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Microgrid Technology with Distributed Energy – A Review

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Abstract - As one of the key technologies to achieve the large-scale application of distributed power generation, microgrid can overcome the randomness, intermittence and dispersity caused by distributed energy and promote the development and utilization of new energy and renewable energy to ease the shortage of energy all over the world. In this paper, the characteristics and key technology of microgrid and the challenges may exit during development of microgrid are briefly introduced. Microgrid complies with the requirements to promote renewable energy power generation and social sustainable development, and will definitely occupy a vital position in the development of grid construction.

Keywords- *Microgrid; Challenge; Distributed energy*

I. INTRODUCTION

Due to the limited quantity of conventional fossil fuels and the environmental pollution problem, the development and utilization of renewable energy has been paid more and more attention all over the word and the scale is expanding. As the core content of energy transformation and the important commitment to deal with the climate, China has made the objective that the proportion of non-petrochemical energy consumption increased to 15% of primary energy consumption and 20% in 2020 and 2030 respectively. However, with the increase of non-petrochemical energy consumption proportion, intermittency and volatility of utilization of renewable energy has put forward new challenges to the stable operation of power systems. When the low-voltage distribution network in the distributed power capacity achieves a high proportion, namely high permeability, the realization of balance of distribution network power and the reliability of high-power supply will be very difficult.

As one of the key technologies to realize the large-scale application of distributed power generation system, microgrid aims at realizing the flexible and efficient application of distributed power generation technology in medium and low voltage level and solving the problem when large and diversified distributed energy operates in distribution network [1]. So the development of microgrid to a certain extent determines the application scale of renewable energy. In this paper, the development of microgrid at this stage and the problems exits during development are briefly introduced.

II. CONCEPTS AND CHARACTERISTICS

A. The concepts of microgrid

The CERTS, namely Consortium for Electric Reliability Technology Solutionsfirst puts forward the concept of microgrid in 2001, microgrid is a system consisting of load and miniature power supply, which provides both electric and thermal power. The power supply inside the microgrid is power electronic devices which are responsible for energy conversion and provide the necessary control. Compared to the bulk grid, the microgrid behaves as a single controlled unit and simultaneously meets the customer's requirements for power quality and power supply safety [2]. Since then, the European Union and Japan give their own definition due to their research. Our country puts forward the concept of microgrid in a "micro-network technology system research" work conference held by the State Grid Electric Power Research Institute in 2009, microgrid is a small modular, decentralized energy supply network based on distributed power generation technology with the subject of decentralized resources and small power plants and combined with power quality management and energy utilization technology [3]. Although the definition of microgrid is not the same, they do all identify that the micro gird is a integrated unit of energy storage devices, control devices and protection devices, which based on distributed power generation technology and can work in isolated network running and grid-connected running [4].

B. Characteristics of micro grid

Flexibility: As defined in the paper, the micro grid can run both in isolated network and grid-connected. The grid- connected mode acts as the normal operation, in which model the system can either absorb power from the grid network or supply power to the main network. When something happens to the grid, the micro grid disconnects the link with the main network by turning off the demarcation switch and turned into isolated network state.

Interactivity: Operating in isolated network state cannot only shorten the customer's power outage time, but also help the reboot of the bulk grid, which is particularly valuable during the unconventional disaster or war. So, the micro grid can play a role as own emergency power supply, which should be considered in the grid black start program.

Compatibility: Micro grid is the most effective way to achieve the connection of distributed energy. It integrates the original distributed energy and stabilizes the power supply and balance between supply and demand through energy storage and control protection, which effectively overcome the randomness and intermittent of distributed energy and solve the problem when micro grid connects to the bulk grid [5].

Economy: Micro grid access to large amount of renewable energy, which means we can distribute the output of different micro source optimally. Besides, combining the micro gird with medium-sized heat supply can reduce the conversion of different energy forms and improve energy efficiency, optimize the energy structure in order to achieve the best economic benefits of micro gird through the realization of temperature counterparts, cascade utilization and energy matching.

III. KEY TECHNOLOGY OF MICRO GRID

A. The operation of the micro grid

As mentioned in this paper, the microgrid can work in isolated network running and grid-connected running. When connected to the bulk gird, the microgrid can provide excess power generated by distributed energy to the grid or supplement their own power generation deficiencies from the grid. When detecting the failure of the grid or the power quality does not meet the requirements, the microgrid will disconnect from the bulk network and the power supply will be provided by the distributed generation system (DGS). The isolated network running of the microgrid provides a higher power supply reliability and irreversible power supply for the system [6]. Through experimental system operation, it turns out that the microgrid can be connected network or isolated network and switch from one state to the other smoothly under reasonable control strategy.

B. The control of microgrid

As a modular and controllable unit, microgrid need to provide power to customer and to achieve these functions, the good management and control within the microgrid is necessary. Through the microgrid control, adjusting the feed flow to decoupling control the active and reactive power independent and make sure that the operation of each micro- power can be micro-response and supply the customer demand.

In the process of operation control, the microgrid can make a quick and independent response to the accident occurred in the bulk grid based on the local information. When the voltage drops in the connected network or power failure, the micro-distributed power generation system will be switched to separation of the main network or parallel or achieve the transition between the two-operation model according to the fault condition or the system smoothly. Nowadays, there are three main methods to control the microgrid. First is plug and play control and peer-to-peer control based on power electronics technology [7]. Second is the control based on power management system [8]. Last but not least is microgrid control based on multi-agent technology [9]. The main control equipment is distributed generation system controller, controllable load manager, central energy management system and relay protection device.

C. Energy Storage Technology

Given the fact that the ability of microgrid to bear the disturbance is relatively weak, the application of energy storage system plays an important role in stabilizing the fluctuation of renewable energy and maintaining the stable operation of the system. There are different storage technologies and the main technologies are mechanical energy storage, electromagnetic energy storage and electrochemical energy storage etc. Among all these storage technologies, batteries become the best option for renewable energy grid and intelligent micro-network because of its easy installment and manufacture. Lithium-ion batteries, nickel- metal hydride batteries, sodium sulphur batteries, liquid batteries, lead-acid battery technology are relatively mature in a variety of chemical batteries and the comprehensive performance of lithium battery is the best while liquid batteries have a wild application in the field of large-scale. The best energy storage technology works for the microgrid is those with high system efficiency, long cycle life and high economy.

D. Economics of microgrid

The economics is the important foundation for promotion and development of microgrid technology. Microgrid can refer the knowledge and experience obtained from the operation of grid in scheduling principles, power transactions, resource optimization and other aspects to optimize the design and provide different levels of power quality and reliability services for different customers and even provide black start and other auxiliary services. At the same time, the economic optimization of microgrid is also different from the traditional grid and the biggest difference is that distributed generation can supply electricity and heat in the form of CHP. In addition, the unique design of the microgrid can provide higher reliability than traditional distribution network and meet the special requirements of customers, improve the added value of electricity.

IV. THE CHALLENGES IN THE DEVELOPMENT OF MICROGRID

The ultimate goal of microgrid is to achieve seamless incorporation of a variety of distributed power supply. In general, a large amount of distributed power supply connected to the microgrid will obviously have a profound impact, therefore we need to address the operating characteristics and the interaction mechanism between traditional grid and microgrid, grasp energy optimization management and other aspects of a series of complex issues.

Reliability and Stability: Microgrid is distributed in the distribution grid as a special power source which can both import and export energy, the interaction between the microgrid will further affect the reliability of the distribution grid. The mechanism of the interaction between the microgrid and the distribution grid is the prerequisite for improving the safety and stability of the distribution grid, and it is necessary to discuss the new theory and method to analysis stability and reliability.

Programming and Designing: It is necessary to consider a series of problems during the programming and designing, such as distributed power supply, microgrid structure, the location of micronet access and integrated optimization of distribution grid. The demand of cold and thermal load in the grid should also be considered to reflect the scientific and forward-looking of programming.

Controlling: The distributed power supply mostly connects the grid through electronic inverter because there is no self-synchronization. The load fluctuation in microgrid and distribution grid has a great impact on the power output. The diversity, intermittent and randomness also increase the difficulty of voltage and frequency control in distributed power supply and the control of coordination between multi- micro-grid is more difficult. Besides, the power quality is also a concern that we should pay attention to.

Protection: Because of the bidirectional trend of microgrid, it is our primary task to ensure the safety and stability of the entire system when some failure happened and when there is something wrong with the distribution network or the distribution network operates under abnormal condition, it's necessary to protect the distributed power and microgrid, response when it's required, don't operate when there is no need, response rapidly. In addition, different distributed generation technologies may have different protection criteria when system fails and network reconstruction also requires protection device with adaptive tuning function.

Scheduling Operation: Due to its complexity, the effective scheduling and management of microgrid must be achieved by using auxiliary tools. First of all, we need to model and simulate the microgrid to achieve rapid protection for isolated network state and grid reconstruction algorithm, overcome the unfavorable factors of intermittent and randomness brought by renewable energy under the high permeability to ensure the safety and stability of the system under extreme weather conditions and failure condition [10].

V. DEVELOPMENT DIRECTION

Microgrid technology has been vigorously researched recently with its high reliability, environmental protection, flexibility and other characteristics in developed countries, such as Europe and the United States. Our country also began some National High-tech R&D Program (863 Program), National Key Basic Research and Development Program (973 Program), and other national key research and development plan to encourage and support the various universities and research institutes in the microgrid technology research. The next few years, microgrid theory and related technology will be certificated through demonstration engineering and get widely practiced and promoted. In the future, the main research direction of microgrid will be as follows:

The different ways to connect microgrid to traditional grid and operate isolated network, the coordinated control of the microgrid and energy storage components make the energy flow in microgrid multi-path and multi-channel, therefore we need to establish suitable theory about grid structure planning and operational and other related aspects according to the above characteristics; Design a real-time, flexible, intelligent distributed power controller and central management unit for distributed generation system with renewable energy such as wind power to enable it to have complex functions such as self- healing, autonomous and self-organizing [11]. In addition, according to the requirements of the load (sensitive load and non-sensitive load) and the operation of the power grid, optimize and improve the control strategy, especially the integration of different control strategies, coordination and smooth transition to explore the appropriate operation mode and management strategies for microgrid; Using neural network, wavelet analysis, gray theory and system prediction technique establishes the random load model. Based on the scheduling scheme of the main network and the load capacity of the microgrid and the requirements for power quality, and combine the intelligent control (artificial neural network, fuzzy control) and modern control theory, to establish internal random flow control model for microgrid; Establish the new economic relations between the main grid and microgrid, research and formulate the technical guidelines for isolated network running and grid-connected running properly, especially the operational specification for micro- distributed power supply under isolated network running and investigate the impact of technology promotion on electricity market further.

CONCLUSIONS

In the context of the energy shortage globally, microgrid has aroused concern around the world as the effective complement to the traditional grid and the effective forms to use distributed energy. Compared with the traditional centralized power supply system, microgrid can reduce the loss greatly and save investment for transmission and distribution construction. As aggregate of power generation, heating, cooling and other service functions, microgrid can effectively achieve the cascade utilization of energy to achieve higher energy efficiency, while improving the safety and reliability of power supply. Microgrid can effectively reduce or eliminate the direct impact to gird caused by access of distributed power supply, which provides a new path for the large-scale application of new and renewable energy in connected grid. Microgrid complies with the requirements to promote renewable energy power generation and social sustainable development, and will occupy a vital position in the development of construction of grid.

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