Study on coordination control methods of VPP

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Abstract. China has become the world's largest energy producer, so we must speed up the construction of a clean, low-carbon, safe and efficient energy system. The large-scale access of renewable energy has an impact on the safe and stable operation of power grid, which makes it unable to directly join the power market operation. The coordination control objects of virtual power plant (VPP) mainly include various DERs, energy storage system, controllable loads as well as electric vehicles. The coordination control methods are mainly divided into centralized control, centralized decentralized control and completely decentralized control. In China, the demonstration project of VPP operation has been carried out in State Grid Jibei and Shanghai Electric power company.

1. Introduction

In recent years, with the rapid development of new energy in China, it has become the largest grid connected with new energy in the world[1]. With the access of a large number of distributed renewable energy, its characteristics of volatility, intermittence and randomness bring severe challenges to the economic dispatch of power grid[2]. Only relying on the traditional regulation ability can not meet the consumption of new energy. Therefore, a virtual power plant is proposed to solve this problem[3].

2. Concept of VPP

Relying on modern information and communication technology and artificial intelligence technology, virtual power plant integrates multi type, multi energy flow and multi-agent resources with electricity as the center, promotes the integration of energy flow, business flow and data flow, realizes multi energy complementarity on power supply side, flexible regulation and control capability on grid side and flexible interaction on load side, and can provide auxiliary services such as peak load regulation, frequency regulation and standby for power system, as well as It provides a new way for users and market entities such as distributed energy to participate in power market transactions[4], as shown in Figure 1.
The difference between virtual power plant and traditional power plant is that traditional power plant has stable property, while virtual power plant is flexible and expandable [5]. The installed capacity of traditional power plant is fixed. As long as there are more and more distributed generation or load, the capacity of virtual power plant can be expanded, and the speed can be adjusted flexibly [6]. This is also where the virtual power plant is superior to the traditional power plant, which has flexible adjustable speed and can play a greater role in the auxiliary services of the power market.

3. Operation management mode of VPP
The operation management mode of virtual power plant is divided into centralized control and decentralized control. Under the condition that the retail market has not yet been established, it is necessary to explore the operation and management mode suitable for the development of the national unified power market.

3.1. Centralized control mode
Centralized control mode centralized control mode is to connect all resources to the centralized management and control platform of virtual power plant, fully grasp all information of distributed units within its jurisdiction, and fully control all power generation or consumption units, as shown in Figure 2. The centralized control mode is consistent with the current operation mode of the market at the receiving side. It gives full play to the role of market institutions, ensures the security of the system, reduces the risk of default of all parties, and effectively protects the interests of all parties in the market through unified standards, unified management and unified operation. The disadvantage is that the pressure of the platform is relatively large, which requires the platform to be able to process massive data in real time. In order to standardize the operation, it is necessary to sacrifice the diverse business needs of virtual power plant operation. It is more suitable for areas with less total adjustable resources and large capacity.
3.2. Centralized decentralized control mode

The centralized decentralized management and control mode is divided into two layers, the centralized management and control platform of virtual power plant and the decentralized management and control platform, as shown in Figure 3. Decentralized management and control mode can give full play to the role of virtual power plant operators, flexibly aggregate all kinds of adjustable resources, divide wholesale market and retail market, and reduce the pressure of centralized platform management and control. The disadvantage is that the security and reliability of power system is reduced. Due to the lack of monitoring of operators, market players have operational risks after access. Centralized decentralized management and control mode is more suitable for areas with large amount of adjustable resources, distributed capacity and sound market mechanism.
Fig. 3 The centralized decentralized control mode of VPP

3.3. Completely decentralized management and control mode

In the fully decentralized control mode, the virtual power plant is divided into independent autonomous intelligent sub units, and there is no centralized control platform for the virtual power plant, as shown in Figure 4. A single virtual power plant management and control platform is responsible for data exchange through data processing and trading center, only providing market price, weather forecast and other information. This mode has a relatively high level of intelligence, effectively optimizes internal processes, improves customer service level, and reduces operating costs. The disadvantage is that the processing speed and throughput affect the overall performance of the system. For massive data, the system security and stability are not high. This mode is suitable for microgrid applications.
4. Demonstration and application of VPP
The demonstration project of virtual power plant operation has been carried out in northern Hebei and Shanghai at present. It covers interactive resources such as optical power station, electric vehicle charging station, energy storage and flexible load. The main functions of virtual power plant management and control platform and related business system are basically available. The ecological environment of virtual power plant as the main body of the market is preliminarily available. The North Hebei pilot project officially participates in the North China peak shaving market, and the Shanghai pilot project participates in the Shanghai demand side response market.

5. Conclusion
At present, the virtual power plant is highly concerned by all walks of life. The next step is to carry out the construction and development of the intelligent management and control platform of the virtual power plant, integrate the operation, management and transaction service functions of various distributed resources of the virtual power plant, establish the access standards and technical indicators of the virtual power plant and flexible resources, and study the coordination and control optimization of the distributed terminal of the virtual power plant and the transaction auxiliary strategy mechanism.

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