Research on Key Technologies of Intelligent Operation Control of Super-large Urban Power Grid Based on Multi-center Structure

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Abstract: Under the background of higher and higher requirements of intelligent, reliable, green and efficient operation of power grid, the traditional operation control technology of urban power grid can no longer fully meet the new requirements of integrated operation and intelligent dispatching. The increasing environmental pollution and the gradual shortage of natural resources promote the rapid development of intelligent technology for distribution network dispatching. Traditional urban distribution network management ideas, especially the concept and mode of distribution network dispatching, can no longer adapt to the new situation, and need to be repositioned and studied deeply. In the construction of intelligent distribution network, intelligent control system is a very important part, which has a very positive significance for the overall operation of the power grid. This paper takes the construction of intelligent distribution network dispatching system as the long-term vision, extends the development and application trend of intelligent distribution network dispatching technology, and puts forward ideas on how to construct the concept and key technology of intelligent distribution network dispatching suitable for China's super large cities based on the city multi-center structure.

1. Introduction

With the development of modern power grid technology and the update of user power technology, various uncertain factors and potential risks have an increasing impact on the safe operation of the power system, and users have put forward higher requirements for the continuity and quality of power supply [1]. The essence of the economic distribution problem is to improve the economic efficiency of the power system operation as much as possible on the premise of satisfying the constraints of power balance, line flow and generator power upper and lower limits. With the increasingly serious environmental pollution and the gradual shortage of natural resources, prompting the rapid development of intelligent dispatching technology of distribution network, the intelligent system technology of urban large-scale distribution network dispatching must be designed on the premise of green and renewable energy [2]. The current level of urban power distribution network technology management is difficult to adapt to the rapidly accelerating urbanization process and large-scale power grid construction. This is prominently reflected in the rapid growth of electricity load in these mega-cities, and the internal and external environments of safe, stable, and economical power grids. Great changes have taken place [3]. The development of modern cities has promoted the adjustment of the industrial structure to modern service industries and advanced manufacturing industries, and has put forward higher requirements for the reliability of power supply, power quality, and the...
diversification and individualization of power services [4]. In the construction of the intelligent distribution network, it is necessary to be able to do a good job in the deployment of the dispatch control system to better achieve the operation goal of the distribution network.

The economic distribution problem of power system is actually a high-dimensional, nonlinear mathematical problem, the model is complex and difficult to solve [5]. Traditional urban distribution network management ideas, especially distribution network scheduling concepts and models, can no longer adapt to the new situation, and need to be repositioned and studied in depth. The design concept of the distribution network dispatching intelligent system is: use the flexibility of distributed energy to adjust the technology of the network, integrate the flexible load resources and storage energy resources of the distribution network, and use the regulatory environment method and the criteria of distributed energy access. The system is designed reasonably [6]. There is a significant difference between intelligent distribution network dispatching and traditional distribution network. The main manifestation is that intelligent distribution network dispatching is based on connected distributed power sources as the basis for power generation, and operators control storage energy units and distribution networks. Unit [7]. The complexity of power system characteristics puts forward higher requirements for grid operation control. The grid side has more levels and complex structure, and multiple stable forms such as static, transient, dynamic, voltage and frequency coexist, which increases the difficulty of grid stability control [8]. This paper takes the construction of the intelligent distribution network dispatching system as the long-term vision, and extends the thinking about the development and application trend of the intelligent distribution network dispatching technology. Based on the multi-center structure of the city, how to build a smart distribution network suitable for my country's super large cities The concept of scheduling, key technologies and ideas.

2. General framework of operation control system for super-large city power grid

2.1 Emergency control plane and dispatching monitoring plane of control strategy

In the system, the information platform is a data integration platform with good scalability and standardized interface, and information service and integration of power grid information resources are the core functions of the platform. In actual operation, the power grid systems of different systems will be integrated after collection. For power grid information resources, it is the general name of different facilities, users and power grid equipment in distribution network, including geographic information, topological information, electrical equipment parameters and facility account information, etc., and also has different types of graphic resource information. In order to achieve the overall operation goal of safety, high quality, economy and high efficiency, the power grid operation control needs to formulate relevant control measures according to the requirements of the control goal, and undertake the implementation through the corresponding control system, and determine the corresponding time scale of the control strategy [9]. In the specific work, in order to better carry out the maintenance and load transfer work in the first area, and to analyze the priority failure emergency repair in the second area, it is necessary to be able to do a good job of power supply reliability analysis, and provide support for load transfer, load reduction and emergency repair work after obtaining the results through comprehensive analysis. Intelligent distribution network dispatching not only serves power enterprises, but also faces users, which is the key part for users to feel the intelligence of power grid, and also the ultimate realization of the service value of smart grid. In order to meet the requirements of safe, stable, reliable and economic operation of the power grid and achieve the control goal of system-wide optimization and coordination, we should examine all kinds of control objectives from an overall perspective, analyze the synergy between protection and control functions at all levels, and fully combine the actual operation needs to achieve global optimization and coordination control.

2.2 Hierarchical analysis of power grid operation control function

Wide-area protection and control system uses wide-area information to achieve coordination and optimization of protection and control from the perspective of overall security and stability of the
power grid, thus improving the overall power supply reliability of the power grid. How to extract the key features and weaknesses that can represent the current distribution network online and in real time from the high-dimensional space has become the first problem to be considered in intelligent distribution network scheduling. The intelligent operation of urban large-scale distribution network dispatching is different from other distribution network dispatching systems, which requires a wide range of real-time, effectiveness and reliability of general distribution network dispatching systems. However, there are still many deficiencies in the system design of intelligent operation of urban large-scale distribution network dispatching, which cannot meet the standards of large-scale distribution. In the actual operation of the power grid, there may be differences in the issues concerned by the power grid at all levels, the goals to be achieved and the operation control strategies adopted. The information required for the operation control function of the station-oriented system is limited within the scope of the station, and the optimization of the operation control function and the monitoring and operation of the equipment in the station can be realized by collecting the information of the primary and secondary equipment across the interval.

The dynamic part of the integrated information model mainly stores the message format template of real-time data collected by sensor nodes, and analyzes and updates the real-time collected data according to the template to form data suitable for the storage format of the data service system. Table 1 lists the preparation data on the transmission accuracy, transmission speed and safety level of the selected feed data.

| Projects                                | First time | Second time | Third time |
|-----------------------------------------|------------|-------------|------------|
| Transmission accuracy of feed data      | 36%        | 34%         | 38%        |
| Transmission speed of feed data         | 66%        | 62%         | 72%        |
| Security level of feed data             | 6          | 7           | 5          |

The first n components of the control vector of the intelligent operation system design of the distribution network represent the generation output power of the control vector of the distributed unit in the system design, and the mth component represents the charge and discharge power of the stored energy of the distributed unit in the system design. The W component represents the design of the switch position. The model function based on the intelligent system operation design of the large-scale urban distribution network is:

$$\min Q = \sum_{i=1}^{K} \left( \sum_{p=1}^{l} C_p(t) R_p(t) \Delta T + \sum_{i=1}^{n} C_i(t) R_{i,n}(t) \Delta T \right)$$  \hspace{1cm} (1)$$

Among them: k represents the number of unit stages divided in the dispatching cycle of the distribution network; $C_p(t)$ represents the power cost of the p-th current feedback line at stage t and the power of the p-th current output; n represents the distributed The number of power supplies; $C_i(t)$ represents the power cost of the i-th distributed charging and discharging unit at stage t and the power of the i-th distributed charging and discharging unit.

In order to realize the system's monitoring and error warning of other equipment and improve the analysis results of various equipment monitoring methods, the system must have a certain degree of scalability, which can be used for power equipment monitoring and early warning methods. The ring grid power supply smart grid shown in Figure 1 is a general closed-loop design, and the power line can form a closed loop, which can be expressed as a smart grid model and will be expressed according to the structure shown in Figure 2.
The advantage of closed-loop design is that smart grid can provide bidirectional power supply. If a branch fails, the affected node can supply power through the other direction of the network loop, thus reducing the impact of the failure.

Figure 1 Smart grid network model of ring power supply

In the dispatching and monitoring plane, it mainly includes the functions of power grid monitoring and operation, risk early warning and defense, system optimization and coordination control, etc. Its analysis and decision-making objects run through the emergency control plane, which can realize cross-plane collaborative control. As the ultimate realization of power service value, there is a natural connection between distribution network dispatching and power marketing, and the urbanization process will further require improving the quality service level of power supply. Intelligent marketing has not only the technical upgrading of marketing structure, but also the diversified transformation of marketing working methods [10]. General distribution network dispatching system has strong and reliable performance compared with intelligent operation of distribution system in large cities. This requires the distribution system in large cities to have the autonomy to quickly restore power when it fails, and switch the load barrier to other power sources with reliable performance, thus reducing the data loss of the distribution network system.

3. Composition of high level application system for intelligent distribution network dispatching

Centralized feeder automation is the main type of feeder automation in the main station. When communication means are applied, the distribution emphasis will be coordinated with the distribution main station, so as to ensure that after the fault occurs, the equipment can judge the regulatory area in time on the basis of obtaining the fault signal, and isolate the fault area by remote control and manual methods according to the actual situation. In the future, the intelligent distribution network dispatching technology will be closely combined and cross-merged with the above three aspects to form an intelligent dispatching management system with the characteristics of super-large urban distribution networks. When restoring a fault, if a new fault occurs in the process, it is necessary to judge the specific situation to see if the new fault will have an impact on the problem being handled at present. After obtaining the analysis results, the treatment scheme will be optimized and adjusted in a dynamic way to ensure the scientificity and effectiveness of the scheme.

Different from the dispatching and monitoring plane, the emergency control plane is constrained by strong real-time and reliability, and its hierarchical division has little to do with the deployment position of equipment and the data interaction between equipment. In reality, the network topology and equipment information change rapidly, so it is necessary to update and flexibly display the real-time/quasi-real-time network topology to provide basic data for various advanced applications. Chengdu Electric Power Bureau adopts a reliable interface with the real-time data acquisition system under the visual system structure, and automatically generates the distribution network topology graph...
according to the interactive data [11]. In today's power grid operation monitoring and emergency repair, there are mainly two kinds of directions, first, applying GIS platform to apply spatial mode. Secondly, slicing and mapping aerial photographs provided by GIS are applied, and equipment paths are drawn manually by staff. However, for this part of methods, there are deficiencies in maintenance and scalability. In the future, many fuzzy factors must be considered in the dispatching and maintenance work of intelligent distribution network, which is closer to the actual situation than the deterministic model [12].

The essence of power system economic allocation problem is a nonlinear optimization problem which takes power balance, power flow and generator capacity as constraints and takes the minimum total cost of power generation as the objective. Its objective function can be expressed as:

$$C(P_G) = \sum_{i=1}^{n} C_i(P_{G,i})$$  \hspace{1cm} (2)

At the same time meet the following power balance conditions:

$$P_d - \sum_{i=1}^{n} P_{G,i} = 0$$  \hspace{1cm} (3)

$P_G = [P_{G,1}, P_{G,2}, \ldots, P_{G,n}]$ is the output vector composed of the output of each generator, $P_{G,i}$ is the active output of the $i$-th generator, $C_i(P_{G,i})$ is the cost function of the $i$-th generator, and $P_d$ is the total load of the power grid.

Because defect feature extraction is mainly used for health assessment and fault prediction, in experiments, defect features obtained by various methods are applied to health assessment, and the results of defect extraction are verified by observing the health assessment results. The deviation curve of main fault characteristics is shown in Figure 3.
promote the optimization of emergency control, recovery control and protection performance, and realize the grid security defense system based on wide-area information. In order to improve the coordination of power system security defense system, we should make full use of the advantages of dispatching and monitoring system in risk early warning and defense calculation for large power grid, and optimize the stability control strategy of wide-area protection and control system online through reasonable horizontal interaction mode.

4. Conclusions
In the design of intelligent operation mode system for urban large-scale distribution network dispatching, real-time collection of user data and intelligent distribution management are important steps of dispatching, which need the support of safe, intelligent and reliable information. In-depth study on intelligent operation control technology of mega-city power grid is very important to improve the security and stability level of mega-city power grid, the safety and quality of urban power supply and realize intelligent, reliable, green and efficient operation. Economic load distribution is an important optimization problem in power system operation control, which requires a large amount of information and complex solution process, and requires high information integrity and communication reliability. In order to improve the coordination of power system security defense system, we should make full use of the advantages of dispatching and monitoring system in risk early warning and defense calculation for large power grid, and optimize the stability control strategy of wide-area protection and control system online through reasonable horizontal interaction mode. High-performance, low-cost intelligent model for distribution network dispatching in megacities can effectively improve the utilization rate of assets and play a role in urban distribution network management center. In the future work, it is necessary to optimize and improve the technical scheme in full combination with the actual work.

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