

Research on Evaluation Index System and Model of World-class Power Distribution Network

Cai Liang*, Yuan Hu, Guowei Gao and Tuo Liu

Stage Grid Energy Research Institute Limited Company, Future Science Park, Changping, Beijing

*Corresponding author

Abstract—First-class cities match first-class power grids, build world-class modern distribution networks, and accelerate the construction of distribution networks in world-class cities to become the mission that Chinese power grid enterprises must undertake. There is no consensus on the current connotation characteristics and evaluation of the “world-class city distribution network”. This paper constructs the evaluation index system and evaluation model of the world-class distribution network. The analysis results show that China's power supply reliability, distribution network automation level, distribution network design, distribution network asset efficiency, innovative service capability; distribution network enterprise management there is a big gap in the level and other aspects.

Keywords—evaluation model; world-class distribution network; indicator system

I. INTRODUCTION

With the accelerating urbanization process, the optimization and upgrading of industrial structure has been accelerating, and the reform of the power system has been gradually deepened. Higher requirements have been placed on the support capacity, power supply reliability and power quality of the distribution network. The development of China's distribution network is also unprecedented. First-class cities match the best-in-class grid. Adhere to the most advanced concepts, the highest standards, the best quality, and improve the power supply capacity and service quality of urban distribution networks. To build a first-class modern distribution network and accelerate the construction of distribution networks in world-class cities has become a mission that Chinese power grid enterprises must undertake. However, there is still no consensus on the connotation characteristics and evaluation of the “world-class city distribution network”. This paper first analyzes the typical characteristics of the world-class distribution network, and secondly builds the evaluation index system and evaluation model of the world-class distribution network. Through the example verification with a certain city in China, it analyzes the main problems of China's distribution network and world-class level.

II. Typical characteristics of world-class distribution networks

Drawing on the experience of distribution network construction in first-class cities such as Paris, Tokyo, Hong Kong, we will build a first-class urban distribution network

from the aspects of strong grid, distribution automation, Internet + power distribution and management innovation, and comprehensively upgrade urban distribution. Network power supply capability, improve power quality, promote clean energy consumption, improve quality service level and user interaction ability, and propose "safe and reliable, cost-effective, green, low-carbon, friendly interaction" as the connotation of the world-class city distribution network.

A. Safe and Reliable

Safe and reliable power supply is the first and most basic requirement of the first-class city distribution network. Strong grid, excellent technical equipment and efficient operation and maintenance management are the most important guarantees for the production and transmission of electric energy.

B. Economically Efficient

Efficient economic benefits are the basic guarantee for the sustainable development of distribution networks in first-class cities. For striving for a world-class power supply enterprise, we must base ourselves on the current situation and focus on the long-term. We must provide a strong power supply guarantee for regional economic and social development, while ensuring the preservation and appreciation of state-owned capital.

C. Green low Carbon

Creating good environmental benefits and building a green and environmentally-friendly distribution network is the development trend of first-class urban power grids. "Environmentally friendly and resource-saving" has become the future direction of economic and social development. It is one of the core characteristics of the smart grid to fully and effectively absorb clean energy and provide high-efficiency and low-carbon green energy for the whole society.

D. Friendly Interaction

Achieving friendly interaction with users is an important development direction for the distribution network of first-class cities. In the future, the urban distribution network should not only focus on ensuring the basic requirements of safe and reliable power supply, but also focus on improving the level of user interaction and value-added services, and realize the power flow, information flow, and service flow between the distribution network, power supply and users. To interact and improve the overall efficiency of the grid.

III. EVALUATION INDEX SYSTEM OF WORLD-CLASS DISTRIBUTION NETWORK

The research team selected world-class distribution network companies such as Singapore Energy Corporation, Tokyo Electric Power Company and French Power Company as research objects. From the four aspects of technology level, service level, operational efficiency and management level, the evaluation index system of “world-class distribution network enterprise” is constructed, as shown in Table 1. Then, 15 industry experts were selected to evaluate the performance of the company's distribution network and world-class

distribution network enterprises based on Delphi and AHP. The professional background of the selected experts covers power system, energy economy, enterprise management and other fields. There are both experts in the system and experts outside the system. They all have senior titles and have rich experience in distribution network technology and management, as shown in Figure 1. Professional background is power system, energy major, economic management; strategic research years are 1-5 years, 5-10 years, 10-15 years; system internal and external systems are outside the system, system; title is deputy senior, positive and advanced.

Table 1 Evaluation Index System for World-class Distribution Network Enterprises

Dimensional	Evaluation index
Technical level	Design development concept
	The strength of the grid structure
	Distribution network safety level
	Distribution automation level
	Operation and maintenance work quality
	Resource coordination capability
	Intelligent distribution level
	Emerging technology application capabilities
Service level	Power supply reliability level
	Customer satisfaction rate
	Power efficiency
	Service innovation ability
Operational efficiency	Distribution asset utilization
	Return on investment in distribution assets
	Cost control level
Management level	Distribution network management structure and level
	Distribution management informationization level
	Advancement of business operation model
	Operational process advancement
	Assessment of incentive effectiveness
	Talent team building

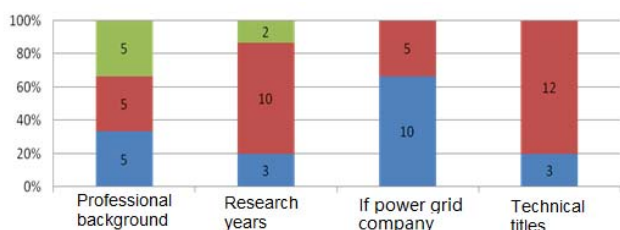


FIGURE I. BASIC INFORMATION OF PARTICIPATING EVALUATION EXPERTS

IV. WORLD-CLASS DISTRIBUTION NETWORK EVALUATION MODEL

The first step is to calculate the degree of achievement of a single indicator.

For each indicator, the degree of achievement is evaluated by expert scoring, and the highest standard of world-class companies is recorded as 100 points. Based on the combination of quantitative and qualitative analysis, based on the status quo and index data of China's distribution network, compared with world-class standards, according to the experience of experts, the evaluation score of the index is given, and the percentage is realized.

The second step is to set the weight of each dimension.

The weights are set for each dimension. This topic uses the combination of the analytic hierarchy process and the Delphi method. The analytic hierarchy process is based on affiliation to arrange various factors into several levels, establish the relationship between the two elements of the adjacent two layers, compare the two pairs, get the relative importance, and find the order of the most relative importance. The advantage is that It embodies the characteristics of decomposition, judgment

and synthesis of human thinking. It has good system city and simple calculation. The Delphi method is the experience and opinion of the concentration experts, determines the weight of each indicator, and obtains satisfactory results in continuous feedback and modification. The advantage is that the opinions obtained are more concentrated and reliable.

Based on the analytic hierarchy process, the judgment matrix is first established, and the Delphi method is introduced in the process of forming the judgment matrix, so as to avoid the subjective guidance of individual experts and to obtain more stable and objective results. Then comprehensive expert experience forms the order of importance of factors, calculates weights and tests consistency.

The third step is to calculate the degree of achievement of each dimension. According to the completion degree of each indicator and the weight of each indicator, the horizontal score of each dimension is calculated.

The fourth step is to calculate the overall degree of achievement.

Integrate the degree of realization of each dimension, and get the overall degree of realization = \sum the weight of each dimension * the degree of realization of each dimension.

The fifth step is to analyze the results.

V. ANALYSIS OF EVALUATION RESULTS

According to the overall score and the scores of each dimension, the company's distribution network is evaluated to be world-class, and the main gaps and shortcomings are analyzed. As shown in Figure 2.

A. Power Supply Reliability

The average power supply reliability rate of the city (city center + urban area + town) is 99.971%, the annual average power outage time is 2.59 hours/household; the average power supply reliability rate of rural users is 99.935%, and the annual average power outage time is 5.72 hours/household, such as Table 5-6 shows. Compared with the international advanced level, Singapore's power supply reliability rate reaches "6 9", and the average power outage time is 0.74 minutes; Japan's Tokyo power supply reliability rate reaches 5 9s, and the average power outage time is 5 minutes. It can be seen from this that China's power supply reliability has increased space and pressure.

B. Distribution Network Structure

Singapore, Paris, and Tokyo have built a scientific and rational distribution network target grid to meet the N-2 standard. However, a certain line city in China has fully built a chain structure target grid, which has not fully met the N-1 standard. The Paris city cable network adopts three-ring network T connection or double ring network T connection mode; Tokyo 22 kV cable network adopts main line backup line, ring and point network connection mode, and 6 kV overhead network adopts multi-segment multi-contact mode; Singapore The cable network adopts a "petal type", that is, a

closed network cable. China's urban high-voltage distribution network is similar to the international advanced distribution network. It is mainly operated by ring network and radial operation. However, the medium-voltage distribution network has a large space for improvement, and the power grid structure is relatively weak. It is urgent to strengthen the medium-voltage line contact rate and improve the load transfer. Supply capacity.

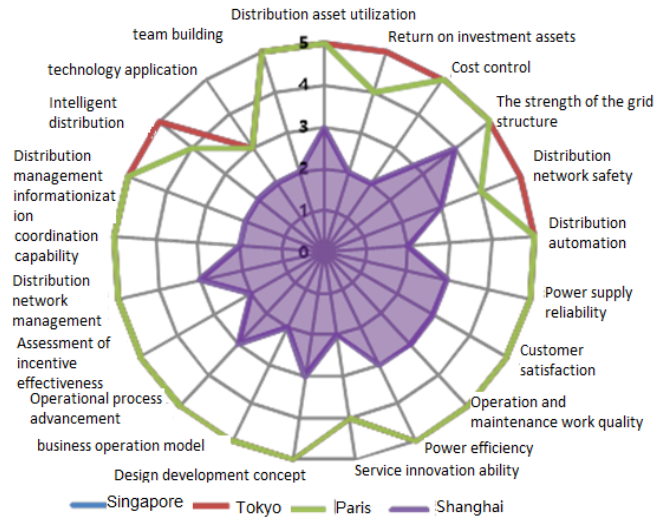


FIGURE II. SCHEMATIC DIAGRAM OF THE EVALUATION RESULTS OF WORLD-CLASS DISTRIBUTION NETWORK ENTERPRISES

C. Distribution Automation Level

At present, the overall coverage rate of distribution network automation in first-tier cities in China is 20%, Japan's automation coverage rate is almost 100%, and France is 90%. As far as the actual situation is concerned, some first-tier cities in China have initially achieved considerable controllability of the distribution network, but the operational monitoring and automation control capabilities of other regions are lacking, and there is still potential and task for substantial improvement.

D. Distribution Network Asset Efficiency

A comprehensive and systematic grasp of the health level of existing distribution network equipment and networks should be the starting point for lean and efficient management of distribution network assets. How to effectively use existing equipment and networks, use modern asset management technology to implement corporate social responsibility, rationally control the power grid, and improve profitability are the consensus reached by foreign advanced distribution network enterprises. Taking the London distribution network as an example, the UK distribution network has formed a lot of advanced experience in technical specifications, software and hardware platform development and application. In contrast, domestic asset management concepts and technologies started late, and asset management techniques and levels still need to be significantly improved.

E. Customer Service

Foreign advanced distribution network enterprises can identify customer electricity usage based on the application of smart meters and their data assets, and provide active services such as tax and fee advice, energy-saving equipment installation suggestions, and customer classification. While improving customer stickiness, it flexibly proposes demand management strategies, grid investment and photovoltaic power generation planning strategies, achieves scientific matching of power supply capacity and user peak load, and implements the theory of “supply following demand” to enhance the initiative of power distribution. In terms of user access services, users are subdivided to provide basic access, negotiation, and apportionment services, such as access, differentiated services, to meet the needs of different types of users, and to achieve flexible and fast access. In the above aspects, there is still a gap between the company and the world's advanced level.

F. Distribution Enterprise Management Efficiency

The world's advanced distribution network enterprise organization is flat and streamlined, and the management functions are intensive and efficient. For example, Enedis in France has set up two levels of organizations at headquarters and regional companies. The departmental settings of the regional companies are slightly different, but they are basically divided into functional auxiliary departments and business departments. Many administrative departments do not set up deputy internal departments, and the department heads directly manage and distribute work. The reduction of administrative management level and redundant personnel has improved work efficiency and reduced labor costs.

VI. SUMMARY

According to the analysis of this paper, the world-class city distribution network has the characteristics of “safe and reliable, economical and efficient, green and low-carbon, friendly and interactive”, as well as strong risk resistance, resource allocation, service guarantee, sustainable development and user interaction. Distribution network. The analysis of the world-class distribution network evaluation model built in this paper shows that China has more advantages in power supply reliability, distribution network automation level, distribution network design, distribution network asset efficiency, innovative service capability, and distribution network enterprise management level.

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