

# Research on Principles and Key Elements of Active Distribution Network Planning

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**Abstract:** With the rapid development of China's social economy, people's demand for electricity is growing, and the quality requirements for power supply and distribution work are becoming higher and higher. The operation level of distribution network system will directly affect the quality of power supply and distribution. Active distribution network planning needs to follow the principles of automation system construction, communication system construction, new energy access and voltage management. In the process of active distribution network planning, full consideration should be given to power load, resource technology and comprehensive evaluation to build a safe and stable active distribution network

## 1. Introduction

Active distribution network model is a technical solution that can optimize the use of distributed energy resources [1]. At present, the international community is still in the exploratory stage. The main problem faced by active distribution network planning in developed countries is to use various DER (Distinguished Encoding Rules) to achieve multi-time scale power balance in mature distribution networks. However, the active distribution network planning in China is still facing the rapid growth of load demand. The main problem to be solved is to meet the rapid growth of load at the same time, to cope with the high penetration of various types of distributed energy access. It requires not only to satisfy the optimization of network layout, but also to optimize the allocation of non-network solutions. In the traditional radial and unidirectional power flow medium voltage distribution network, it is designed as a passive load network. When the permeability of distributed generation is high, the access of distributed energy will bring a series of impacts on the short-circuit level and equipment selection, reactive power and voltage distribution, fault clearance process, protection, unplanned island operation, planning and operation mode of existing distribution network. With the development of power grid, while the user load increases, the access scale of distributed generation and energy storage equipment is gradually expanding, and consumer expectations are also increasing. All these make the planning, design and operation of distribution network face new challenges. As a part of the new model, the technological progress of small-scale distributed generation system, the new requirements for its efficiency, safety and quality of power supply, and the opening of power market make it possible for distribution system operators to control and optimize the operation of distributed energy within their responsibilities to integrate the distributed energy and distribution network management. Under this conception, the planning concept of distribution network realizes the transition from passive distribution network to active distribution network [2].

## 2. Principles of Active Distribution Network Planning

### 2.1 Principle of Automation System Construction.

Distribution automation system is mainly composed of main station, distribution terminal and communication network. By collecting real-time and quasi-real-time data of medium and low voltage distribution network equipment operation, running through the electrical connection topology of high

voltage distribution network and low voltage distribution network, integrating business information of distribution network related systems, supporting distribution network dispatching operation, fault emergency repair, production command, equipment maintenance, planning and design, etc. The construction of lean management distribution automation system should follow the relevant technical requirements of the State Electric Power Regulatory Commission and the relevant provisions of the company on the safety protection of medium and low voltage distribution network. The main characteristics of new energy generation equipment should be involved in the distribution deterministic modeling based on active distribution network, and the uncertainty modeling and deterministic modeling should be carried out according to its characteristics. From the normal distribution statistics of the electric vehicle's power generation performance and power characteristics, it is found that the driving mileage of the electric vehicle cannot bear the corresponding coincidence. Under the Monte Carlo simulation method, the electric bicycle should be charged orderly to balance the overload load of the electric vehicle. The second point is to analyze the distribution network planning problem in detail, and the given objective function is given, and the constraints are also determined. The first constraint is the system capacity constraint. The second constraint is capacity constraints of distributed generation and electric vehicle charging station, and the third constraint is permeability constraints [3].

## **2.2 Principle of Communication System Construction.**

This paper studies the specific objectives and quantitative indicators of terminal communication access network planning level year, and sets differential targets for different distribution areas. Quantitative indicators include but are not limited to the following indicators. Wireless and carrier should be described separately referring to the overall design of distribution communication network. According to the planning objectives and technical policies, the key projects of terminal communication access network to the planning level year are put forward, and the necessity, construction scale and expected objectives of key projects are briefly discussed. According to the construction sequence of key power distribution and telecommunication projects in the planning period, the project arrangement is given year by year. According to the technical requirements of information exchange bus, we should configure the hardware and software of information exchange bus reasonably according to the size of main station and the number of interfaces of related information system.

## **2.3 Principle of New Energy Access.**

The Technical Guidelines for the Planning and Design of Distribution Networks have made relatively reasonable provisions for the distribution network to have its own distributed power supply acceptance capacity [4]. The guidelines provide some principles and opinions on the maximum access capacity of distributed power supply, but in fact, the factors limiting the maximum access capacity of distributed power supply are far more than those described in the guidelines. When the distributed photovoltaic system is connected to the grid with the maximum access capacity, the maximum access capacity level of the distributed photovoltaic system will be determined by all factors affecting the stability and power quality of the distributed photovoltaic system connected to the grid. The main factors affecting the maximum access capacity of photovoltaic are as follows. The load capacity of PCC (Programmable Computer Controller) at the access point of distributed photovoltaic system is strong or weak. Reactive power compensation status of distributed photovoltaic system. Regulating capacity of conventional units in the system. As the power output of distributed photovoltaic system is susceptible to illumination, it is necessary to have a certain spinning reserve capacity.

## **2.4 Principle of Voltage Management.**

The connection mode of traditional distribution network is single, and energy can only flow in one direction. However, with the access of distributed grid, on the one hand, the original fixed connection mode has been changed, so that the grid energy can be adjusted according to the actual situation at any time, giving full play to the essential characteristics of the network topology structure, its

advantage is that it can adjust the grid structure, and then change the direction of energy flow. On the other hand, due to the use of power electronic converter in distribution network, the original characteristics of reactive power and voltage are effectively changed. Through analysis, it is found that there are intuitive changes in both steady-state and transient state of the system, which is a good opportunity for the development of reactive power and voltage allocation. Active distribution network makes controllable by combining advanced technologies such as information communication, power electronics and intelligent control. The network topology can be adjusted flexibly and has better observability. It can achieve coordination, optimization, management and control functions. As one of the core tasks of active distribution network operation, active distribution network optimizes and controls the operation of grid-connected, energy storage, on-load tap-changer, reactive power compensation, etc. under the condition of satisfying the load demand of power users through reactive power and voltage control of cross-voltage level, so as to achieve flexible control system of supply voltage, improve the operation level of reactive power and voltage, and reduce the operation level of reactive power and voltage.

### **3. Key Elements of Active Distribution Network Planning**

#### **3.1 Power Load.**

The controllability of user load is mainly affected by environment, habits and production, and can be divided into three types: uncontrollable, power controllable and time controllable. The uncontrollable load mostly belongs to the necessary load related to production and life, and can only be executed within a prescribed time. Generally, it has no adjustable potential. Power adjustable load is mainly related to heating, ventilation and air conditioning, which is vulnerable to the dual effects of environment and habits. Time-controllable loads are mostly concentrated in industrial or commercial areas. Its execution time has little effect on the utility of electricity, and can be arranged freely in a certain period of time. In the overall construction of active distribution network, the problem of power load has always been a very serious one. Because the size of electricity is very difficult to choose. If the connected power is too large, it is easy to cause the overload of the power grid to be too large, which will cause the complete collapse of the entire power grid and cause serious losses. If the interpreted power is too small, then in the use of electricity, there will be insufficient power, resulting in frequent blackouts or weak current phenomenon. Let people use the process of problems. Therefore, in the construction of active distribution network, we need to do a good job in these aspects. The first is the investigation. It is necessary to investigate the number of electricity users provided by the distribution network, so as to calculate the large amount of power consumption caused by personnel. Only in this way can the distribution network respond. So as to better ensure that the active distribution network will not be overloaded. Secondly, the power consumption situation is forecasted. To predict the peak value of people's power consumption, the construction of distribution network should be carried out according to the peak value, but not according to the average situation. Otherwise, it is easy to damage the distribution network. At the same time, the active distribution network and the transmission distribution network have many differences, we need to pay attention to the government's electricity policy. Only under the leadership of the government can the construction of active distribution network be considered comprehensive and be trusted.

#### **3.2 Resource Technology.**

In addition to power load forecasting, the key problem of active distribution network planning is the understanding of resources. Each resource used in active distribution network has its own unique intrinsic technology, and the characteristics of technology directly affect the accuracy of power transmission in distribution network. Although the resources in the planning process will not be converted into electricity, the resources in the planning will also exist while users use electricity. In order to determine the technical performance of resources, it is necessary to have a full understanding of user information. The user's power consumption represents the power load that will be brought to the active distribution network. Researchers decompose loads and analyze their characteristics, and

then get the technical characteristics of resources in distribution network. The randomness and uncertainty of wind power output. Influenced by region, terrain and season, the average daily output of wind power also has different effects. When there is more windy weather in a certain region and season, there will be large wind power output or small wind power output for many days in a row. When the weather is not ideal, there will often be zero wind power output. Much depends on the weather, and the uncertainty is high. Solar power generation is not limited by the geographical distribution of resources, and the time to obtain energy is short, the quality of energy is very high, and the main material of solar cells, silicon, is very rich in natural reserves, good stability, and equipment maintenance procedures are relatively simple. However, due to the low energy distribution density of solar irradiation and the low annual power generation hours, the solar power output is relatively stable in a specific season due to weather factors such as season, day and night, and cloudy and sunny weather. It can maintain a relatively good continuous and large output in a short period of time. However, it is still difficult to accurately predict the power output of the system.

### **3.3 Comprehensive Assessment.**

The evaluation of planning scheme includes feasibility evaluation, economy evaluation, reliability evaluation, risk evaluation, etc. We can improve the DG permeability of active distribution network by means of static and dynamic reconfiguration, and evaluate the impact of this method on permeability. Compared with using reliability or economy as a single index, comprehensive evaluation using multiple indicators can better reflect the level of energy efficiency, and help to accurately find the energy efficiency improvement point and effectively carry out active distribution network planning. Active distribution network technology has a comprehensive impact on the distribution network. It will not only improve the economic benefits of the distribution network, but also enhance the power supply capacity of the grid. It will also produce certain environmental benefits for the rational use of distributed Renewable energy. Based on the principle of constructing comprehensive evaluation index system and the characteristics of active distribution network planning scheme, this paper comprehensively evaluates active distribution network planning from seven aspects: power supply capacity, power supply security, power supply reliability, network structure level, equipment technology level, economic benefits and environmental benefits. Comprehensive evaluation is to evaluate the multi-attribute architecture of complex objects globally and wholly. The scientificity of the comprehensive evaluation method is related to the rationality and credibility of the comprehensive evaluation results. The index weight can be calculated by analytic hierarchy process. Analytic Hierarchy Process is to decompose complex problems into distinct layers, establish hierarchical structure, and compare all factors at the same level in two ways to determine the relative importance and construct a judgment matrix. By solving the eigenvector of the maximum eigenvalue of the judgment matrix, the weight of all factors at the same level can be obtained. Analytic Hierarchy Process quantifies the decision-making problems which are difficult to quantify quantitatively by subjective judgment, which can make the assignment of each factor more reasonable.

## **4. Conclusion**

There are many problems in active distribution network planning, and the current research on this aspect is in the initial stage. Therefore, research institutes and staff should intensify their deep exploration of these problems, and pay attention to using modern technology to solve them to optimize the active distribution network planning, accelerate the application pace of active distribution network planning and achieve the expected goals.

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