Research on Construction and Operation of Microgrid

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Abstract: In order to cope with the objective contradiction of the worsening environmental problems and the rigid demand for energy due to the rapid economic development, it is of great significance to explore the technology and management mode of microgrid which is self-used and locally consumed with renewable energy. In this study, on the basis of clarifying the construction goal of microgrid, the energy management system of microgrid is designed, the control mode consistent with the characteristics of renewable energy is selected, the business scope of microgrid is expanded according to the interactive needs of different users, and the intelligent interactive operation of microgrid is realized, which can make better use of renewable energy to meet the rising demand for energy while protecting the environment.

1. Introduction

Since the beginning of the 21st century, the world economy has developed rapidly and the demand for energy has continued to increase. In order to meet the rapidly growing energy demand, coal, oil and natural gas still occupy the main position in energy supply, and bring about the shortage of fossil energy and environmental pollution, which threatens the sustainable development of human society. Therefore, developing renewable energy and increasing its consumption share have become the main energy transformation strategy of various countries. However, in the remote western provinces of China, far from the large power grid without power, power shortage areas, many have good water, wind, light and
other renewable energy resources conditions, but there are scattered resources, small single scale, poor stability and other problems, power development and transmission is difficult, seriously affect the application of renewable energy. In addition, due to their special political and military status, in some regions of China, after the large power grid is cut off due to abnormal events, there are many scenes of normal power supply protection. However, the traditional mode of power supply protection, such as diesel power generation and emergency generation vehicles, also has environmental pollution problems and does not meet the requirements of the national carbon neutrality strategy.

Based on this, the use of renewable energy to build microgrid and ensure its smooth operation is of great significance for China's economic development, environmental protection, national security and improvement of people's livelihood.

2. The construction goal of microgrid

Microgrid is a small power generation system composed of load, distributed power supply (including energy storage equipment), power electronic equipment, measurement, monitoring and protection devices. It is an independent autonomous system that is a single controlled unit for external large power grid, and can realize self-control, protection and management. At the same time, it can meet users' needs for power quality and power supply security. It can not only be connected to the grid, but also operate in island.

Microgrid optimizes the configuration and integration of the original distributed power sources, and centrally connects them to the same physical network. Generally, there is only one common connection point with the large power grid, and uses energy storage devices and reactive power compensation devices to adjust and compensate in real time to smooth the power and voltage fluctuations of the system. The control system and energy management system are used to maintain the dynamic balance of power generation and power consumption in the microgrid, and maintain the stability of frequency and voltage in the microgrid. Externally, the microgrid is a single controllable unit: when the microgrid is connected to the large power grid, it can respond to the demand of the large power grid as a flexible and dispatachable quality load, provide necessary reactive and active power, and effectively improve the security and stability of the power system. When the microgrid operates independently, the different distributed power sources, energy storage devices and loads in the microgrid maintain stable and efficient operation through the control protection and energy management system, and provide reliable and high-quality power. In short, the microgrid system needs

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to effectively overcome the randomness and intermittency of different distributed power sources, and enhance the ability of the grid to accept diverse distributed energy.

3. Energy management system of microgrid

Energy management system is an important integration point of energy and information in microgrid. The safe and economical operation mode and high-quality power supply service of microgrid are inseparable from the perfect energy management system[1]. According to the construction goal of microgrid, a unified energy management system of microgrid is essential. It is the "brain" of microgrid, which controls the access of many internal distributed power sources, coordinates the balance of internal power consumption and power supply, and switches with the external large power grid without gap[2].

3.1 System structure

Microgrid control system includes remote control and local control. The remote control structure mainly consists of a set of Energy Management System (EMS) and its communication unit to form the Microgrid Central Controller (MGCC). To achieve different functions from maximizing the benefits of the microgrid to coordinating the local Microsource Controller. The local control part is mainly implemented through the Microsource Controller(MC), which is responsible for monitoring distributed energy sources, such as distributed power sources, energy storage devices, and loads[3]. The MC can be a stand-alone hardware device or software installed in the electricity meter, electronic interface of the distributed power supply, or any field device with sufficient processing power.

3.2 Control mode of microgrid energy management system

There are two main control modes for microgrid operation: master-slave control and peer to peer control, which need be selected according to the distributed power supply[4].

In master-slave controlled microgrid, one or several micropower sources are usually selected as the master DG, and the constant voltage/constant frequency control (V/F control) is adopted to stabilize the voltage and frequency of the microgrid. Other micropower sources in the system are controlled by constant power control (PQ control) to achieve safe and reliable operation of the microgrid. In master-slave control, the central controller of the microgrid assumes the responsibility of maximizing the benefits of the microgrid and optimizing the operation of the microgrid. The central controller of the microgrid fully considers the actual output of the distributed power supply, the system safety and the electricity price of the large grid, and determines the power generation of each distributed power supply to maximize the benefits of the whole network[5]. At the same time, the non-critical and adjustable load is reduced when the output is insufficient. The technical difficulty and risk of master-slave control are relatively small, and it is widely used in the current microgrid system projects.

In the peer-to-peer control microgrid, all micropower sources have the same status regardless of primary and secondary. In this kind of microgrid, the micropower sources rely on local information to control, and realize the automatic power allocation of micropower sources with voltage source output characteristics based on local information. There is no need to change the control strategy when the operation mode of the microgrid is switched, and the plug and play of the micropower supply to the microgrid can be realized. In peer-to-peer control, each micropower controller assumes the main responsibility[6]. They optimize their output power to meet the needs of the microgrid through competition and cooperation, and locally control the micropower to transmit power to the main grid as much as possible under the condition of ensuring the safe and reliable operation of the microgrid. Therefore, the microgrid under peer-to-peer control is more robust and reliable.

4. Operation strategy of microgrid

In isolated grid operation, in order to ensure the stability, it is necessary to balance the sum of distributed power and the total load power. In order to ensure the normal and stable operation of the isolated power grid, it is necessary to limit the power generation of part of the power supply or cut off part of the load when there is surplus or insufficient power generation to meet the load power demand. Generally, photovoltaic power generation will be maximized, and lead-carbon battery energy storage system will be used for charging and discharging adjustment[7]. If there is a diesel generator set, it will be used as backup and peak regulation power supply. If the output of the hydropower station is constant, the hydropower will give priority to ensuring the power supply of these important loads such as hospitals, traffic lights and government agencies. The load can be interrupted when necessary, Such as residential electricity, advertising lighting, etc.

The above operation strategy can be divided into two parts: the first part is power consumption management; The second part is the dispatching and control of microgrid.

4.1 Power consumption management

The main task of power consumption management is to realize the real-time interaction of power flow, information flow and business flow on the basis of meeting users' requirements for power quality and power supply reliability, and establish a new relationship between power supply and power consumption. Power consumption management includes three functional modules: power quality monitoring, centralized meter reading and user interaction. The main task of power quality monitoring module is to complete the measurement, recording and analysis of power quality data, and can realize the location and analysis of different interference sources. The main task of centralized meter reading module is to provide basic data for power marketing business and dispatching business, and realize

the function of power consumption analysis. The goal of the user interaction module is to achieve orderly power consumption and economic power consumption, to provide bidirectional interactive support for power price information, power consumption and power supply information for power generation users and ordinary users respectively, and to realize the interaction between intelligent power generation users and energy optimal scheduling of microgrid[8].

4.2 Microgrid dispatching and control

The rapid regulation and grid connection of distributed power supply in microgrid and the fluctuation after grid connection need to rely on effective system-level coordination control means. Microgrid dispatching and control includes three functional modules: real-time security and stability control, energy optimization dispatching and fault self-healing[9].

The real-time security and stability control of microgrid in grid-connected and isolated operation mode includes not only the millisecond level local decentralized control of physical component layer, but also the second-level real-time control of power flow, voltage and frequency coordinated by the system as a whole. These controls need to be carried out in real time. In order to realize the optimization and coordination in grid-connected state, islanding state, grid-connected to islanding state, islanding to grid-connected transient state;

The energy optimization scheduling of microgrid is based on the analysis of distributed power supply, energy storage unit, load and the current state of power grid operation and historical data, and then make scientific evaluation and prediction. According to the priority dispatching right classification and load classification of various types of distributed power sources in the microgrid system, as well as different choices of electricity price types in the main grid system and different energy dispatching strategies, the corresponding optimal dispatching model is determined, and an effective algorithm is used to solve the optimal operation plan of different dispatching periods in the future. Including day-ahead output plan, day-ahead scheduling plan and real-time scheduling plan for dispatchable units in the microgrid system.

The fault self-healing function mainly realizes the functions of fault identification, self-healing control and black-start control of microgrid. The internal and external fault identification methods of the microgrid are established. When the fault occurs under the condition of grid connection, the microgrid is disconnected first, both on the microgrid side and on the distribution side, so as to avoid the complication of fault characteristics or the influence of reclosing strategy due to the addition of the microgrid. The control scheme of power supply recovery after microgrid fault isolation is established. The prevention and control scheme for expected faults under normal operation condition of microgrid is established. Establish the correction control scheme under the emergency condition of microgrid branch or voltage overlimit; The control scheme is established when the system collapses when the system is in islanding operation.

5. Intelligent operation of microgrid

With the continuous development of emerging elements such as distributed power supply, microgrid and electric vehicles, the requirements for user interaction are constantly improving. Therefore, it is urgent for microgrid to implement the thinking of "Internet ", make energy and information deeply integrated, and realize information interaction, energy interaction and business interaction between operating companies and customers.

5.1 Demand analysis of power consumption interaction

Power users can be divided into three categories: residential users, industrial and commercial users and large users. Different types of power users have different ways and characteristics of electricity consumption, which determine their different interactive demand for electricity consumption, mainly as follows.

First, the interaction of business flow includes the interactive demand of traditional services such as electricity information collection, the interactive demand of new smart grid services such as multi-channel payment, and the interactive demand of value-added services such as centralized collection of water, electricity and gas.

Second, power flow interaction includes user-side interaction requirements such as distributed power supply access; Intelligent "virtual power plant" and other grid-side interaction requirements.

Third, the interaction of information flow includes the interactive demand of power consumption status and other energy consumption information, and the interactive demand of non-energy consumption information such as smart home and industrial park production plan.

Based on the above interactive requirements, the operation of microgrid needs to provide information interactive services, marketing interactive services and electric energy interactive services [10].

5.2 Information interactive services

First of all, microgrid operators can use the Internet to open online business hall business, develop mobile phone APP, provide users with online services, mobile phone services and other terminal online information interaction services, to meet users' basic payment, inquiry, complaints and other business needs. Through information interaction, on the one hand, operators can timely grasp the user registration, basic electricity consumption information, reduce the pressure of business hall business management, realize the transformation of service mode, and create a more friendly and interactive environment for users; On the other hand, users can handle business more quickly and conveniently, and at the same time, they can timely understand the latest announcements, policies, package preferential activities, real-time electricity price changes and other information of operators.

5.3 Business Interactive business

Business interaction service mainly includes information interaction and marketing interaction in the process of business handling, such as electricity application and installation service, emergency repair service, application for electric vehicle charging facilities, access application for distributed power supply and energy storage devices on the user side, application for energy efficiency management service and signing of energy efficiency contract. Microgrid operators can use big data technology to analyze the power consumption characteristics of various users and design different personalized comprehensive energy solutions according to their characteristics. Through business interaction, on the one hand, operators can improve the service package business, meet different customer groups with different needs, provide humanized services, and improve the service level and quality. On the other hand, it is beneficial for users to use electricity conveniently, safely, transparently and economically. At the same time, users can independently choose corresponding service products and service packages[11].

5.4 Energy interactive service

Energy interactive business is an interactive business model of energy interaction between different customers and the power grid in the process of intelligent electricity consumption, which mainly includes two parts: distributed power supply business and charging and discharging facilities business. Through the energy interactive business, in terms of distributed power supply, users can realize self-power supply, flexible power consumption, avoid the peak of power consumption, more economical, and can also realize the profit of electricity sales; In terms of charging and discharging facilities, users can not only charge and discharge conveniently anytime and anywhere, but also get profits from selling electric vehicle discharge.

6. Conclusion

In short, the construction and operation of microgrid needs to design the physical architecture, especially the energy management system of microgrid, on the basis of clarifying its construction objectives, and make full use of local renewable energy to establish an orderly topology. According to the type of energy access, master/slave or peer control is selected to realize the advanced application functions of microgrid, such as real-time security and stability control, fault self-healing, energy optimization scheduling, user two-way household movement, centralized meter reading, power quality monitoring, etc. In order to meet the demand of different users and their increasing demand for interactive services, through the deep integration of energy and information, the business scope of information interaction, business interaction, energy interaction and other services of microgrid are expanded, and the intelligent operation of microgrid is realized.

Through the construction and operation of microgrid, the local renewable energy resources can be fully utilized to meet the local electricity demand and achieve the self-balance of electricity in the areas where the large power grid cannot be extended. In the future, after the extension of the large power grid arrives, it will be interconnected with it to form a modern power mode with separate transmission and distribution. It can not only reduce a large amount of investment in power grid construction, improve the utilization level of power grid assets, and shorten the construction period, but also improve the overall disaster resistance capacity of power grid and emergency power supply capacity after disaster, and improve the level of power supply guarantee.

In the next step, further research can be carried out to deepen the operation mechanism of the microgrid market, and a new profit model of the microgrid under the opening of the electricity sales side can be designed, which can further promote the continuous construction and smooth operation of the microgrid.

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