Comparative Study on the Capability Assessment of Multi-regional Distribution Network Owner Project Teams Using Combined Weights

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Abstract. This paper introduces a comparative evaluation method for assessing the carrying capacity of the owner's project department using combined weights. The method integrates grid companies' requirements and current challenges in distribution network construction to establish a systematic evaluation index system. It determines indicator weights through the coefficient of variation (CV) method (objective weights) and the analytic hierarchy process (AHP, subjective weights). A comprehensive scoring model calculates normalized indicator values and weights to generate evaluation results. Empirical analysis shows that power supply enterprises achieve an optimal E-carrying capacity level of 0.93. The model provides an objective assessment of carrying capacity across different enterprises and offers theoretical and methodological support to improve distribution network project management.

Keywords: Coefficient of variation method, Hierarchical analysis, Bearing capacity, Comparative evaluation.

1 Introduction

Over the past decade, the rapid growth of power distribution infrastructure has necessitated a surge in both the volume and complexity of engineering initiatives. Typically administered by localized administrative entities—including county, district, and municipal authorities—these projects face systemic challenges. A critical issue lies in the disproportionate relationship between the escalating scope of construction activities and the availability of qualified personnel for oversight and execution, which impedes the adoption of standardized practices and operational efficiency in network development. To address this issue, it is necessary to refine the management of distribution network construction, align it with the staffing theory, and evaluate the carrying capacity, which means the number of projects that a project department can undertake. This will help standardize the entire process and identify existing problems in current management practices. Such efforts are crucial for promoting the reform of the distribution network construction management model and improving construction management efficiency. However, there is a lack of comprehensive literature on the carrying capacity

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evaluation and analysis. Regarding the evaluation and practical implementation of carrying capacity, literature [1] quantifies the dispatching business and the available time of personnel by establishing a calculation model for the dispatcher carrying capacity of the power company, and evaluates the work intensity of the dispatcher during duty. To check whether the dispatcher configuration is reasonable, to provide a basis for power outage planning and to reduce potential safety hazards. The literature [2] combined the project department personnel, operation team personnel, machinery and equipment and other factors to construct the enterprise carrying capacity calculation model, which realizes the quantitative analysis of the business carrying capacity of electric power enterprises. Literature [3] introduced the entropy weight method and four-quadrant analysis method to construct a construction crew load-bearing capacity assessment system, which improves construction efficiency and reduces production and management costs. In terms of project risk analysis, literature [4] investigates early-warning strategies for managing subcontractor capacity limitations and associated risks, reflecting the challenges posed by the rapid expansion of electrical infrastructure and the drive toward efficient resource utilization. The immediate goal of implementing bearing capacity and risk early warning control is to accurately grasp the construction bearing capacity of each subcontractor. In terms of project staff optimization, literature [5] used the non-dominated sorting genetic algorithm NSGA-II to solve the construction staffing optimization model, which reduces the project duration and labor cost. The evaluation system and selection methods discussed in the literature provide valuable theoretical and methodological support for the project research. However, there are limitations in analyzing the carrying capacity of the project department and conducting horizontal comparative evaluations across multiple regions. The existing research does not fully integrate the unique aspects of network operations with the operational conditions of the project department. This study first considers the unique features of distribution network project management, then incorporates the project management requirements and conditions of the owner. A scientifically designed evaluation index system is established, and subjective and objective weights are determined using CV method and AHP. Finally, a comprehensive scoring method is applied to obtain evaluation results, with empirical analysis conducted to validate the feasibility and effectiveness of the model.

2 The Main Idea of the Technical Method

First, collect the necessary data for index calculation and compute the index values based on their definitions and formulas. Then, normalize the indicators, using different normalization functions to transform data into the [0, 1] interval according to the index attributes. In the weight calculation model, both the AHP and the CV method are used to determine subjective and objective weights for the indicators. These weights are combined into a single set using a combined weighting method. The index weight remains relatively stable over time, but may shift with changes in power demand or grid development. This weight is based on professional opinions and the management requirements of the owner's project department. The AHP is applied to assign weights to the evaluation indicators based on expert input. Finally, a comprehensive scoring model is used to calculate the overall carrying capacity evaluation score of the project department for each power supply enterprise, considering both normalized index values and their weights.

3 Comparative Evaluation Model

3.1 Evaluation Index System

The project department's carrying capacity evaluation system is based on structured manuals, performance checklists, and other guidelines. It emphasizes staffing and process management within distribution network projects, focusing on quality, schedule, and cost performance. To improve practicality and guidance, a benchmarking index system is established as shown in Table 1:

Table 1. Carrying capacity evaluation index system

First-level index	Secondary indicators	Three-level indicators (Number)
Carrying capacity level	Project scale carrying capacity	Scales of investment and personnel support rate ①
	Personnel capacity	Work/Life support ratio for project managers ②
		Qualification saturation of project department staff ③
	Foundation bearing capacity	Rate of milestone plan execution ④
	Schedule carrying capacity	Overall completion rate of the distribution network project ⑤
		Rate of adjustments in allocation reform items ⑥
		Alignment rate of "Four Elements" ⑦
	Safe carrying capacity	Count of individual safety incidents ⑧
	Mass carrying capacity	Investment deviation rate ⑨
	Cost bearing capacity	Duration ratio of final settlement ⑩

3.2 Evaluation Weight Determination

Principles and Steps of AHP. The AHP decomposes a decision problem into distinct objective layers, every one representing a key aspect. It then creates a judgment matrix based on evaluation criteria, calculates the feature vector to determine the weights of each element, and uses the summation technique to calculate the ultimate value of each option. The option with the largest weight is the optimal choice.

1) First, a hierarchical structure is built by decomposing the decision-making problem into multiple core elements, organized from top to bottom. AHP analyzes the problem by breaking it down into various elements, which are then further divided into levels based on their attributes. This results in a hierarchical problem structure model that forms the foundation for the AHP.

2) A comparison matrix is created to illustrate the weight relationship among the various components. Typically, the 1-9 scale method is used, where numbers 1-9 and their reciprocals are employed to evaluate the relative importance between elements.

3) The single ranking consistency test uses the consistency index (CI) to assess whether the judgment matrix is logically sound. A CI value less than 0.10 indicates that the matrix is reasonable and free from significant logical errors.

4) Once the alignment of individual rankings satisfies the requirements, a final coherence evaluation is necessary. If passed, the current weight rankings can serve as the final decision basis.

Theory of CV Method. The CV method computes the variation in system metrics using statistical techniques, giving higher weights to those with greater fluctuation and lower weights to those with less variation. This objective method reflects the change information of the data, allowing for more accurate weight assignments. Indicators with a large gap between their current and target values are given higher weights, indicating they are more difficult to achieve.

1) Given n samples and p assessment metrics, the initial data table for the indicators is constructed:

$$\boldsymbol{X} = \begin{pmatrix} x_{11} & \cdots & x_{1p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{pmatrix} \tag{1}$$

2) The mean and standard deviation of the j-th evaluation index are calculated:

$$\bar{x}_j = \frac{1}{n}\sum\nolimits_{i=1}^{n} x_{ij} \tag{2}$$

$$s_j = \sqrt{\frac{\sum\nolimits_{i=1}^{n}\left(x_{ij} - \bar{x}_j\right)^2}{n-1}} \tag{3}$$

3) The CV for the j-th evaluation index is computed:

$$v_j = s_j / \bar{x}_j, j = 1, 2, \cdots, p \tag{4}$$

4) Normalize the CV to determine each indicator's weight.

$$w_j = \frac{v_j}{\sum\nolimits_{j=1}^{p} v_j} \tag{5}$$

3.3 Determination of Comprehensive Evaluation Results

First, the weights obtained from the hierarchical analysis method as well as the CV method are summed and averaged to obtain the combined weights. Then, the additive method is applied to combine standardized metric values, producing an overall score:

$$y = \sum_{j=1}^{m} w_j a_j \tag{6}$$

$$\sum_{j=1}^{m} w_j = 1, 0 \le w_j \le 1, j = 1, 2, \cdots m \tag{7}$$

Where y represents the system's overall score, a_j represents the normalized value of the index, and w_j is the combined weight coefficient.

4 Empirical Analysis

Choosing nine local electricity providers under A Province's Electric Power Corporation as the research subjects, the information is obtained from the actual operational data of the municipal energy firms in the region, as shown in Table 2.

Table 2. Table of raw statistics.

Evaluation index	Unit	A	B	C	D	E	F	G	H	I
①	%	114.34	107.43	89.76	113.45	121.55	97.23	100.11	102.31	112.21
②	%	49.36	60.23	46.23	56.32	51.43	62.11	45.32	53.25	56.11
③	%	17.18	19.23	23.11	21.56	32.14	32.11	16.23	19.23	24.12
④	%	100.00	98.23	91.43	92.35	99.23	95.43	94.34	95.21	97.34
⑤	%	78.00	82.31	75.32	90.32	81.23	75.23	79.53	83.22	86.32
⑥	%	98.34	97.23	95.44	94.33	96.23	97.11	93.22	91.43	90.55
⑦	%	100.00	100.00	90.00	90.00	90.00	90.00	90.00	95.00	95.00
⑧	/	0	0	0	0	0	0	0	0	0
⑨	%	5.00	4.78	6.87	6.43	5.31	5.75	4.97	6.11	5.88
⑩	%	85.00	84.23	86.34	82.11	79.66	83.22	84.21	85.87	81.09

By integrating the CV method with AHP, subjective, objective, and comprehensive weights are obtained, as shown in Table 3

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Table 3. Weight calculation results.

Evaluation index	Objective weight	Subjective weight	Comprehensive weight
①	0.12	0.08	0.10
②	0.14	0.08	0.10
③	0.33	0.02	0.17
④	0.04	0.11	0.08
⑤	0.08	0.09	0.09
⑥	0.04	0.14	0.09
⑦	0.06	0.14	0.10
⑧	0.00	0.16	0.08
⑨	0.16	0.06	0.11
⑩	0.03	0.12	0.08

Based on the calculations, the carrying capacity for project departments of network owners across regions is as shown in Table 4.

Table 4. Evaluation results of the carrying capacity

Company name	A	B	C	D	E	F	G	H	I
Evaluation results	0.8510	0.8712	0.8661	0.8973	0.9300	0.9292	0.8088	0.8668	0.9013

The findings indicate that Area E demonstrates the highest capacity. Metrics like investment scale, staff-to-support ratio, project manager experience, and qualifications saturation of team members perform exceptionally well, while other factors show balanced results. As a result, Area E ranks first in capacity. Moving forward, the superior management practices of Area E should be further examined to improve operational efficiency.

5 Conclusion

This paper introduces a combined-weight evaluation model for assessing the capability of the owner's project teams. The model incorporates existing management practices, conditions, and essential performance metrics to evaluate capacity in a systematic way. Empirical analysis confirms the model's effectiveness, showing that Area E in Province A achieves an optimal carrying capacity level of 0.93. Factors such as investment scale, personnel support ratio, and staff qualifications are identified as key to enhancing carrying capacity.

The evaluation index system developed in this paper primarily relies on the current management processes and assessment criteria, which may have limited applicability when applied to different regions, enterprise sizes, or management models. Future research should focus on exploring the specific impacts of inter-regional economic, resource, policy, and other contextual factors on carrying capacity to enhance the generalizability and robustness of the proposed model.

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