Research on electric power distribution network operation and evaluation under energy saving and emission reduction environment

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Abstract. This paper puts forward a four-step evaluation method based on data mining directly from information system under energy saving and emission reduction environment, including taking data, finding problems and putting forward measures. Through distribution network core indexes, an example was given to prove the method is scientific and practical.

1. Introduction
In order to strengthen the management innovation in the field of distribution network investment [1-6], and respond to the “two networks” integration strategy of the digital construction of the State Grid Corporation, it is necessary to explore effective post-evaluation methods for distribution networks. The key to high-quality development.

By focusing on the efficiency of investment, we can show the problems and deficiencies in the current investment in distribution network construction, and strengthen the investment, operation and maintenance efficiency in the field of distribution network in a targeted manner. However, there are two shortcomings in the current research:

1. Most of the distribution network evaluation index systems focus on efficiency, and the evaluation results do not play a strong role in guiding the actual work of investment.
2. The evaluation data are mostly manually reported, which causes the problem of inaccurate evaluation data and affects the evaluation conclusion after evaluation. Distribution network investment management and operation and maintenance management are very complicated. At the State Grid, the current post-evaluation of the distribution network is still in the pilot and initial stages, and the information system is often incomplete. It is difficult to collect data in all directions, and the accuracy of manual data reporting is poor. The traditional comprehensive evaluation is difficult to adapt to the post-evaluation of the distribution network.

In general, according to the new situation and new requirements as a starting point, in order to break through the shortcomings of the existing distribution network evaluation system, this study plans to construct a set of analysis methods focusing on efficiency by combing previous results, in order to give full play to the system. The advantages of direct mining are job requirements to meet the interests of all parties. With key indicators as the starting point, design a reasonable and feasible correlation analysis paradigm, and use the methods and methods of distribution network investment evaluation to find, analyze, and solve problems.

The following problems existed in the original manual data submission:
First, the basic data involves many business departments, the source system is complicated, manual reporting and collection are difficult, and the finishing work is intensive. Second, the evaluation index calculation formula and the reference data are inconsistent, and the indicator caliber is not uniform. Third, the indicator calculation workload is large. The long implementation period affects the efficiency of evaluation and analysis. Fourth, the indicators are manually submitted offline, and it is easy to adjust the indicators artificially. The authenticity and accuracy of the data are difficult to guarantee.

Using the system to directly collect data as a means, a unified standard for the distribution network analysis mechanism with consistent data and unified indicators is formed at the four levels of the headquarters, provinces, cities, and counties, and they are linked up and down: self-evaluation and self-building of investment management at all levels of service companies.

2. Method

2.1. Fixed index

This step is mainly to determine the core indicators of efficiency and effectiveness. After screening and analysis of the source data of the index, form Determined core indicators. The main steps are as follows: 1. Inherit the existing guidelines and standards, focus on efficiency and efficiency, and sort out the source data of existing related indicators. This step is mainly to determine the source of parameters behind various standards and prepare for the next step of calculating indicators. 2. Summarize the basic parameters of the source data and determine the important parameters. This step is mainly to narrow the scope of data collection and determine the scope of core parameters. 3. Based on the important parameters, determine the core indicators of efficiency and effectiveness and their related indicators.

In combination with the current new situation and new requirements to strengthen the investment efficiency of distribution networks, the key indicator system constructed in this study includes core indicators and related indicators. Core indicators directly reflect the efficiency and effectiveness of investment, and related indicators refer to the comprehensive goals and boundary conditions of distribution network development in terms of safety and reliability, power supply quality, grid structure, power supply capacity, and equipment level, which indirectly affect distribution network indicators of efficiency and effectiveness.

2.2. Take the data

This step is mainly to determine the data source of the important parameters in the previous step, and to design the system to implement direct mining, eliminating manual data intervention. The steps to be adopted are as follows: 1. sort out the company's existing information system and select the relevant available data; 2. based on the direct acquisition of the information system to count the source data; 3. supplement the data that is lacking in the existing system to improve the original data; 4. Calculate the values of core indicators and related indicators to eliminate anomalies. Utilizing the system's direct mining, a key index system for the investment evaluation of the distribution network is constructed to form the core and related indicators of the operation efficiency of the investment in the distribution network. A subsubsection. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

2.3. Find a problem

This step is mainly based on the core indicators to analyze the actual problems behind the indicators and find the actual problems behind the indicators. The proposed steps are as follows: 1. Analyze the key indicators to find inaccurate and unreasonable investment issues; 2. Combine the core indicators and related indicators Carry out correlation analysis to locate problems in depth from provinces, cities, counties, and equipment; 3. Analyze the nature of the problem, and combine the characteristics of the problem county to find out the reason.
2.4. Measures
Based on the key indicator system, the core indicator is analyzed through penetration, and the essence of the problem is found by combining the related indicators. Aiming at the key issues of investment efficiency and efficiency of the distribution network, the effective changes of key indicators are used to propose effective measures from the aspects of possible investment inaccuracy, irrational investment, and non-investment problem solving.

3. Empirical analysis
Take A Province as an example to carry out empirical analysis. With the load rate as the investment efficiency index of the distribution network, analyze equipment problems at every level in provinces, cities, and counties, find actual problems, and analyze the underlying causes. The target indicators mainly include the power supply reliability rate (RS-3), the comprehensive voltage qualification rate, the N-1 pass rate, the 10 kV power supply radius, the 10 kV line connection rate, and the average distribution capacity of each household. Sort out and analyze the target indicators of each city and county, find cities and counties that do not meet the distribution network construction guideline standards, and the level of indicators is significantly lower, and jointly analyze with problem indicators to achieve the operation efficiency of the distribution network of each city and county, economic benefits, safety and reliability, power supply quality, power supply capacity, grid frame structure all-round portraits, while ensuring the basic goal of distribution network construction, improve the efficiency and efficiency of investment in distribution network.

The light load ratio of 10 kV distribution transformer in A Province reached 24.16%, and the light load problem is serious. For the light load problem, increase the analysis dimension and locate the light load type. Including the operation time into the analysis dimension, in the light load distribution transformer, the distribution transformer within 3 years of operation accounted for a relatively small, 8.67%, and the majority of light load distribution transformers became more than 3 years, accounting for 91.33%.

| Table 1. Light Load Percentage |
|-------------------------------|
| 10kV Distribution Transformer Index Proportion          | Light Load Percentage |
| Proportion of light load distribution transformers       | 24.16% |
| Proportion of operating life in light load distribution transformer within 3 years | 8.67% |
| In the light-duty distribution transformer, the operating period is 3 years or more | 91.33% |

According to the proportion of light load distribution transformers, the district and county companies with relatively serious light load problems are screened. For urban networks, there are 3 urban districts with light-load distribution transformers accounting for more than 30%; for rural power networks, 28 county-level companies account for more than 25% of light-duty distribution transformers.

| Table 2. Light Load Percentage of Urban Company |
|-----------------------------------------------|
| Proportion of light load distribution transformers (%) | Urban company names (Proportion from largest to smallest) |
| Light load accounted for more than 30% | ... |

| Table 3. Light Load Percentage of rural company county-level Company |
|-------------------------------------------------------------------|
| Proportion of light load distribution transformers (%) | Rural company county-level company names |
| Light load accounted for more than 30% | ... |

In 2018, the problem of light load in typical urban areas was more serious, which increased compared with 2017, and 2 consecutive years of young load equipment accounted for a higher proportion; power supply capacity, power supply reliability, power supply quality and other aspects met the guidelines.
There are problems: Although the N-1 pass rate of the target indicator lines has increased, the proportion of light loads in the problem indicators has increased. First, in terms of problem indicators, the proportion of light loads has increased, from 40% to 60%, and there are continuous light load problems; second, in terms of target indicators, average household power outage time, comprehensive voltage qualification rate, power supply reliability, and power supply radius such as the target indicators change little, the power supply level rose slightly.

Table 4. Light Load Percentage of Urban Company

| Question-type indicators (A-E) | Goal-type indicators (F-J) | Other auxiliary analysis quantities |
|-------------------------------|----------------------------|-----------------------------------|
| **year**                      | **Load**                  | **Capita power outage time**      |
| A: Heavy                      | B: Overload               |                                 |
| 2017 3.33%                    | 0%                        | 6.4h                              |
| 2018 2.03%                    | 0%                        | 5.6h                              |
| C: Light                      | D: Two year in a roll     | G: voltage quality rate           |
| 40%                           | 39.95%                    | 99.99%                            |
| 60%                           | 81.77%                    | 99.99%                            |
| E: operation time more than 3 years |                          | I: power supply radius           |
| 3.6h                          | 4.31km                    | 95.32%                            |
| F: Per capita power outage time |                          | J: N-1 pass rate                 |
| 6.4h                          | 99.99%                    | 221                               |
| G: voltage quality rate       | 99.99%                    | ¥33761                            |
| H: Power supply reliability   | 99.93%                    |                                  |
| I: power supply radius        | 99.99%                    |                                  |
| J: N-1 pass rate              | 95.32%                    |                                  |
| K: 10 KV Investment           | 221                       |                                  |

Rural Network—Analysis of the Causes of the Efficiency of Typical County Companies

In 2018, typical county companies had serious light load problems, which increased compared with 2017. Two consecutive years of young load equipment accounted for a higher proportion; power supply capacity, power supply reliability, and power supply quality met the guidelines.

There is a problem: the proportion of light loads has increased. First, in terms of problem indicators, the 10kV investment amount remained stable, and the heavy load problem decreased, but the light load accounted for a high proportion, and there were continuous light load problems. Second, in terms of target indicators, the average household power outage time, comprehensive voltage qualification rate, and power supply Reliability, power supply radius, and other target indicators changed little, and the power supply level rose slightly.

Table 5. Light Load Percentage of rural network

| Question-type indicators (A-E) | Goal-type indicators (F-J) | Other auxiliary analysis quantities |
|-------------------------------|----------------------------|-----------------------------------|
| **year**                      | **Load**                  | **Capita power outage time**      |
| A: Heavy                      | B: Overload               |                                 |
| 2017 1.37%                    | 0%                        | 4.7h                              |
| 2018 0.74%                    | 0%                        | 3.6h                              |
| C: Light                      | D: Two year in a roll     | G: voltage quality rate           |
| 48%                           | 58%                       | 99.99%                            |
| 41.37%                        | 77.65%                    | 99.99%                            |
| E: operation time more than 3 years |                          | I: power supply radius           |
| 3.6h                          | 6.42km                    | 92%                              |
| F: Per capita power outage time |                          | J: N-1 pass rate                 |
| 4.7h                          | 99.99%                    | 34                               |
| G: voltage quality rate       | 99.94%                    | ¥11660                            |
| H: Power supply reliability   | 99.95%                    |                                  |
| I: power supply radius        | 5.44km                    |                                  |
| J: N-1 pass rate              | 95%                       | 40                               |
| K: 10 KV Investment           | 34                        | ¥7385                            |

4. Conclusion

4.1. City Network—Analysis of the Causes of Efficiency Problems in Typical City Areas

(1) There are many home distribution equipment in light load: 2016-2017 did not receive transferred assets, 2018 received 280 million yuan of distribution assets, total distribution assets received accounted for 12.3% of the new distribution network assets in 2018, 2018 young distribution A total of 1124 units were changed, of which 568 were for residential residents.

(2) Large-capacity public distribution transformers have a large investment and large capacity and margin: special measures have been launched to increase household capacity since 2016, and a large number of 400 kVA distribution transformers have been used to replace small-capacity distribution transformers in the past three years (2016-2018). Among the newly added (including retrofitted)
distribution transformers, the investment in distribution transformers with a capacity of 400 kVA and above accounted for 73.29% of the new distribution transformer investments.

4.2. Suggestions for light load problems
(1) Reasonable choice of access method: In view of the high proportion of light distribution of residential distribution, consider guiding the government's residential distribution construction policy. Developers can pay according to the area's electricity demand based on area. Power supply companies allocate capacity as needed and choose economical and reasonable connection. Entry scheme

(2) Improve the load distribution rate of public distribution transformers: In response to the low utilization efficiency of low-voltage users after accessing public distribution transformers, we should fully publicize and optimize the business environment policy, guide and encourage 100-160 kVA users to access public distribution transformers, and improve public utilities. Distribution load rate

(3) Strengthen load switching: In response to the problem of high proportion of light load and large capacity margin in distribution transformers, load switching should be strengthened during distribution network operation to improve the utilization efficiency of light load equipment.

4.3. Rural Network—Analysis of the Causes of the Efficiency of Typical County Companies
(1) The utilization efficiency of rural power supply integrated transformers is low. Typical county light-load distribution transformers are mainly concentrated in rural areas of townships and towns, and 1,744 light-load distribution transformers with low comprehensive utilization efficiency in rural areas account for 65.64% of the total light-load transformers.

(2) Large-capacity public distribution transformers have a large investment and large capacity and margin. In recent years, in order to improve the business environment in A province, distribution transformers have mostly been constructed in advance based on the principle of once-in-place capacity, and a large number of 400 kVA capacity distribution transformers have been used. 37.2%.

4.4. Suggestions on measures for light load problems of rural power grid companies
(1) Optimize investment strategies and control distribution and capacity expansion. In light of the high proportion of distribution transformers with light loads and large capacity margins, the investment in distribution network should further focus on upgrading the grid structure and strengthening the construction of standard grids;

(2) Guide the home allocation policy and allocate capacity as needed. Aiming at the high proportion of residential light load, consider to guide the government's residential construction policy. Developers can pay by area according to the electricity demand of the community, and the power supply company allocates capacity on demand and chooses an economical and reasonable access plan;

(3) Implementing and optimizing business policies to increase the load rate of public distribution transformers. In view of the low utilization efficiency of public distribution transformers, we should fully publicize and optimize the business environment policy, guide and encourage 100-160 kVA users to access public distribution transformers, and increase the load distribution rate of public distribution transformers;

(4) Optimize the operation mode and adjust the layout reasonably. Aiming at the problem of low utilization efficiency of public distribution transformers, appropriately transferring low-voltage power loads, merging light-load distribution transformers, optimizing the network framework of low-voltage stations, and continuously optimizing distribution transformer distribution points;

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