Evaluation of the Application of Facility Reliability Evaluation Indicators in the Development of Distribution Network Industry

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Abstract. The application effect evaluation of reliability indicators for distribution network facilities should be in line with national conditions, especially considering the current situation of enterprise facility reliability management, personnel quality, facility type, and advanced level of facilities. The evaluation should be progressiveness and appropriately advanced, but it should not be too advanced. If the advanced model is not accepted by the enterprise or the conditions for its implementation are not yet mature, it will lose its role in promoting actual work. Therefore, this article studies the application effect evaluation of the promotion and application of reliability evaluation for distribution network facilities. Firstly, it sorts out the various reliability evaluation indicators defined in the guidelines for reliability evaluation of distribution network facilities. Then detailed the content that should be focused on in the assessment system of power enterprises and regulatory agencies, and finally provided the next steps and future trends.

Keywords: distribution network facilities · reliability assessment · indicator implementation estimation

1 Introduction

China's power transmission and transformation facilities have a specialized information management system responsible for collecting, calculating, analysing, and reporting facility reliability data [1, 2]. The reliability evaluation and management of power transmission and transformation facilities have been carried out nationwide and achieved significant results. Reducing various costs without reducing reliability indicators has become an important driving force for promoting the transition of power transmission and transformation facilities from condition-based maintenance to reliability centered

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maintenance (RCM). However, the number of distribution network facilities is extensive, and compared to transmission network facilities, their own value is not high and the impact of faults is not significant. As a result, the maintenance and management of distribution network facilities in most regions of China still rely mainly on regular maintenance and direct replacement.

The evaluation of the application effect of reliability indicators for distribution network facilities in China is very limited, and most of the literature is about the construction of facility reliability assessment models or research on evaluation methods for the reliability of certain important transmission network facilities [3, 4]. To fill the gap in application effectiveness evaluation of reliability evaluation of distribution network facilities, this article explores the evaluation of the application effect of reliability evaluation of distribution network facilities. Firstly, the key content of the "Guidelines for Reliability Evaluation of Distribution Network Facilities" (draft for approval) [5] is briefly described. Then, based on the current situation of power enterprises and regulatory agencies, the main aspects that should be paid attention to in the application of reliability evaluation of distribution network facilities are presented. Finally, the future development trend of reliability evaluation implementation, promotion, and application evaluation is proposed.

2 Guidelines for Reliability Evaluation Indicators of Distribution Network Facilities

The project team has unified the classification of distribution network facilities and the classification of facility status in the "Guidelines for Reliability Evaluation Indicators of Distribution Network Facilities" (draft for approval), and calculated various reliability indicators based on facility status. The guidelines classify distribution network facilities into 8 categories. They are overhead lines, cable lines, pole mounted switches, outdoor distribution transformer stations, distribution stations, switch stations, distribution automation facilities, and DC distribution facilities. Add backup status to the facility status classification, and subdivide it layer by layer from the perspectives of capacity status, usage status, and status reasons, highlighting the reasons for this status, as shown in Fig. 1.

In the construction of the indicator system, a "two-dimensional, three-category" evaluation system has been formed. The "two-dimensions" refer to facility maintenance - "shutdown" and system maintenance - "shutdown and power outage". The "three-categories" refer to indicators in three categories—frequency, time, and proportion. Among them, frequency indicators reflect the average number of outages, time indicators reflect the average single outage time, and proportion indicators are comprehensive indicators that reflect the reliability of facilities.

3 Assessment Content for Power Enterprises

3.1 Information System Standardization

Three indicators can be selected for evaluation—data acquisition completeness, information acquisition accuracy, and data update timeliness. Among them, completeness and accuracy determine whether the input data calculated by the indicator matches the actual data.

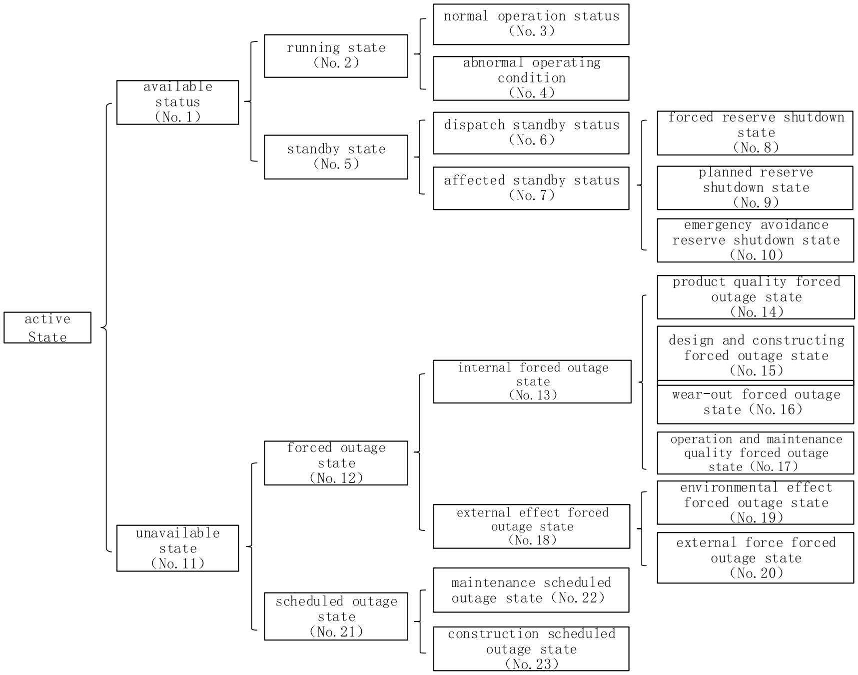

Fig. 1. Classification of distribution network facility status.

3.2 Diversified Application Scenarios

Scenario application is a visual manifestation of the implementation of reliability evaluation indicators for distribution network facilities. The basic application scenarios for facility reliability evaluation include procurement and selection, construction and installation, operation and maintenance, troubleshooting, and retirement treatment. When applied, it can be extended forward to the research and development, design, and testing stages before facility production, and backward to the recycling and reuse of retired components. It can also further refine its application in various stages.

The evaluation of this dimension selects three indicators—basic scene coverage, basic scene refinement, and basic scene expansion.

3.3 Adaptability of Management System

Reliability management should gradually transition from pure technical organizational management to a combination of economy and technology, placing economy in the dominant position.

3.3.1 Clarity of Strategic Objectives

Strategic goals are the starting point and foothold of facility reliability management practice. Strategic goals are formulated and decomposed into annual plans. Then, through the goal decomposition tool of performance management, they are decomposed and implemented to each department to form departmental performance goals, which are then implemented to each employee and form employee key performance indicators (KPIs).

3.3.2 Professionalism of the Workforce

The growth of a reliable workforce is a process of development from quantity to quality, and personnel must undergo specialized training. On the one hand, it is necessary to gradually master reliability engineering, maintainability engineering, economics, systems engineering, computer technology, etc. On the other hand, it is also necessary to develop in the direction of one specialization and multiple abilities.

3.3.3 Scientific Mode Selection

The following are key explanations for the bidding stage, operation and maintenance stage, and retirement stage.

1) In the bidding and procurement management stage, facilities should be purchased based on economy and reliability. The inherent reliability level of facilities constitutes the foundation of reliability, which should be prioritized, that is, the focus of facility reliability should be on maintainability and reliability design. Strive to endow facilities with a high level of reliability during the design and manufacturing stages, so that they can perform their functions reliably for a long time in the day after tomorrow. Supervision and control over contractors and suppliers can be strengthened in advance during the facility design and production stage.
2) In the operation and maintenance management stage, it is necessary to handle the ratio relationship between centralized maintenance and decentralized maintenance.

   In the actual maintenance management process, either completely centralized or completely decentralized maintenance may cause problems. Complete centralization may lead to a decrease in efficiency, delayed service, and increased outage losses. Completely decentralized may lead to excessive inventory, redundancy, and increased maintenance expenses. Selective centralization and decentralization can be implemented, namely centralized maintenance of some specialized facilities and decentralized maintenance of some simple facilities. Alternatively, a centralized and decentralized approach can be adopted, where the operating department only performs basic repairs, professional repairs are completed by the maintenance department, or basic maintenance organizations undertake the majority of maintenance tasks, while professional maintenance organizations only undertake tasks such as emergency support, solving important and difficult problems, equipment technical transformation, and new equipment introduction.

   In addition, the socialization and specialization of maintenance in China are developing rapidly, and enterprises can choose to utilize various services provided by social maintenance service institutions.
3) Establish a sound disposal system during the stage of facility scrapping. Establish a comprehensive hierarchical approval process for scrapping and disposal of facilities. The main structure of the facility is severely damaged, unable to be repaired or

economically inefficient, or must be phased out according to national policies before it can be scrapped. Those that still have a certain value for use shall be disposed of as scrap or degraded for use, or other parts that can be used shall be recycled, or discarded old materials that cannot be used shall be disposed of.

In summary, three indicators were selected for evaluation—strategic goal clarity, employee training qualification rate, and stage mode scientificity.

3.3.4 Total Cost Optimization

Three indicators, namely annual unit average input cost, annual unit average operation and maintenance cost, and annual unit average retirement cost, are used for assessment.

4 Assessment Content of Regulatory Agencies

4.1 Facility Reliability

Count the reliability index usage of various facilities in power enterprises based on local companies. Four indicators are used for assessment—timeliness of indicator reporting, accuracy of indicator calculation, depth of indicator application, and coverage of application scenarios.

4.2 Fund Utilization Rate

For each type of distribution network facility, the annual total cost savings rate is used for assessment.

4.3 Reliability Organization Management Efficiency

The procurement, operation, maintenance, asset management, and other departments of power enterprises are all components of facility reliability organizations. The evaluation of facility reliability organization and management efficiency is evaluated from five aspects—strategic management, organizational management, employee management, institutional management, and knowledge management. Strategic management assesses the rationality of formulating strategic objectives and the execution of strategic objectives. The clarity of job division and power responsibility relationship in organizational management assessment, as well as the execution ability of organizational work objectives. Employee management includes passing rate of stage assessment and employee work motivation. The standardization of the system management and assessment process, as well as the execution of the system and process. Arrangement of knowledge management assessment and training mechanism, and innovation ability in knowledge application.

4.4 Development Level of Reliability Technology

The technical level of facility reliability is determined by the technical level of the facility, the level of operation and maintenance, and the quality of relevant personnel. In addition, absorbing experts from outside the enterprise is beneficial for introducing new ideas and methods, and is also an important assistance for the implementation and promotion of facility reliability evaluation. For example, in-depth technical research and assistance in personnel training can be used to help power companies improve the theoretical and technical level of facility reliability. Evaluate from three aspects: reliability research level, conversion rate of technical achievements, and skills of employees.

5 Example

Assuming that a certain enterprise has undergone self-assessment, the scores for each item are as follows:

Information system standardization score is 90 points, scores for the three indicators of diversified application scenarios (out of 100) are—basic scene coverage 90, basic scene refinement 80, and basic scene expansion 75. Scores for the four indicators of adaptability of management System are—clarity of strategic objectives 90 points, professionalism of the workforce 80 points, scientific mode selection 65 points, and total cost optimization 75 points. The weights of the eight indicators are the same.

Figure 2 is the radar chart of the enterprise's self-assessment results. It can be seen that the standardization construction of the enterprise's information system and the company's strategic goals are very clear. However, the scientific nature of its mode selection, basic scenario expansion, and overall goal optimization need to be strengthened.

Assuming that the regulatory authorities evaluate the enterprise as follows—timeline of indicator reporting score is 87, the accuracy of indicator calculation score is 95, depth of indicator application score is 83, and coverage of application scenarios score is 76. Final total cost savings rate score is 81, strategic management scored 84, organizational management scored 87, employee management scored 89, institutional management scored 90, and knowledge management scored 82, the reliability research level score is

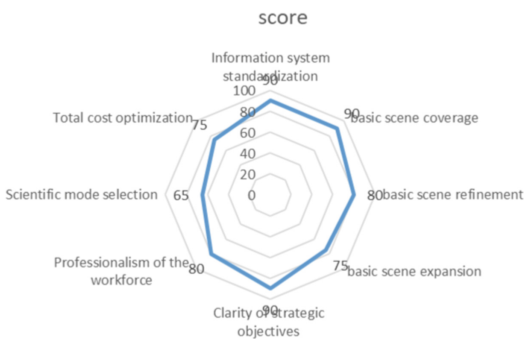

Fig. 2. Radar chart of Enterprises' Self assessment

Fig. 3. Radar chart of Regulatory Authority's Evaluation of Enterprises

78, the conversion rate of technical achievements score is 74, and the skills of employees score is 83. The weights of the eight indicators are the same.

Figure 3 is the radar chart of the regulatory authority's evaluation results of the enterprise. The company has done a good job in the accuracy of indicator calculation, enterprise management, and employee management; However, there are significant deficiencies in the conversion rate of technological achievements and the coverage rate of indicator application scenarios.

6 Conclusions

It should be noted that whether it is the assessment of the enterprise itself or the assessment of regulatory agencies, the formation of a specific performance evaluation system also requires clear evaluation rules to correspond to it. By providing detailed descriptions of detailed rules and specific assessment methods, scoring and evaluating indicators, and regularly rolling revisions, a complete performance assessment system for facility reliability implementation and application can be formed. In specific operations, reliability targets can be set for each region based on historical data. When a certain region reaches or exceeds the target, a certain degree of reward will be given, and otherwise, a certain economic punishment will be given, thereby incentivizing power enterprises to attach importance to facility reliability and actively implement it in various work. This will also be the next step of this work.

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