Research on New Urban Virtual Power Plant System

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Abstract. With the continuous development of energy industry, the contradiction between supply and demand is becoming increasingly serious. In order to coordinate the contradiction between power system and distributed renewable energy, and deal with many challenges brought by new energy power to power system.We should fully exploit the value and benefits of new energy for power system and users. In this paper, a new urban virtual power plant system is proposed, which integrates distributed generation units, energy storage system and controllable load. It uses advanced data communication and coordinated control technology to realize the organic overall regulation and control of various types of distributed energy and load, to reduce the challenge of randomness and volatility of high penetration distributed generation to power grid operation and dispatching, and to alleviate the contradiction between supply and demand.

1 Introduction

As the basic industry of national economy, energy industry is not only the necessary premise to ensure the national strategic security, but also an important guarantee to realize the sustainable development of economy. Although China's energy production and consumption are in the forefront of the world, there are a series of prominent problems in energy supply and utilization, such as unreasonable energy structure, low energy efficiency, low proportion of renewable energy development and utilization, and the level of energy security needs to be further improved.

The purpose of virtual power plant is to integrate all kinds of distributed energy, including distributed generation, controllable load and energy storage devices, and fully tap the value and benefits of distributed energy for power grid and users. Based on the theoretical research of virtual power plant, a series of virtual power plant engineering demonstration projects have been carried out in foreign countries, such as "e-energy" project in Germany, pilot project of solar energy supply Technology Research Institute of Kassel University in Germany, EU virtual fuel cell power plant project, EU Fenix project, which are mainly aimed at achieving the goal of reliable grid connection of distributed generation and power market operation In the United States, virtual power plants are mainly based on demand response planning, and controllable load is the main component. At present, virtual power plant technology is still in its infancy in China. Although Jiangsu, Beijing and Shanghai have carried out the practice of virtual power plant, the control object is translatable load, which can not fully cope with the huge impact of the rapid development and various types of distributed generation and controllable load on the safe and stable operation of power grid.

Based on the existing foundation, this paper proposes a new type of urban virtual power plant system, which is connected with a variety of user side resources, and at the same time actively responds to the power grid dispatching signal to coordinate the supply and demand balance of the power grid, so as to realize the optimal allocation of various energy resources.

2 Urban virtual power plant system

2.1 System architecture

The system architecture of urban virtual power plant is divided into three layers, which are equipment acquisition layer, data transmission layer and platform application layer.

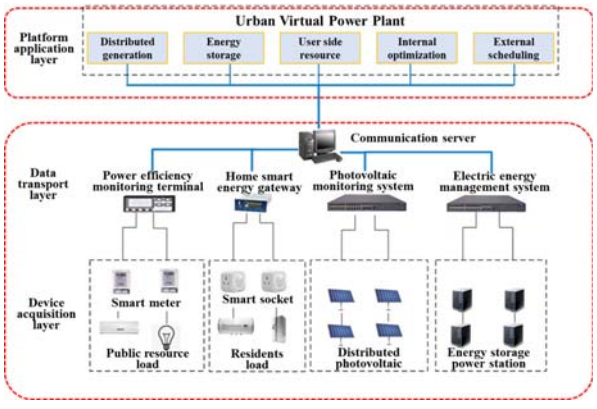

Fig. 1. Urban virtual power plant system architecture

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The device acquisition layer is connected to a variety of user side devices, including residential power equipment, public resource flexible load, distributed photovoltaic, centralized energy storage, charging pile, etc.The device acquisition layer can collect the energy consumption information of the user side, and upload it to the platform application layer through the data transmission layer. The virtual power plant system analyzes the received data and issues the control instructions through different functional modules.

The user side resources of urban virtual power plant system form a virtual power plant resource pool covering source, load and storage, which ensures the integrity of the whole business process. At the same time, it interacts with marketing basic data platform and dispatching system in real time, receives user load data and regional load data from marketing basic data platform, receives regional load data and dispatching instructions from dispatching system, and participates in power grid dispatching. Through the time-sharing and gradient response of the virtual power plant resource pool to the power grid signal, the supply and demand balance of the power grid is coordinated, and various resources are optimized.

2.2 Business architecture

The business architecture of urban virtual power plant system is shown in the figure.

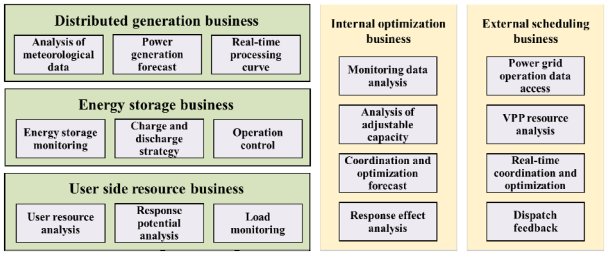

Fig. 2. Urban virtual power plant business architecture

Distributed generation, energy storage, user side resources, in plant coordination and optimization, out of plant scheduling optimization and other businesses in the system business architecture comply with the requirements of business functions in marketing and scheduling business domain.

Distributed generation service, energy storage service and user side resource service are used to analyze, predict and control the resources integrated into the virtual power plant system. It provides support and feedback for in plant coordination optimization business and out plant scheduling optimization business of virtual power plant.

3 User side resources of urban virtual power plant

User side resource access of urban virtual power plant is divided into four parts, including public resource load, residents load, distributed photovoltaic system and energy storage power station system.

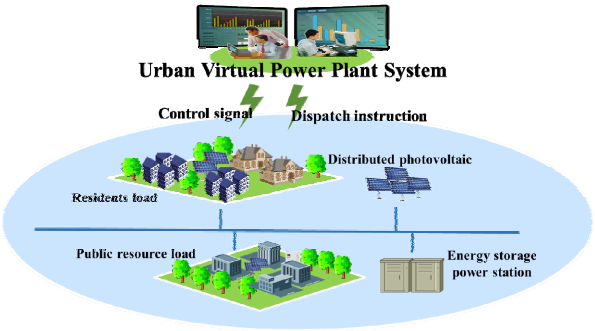

Fig. 3. User side resources of urban virtual power plant

Public resource load: the public resource transformation is mainly aimed at the three parts of the central air conditioning system, including the chiller, circulating water pump and fresh air unit. They are connected to the urban virtual power plant system through the installation of public resources power efficiency monitoring terminal and public resources smart meter.

Residents load: we install home smart energy gateway and air conditioning controller, select flexible and controllable high-power household appliances such as residential air conditioning for data acquisition and control, and access to urban virtual power plant system. The principle of combining optical fiber communication with wireless communication is adopted to realize the interconnection between master station and gateway.

Distributed photovoltaic system: according to the capacity of photovoltaic power generation system, we configure the multi-channel collection photovoltaic grid connected inverter tuning control module, which can realize the group tuning of inverter group. The serial port of inverter and virtual power plant system is connected by 485 interface, and the interconnection between them is realized by wireless communication. Photovoltaic power generation system sends measurement and control data to urban virtual power plant system. It uses the embedded information communication module to upload information. Through the city level virtual power plant system, it can dynamically adjust the output power of the photovoltaic power generation system in the relevant area according to the current load, power quality and other parameters.

Energy storage power station system: we access EMS energy management system of energy storage device through optical fiber special network. The urban virtual power plant system regulates the centralized energy storage power station by controlling the EMS of the energy storage device. The battery is discharged in peak time and charged in valley time.

4 Operation mode of urban virtual power plant

4.1 Control mode

According to the different control structure of information flow transmission in virtual power plant, the

control mode of virtual power plant can be divided into centralized control mode, decentralized control mode and completely decentralized control mode.

In the centralized control mode, the virtual power plant can fully grasp all the information of the distributed units within its jurisdiction, and fully control all the power generation or consumption units.

The virtual power plant under decentralized control is divided into several levels. The control and coordination center of the virtual power plant in the lower level controls the power generation or power consumption units within its jurisdiction, and then the control and coordination center of the virtual power plant in this level feeds back the information to the control and coordination center of the higher level virtual power plant, thus forming an overall hierarchical structure.

In the fully decentralized control mode, the virtual power plant control coordination center is replaced by the data exchange and processing center, which only provides market price, weather forecast and other information. The virtual power plant is also divided into independent autonomous intelligent sub units. These sub units are not controlled by the data exchange and processing center, only receive the information from the data exchange and processing center, and optimize their own operation status according to the received information.

4.2 Control mode

There are two scheduling methods of urban virtual power plant system: internal optimal scheduling and external optimal scheduling. Among them, the internal optimal scheduling is mainly to optimize the capacity configuration or output of multiple power sources in the virtual power plant. The external scheduling is the optimal scheduling of the virtual power plant as a whole by the power grid scheduling. The virtual power plant system no longer performs the internal optimal scheduling, only receives and executes the scheduling instructions.

The emphasis of city level virtual power plant system is different in different application scenarios. In the rigid scenario, emergency is the most important, safety and reliability are the most important, and technology oriented control function is the most important, so as to achieve the instantaneous / short-term balance of power supply and demand. In the flexible scenario, the conventional operation is the main one, focusing on the economic and efficiency objectives, focusing on the optimization function of value return leading, so as to achieve the time balance of power supply and demand. Under the target demand of different scenarios, the source storage interaction realizes the whole process management according to the event type, which not only covers all kinds of scenarios in the power grid operation, but also covers the multi-scale control on the power grid operation time axis.

External optimal dispatch: power grid dispatching virtual power plant responds to power grid dispatching instructions and has multi time scale response capability, including second level response, minute level response, four hour level response and day ahead response.

Internal optimal scheduling: the virtual power plant will cut peak and fill valley according to market, load, new energy output and other factors. Taking the control center as the core, the internal dispatching mode is coordinated and optimized by the equipment layer, generation layer, load layer and power market layer. The power generation layer is responsible for providing the operation status, output prediction and other information to the control center. According to the importance of the load, the load layer divides the priority and sends different kinds of load information to the upper control center. According to the control instructions and self constraints of the upper control center, the power generation and load are dynamically adjusted, and the power information is timely fed back to the upper control center.

The control center of the virtual power plant adjusts the operation plan of the lower generation layer based on its own generation forecasting and regional load forecasting. At the same time, it receives the electricity price issued by the power market layer, takes maximizing its own benefits as the goal, and uses the core algorithms such as the targeted accurate decision-making technology of the city level virtual power plant system, the automatic command allocation technology, the multi resource combination optimization technology, the virtual energy storage optimization coordination control technology to adjust the operation strategy of the power generation layer, so as to realize the internal optimal scheduling of the city level virtual power plant system.

4.3 Interactive mechanism

Price and incentive mechanism are the mechanism guarantee of urban virtual power plant system. Virtual power plant is the main form of market operation under the friendly interaction of source storage and load. It is built by the government, power grid, users and other forces according to the principles of responsibility sharing, asset ownership, government and society co construction. According to its own coordination scheme, it can play a market-oriented game with the power side, and realize the optimization of economic benefits, environmental benefits and energy benefits on the premise of achieving user satisfaction.

Price and incentive mechanism are the main market mechanism under the friendly interaction between source, storage and load. It plans and manages the energy consumption terminal, and puts the user side schedulable resources into the grid operation process as an alternative resource. Through the adjustment of price signal and incentive signal, we encourage multi participants to trade electricity voluntarily according to market rules, so as to achieve the same energy consumption effect in the most economical and friendly way. With the advancement of power market reform and the development and improvement of competitive market, the stakeholders of power system are gradually diversified, and the

interaction among source, storage and load is more and more close. Both price and incentive mechanism can comprehensively plan the resources of generation side and demand side, which is the objective demand to adapt to the development of power market and promote the interaction between source, storage and load.

5 Conclusion

In this paper, the construction and application of a city level virtual power plant system is proposed to improve the peak shaving means of power grid, improve the power supply structure of power grid, and effectively solve the contradiction between power supply and demand. It optimizes load control, promotes friendly interaction between users and power grid, and improves energy consumption level. At the same time, it plays an important role in promoting the practice of domestic virtual power plant technology and the application of VPP power centralized management system, and plays an important role in promoting the construction of resource-saving and environment-friendly society.

Acknowledgments

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