

Research on Development Strategies of Distributed Generation Based on Micro Grid Technology

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Abstract

With the continuous development of economy and social progress, the social requirement of power network is more and more high. This paper, as a basis research of distributed generation, proceed mainly from the impact of distributed generation on power grid, detailed fine analysis of the influence of all kinds of distributed generation on power network adverse, including power system stability, power quality, power supply reliability effect. In order to avoid these adverse effects, we combining the distributed grid technology and smart micro grid, put distributed generation as a branch of the micro grid that can be ideal to connect grid and can avoid most of the problems mentioned above. Distributed intelligent micro grid system uses variety of new energy supply, it is a comprehensive model of power electronic technology, distributed generation, renewable energy power technology and energy storage technology. The paper provides a reference for the use of future distributed power generation.

Keywords: *network, distributed generation, grid technology, micro grid*

1. Introduction

Distributed generation (DG) refers to power in the range of tens of kilowatts to tens of megawatts, modular, distributed load near the clean and green power generation facility to the economic, efficient and reliable power generation. Distributed generation is different from the traditional centralized power generation, long-distance transmission, power generation in the form of large interconnected networks [1].

Distributed generation has the advantages of low investment, small occupied area, short construction period, energy saving, environmental protection and other features, for the peak of the power load more economical and effective than centralized power, so it can be supplied useful supplement for centralized power. As a standby power, distributed power generation can be used as backup power to provide electricity for peak load and improve reliability; can supply power for users in remote areas, commercial and residential; can be used as a local power saving of power transmission and transformation construction cost and investment, improve energy structure and promote the sustainable development of electric energy. The application of distributed generation and energy, technology development, environmental protection and electricity market liberalization have relations, impact analysis, the grid application on the traditional power system control and protection *etc.* the far-reaching, further may cause the change of electricity market, the user side management and other aspects.

The advantages of distributed generation that can fully develop and utilize the various available dispersed energy sources, including fossil fuels and renewable energy can be conveniently obtained locally, and improve energy efficiency.

Distributed power supply usually accesses the medium or low voltage distribution system, and will have a far-reaching influence on distribution system. Traditional distribution system is designed only with the function of the distribution of electricity to the end of user, and the future distribution system is expected to evolve into a media of exchanging power, it can collect power and transmit them to any place, and distribute them at the same time. Therefore, in the future it may not be a distribution system but a power delivery system. Distributed generation has the characteristics of dispersion and randomness, access to a large number of distributed powers, will greatly influence the safe and stable operation of power distribution system [2].

Traditional distribution system analysis methods, such as the power flow calculation, state estimation, reliability evaluation, fault analysis and restore the power supply and so on, are due to varying degrees by the impact of distributed generation and the need to improve and perfect.

Around the world, the country of the higher energy efficiency and better environmental protection keener support for the development and application of distributed energy source technology, and support policy more clearly [3]. Such as Denmark, Holland, Japan on distributed power Sources have taken a series of policies to encourage; after "911 incident", taking into account the power security, the developed countries accelerate the pace of construction of distributed power, so far, Britain has more than 1000 seat distributed power station, even the queen of England's Buckingham Palace, Prime Minister of the 10 Downing Street residence, all use of gas turbine distributed energy Station; the United States has more than 6000 seats distributed power station, there are more than 200 seats distributed energy station in university campus. In the many countries, Denmark is by the worlds recognized the model, to realize the sustainable development of the country. Over the past 20 years, Denmark's GDP over one time, but the energy consumption is not increased, environmental pollution has not increased, and the secret lies in the Danish actively the development of cold, Heat and electricity cogeneration, advocate scientific use of energy, support distributed energy, by enhancing the development efficiency of energy use in support of national economy. At present, Denmark did not have a thermal power plant is not heating, nor a heating boiler room is not power, they put the production of cold, heat and electricity become high-tech cogeneration of cold, heat and power, so that science and technology become true positive productivity.

According to reports in the literature, before 2010, about 25% to 30% of global new generation capacity is distributed generation electric. USA is the world's developed the most countries of new energy and renewable distributed energy generation, is the world's the main provider of commercial distributed power supply equipment. In 2004, the total capacity of USA distributed generation is 67 GW, accounting for about 7% of America domestic total generating capacity, reached the average level of the world, according forecasting of USA electric power scientific institute research, 25% of new generating capacity in 2010 American will use the distributed power, while National Gas Foundation estimated as high as 30%, by 2020 more than half of the new commercial or office buildings use distributed power supply, the existing building at the same time to 2020 15% by the distributed power supply. The European distributed generation resources develop in the leading level of the world; in 2000, in the EU area DG installed capacity of 74 GW, while the 2004 the total power generation of Denmark, Holland, Finland DGRs accounted for the total domestic electricity generating capacity of 52%, 38% and 36%, the EU forecasts 2020 will reach 195 GW, power generation capacity will reach a total generating capacity of 22%.

In our country, ensure an adequate supply of electricity for sustained economic development will play a decisive role, in based on the established central power plant and the power grid, it will be the inevitable future development trend to develop DG technology. The current research on distributed energy system in China has already started, some research institutions, research universities have invested human and financial resources into the distributed energy system. University of Shanghai for Science and Technology in Capstone C60 Micro Gas Turbine Company production as the core, combined with the after burning waste heat boiler, staged combustion absorption refrigerating machine, Cold storage and heat storage system and construction of demonstration type energy island, for the study of distributed energy system. Xi'an Jiao tong University using 100kW gas turbine as the core, set up the distributed energy to the hotel for the application object System. Institute of Engineering Thermo physics and there are a lot of distributed advanced energy system mode and related evaluation system Study on the price of the. North China Electric Power University energy clean and focus on the use of laboratory, established a dual source reversible heating (air conditioning) system experimental platform.

Overall, the distributed energy system research in advanced western countries has achieved fruitful results, the research field of distributed energy systems from a single run to just the rise of distributed energy systems and near join a large grid, has extensive experience in distributed energy system operation. While in China, the research of the distributed energy system is still in its early stages, the large-scale use of distributed energy system is still a long way to go. Domestic on research of the independent operation of the distributed energy system research much more, mainly the economic evaluation and the evaluation standard of distributed energy system with various grid.

2. The Research Significance and the Advantage of Distributed Generation

2.1. The Defects of Distributed Generation

The power system of centralized power, long-distance power transmission and large power grid interconnection is the main mode of the production of electric energy, transportation and distributing, is to supply power to more than 90% of the world's electric power load. But it also has some malpractices [4].

There are mainly:

(A) In large-scale power grid local accident easily spread, small disturbance fault at any point of the generated will be greater impact on the whole power, resulting in a large area power outage, or even the whole network collapse, while The larger power system, the higher the probability of the accident.

(B) Large power grid vulnerable to destruction of war or terrorist forces, serious will endanger state security.

(C) Changes in large power grid cannot be flexibly tracked of power load change, such as a surge of air conditioning load in summer causes power supply short deficiency, in order to short-term peak load to build power plants and transmission facilities huge cost, very low economic benefit, with the continuous increase of load peak valley difference, load rate is decreased year by year; the use rate of power facilities has a downward trend.

Therefore, we need to study the combination of mixed system of large power systems and distributed power generation systems, not only can save investment, reduce energy consumption, but also can improve the safety and flexibility of the system.

2.2. The Advantages of Distributed Generation

(A) Energy saving

In the current background of building a conservation minded society and promoting energy-saving environmental protection, distributed generation can be said to be a bright star of electric power industry, once the face of international development in distributed generation can be seen: the country of the higher energy efficiency and better environmental protection keener support for the development and application of distributed energy source technology, and support policy more clearly. There are two obvious difference between the traditional power grid and distributed power supply: first, the distance of traditional large power grid and electricity load is very far, usually to input to give user remote, especially in China, large power distribution is extremely uneven, electricity consumption of long-distance transmission is very considerable, and distributed power supply is closer to the user site, thus the net loss decreased significantly; second, the form of the traditional great power supply mode is single, and distributed power supply can provide various forms of energy, typically cold, heat and power cogeneration can achieve three energy cascade utilization. In line with the "temperature counterparts, cascade utilization" principle, thus greatly improves the overall efficiency of energy use.

(B) Reduce air pollution

Air quality is closely linked with our life quality, air pollution is in large part from the various fires power station, in our country at present, and the efficiency of thermal power generation in the world is not high. Raw material of distributed power generation is using natural gas, oil and other clean energy and wind power, hydro, tidal, geothermal and other renewable energy, to reduce carbon dioxide, carbon monoxide, sculpture and nitrogen compounds and other harmful gases emissions, at the same time, because the voltage class of distributed energy system power is relatively low, the electromagnetic pollution is much smaller than traditional set Chinese generation.

(C) Increase the economy of power grid

Using the technology of distributed generation, the demand of the new centralized power plants and long-range transmission lines will be reduced less. First of all, the large of new load will meet by distributed generation; secondly, because the distributed may cut a peak and fill valley load, balancing power, the use rate of existing power generation and transmission facilities will be greatly improved, the some utilization rate is extremely low, only to meet the need of the peak load generation and transmission facilities will no longer have the necessary construction. Thus greatly enhance the network economy. In addition, the distributed generation can also be used as a backup power for peak load Provide power, not only to improve the economy of power network, but also improves the reliability of power grid operation.

(D) Reduce line loss

Because distributed generation can be used as a local power supply, so the transmission and distribution loss is very low, not only saves the construction cost and investment of power transmission, but also can reduce the power consumption of the long distance transmission lines. In addition, we also can real-time monitor the quality and performance of regional electric power, to further reduce the loss and improve power transmission efficiency, very suitable for mountainous rural and pastoral areas, residents, power supply in the development of medium and small cities or commercial district.

(E) High reliability and power quality

In unabated trend of rapid expansion of the large power plants construction, the rapid expansion of power grid brings a great threat to the security and stability of power supply.

Once the power plant and transmission route failure occurs, it will lead to large area blackout. Distributed power supply uses the control equipment of advanced performance. Open and stop convenient, simple operation, flexible load regulation, and it can greatly improve the reliability of power supply with large power grid distribution, make up the shortage of its security and stability. When it appears the collapse of power grid and unexpected disaster harm (earthquakes, snowstorms, man-made destruction, and war) it can maintain the power supply of important users.

The internal of distributed power supply usually install a local voltage regulation and reactive power compensation, thus ensuring the quality of electric energy. In addition, the investment of distributed power supply relatively compared with large power grids and large power plants is very small, the risk is also smaller, and the construction period is short, is conducive to a short period of time to solve the problem of power shortage [5].

3. Classification and Energy Forms of Distributed Generation

(A) Distributed generation technologies based on fossil fuel

Reciprocating engine technology: reciprocating engine using distributed generation use fire or compression ignition of four stroke point, with gasoline or diesel oil as fuel, is distributed generation method by being used widely at present. But this approach will have an impact on the environment, recently by improving on its technology, has greatly reduced the noise sound and the exhaust emission pollution.

Micro gas turbine technology: micro gas turbine is ultra small gas turbine referring to the power of below hundreds of kilowatts and natural gas, methane, gasoline, diesel oil as fuel. But the efficiency of micro gas turbine is low compared with other power generation technology. The efficiency of the full load operation is only 30%, while in the half load operation, its effect rate is only 10% ~ 15%, so the current use of domestic cogeneration way by using equipment of waste heat to improve its efficiency (up to 75% or even higher). The characteristics of micro gas turbine are small in size and weight .The implementation of cogeneration is light, high power generation efficiency, low pollution, easy operation and maintenance. It is one of the most mature and business competitiveness the distributed power supply. The key technology is mainly the high-speed bearing, high temperature materials, and parts processing *etc.*

Fuel cell technology: the fuel cell is an electrochemical device that can directly converts the chemical energy into straight current under isothermal state. Fuel cells work does not need to be burned, and no environmental pollution, its power is obtained by electrochemical process. In the anode through a hydrogen rich fuel, a cathode is above through the air, and put the separation of the two substances by electrolyte. In the process of obtaining electric energy, some of the by-product is only heat, water and Oxidation Carbon *etc.* Hydrogen fuel can be made of various hydrocarbon sources, under the pressure of steam reforming process or by the reaction of oxidation.

(B) The technology of hybrid-type distributed generation

An important direction is multi-objective generation energy supply systems of being mentioned thermo, electric, and cold, usually referred as the distributed energy supply system. In the production of electricity at the same time, it can also provide heat or satisfy heating and cooling requirements. Compared with the power supply system, distributed energy supply system can be integrated with energy cascade of science, thus greatly improving the energy efficiency of thermal economy and reducing environmental pollution, improve thermal economy of the system.

Cogeneration is 2 kinds of circumstances [6]:

Mainly for power generation, using a large capacity units, only a small part of utilization of waste heat, electricity into high voltage transmission network distribution, this should be attributed to the centralized power cogeneration;

To heat determine power, in the premise of satisfying certain heat load demand, to the construction of small heating unit, power digestion by the users themselves, or digestion in the local distribution network in the region.

(C) The technology of distributed generation based on renewable energy

Solar photovoltaic power generation technology: solar photovoltaic technology is using the photoelectric effect of optoelectronic semiconductor material that may directly convert solar energy into electric energy. Photovoltaic power generation has the advantage of no consumption of fuel, not subject to geographical restrictions, scale flexible, non pollution, safe and reliable, simple maintenance *etc.*. But the cost of this kind of distributed power generation technology is very high, so the solar power generation technologies need improvements in technology at the present stage, to reduce the cost suitable for wide application.

The wind power generation technology is generation technology by converting wind energy into electric energy power generation technology, as the wind power is environmental protection and can be regeneration, the global feasible, low cost and the high scale benefit, has been more and more widely welcome, become the one of new energy of the fastest development. It can be divided into independent and grid connected operation, the former is micro or small wind power generation unit, capacity is 100W ~ 10kW, the capacity of the latter is usually more than 150kW, usually have more than one larger capacity wind turbine components of wind generator group, called the wind farm (also known as the wind field, wind field), with machine group of large-scale, centralized installation and control characteristics. In recent years, the wind power generation technology is making rapid progress; the technology of stand-alone capacity in the following 2MW has been very mature [7].

4. The Adverse Effects and Solutions of Grid Connected Distributed Generation on Power Network

4.1. The Adverse Effects of Grid Connected Distributed Generation on Power Network

In recent years, the rapid development of distributed power supply, more and more application, in the enormous energy-saving effect at the same time, there are many bad phenomenons; the most prominent is the related problem of distributed power grid.

The main problems are as follows:

(A) Large changes of network structure

The distribution system will be a fundamental change: from a radiation type network into a throughout power and user interconnection network networks, somewhat similar to internet. The control and management of the distribution system will become more complex. The introduction of distributed generation will make the operation and planning of the traditional distribution network (such as reactive power compensation and voltage control) completely change; distribution automation and demand side management (DSM) also need to be reconsidered; distributed power between the control and scheduling must be coordinated and laws, regulations and industry standards associated with the distributed power supply also need to be properly formulated [8].

(B) Setting problem of distribution network relay protection device

The introduction of distributed power supply and uncertainty of the distribution network power flow will cause the distribution network voltage control trapped difficult, cause voltage flicker, lead to disoperation of relay protection, will also have a short circuit current of the power system, relay protection setting and operation value setting increased certain difficulty, need to solve the reliability problem, and especially is the coordination problem of relay protection. DG by 10 kV feeder access to distribution system, and the level of the match electric system generally uses 3 section current protections (instantaneous current quick break protection, timing and limiting current quick break protection, over current protection). DG access may lead to reduce the sensitivity of the protection device, and even refused to move, may also lead induced protective device disoperation, and temporally adjacent line quick break protection device malfunction, lose selectivity.

(C) The introduction of a large number of harmonics, power quality decline

Distributed power grid, due to the large number of power electronic devices used in distributed power supply, so it cannot avoid Free to bring a large number of harmonics to the influence of the system, the harmonic amplitude and order by generating mode and working mode of the converter. At the same time, stability and voltage on the voltage waveforms have different degrees of impact.

(D) The influence of the static stability of power distribution network

Distributed power grid will produce the effect of static stability of the distribution network, the extent of influence depend on the different types of distributed power supply. For the use of asynchronous generator interface DG, grid connected have a negative effect on static voltage stability of the system, grid position is far from the most weak branch system, the negative impact is on the more small; for the synchronous generator without excitation of the DG interface and with the variable power control unit Heat exchanger as the interface of DG, grid can improve the static voltage stability of the system, grid position is closer to the line the most weak branch, is to improve static voltage stability of the system the more significant.

(E) Other problems

Distributed generation have the problem of covering, the efficiency and of meter. If a distributed power stations construct inside the city, the city is very crowded .Because energy is a two-way flow, such as results the roof installed solar energy, so the day no one is at home without electricity, the electric energy into the distribution network. So these conditions of the ammeter will record all. Now the foreign adoption meter bidirectional measurement. If we do this method, so a great deal of meter should be changed. The problem of efficiency, the efficiency of distributed generation can reach more than 80%, but sometimes can reach more than 60%. There are problems of environmental protection and fire safety problem [9].

4.2. The Solution for Grid Connected Distributed Generation Adverse Effects

Micro grid technology is inventing the name by American first. The establishment of micro grid, when there is a fault in a distribution network, it can avoid trip, because the micro grid structure makes contact of the whole grid and distribution network weak. Once there is the failure of words, it can connect to jump off. At the same time, there are many branches of micro grid structure; the less important load put on a branch, when you need cut off, you can cut all the less important branches. The use of micro grid structure, there will be a lot of transformation, relay protection and all control equipment is not the same. This is the characteristics of micro grid. Putting the distributed generation as a branch of the micro grid, it can be the ideal with grid connected and can avoid most of the problems mentioned above [10].

Distributed intelligent micro grid system uses variety of new energy supply, it is a comprehensive model of power electronic technology , distributed generation, renewable energy power technology and energy storage technology, the integration of multiple distributed generation units and loads as a separate power grid system, independent supply power to the load or with the city power supply power to the load by the wind light wood electronic system composed of distributed micro grid structure shown in fig. 1.

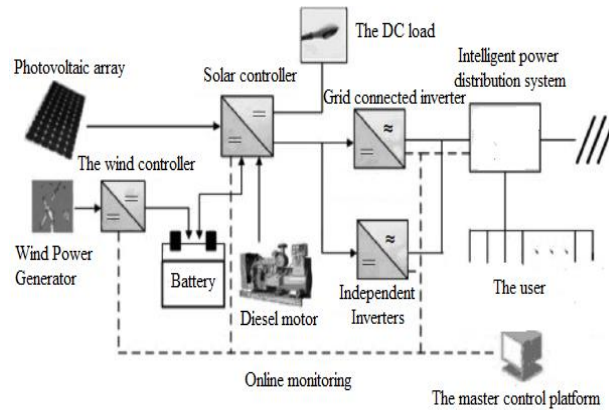


Figure 1. The Structure Diagram of Distributed Intelligent Micro Grid System

Mode of power supply: solar and wind power generation first storage, when the battery is full, solar and wind power automatic switch energy to grid connected power supply mode, and with an external power grid power to the load (Plant configuration of backflow prevention device). When external power grid appear failure or disaster, the micro grid system automatically cut off the external power grid, independent power supply mode automatic will start, by a diesel generator and battery device after the conversion of electric energy to control to the important load power supply.

With the development of power electronic technology, computer advanced control technology, communication technology is closely related to micro grid technology, the intelligent micro grid system contain with the following components.

(a) The master control platform. It can be achieved to realize the energy management platform of the whole system, using dual function of the system operation and display platform, is a management tool of intelligent micro grid autonomous operation.

(b) A variety of distributed power supply.

(c) More intelligent load user.

(d) The power network self-healing ability. Composing of a measuring device, a switching device and a communication device, it can realize the functions of fault location diagnosis and isolation, and automatic recovery of power supply.

(e) Reservation extensible interface.

Distributed generation will become the future of an important energy production, it will with micro grid and smart grid with the change in power system network structure and operation mode of low level, and the distributed intelligent microgram system based on intelligent power distribution network as a platform, the effective integration of distributed generation technology and micro network technology, play technology the advantage of them, i.e. the combination of advanced power electronic technology, will be a variety of distributed micro power supply, load, energy storage system and control device combined system unit composed of a single controlled, at the same time alone or with external power grid with the supply of electric power to the users.

5. Conclusion

The human production and life are increasingly troubled by the current energy crisis shadows, in order to solve this problem; people begin to pay attention to the new energy, distributed power supply. Distributed generation play a more and more important role, as an important supplement to the traditional forms of power generation, power industry at present. This paper, as a basis research of distributed generation, proceed mainly from the impact of distributed generation on power grid, detailed fine analysis of the influence of all kinds of distributed generation on power network adverse, including on power system stability, power quality, power supply reliability effect *etc.* In order to avoid these adverse effects, we combining the distributed grid technology and smart micro grid, put distributed generation as a branch of the micro grid that can be ideal to connect grid and can avoid most of the problems mentioned above. The paper provides a reference for the use of future distributed power generation.

References

- [1] Y. W. Liang and Z. J. Hu “Research Review of Distributed Generation and its Application in Power System”, Grid Technology, vol. 27, no. 71, (2003).
- [2] F. I., “System Research on Uninterrupted Access on Distributed Power Substation”, The Relay, vol. 35, no. 13, (2007).
- [3] X. X. Liu, “Study on Mechanism of Distributed Power Supply System of Power Quality of Distribution”, Grid Technology, vol. 20, no. 21, (2009).
- [4] H. Y. Chen and J. F. Chen, “Power Flow Calculation of Distribution Networks with Distributed Generation”, Automation of Electric Power Systems, vol. 30, no. 35, (2006).
- [5] Y. Z. Lei, “Studies on Wind Farm Grid”, Automation of Electric Power Systems, vol. 27, no. 84, (2003).
- [6] C. M. Shen and M. A. Laughton, “A New Type of Power System”, the Micro Grid, Microgrid, Research Review, Proceeding of IEEE, vol. 117, no. 2117, (2009).
- [7] J. Sheng and L. Kong, “The Reliability Model of Electric Vehicle Driving Motor and Expected”, The Relay, vol. 35, no. 75, (2007).
- [8] L. Han, “Application of Photovoltaic Technology in Energy Saving Building”, Low Voltage Electrical Apparatus, vol. 2, no. 4, (2009).
- [9] Z. H. Zheng and Q. Ai, “Consider the Distributed Environment Factors Multi-objective Optimal Allocation of Power”, Chinese CSEE, vol. 29, no. 23, (2009).
- [10] Z. H. Zheng and Q. Ai, “Research on Multi-objective Optimal Operation of Smart Grid”, International Conference on UHV Transmission, vol. 3, no. 20, (2009).

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