A Review of Microgrid Development and Technology

A Review of Microgrid Development and Technology

Chunyang Liu *

School of Electrical and Electronic Engineering, North China Electric Power University, Baoding, China.

* Corresponding author e-mail: 1026735857@qq.com

Abstract. The development, characteristics, types and key technologies of microgrid are summarized in this paper. This paper focuses on the operation control of microgrid, including the control method based on power electronics, energy management system and multi-agent technology. The article finally has made the forecast to the future development of the microgrid.

1. Introduction

With the rapid development of the world economy, the contradiction between the limited natural energy and the continuous increase of human energy demand is becoming more and more serious. How to balance economic development and energy consumption has always been a difficult problem for social and economic development to face and solve. Increasing the proportion of new and renewable energy consumption, meeting the high permeability of Distributed Renewable Energy access and absorption of micro-grid applications, using energy-saving and environmental protection of distributed power supply to improve the reliability of power supply has become the trend of social development.

Compared with the traditional centralized energy system, microgrid has many advantages, such as close to load, remarkable reduction of line loss, less investment in construction and operation costs; distributed energy has many service functions such as power generation, heating, refrigeration and so on, which can achieve higher comprehensive utilization efficiency of energy. The development of micro grid is conducive to the utilization of various renewable energy sources (solar power generation, wind power generation, biomass power generation, etc. The microgrid can handle some of the peaks and the back-up, and adapt to seasonal and regional power demands, which makes the economy of the power system optimal and balanced; Microgrid can improve the reliability, quality and safety of power supply. Developing micro-grid technology can form a harmonious and diversified grid pattern.

2. Analysis of Development and Current Situation

In recent years, the European Union, the United States and other countries have carried out microgrid experimental demonstration project research.

The United States was the first country to put forward the concept of microgrid. The micro-grid proposed by American scholars is mainly composed of small micro-power sources and loads with capacity less than 500 KW. The basic idea of the micro-grid control technology advocated by American scholars is to establish the dynamic model of the micro-grid through the state space model of modern control theory, and to study and determine the power control strategy and optimization parameters of the micro-grid. In 1999, the American Association of Reliability Technology Solutions first studied the

structure, control and economy of microgrid, and formally put forward a relatively complete concept of microgrid in 2002. It is the most authoritative concept of microgrid at present.

European countries put forward the Smart Power Networks plan in 2005, and then introduced the technical implementation strategy of the plan. The Smart Power Networks project, as the development goal of electricity in Europe in 2020 and the follow-up, shows that the future European power grid should have the following characteristics: flexibility, accessibility, reliability and economy. In Europe, the corresponding control strategy of output inverters of micro power supply is proposed: PQ control VSI (voltage source inverter) control strategy. The basic idea of VSI control strategy is to provide reference voltage and reference frequency with one or more voltage source inverters. VSI control strategy is gradually developed from single to multiple, that is, the inverters providing reference voltage and frequency are changed from one to multiple, which further improves the security and reliability of microgrid access to large power grid. At the same time, the optimization constraint equation is proposed, and the penalty scheme for the abandonment of excess heat energy is formulated. Finally, under the condition of meeting the dual demand of electricity and heat in microgrid, an optimal power allocation scheme is proposed to minimize the fuel consumption of the system.

3. Characteristics of Microgrid

Micro-Grid is a small power distribution system consisting of distributed power supply, energy storage device, energy conversion device, load, monitoring and protection device. The proposed microgrid aims to achieve flexible and efficient application of distributed generation, and to solve the problem of large number and diverse forms of grid-connected distributed power supply. The development and extension of micro-grid can fully promote the large-scale access of distributed generation and renewable energy, and realize the high reliable supply of multi-energy forms. It is an effective way to realize active distribution network and make the transition from traditional grid to smart grid. Microgrid has three characteristics:

(1). The power supply in the microgrid is mainly controlled by power electronic devices.

(2). The microgrid is a single controlled unit relative to the external large power grid, and it can satisfy the users' requirements on power quality and power supply safety.

(3). There are two typical operation modes in micro-grid: the normal operation of micro-grid connected with conventional distribution network is called networking mode; when the grid fault or power quality is detected, micro-grid will be disconnected from the grid in time and run independently, which is called islanding mode. The switch between the two must be smooth and fast.

4. Types of Microgrid

DC microgrid: Distributed generators, energy storage devices and loads are connected to DC bus, and DC network is connected to external AC network through power electronic inverters. DC microgrid can provide power to AC and DC loads of different voltage levels through power electronic conversion devices, and the fluctuation of distributed generation and load can be regulated by energy storage devices on the DC side.

AC microgrid: Distributed power supply and energy storage devices are connected to AC bus through power electronic devices. At present, AC microgrid is still the main form of microgrid. By controlling the switch at PCS, the conversion between grid-connected operation of microgrid and islanding mode can be realized.

AC/DC hybrid microgrid: It contains both AC bus and DC bus, which can supply both AC load and DC load directly.

Medium-Voltage Distribution Branch Microgrid: A microgrid that integrates distributed generation and load effectively on the basis of medium-voltage distribution branch. It is suitable for supplying power to user areas with medium capacity, high reliability and concentration.

Low Voltage Microgrid: A microgrid formed by properly integrating users' distributed generators and loads at low voltage level. Most of these microgrids are owned by power or energy users, and their scale is relatively small.

5. Key Technologies of Microgrid

5.1. The Operation Control of Microgrid

In the field of microgrid research, the most critical technology is the operation control of microgrid. At present, there are three common microgrid control modes:

(1). Control methods based on concepts such as power electronics technology. According to the control requirements of microgrid and the sagging characteristics of generators, this method assigns unbalanced power to each unit dynamically, which has the advantages of simplicity, reliability and easy realization.

(2). Control based on energy management system. This method uses different control modules to control active and reactive power respectively, which satisfies the various control requirements of microgrid. In addition, according to the different requirements of reactive power in microgrid, different control methods are adopted in power management system to improve the control performance.

(3). Microgrid control based on multi-agent technology. This method applies the multi-agent technology in the computer field to the microgrid. The autonomy and spontaneity of the agent can well meet the requirements of decentralized control of microgrid.5.2 The protection method of microgrid.

5.2. The Protection Technology of Microgrid

The protection method of micro-grid is different from that of traditional distribution network, mainly because of the multi-power characteristics of microgrid, which makes a great difference between them. The main difficulties are the bidirectional flow of power flow, the change of short-circuit capacity in grid-connected and isolated operation. Therefore, the traditional method of centralized reactive power compensation in low-voltage side of distribution network is no longer suitable for microgrid.

5.3. Grid Connected Technology of Microgrid

Most of the energy generated by the new energy generation technology can not meet the requirements of the existing interconnected grid at the frequency and voltage levels, so it can not be directly connected to the grid, and only through the power electronic equipment can it be accessed. Therefore, it is necessary to strengthen the research of power electronics technology and develop some new power electronic devices as supporting facilities, such as grid-connected inverters, static switches and power control devices.

The access of renewable energy, such as solar energy and wind energy, to the power grid has a great impact on the power system. Although the cost of renewable energy is not low compared with the traditional energy generation, its new generation technology plays a key role in the development of the power grid.

5.4. Energy Storage Technology of Microgrid

Energy storage technology is a very important technology in microgrid. It has the function of cutting peak and filling valley, thus improving the efficiency of intermittent energy utilization. The key of this technology is superconducting energy storage technology, supercapacitor and so on.

6. Development Trend

With the development of society and the rapid iteration and renewal of information age, the problem of energy consumption is becoming more and more serious; the rapid growth of population and economy makes the environmental problems of the earth more and more serious, and the available energy in natural resources and nature is declining sharply; under the premise of non-stop economic development, the problem of energy consumption must be a major problem to be solved in economic development.

In the case that natural energy can not be recovered quickly, new energy and renewable energy will inevitably become the key breakthrough of energy consumption. Then, it must be an important demand under the rapid economic development to meet the access and absorption of high permeability

Distributed Renewable Energy and the application of microgrid and energy-saving and environmental protection distributed power supply.

Microgrid is a valuable technology to promote the future social and global development because of its unique flexible functions, such as separating from the main network and operating independently, realizing the fast interaction between source network and core, and having many kinds of operation modes that traditional power grid does not have.

7. Conclusion

As a way of distributed generation optimization and integration, microgrid has many advantages, but there are still many problems to be solved before large-scale application. However, it has become the focus of research around the world. Microgrid will play an important role in the future.

References

[1] MEHRIZI-SANI. A, IRAVANI. R, Potential-FunctionBased Control of a Microgrid in Islanded and Gridconnected Modes [C]. IEEE Transactions on Power Systems, 2010.
[2] Chen S X, Gooi H B, Sizing of energy storage system for microgrid [J]. IEEE Trans. on Smart Grid, 2012, 3 (1): 142-151.
[3] Siow. L. K, So. P. L, Gooi. H. B, et al. Wi-Fi Based Server in Micrgrid Energy Management System [C]. IEEE TENCON 2009 Proceedings, 2009.
[4] Su Ling, Zhang Jianhua, Wang Li, et a1. Study on some key problems and technique related to microgrid [J]. Power System Protection and Control, 2010, 38 (19): 235-238.
[5] Sheng Wanxing, Yang Xusheng. Application of multiagent system in power system [M]. Beijing: China Electric Power Press, 2007: 2-8.
[6] LIU Jiayi, QIN Wenping, HAN Xiaoqing, et al. Control method of interlink-converter in DC microgrid [J]. Power System Technology, 2014, 38 (2): 304-310.
[7] Navid E, Ebrahim F. Power control and management in a hybrid AC DC microgrid [J]. IEEE Transactions on Smart Grid, 2014, 5 (3): 1494-1505.