China Southern Power Grid's power supply reliability development strategy under digital transformation

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Abstract: Power supply reliability management is a systematic work that requires long-term persistence and continuous improvement. The four factors that restrict the improvement of reliability are: grid, equipment, automation and management. In the long run, the grid structure, equipment quality and automation level of the power grid are the material basis for improving the reliability of power supply. Continuous investment in power grid construction is needed to build a strong and reasonable standardized grid structure, and the application of sturdy and durable high-quality equipment to improve distribution Practical level of electrical automation, improve the ability of the distribution network to transfer power supply, and reduce the failure rate of the distribution network. In view of this, this article mainly analyzes the development strategy of China Southern Power Grid's power supply reliability under the digital transformation.

1. Introduction
The "14th Five-Year Plan" is the first five-year planning period for China to embark on a new journey of building a socialist modern country in an all-round way. It is a critical period for the comprehensive implementation of high-quality development requirements and the in-depth advancement of the energy production and consumption revolution. Adhering to the people-centered development concept and fully meeting the energy needs of the people for a better life, grid companies must provide safe and reliable power guarantees for economic and social development, and continue to improve the reliability of power supply.

2. Overview
China Southern Power Grid Co., Ltd. (hereinafter referred to as the "Network Company") attaches great importance to power supply reliability management, based on its own development strategy planning and grid regional characteristics, in accordance with the key work requirements of "a set of data, multiple applications", and fully integrate the company's current With the results of informatization construction, through the launch and popularization of the integrated application module of power supply reliability management of the asset management safety production management information system (hereinafter referred to as the "production system"), the entire process of information management and control of the power supply reliability data of the entire network is implemented to achieve Reliability data "decentralized collection, unified push, automatic statistics" has been standardized, the reliability data management process has been standardized, data duplication has been greatly reduced, data maintenance has been streamlined, data timely and accurate transmission has been ensured, and work efficiency has been improved. The management level has laid the foundation for achieving lean management goals[1].
The integrated application of power supply reliability adopts a centralized deployment method at the network and provincial levels. That is, the headquarters of the network company and each branch (provincial) company deploy a unified version of the system module. Loading, ETL) tools to perform daily data extraction and data synchronization to meet the reliability business management needs of different ranks and levels of network companies, branch companies, and grass-roots units. The reliability business management professionals of each branch company and each grass-roots unit are mainly responsible for data entry, data review, index summary statistics, etc., while the reliability management personnel of the network company are responsible for the entire network reliability data management, report management and analysis, and reliability Index parameter configuration management, etc.; at the same time, based on the national facility reliability management regulations and coding rules, refer to the IEEE distribution network reliability index guide, the power supply system user power supply reliability evaluation regulation, etc. The integrated application interface specification, the power supply is reliable The integrated application will uniformly push the power supply reliability data of the production system to the China Southern Power Grid reliability system, and then submit it to the China Electricity Union User Power Supply Reliability System (referred to as the China Electricity Union Reliability System) of the National Energy Administration for better realization The smooth push and seamless connection of data between the production system and the reliability system of the China Southern Power Grid, and the reliability system of the China Southern Power Grid and the reliability system of the China Electric United Index calculation, index statistics, index summary, index query, function export, etc[2].

3. The main factors affecting the reliability of power supply

3.1. Grid transformation and planned power outages
The vigorous transformation of the power grid has significantly increased the number of planned power outages, and the mutual supply capacity between the distribution network lines needs to be improved. On the other hand, scheduled power outages such as maintenance and engineering construction are the main cause of power outages and will also lead to power supply reliability. Problems such as performance degradation occur within a period of time[3].

3.2. Environmental factors
Environmental factors are mainly reflected in component failures caused by snowstorms, floods, and heavy rainfall. From the perspective of influencing factors in this respect, there are obvious uneven distribution characteristics in both the time of occurrence and the place of occurrence, that is, different regions have differentiated fault characteristics. As the distribution network is highly sensitive to geographical factors, the possibility of cumulative failures is relatively high under different climatic conditions and geographical environmental conditions. Therefore, it is necessary to classify different environmental conditions in management work, and describe them with expected values through system simulation and other methods.

3.3. hardware facility failure
Hardware facility failures are reflected in two aspects: □ internal and external voltage problems; □ facility performance problems. Under the premise that the insulation level of the distribution network is too low, various lightning accidents and other factors are the main influencing factors. In addition, it also includes arc overvoltage, disconnection overvoltage, etc., which are the main reasons that affect the reliability of power supply, and they are also common problems in the distribution network. On the other hand, the performance degradation, wear, and aging of insulation facilities and configurations have also affected their normal working conditions. Generally, the optimization plan needs to consider various constraints such as various voltage limiting measures and insulation strength to develop the optimization plan[4].
3.4. Distribution network architecture

The distribution network architecture should first be analyzed from the aspect of network structure. For example, the single-power radiation interface mode used for a long time, although the wiring is simple, but the load cannot be transferred when a fault occurs. For another example, the segmented connection connection mode will not affect the normal power supply of other lines when any line section fails, and the reliability has a more significant guarantee. For these different distribution network architectures, the reliability index should be calculated under the premise of the same load capacity. On the other hand, power supply capacity is also the main influencing factor in the work of distribution network architecture. Within the receiving end system, the distribution network problem still exists, and even in many cases the grid architecture cannot meet the safety requirements and system performance, and the stability of the system has certain deficiencies. For example, although the neutral grounding method has been improved with the continuous improvement of technology, the distribution network will still encounter technical errors and other problems due to the difference in grounding methods.

| Grounding mode       | SAIFI  | SAIDI  | AISI     | Investment coefficients |
|----------------------|--------|--------|----------|-------------------------|
| Single source radiation | 3.5102 | 15.11  | 99.862   | 1                       |
| Ring type            | 2.8416 | 8.809  | 99.935   | 1.15                    |
| Segmented            | 2.54113| 7.221  | 99.969   | 1.2                     |
| N-1                  | 1.5425 | 6.669  | 99.989   | 1.5                     |

4. China Southern Power Grid's power supply reliability development strategy under digital transformation

4.1. Build a digital power distribution management architecture

The basis for improving power supply reliability in the context of digital transformation is to build a set of digital power distribution management architecture, and in-depth study of the impact of digital power distribution technology applications on planning and construction, scheduling operations, production operation and maintenance, decommissioning and scrapping. Applying new technologies such as "cloud big things, moving intelligence", relying on the three digital basic platforms of China Southern Network Cloud, Grid Digitization and Global Internet of Things, build a digital power distribution system architecture including perception layer, network layer, platform layer, and application layer, and promote distribution The level of digitization and intelligence in the electric field.

4.2. Research on digital power distribution technology

Digital power distribution technology is a strong support for improving the reliability of power supply. Relying on the three digital basic platforms of China Southern Network Cloud, Grid Digitization and Global Internet of Things, we will open up all aspects of perception, analysis, decision-making, and business, improve state awareness, decision-making capabilities, and execution capabilities, and advance the level of digitalization and intelligence in the power distribution field. Research and develop power distribution line status monitoring programs, and apply technical means such as overhead line fault location, cable sheath circulation, and local line monitoring to achieve the ability to intervene in advance to eliminate equipment risks and improve the reliability of power supply in the distribution network. The system reliability index and evaluation error are shown in Table 2.
Table 2 Statistical results of system reliability indicators

| System indicators | Statistical result | Evaluation of error |
|-------------------|--------------------|---------------------|
| SAIFI             | 0.3744             | 4.25%               |
| SAIDI             | 2.9384             | 7.53%               |
| CAIDI             | 7.8490             | 3.44%               |
| ASAI              | 0.99966            | 0.003%              |
| ASUI              | 0.00034            | 8.82%               |
| ENS(MW \cdot h)   | 83.8248            | 6.45%               |

4.3. Carry out the construction of application scenarios to improve reliability
Sort out typical application scenarios for improving power supply reliability, realize unified collection and management of on-site monitoring terminal data, gradually carry out pilot construction and popularization applications according to local conditions, form large-scale application effects, and realize comprehensive coverage of situational awareness of key equipment in the distribution network. Combining business scenarios such as smart power distribution room/smart station area, overhead line fault location, cable online monitoring, waterlogging prevention and electric shock monitoring, etc., based on the global Internet of Things platform, applying cloud computing, artificial intelligence, edge computing, 5G and other technologies to develop the cloud Research on the application of side-end collaboration technology to support real-time analysis and decision-making needs of business applications in various scenarios of the distribution network, and to improve power supply reliability[5].

4.4. Build an intelligent power supply reliability index management system
Study the evaluation criteria of the power supply reliability index of the "obtained electricity" in the business environment evaluation system, and better support the improvement of the evaluation of the electricity business environment in the five southern provinces. Create an intelligent index management system, respond to the needs of sensitive users of power quality, give priority to provincial capital cities and key cities of the “two districts and one port”, actively grasp sensitive customer information, and carry out technical support for detection and comprehensive treatment of voltage sags, harmonics, etc. service. We will continue to deepen the working mechanism of pairing and tackling hardships to "make up for shortcomings", and effectively increase the guidance, assistance and assessment of power supply bureaus in counties and districts that have backward indicators, frequent line trips, long power outages, and serious low voltage and heavy overloads.

4.5. Strengthen the intelligent management and control capabilities of the distribution network
- Build an integrated secondary system of distribution network that runs through "station-line-station-household" and oriented to the interconnection of source, network, load and storage energy, to realize observable and measurable distribution network, interconnection and interoperability, flexible self-healing, panoramic view and transparency, and accelerate the promotion of new The construction and application of a generation of distribution automation systems have improved the practical level of distribution automation.
- Deepen the application of intelligent fusion terminals in the station area, improve the perception management and control capabilities of power distribution equipment, build a middle station for the application of power grid resources, and promote the digital transformation and upgrading of power distribution network management.
• Strengthen the integrated professional management of power distribution network construction, operation and maintenance, deepen the operation of the power supply service command center, and build a modern service system of "strong front-end and large back-end".

• Make full use of new technologies such as informatization, power Internet of Things construction

4.6. 
*Deepen technological innovation and business application*

• Carry out innovative research on power supply reliability management methods, and promote reliability statistical analysis mechanisms to be further in line with international standards.

• Carry out research on reliability technology of high-proportion new energy distribution network and intelligent active distribution network.

• Deepen the evaluation and analysis of power supply reliability of the distribution network, and develop differentiated reliability improvement strategies.

• Deepen the research on low-voltage reliability calculation models, establish a low-voltage reliability evaluation system, and promote the extension of power supply reliability management to low-voltage.

5. Conclusion

During the "14th Five-Year Plan" period, we should adhere to the combination of far and near. While continuing to carry out the construction and transformation of the distribution network, the power outage management and control of the distribution network should be the main starting point for the current reliability improvement, and further improve the technology of non-stop operation and power distribution automation. The level of application is to increase the precision of scheduled outage management, strengthen differentiated operation and maintenance guarantees, effectively reduce the impact of outages, and further improve customer power experience.

Acknowledgments

Chinese Library Classification Number: TU756 Document Marking Code: A

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