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## Characteristics and Application of Distributed Energy and Micro Grid: Based on Information Technology

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**Abstract:** The development of modern information technology has provided the safeguard for the energy industry change. As in the information age, the distributed energy system, from the point of view of energy industry, is the use of renewable energy to solve the predicament of constraints in the traditional energy sources; From the perspective of the information industry, it is an issue of application of intelligent information technology to solve the problem of information transmission and control of power supply and demand and the problem of distributed generation interconnection problems. Micro grid fundamentally solves the contradiction between the distributed power generation and power grid. This study gives the characteristics of information technology application of the distributed power generation system and emphatically discusses the micro grid characteristics, structure and operation mode. Finally it is talked about the micro grid development present situation and existing problems in China.

**Key words:** Distributed energy resource system, distributed generation, micro-grid

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### INTRODUCTION

Distributed Energy System (DES) is an important trend in the development of the world's energy industry which is important to sustainable human development. It makes the energy efficiency a new level by reducing the energy consumption of intermediate links and by the way of "demanding determines supplying" to achieve "temperature counterparts, cascade utilization" of client-side energy using. DES has been paid full attention by people at the time when several big history events happened which let people realized that centralized-power-supply style of traditional energy system having significant flaws. In 1999, the most part of the North America encountered a massive power failure which leded thousands of persons lost energy supply within 72 h. In 2003, London and Italy both suffered from significant power failure which all caused big troubles of people's daily life. The large scale of power failure caused by the rare snow disaster of South China in 2008 and the Fukushima nuclear power plant explosion accident of Japan in 2011, made people recognize the disadvantage of the traditional way of energy supply and try best to discover a new energy supply style.

As is known to all, the large power grid has difficult in peak time peaking and has security problem of remote power transmission. Distributed Generation (DG) which

fully integrated the unique advantage of distributed energy system, has efficiently solved such difficulties by a number of scattered arrangement mini-power stations and small distribution units as a secondary and complementary source of large power grids. Not only can this develop the energy use efficiency but also release the Reduce the burden on large grid peak load of energy supply terminal. Therefore, the new energy DG has aroused more and more attention around the world which will soon become one of the main development trends of power systems (Li *et al.*, 2007).

Currently, after the first generation of the small units or small grids and the second generation of large units or power grids, the third generation network characterized by large-scale use of renewable energy and intelligence begin to develop in the current world. Smart grid which is characterized by intelligence, is a revolution of the combination of IT industry and energy industry. It is an interacted network combined instantly among users and between the user terminal and the grid which is mainly through a sensor to link users or user terminal and power company, so as to read the data in real time, high speed, the two ways and improve the efficiency of the overall grid (Hua, 2013).

The core requirement of the smart grid is to build a large number of decentralized electricity systems to guarantee the safety of power supply and assistant

peaking. But the attributes of Distributed Electricity (DE) determines that it cannot connected with the main grid directly and needs the help of electronic interface device. At the same time, it is still a barrier that the DE has a high cost of access to main grid and is difficult to control. The Micro-grid, combined the distributed electricity system and smart grid effectively, can solve the contradiction between large power grids and distributed power and promote the development of distributed generation technologies (Lu *et al.*, 2007).

### **THE CHARACTERISTICS OF DISTRIBUTED ENERGY RESOURCE SYSTEM AND DISTRIBUTED GENERATION**

Distributed Energy Resource System (DERS) includes variety of independent products and techniques that spread around the terminal users. It usually makes use of such a kind of small and efficient cogeneration system of which the power range from 3 KW to 400KW which uses gas turbine, steam turbine, reciprocating internal combustion engine, fuel cell, micro gas turbine, the Stirling engine or something as the devices to produce energy and renewable energy technology including photovoltaic system, small hydro and biomass power generation, wind power generation as the fuel to produce. DERS has advantages of developing energy efficiency, reducing the transmission and distribution energy losses, lowering the cost of energy use and the carbon dioxide and other pollutants emissions.

DERS was born in the information age. Concluding the factors of electricity production, heat supply, cooling, dehumidification, rational use of natural gas and environmental pollution control, under the support of information intelligent control and communication remote govern, DERS can be built as an energy-information network system that seems like an internet to integrate electricity, gas, heat and communication network together. It puts the chain of “demand-production-supply” under the control of information to maximize the efficiency of resources and minimize the cost of capital and environment so that we can achieve a balance between multiple benefit (Han, 2010).

Distributed Generation (DG) is usually seen as efficient, reliable power generation units which is small modularity, distribution and locating in the vicinity of the users. Normally its generated output ranges from a few KW to hundreds of MW (also someone recommends that it should be limited in 30 to 50 MW). The ways of DG are including liquid or gas-fueled internal combustion engine,

micro gas turbine, solar power (photovoltaic, solar thermal power generation), wind power and biomass power generation.

Distributed power source can easily meet the load demand and contribute to effectively and intensively use of renewable energy when it access to conventional power grid (Ji, 2009). However, due to the energy (wind, solar, etc.) itself has dispersed, random features, distributed generation may result in the disadvantages of electric power dispersing or randomly changing and so on. For instance, system failure may intermittently affect the peripheral users; it is difficult to optimize energy use synthetically; it will have a significant impact on main grid system’s security and stability when a large number of distributed powers connect to the power grid.

In addition to the features of small, clean and efficient, another two important characteristics the DERS has are: the diversity of energy sources and the use of information technology sufficiently.

Firstly, it has diversity of energy sources. Distributed energy covers all kinds of clean energy and petrochemical fuels. Regional differences lead to different energy endowments. When provide energy for clients nearby, usually, DERS can take advantage of local energy endowment to utilize energy comprehensively. Besides, it can supply energy in a limited region so there is no need to consider cross-regional transfer or areal variation. Take photovoltaic power generation for example, it makes use of solar energy so as to be ideal for those areas with adequate lighting. So do the remote areas with abundant water and wind sources.

Second, it makes full use of information technology. DERS needs to be connected with varieties of power systems so as to form a regional power grid supported by distributed energy and has an access to large grid as the terminal which determines that the DERS has to depend on the most advanced information technology to ensure intelligent monitoring and the remote control of distributed energy effectively. It also requires multiple inputs of information to achieve regional connection and connecting to large grid. Through the collecting monitor to obtain the data stream, then transmits them into information platform via communication network, the DERS can complete the input information collection. After this procedure, we can figure out whether the grid power supply is normal, too much or too little to ensure electricity demand for end users. In the condition of ensuring the safe operation of the power grid, it is proved that micro-grid can provide the best way to connect distributed generation to large power grids smoothly.

## THE APPLICATION AND FEATURES OF MICRO-GRID TECHNOLOGIES

### **The concept and characteristics of the micro-grid:**

Micro-grid is a controllable energy supply system which consists of distributed power, energy storage and load. Micro-grid can smoothly access to large grid and it can also be run independently which is an effective way to play a distributed power performance. This is an effective combination of distributed energy systems and smart grid concept. To develop micro-grid technologies will help improve the ability of distributed energy grid to accept, help improve network resilience and help solve the difficult problem of power supply in remote areas. To develop micro-grid technology while also conducive to energy saving tasks and promote the rapid development of related industries.

Currently, the definitions of micro-grids are different in various countries and regions which are closely integrated with the country's major technological developments. In recent years, there have been several large power outages which makes the power industry of the United States is very concerned about power quality and reliability. Therefore, American scholars often focusing on improving the use of micro-grid power quality and reliability for the study of the micro-grid. Consortium for Electric Reliability Technology Solutions (CERTS) given the definition of micro-grid as follows: micro-grid is a system which by the load and micro power supply. It provides electricity and heat at the same time. Electronic devices by converting the energy provide the internal power for the micro-grid and provide the necessary control. Relative to the external power grid, the micro-grid is controlled by a single unit and can also meet the users' requirements of power quality and power safety. And it can form a "plug and play" and "reciprocal" (peer to peer) control ideas and design concepts (Eto *et al.*, 2009).

Japan is lack of local resources and its emphasis on renewable energy than any other country. However, due the randomness of new energy, penetrating power limits the application of new energy. So, in terms of research micro-grid, Japanese scholars often emphasize the control and electrical energy storage. Researchers in Japan's Mitsubishi Corporation consider that independent power supply system is also included in the traditional micro-grid areas of study. This greatly expands the Micro-grid definition of CERTS. They said: micro-grid is a small controllable system, including power and energy equipment and load. It behaves as a whole unit outside and can access the main network. The reason of establishing New Energy and Industrial Technology Development Organization (NEDO) in Japanese is to make

better use of new energy. It is responsible for the harmonization of the various agencies, such as corporate, State Key Laboratory and domestic universities, research on new energy and its applications.

European Commission Project Micro-grids believe that the main provider of electricity is controlled miniature power supply which is the difference between the traditional and micro-grid power system. In addition to meeting these power load demand and maintain the power balance, there are also likely to be a load. Using miniature power supply can be divided into uncontrollable, partly controlled and fully controlled. And it can be tripled for cold, heat, electricity. It equipped with energy storage devices and adjusts the energy with power electronics devices. Micro-grid research programs in Europe all revolve around reliability, access, flexibility. Smart grid, energy utilization diversification are the important feature of the future of the European grid.

In short, according to the above definition of different countries and regions, we can see that, the main characteristics of the micro-grid as follows: It distributed generation technology, while incorporating energy storage, control and protection devices; it close to the user load; the voltage level of it is the distribution network level; micro-grid can operate in two modes, grid and island.

**The basic structure of the micro-grid:** Micro-grid solve problems of DERS on the grid and because of advanced power electronics technology used is flexible and controllable, the micro-grid can use DERS flow of the tide micro-grid for effective regulation. Figure 1 is the relationship between the performances of the micro-grid with the large grid. As can be seen, the general micro-grid access to power grid through a single point. We see micro-grid from the grid-side which is a controllable power generating unit or load, can be smooth access to a large independent grid and autonomous operation. So that we can take advantage of the complementary of a variety of micro-networks of distributed power and use energy more fully and reduce the impact of various types of distributed power directly into the grid on a large grid. Meanwhile micro-grid can facilitate the distribution network operation and management. And it can reduce investment costs increase, caused by grid upgrades, reduce transmission losses and help to reduce the standby power needs of large power plants.

Figure 2 shows a block diagram of micro-grid of CERTS. It is a decentralized Plug and Play system. It has good flexibility throughout the system and generators can be placed in some places, where the energy can make full use of, thereby improving the utilization of energy. It has

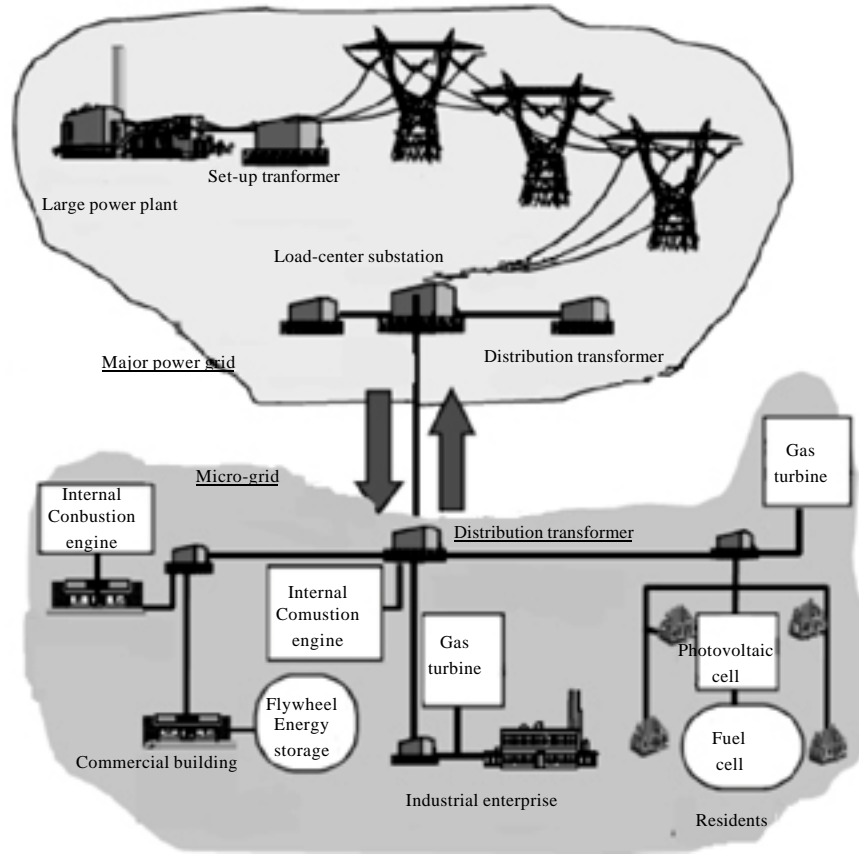


Fig. 1 micro-grid and large power grids

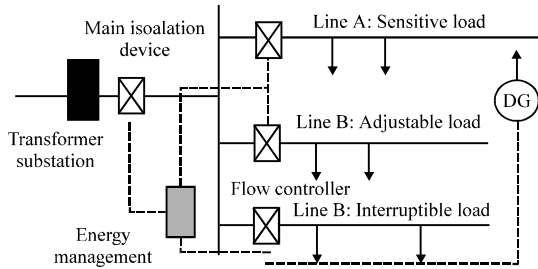


Fig. 2: CERTS micro-grid structure

three categories that have different requirements for the quality of power supply load and that is sensitive to the load, the load can be adjusted and interruptible load. It also contains three feeders and load and has a radiating structure network. Micro power within the micro-grid can be photovoltaic, micro-turbines and fuel cells and other micro-power forms. Micro-power, those close to the heat user, can also provide heat to local users, thus ensuring full utilization of energy. When the load changes, the local

micro-power adjust power output itself. In the micro-grid and it is equipped with the energy management and a flow controller, to achieve the entire micro-grid integrated control and optimization. Only a common connection point makes micro-grid and grid connected large and it is not the big power output of energy.

**The operations and switching mechanism of micro-grid:** There are two ways of micro-grid working which are connecting and islanding operations. In normal, as the micro-grid connects with main grid, it is supported by rigid voltage and frequency of the large grid to adjust its own power delivery under the control of energy management system or local system. When the voltage of large power grid is unsteady such as increasing or decreasing sharply, or it has some problems of the power quality such as unbalanced or harmonic situation, the micro-grid will change to islanding operation. When the grid faults disappear, the micro-grid will connect the main power grid again. The switching mechanism of micro-grid is showed as Fig. 3.

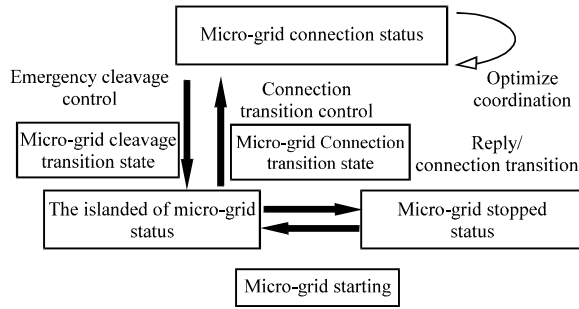


Fig. 3: The switching mechanism of micro-grid

**THE PROBLEM OF THE DEVELOPMENT OF CHINA'S MICRO-GRID**

At present, the Chinese micro-grid technologies have two different forms which include industrial/commercial/residential Micro-grid and remote areas Micro-grid. The former is mainly used in industrial parks, university campuses and commercial buildings to deal with emergency and disaster. And it can improve the quality and reliability of power supply and increase the use of renewable energy and energy efficiency. In generally, it always connects to grid by using plug and play system. The latter, the micro-grid remote areas, are primarily in order to promote the development of electrification in remote areas to reduce the consumption of fossil fuels which works generally in the form of Micro-island network.

The China's "Twelfth Five-Year Plan" will actively promote the development of renewable energy. China's Renewable Energy Development Strategy is one of China's key development strategies. What is mentioned in "Twelfth Five-Year Plan" White study is that in the energy load centers China will accelerate the construction of natural gas distributed energy systems; In the city industrial parks and other energy consumption centers, China will vigorously promote the application of Distributed Renewable Energy Technologies; In rural areas, forest and Sea Island, China will find suitable measures to promote Distributed Renewable Energy Construction in the local condition. China will develop distributed energy standards, improve the distributed energy electricity price formation mechanism and policies and strive to achieve distributed power direct supply and non discrimination. China will also make the policies to support the barrier free access to the grid; During "Twelfth five-Year" period, Distributed energy demonstration building areas will be up to about 1,000. And there will be about 10 typical area's pliancy for natural gas distributed energy projects.

During the practice of the micro-grid construction, Chinese government encourages and supports the development of distributed energy and the implementation of micro-grid demonstration projects. The pilot Micro-grid projects which are conducted by the China National Electric Power Research Institute are as follows: The new Tianjin eco city intelligent business office micro grid demonstration project which is a national ecological demonstration building projects and has completed the plan, design and system integration of the intelligent micro-grid Business Hall (including 5kW wind power, 30 kWp PV, 25 kW\*2 h storage). The new Austrian (Lang Fang) future energy eco city micro power grid comprehensive demonstration project which has completed plan and design in the first phase and equipment selection includes gas-fired power 150 kW, 100 kW photovoltaic, 100 kW micro-grid battery. It will complete micro-grid system integration and commissioning in the second phase; Eastern Mongolia distributed generation and Micro-Grid operation access control engineering which is responsible to the plan and design of CHENBAERHUQI scenery storage micro-grid (grid-connected micro scenery storage network, 100kW PV, 75 kW wind power, 25 kW\*2 h storage), Ergun Taipinglinchang scenery storage micro-network (of island scenery storage Micro-grid, 150 kW PV, 20 kW wind power, 100 kW\*2 h storage) and two pilot projects Eastern Mongolia distributed generation/storage and micro-grid pilot project not only solves the electricity supplying problem of 100 herder households, but also takes a substantial step in the micro-grid construction and coordinate of the micro-grid and Large power grid. The "Twelve Five" new energy plan points that 30 noted Micro-grid demonstration projects will be built across the country.

Overall, seeing from the academic researches on Micro-grid, in China, there is still no clear Micro-grid conception yet. Most studies have focused on the relationship between the Micro-grid and distributed power or to distinguish them. Some of the researches have clarified the key issues of the micro-grid recently and launched the preliminary studies and simulation tests on the Micro-grid control strategies, optimization and stable operation. In addition, it is still at initial stage of establishing the standard system based on the typical features and the operation characteristics of the Micro-grid. There are still a lot of problems in the development of China's Micro-grid which are as follows:

First, It is not mature of technology. Currently the project is still in the experimental grid demonstration phase. Only very few demonstration areas and the islands have applied this technology. The problems exist in all

aspects of planning and designing, equipment selecting and commissioning. For example, many micro-grid equipments are newly developed which cannot meet the actual demands and lacked of experiment in the field (such as Micro-grid operation and management of devices); Micro-grid monitoring and energy management system is still at the development stage, whose function is not perfect and cannot meet the demands of the operation and management; From the operation of perspective, the current micro-grid project reliability level is not high.

Secondly, the investment and the maintenance costs are high. To meet the requirements of the micro-grid isolated operation and to achieve power balance, the capacity of the energy storage device is required more than 80% of total capacity of which system is costly. Micro-grid energy management systems and monitoring platform are still in the trial operation phrase. The cost of investment is high. The micro-grid operators and maintainers need special training as to undertake the responsibilities to operate and maintain the all equipments of the Micro-grid, especially for remote areas and isolated micro-grid island. Therefore, the costs of operation and maintenance of the Micro-grid compared to the general grid are higher.

Furthermore, supporting policies is imperfect. According to China's Renewable Energy Law, "the government shall encourage and support renewable energy connect the grid " and "national implements the institution of the full protection acquisition system of renewable energy generation." Policy environment supports micro-grid connecting to the grid, but lack of reasonable compensation for grid enterprises leading to the benefits of grid cannot be guaranteed. In addition, the policy of micro-grid construction and operation mode, is not clear yet.

Finally, the standard specification is not complete. Currently, distributed power has already had international standards while in domestic the standards are being developed still. As to the micro-grid accessing, planning, constructing and other aspects of equipment manufacturing, there are lacking of the appropriate technique and management standards at the national level in China. The relevant standard-setting works conducting by the China National Electric Power Research Institute are just completed " technical requirements of distributed generation accessing to power grid " (Q/GDW480-2010) and "technical specifications of distribution network storage system accessing to distribution network" (Q/GDW564-2010) in corporate level, while others are also being explored.

## CONCLUSION

Observing the concept of low carbon, the effective way to solve the problem of new energy use is to combine the energy industry and information industry together in the information era. In the information age, the distributed energy system, from the point of view of energy industry, is the use of renewable energy to solve the predicament of constraints in the traditional energy sources; From the perspective of the information industry, it is an issue of application of intelligent information technology to solve the problem of information transmission and control of power supply and demand and the problem of distributed generation interconnection problems. Micro-grid, as an advanced technology of erasing the contradictions between distributed generation system and main power grid, is going through a fast development which has a huge potential in dealing with such problems of traditional grids, as over-loaded power, too large energy consumption and low power stability. Many countries in the world are involved in the micro grid research and development which have set up a lot of micro grid demonstration project and test platform. Theoretical and experimental studies of micro power grid have made certain achievements. The international seminars and communication also greatly promote the development of the micro grid. But how to achieve the optimal control of micro grid, how to monitor micro grid and how the micro power grid to support the superior network, are still in the air needing much further study.

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