Research on Benchmarking Model of Power Grid Infrastructure Management Based on Entropy Weight Method

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Abstract—Improve infrastructure management capabilities by benchmarking domestic and foreign first-class companies is a key task of power grid enterprises. This paper takes the benchmarking analysis of grid infrastructure management as the research object, from the whole process and the whole factor perspective, extracted the core elements; proposes the benchmarking index library collection; introduces entropy weight method to calculate the comprehensive weight of indexes. Finally,9 typical companies are selected as examples to carry out benchmarking calculation analysis. The result verified that the model and algorithm proposed are conducive to the improvement of power grid infrastructure operation, decision-making, and the competitiveness of grid enterprises.

Keywords—grid infrastructure; benchmarking model; Entropy weight method

I. INTRODUCTION

On 15 March 2015, the Chinese government issued “Some Opinions about the Further Deepening of the Reform of the Electric Power System” and put forward related opinions on deepening the reform of the power system, which officially opened a new round of electric power reform[1,2,3].

Therefore, strengthening the power grid infrastructure operation and upgrading construction, comparing domestic and international first-class enterprises, identifying short-term, accurate and comprehensively improving the operation level of power grid infrastructure is not only a key task, but also an important development appeal of power grid enterprises[4,5].

II. CORE ELEMENTS OF GRID INFRASTRUCTURE MANAGEMENT

Grid infrastructure management, can be understood as: “project construction management units (departments) to achieve the overall goal of the project, make full use of enterprise resources, according to the power grid project construction process system, in a certain society, economy, environment and other complex constraint conditions, relate knowledge, skills, tools and technology as well as the system scientific management methods, and apply to power grid project construction management process, finally achieve the expected construction, the paper summarizes that the core elements of power grid infrastructure management includes significant scale, Technology innovation, effective management, benefit contribution, green development, harmonious sharing.

III. CONSTRUCTION OF POWER GRID INFRASTRUCTURE MANAGEMENT EVALUATION SYSTEM

Evaluation indexes are the basis for the evaluation of the construction effect, the selection of the evaluation index is different with the difference of the evaluation purpose and requirements[6]. In addition, the selection of evaluation indicators should be fully combined with the actual situation of power grid infrastructure, and follow the requirements of comprehensiveness, generality and accessibility.

Following the selection principle of evaluation index, the index evaluation system of power grid infrastructure management is constructed in two levels.

According to the characteristics of the power grid infrastructure management, using literature research, expert survey, principal component analysis, optimization methods of judgment matrix, collecting relevant data, and through the analysis of the optimization, based on grid infrastructure management core six elements, identified 11 of the indexes(D1~D11). The core elements and evaluation indexes are shown in table 1

| TABLE I. EVALUATION INDEX OF GRID INFRASTRUCTURE MANAGEMENT |

| Element                  | Index                          |
|--------------------------|-------------------------------|
| significant scale C₁     | Infrastructure investment scale densityD₁ |
| technological innovation C₂ | Technological innovation drive levelD₂ |
| effective management C₃  | Schedule completion rateD₃     |
|                          | Quality compliance rateD₄     |
|                          | Safety control casualty rateD₅ |
|                          | Cost control levelD₆          |
|                          | Infrastructure management labor equivalent levelD₇ |
| benefit contribution C₄  | Unit investment increase supply levelD₈ |
|                          | Safe and reliable upgrade levelD₉ |
| green development C₅     | New energy consumption ratio levelD₁₀ |
| harmonious sharing C₆    | Society affects harmony level D₁₁ |
IV. INDEX WEIGHT CALCULATION

Entropy weight method is an objective weighting method, the weight of the index is determined by quantitative analysis of the actual data of the index, which ensures the absolute objectivity of the weight. In this method, the entropy value of each index is first calculated according to the function, and then the entropy value is normalized to the index weight. Generally speaking, if the information entropy of a certain index is lower, it indicates that the index is more variability, and the more information it provides, the greater role it can play in the comprehensive evaluation, and the greater its weight will be.

With n companies and m evaluation indexes, the steps of entropy weight method are as follows:

Step 1: Data standardization
Step 2: Calculate the proportion of each index
Step 3: Calculate the entropy value $e_j$ of the J-th index
Step 4: Calculate the informational utility value $f_j$
Step 5: Calculate the weight $W_j$ of each index
Step 6: Calculate upper index weight $W_k$

Substituting the standardized data into the above steps, the weight of the index can be obtained, and then the weight and quantitative value of each index can be weighted and superimposed to obtain the comprehensive score value of each company.

V. CASE STUDY

Select 11 domestic company and 8 foreign company to The grid infrastructure benchmarking, the date are shown in fig 1.

The weight of indexes are calculated by the entropy weight method. The results are shown in Table 2:

| Element | Weight | Secondary index | Weight |
|---------|--------|-----------------|--------|
| C1      | 0.10   | D1              | 0.10   |
| C2      | 0.10   | D2              | 0.08   |
| C3      | 0.5    | D3, D4, D5, D6, D7 | 0.08, 0.08, 0.08, 0.08 |
| C4      | 0.12   | D8              | 0.06   |
| C5      | 0.08   | D9              | 0.06   |
| C6      | 0.10   | D10             | 0.08   |
| C7      | 0.10   | D11             | 0.10   |

Among the first-level indexes, the index weight of effective management C3 is the largest, while that of green development C5 is the smallest. Among the secondary indexes, safety control casualty rate D5 is the largest.

According to the weights and quantified values of each index, the grid construction comprehensive scores of 19 companies are obtained, as shown in Figure 2 and table 3.

The top three scores are Company 1, Company 2 and Company 3, and the lower two are Company 11 and Company 19.

Take the company 1, company 2 and company 3 as research
objects, the second-level index scores are compared in detail, as shown in Figure 3.

![Figure III. Secondary Indexes Score](image)

From the above figure, the company’s index D4 and D8 are obviously better than that of company 2 and 3. The index D1, D2, D9 of company 2 are obviously better than that of company 1 and 3.

The relatively low ranking indexes of company 1 are infrastructure investment scale density D1, technology innovation-driven level D2, the relatively low ranking indexes of company 2 are quality compliance rate D4, new energy consumption ratio D10, and the relatively low ranking indexes of company 3 are infrastructure management labor equivalent level D7, etc. It is necessary to make clear the deficiency of infrastructure management development and the direction of construction, and put forward targeted optimization and improvement strategies, so as to provide support for enterprises to comprehensively improve their infrastructure management ability.

VI. Conclusion

Infrastructure work is the key task of power grid enterprises. The evaluation and benchmarking are conducive to the improvement of power grid infrastructure operation, decision-making, and the enterprises' industrial competitiveness. This paper focuses on the benchmarking problem of grid infrastructure management, the comprehensive evaluation method combining benchmarking index system and objective weighting method. Through the study, the following conclusions are drawn:

1. The evaluation index system established in this paper contains 6 first-level indexes and 11 second-level indicators, which can comprehensively and objectively reflect the effect of power grid infrastructure management.

2. Power grid infrastructure management has many evaluation indexes and complex data. In this paper, entropy method is used to conduct quantitative analysis on the indexes and objectively determine the weight, and good results are obtained.

3. The evaluation system constructed in this paper can objectively analyze the grid infrastructure management achievements of a company and provide guidance for the related work of grid infrastructure management.

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