, achieve "high quality, high use, low product offset", and complete the cascade utilization of resources, is the key problem to be solved urgently.
2. Theoretical research on virtual power plant and construction of internal resource quality evaluation system

(1) Theoretical research on virtual power plant

Virtual power plant refers to the integration of distributed generation, electric vehicle, energy storage, controllable load and other resources through technical means. It can help power grid peak regulation, promote clean energy consumption, and improve the safe and stable operation level of power grid like traditional power plants. It transforms the traditional "source following load" mode into a friendly interactive mode of "load following source and load following network", optimizes power consumption behavior and time sequence, plays the role of peak shaving and valley filling, shapes flexible system ecology, improves power system operation characteristics, reduces investment in power generation, transmission and power supply, further improves the overall operation efficiency of power system and improves the capacity of new energy consumption One of the functions and positioning of the power plant.

Among them, distributed generation refers to the small power supply with voltage level below 35KV, including photo-voltaic cell, small wind turbine, micro gas turbine, fuel cell and energy storage equipment. With the development of renewable energy such as photo-voltaic and wind power, distributed generation technology is becoming more and more mature, and the scale is also growing.

As a highly flexible mobile energy storage unit, electric vehicles have great potential in regulating power load, absorbing renewable energy and improving power quality. China is the largest electric vehicle market in the world, and has unique conditions in the field of electric vehicle and power grid interaction. In recent years, many domestic cities have tried to bring electric vehicles into the pilot project while carrying out power demand response, and have made active exploration in the aspect of vehicle network interaction. In many cases, the electric vehicle charging load participates in the spot market bidding through the integrator platform.

Controllable load refers to the "energy consuming" electrical equipment that can adjust the power load according to the operation state of the power grid without affecting the user's electricity consumption experience. The controller of electric appliances such as electric heater, refrigerator and air conditioner has temperature control function. By changing the set value of start and stop temperature, the start-up and stop state of the equipment can be controlled.

(2) Research on internal resource quality evaluation system of virtual power plant

There are many kinds of resources in the virtual power plant, and the characteristics of different resources are different. Therefore, the comprehensive quality evaluation system of virtual power plant is constructed from five aspects of response rate, market participation ability, response completion ability, adjustable ability and response economy, as shown in Figure 1.

![Internal Resource Quality Evaluation System of Virtual Power Plant](image)

Figure 1. Internal resource quality evaluation index system of virtual power plant
Among them, the response rate includes the total response time and the proportion of pure response time, which describes the response speed of resources. The total response time is the time from sending response instructions to completing response tasks, which can reflect the flexibility of resources. The larger the index is, the better; the proportion of pure response time refers to the percentage of actual response time in the total response time, which can reflect the response speed of resources, and the larger the better.

Market participation capability includes the responsive capacity and the responsive range, and describes the response potential of resources. The responsive capacity refers to the capacity of resources that can be used to participate in the response, the larger the better; the responsive range refers to the ratio of the capacity available for participating in the response to the total capacity.

Response completion capability includes ramp rate, response reliability and the proportion of pure duration. It describes the actual performance capability of resources and the performance capability of resources. The climbing rate refers to the rate of change of output when the resource reaches the target value; the response reliability refers to the probability of the resource completing the whole response command; the proportion of realizing pure duration refers to the ratio of the actual output time of the resource participating in the actual response to the total response time, which is greater than 0 and less than 1, and the closer to 1, the better.

The adjustable potential includes the optimization of output curve, the degree of self restriction and the degree of external restriction, which describes the adjustable performance of resources. Output curve optimization refers to the optimization of the output of resources, the greater the optimization potential, the higher the regulatory ability of resources; the degree of self restriction refers to the degree of restriction of the resource's own attributes on the control performance; if the air conditioning load is subject to a higher degree of self restriction, its adjustable potential is low; and the degree of external restriction refers to the restriction process of the market environment of resources on the adjustable potential of resources Degree.

Response economy includes transaction profit and return, which describes the economic benefits of resources participating in response. The trading profit is the profit obtained after the resource participates in the response, the larger the value, the better; the transaction yield is the return of the unit cost of the resource, and the higher the value, the better the profit of the resource participating in the response.

3. Research on internal resource quality classification and cascade utilization strategy of virtual power plant

(1) Internal resource quality classification

According to the internal resource quality evaluation system of virtual power plant, the quantitative analysis of various resources is carried out, and the results are shown in Table 1.

Table 1. Internal resource quality division results of virtual power plant

|                          | Response rate | Market participation | Response completion capability | Adjustable potential | Response economy |
|--------------------------|---------------|----------------------|-------------------------------|----------------------|------------------|
| Distributed generation resources | Medium        | Medium               | Low                           | Low                  | higher           |
| Micro-grid               | higher        | Low                  | higher                        | high                 | high             |
| Controllable load group  | high          | Low                  | high                          | high                 | high             |
| Electric vehicle         | high          | Lower                | Medium                        | high                 | high             |
| Energy storage           | high          | Low                  | higher                        | high                 | Medium           |
(2) Cascade utilization strategy of virtual power plant resources

According to the quantitative analysis results of internal resource quality of virtual power plant, different types of resources are optimized and combined to realize the cascade utilization of "high quality, high use, low product and low use", so as to maximize the potential of virtual power plant and improve the economy of virtual power plant.

For the high-quality response resources, the virtual power plant can participate in the auxiliary service market and provide peak shaving and frequency regulation services; for the medium quality response resources, the virtual power plant can participate in the demand response to ensure the revenue without too much demand; for the low-quality response resources, the virtual power plant can adjust the load deviation to obtain additional benefits.

4. Conclusion

In the increasingly mature environment of virtual power plant technology, this paper evaluates the quality of internal resources of virtual power plants, which provides reliable basis for resource management of virtual power plants and helps them make operational decisions.

According to the quality evaluation results, the virtual power plant can realize the quality division of resources. For the high-quality resources, the virtual power plant can participate in the auxiliary service market and obtain high income; for the medium quality resources, the virtual power plant can participate in the demand response and obtain appropriate income under the condition of moderate yield; for the low-quality resources, the virtual power plant can participate in the load deviation Adjustment, in order to meet the unexpected needs, reduce the cost of deviation penalty. Generally speaking, the quality evaluation of internal resources of virtual power plant can realize the cascade utilization of resources, give full play to the economic benefits of virtual power plant, and further enhance the competitiveness of virtual power plant.

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