Research on optimization and sorting method of power grid reserve project based on comprehensive evaluation of project contribution

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Abstract. The current preferred ranking of reserve projects is only static for the current power grid, and does not consider the impact of the project production sequence on the power grid, and ignores the relationship between reserve projects, resulting in the inaccurate order of project delivery. Therefore, this paper puts forward based on the project production contribution of reserve project dynamic optimization sorting technology method, based on the comprehensive contribution to the overall power grid, establish the correlation between reserve project, fully considering the impact of the project time grid, so as to improve the power grid investment project reserve scientific.

Keywords: power grid reserve project, contribution degree evaluation, preferred sorting technology

1 INTRODUCTION

The research on the optimization and sorting method of power grid reserve projects can further improve the rationality of resource allocation of power grid enterprises and improve the scientific decision-making of enterprise investment projects.

Zhao Juan et al. [1] constructed a comprehensive project evaluation index system from four aspects: urgency, importance, policy and feasibility, and conducted an all-round evaluation of power grid reserve projects. Yang Jian et al. [2] used the analytic hierarchy method to establish a project evaluation index system for power grid project reserves based on the necessity and feasibility of project control. Zeng Ming et al. [3] constructed the power grid investment benefit evaluation index system from four aspects: main grid frame investment, distribution network branch investment, sub-professional power grid investment, and voltage level power grid investment, and then analyzed the linkage mechanism between power grid investment benefit evaluation and project reserve management, and put forward relevant guarantee mechanism suggestions. Xu Wenxiu[4] Considering the uncertain influencing factors (power grid

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operating costs, electricity prices, etc.) in the process of power grid construction projects, an economic evaluation model for power grid construction project investment based on blind number theory was established, and the effectiveness of the model was verified by examples. Fang Jianliang et al. [5] established a hierarchical ranking of power grid reserve projects, which effectively reflected the priority focus on capital and project arrangement, ensured that the investment plan was in line with the company's strategic goals, and promoted the company's operation to improve quality and efficiency.

In summary, for the current evaluation of the investment effect of power grid projects, there is a lack of evaluation methods and standards for reserve projects that know all functional attributes, and most of them are evaluated and calculated from the perspective of a single functional attribute project, which is difficult to effectively guide the investment plan and start plan arrangement.

2 Research ideas in this paper

Based on the current situation of the optimal ranking management of reserve projects in power grid enterprises, this paper puts forward the dynamic optimization ranking method of reserve projects based on the comprehensive contribution of unit cost. This method decomposes the multi-item dynamic preferred ranking mathematical model into a static preferred ranking model with multiple rounds and multiple items, In each round of the optimal comprehensive contribution reserve project selection, Based on the static preferred ranking model for reserve items, Considering the dynamic impact of the previous reserve project construction on the comprehensive contribution of the project, Recculate the project's combined contribution to the overall grid, Open the association between reserve items, After finding the optimal comprehensive contribution reserve project in this round, Then conduct the static optimization sorting round by round, In each round of reserve project selection, Judging the logical relationship between the construction sequence of the reserve projects, Finally, the ranking results are obtained. The research ideas of this paper are shown in Figure 1 below:

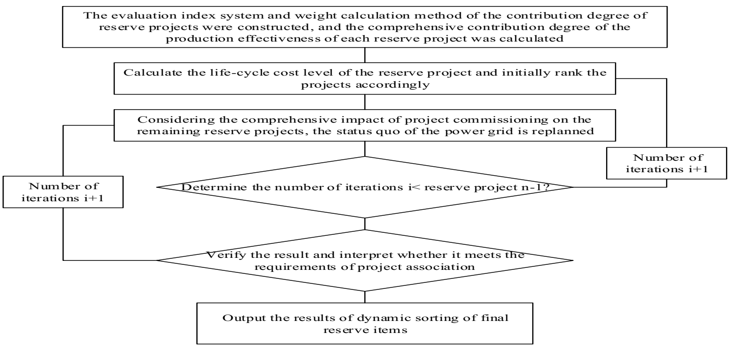

Fig. 1. Technical idea diagram of this paper.

It can be seen from Figure 1 that the optimal ranking technical method of power grid reserve projects based on the comprehensive evaluation of project contribution constructed in this paper includes the following implementation steps: 1) The contribution degree and portfolio weight of each project index are obtained based on the contribution degree of each project to the power grid effectiveness and the combination empowerment result, and the comprehensive contribution degree of the project is calculated. 2) Calculate the life cycle cost of each project, use the calculated comprehensive contribution degree per unit investment to rank the power grid reserve projects, and select the project with the highest unit + comprehensive contribution as the preferred project for this ranking. 3) For the remaining items to be selected, recalculate the grid situation containing the preferred reserve items, and repeat the above steps until all reserve items are dynamically prioritized. 4) Verify the above sorting results and observe whether they meet the requirements of project association. 5) Output the dynamic ranking results of the final reserve items.

3 Research on the comprehensive evaluation method of the contribution degree of power grid reserve projects

3.1 Construction of the evaluation index system

According to the contribution effect of power grid reserve projects, they can be divided into four types of projects: improving the power grid safety level, meeting the new load projects, power supply projects, and strengthening the grid structure projects. Taking into account the characteristics of reserve projects, the actual situation of the power system, and the difficulty of relevant data collection and prediction, this paper constructs the evaluation index system from the four dimensions of safety and reliability, development coordination, economic benefit contribution, and social benefit contribution, as shown in Table 1 below:

Table 1. Comprehensive evaluation index system of the contribution degree of power grid reserve projects.

Evaluative dimension	Evaluating indicator
safe reliability	N-1 pass rate
	Short-circuit current lift degree
	The increase degree of power failure risk
Development coordination	Power supply delivery capacity
	Equipment load rate
Economic benefit contribution	Equipment maximum load rate
	Comprehensive line loss rate
	Increase power supply
Social benefit contribution	New energy emission reduction benefits

3.2 Index weight determination method based on moment estimation theory

Take samples s with the number of d from the subjective weight population, take the samples with the number of q − d from the objective weight population (q is the total number of weight samples), and equivalentize the sample mean and the origin moment of order 2 as the overall expectation and variance. The q weight samples of each attribute G_j need to meet the requirements to make the deviation between the combined weights W_j and the q subjective and objective weights as small as possible, and also consider the relative importance of the subjective and objective weights of different attributes, represented by α and β, then the combined weights solve the following model:

$$\begin{cases} minH = \sum_{j=1}^{n} \alpha(w_j - E(w_{hj}))^2 + \sum_{j=1}^{n} \beta(w_j - E(w_{hj}))^2 \\ s.t. \sum_{i=1}^{y} w_j = 1, 0 \le w_j \le 1, 1 \le j \le n \end{cases} \tag{1}$$

3.3 Calculation method of the comprehensive contribution degree of the reserve projects

First of all, this paper uses all kinds of reserve projects to improve the effectiveness evaluation index of the whole power grid in the aspects of safety, coordination, economy and society, and puts forward the calculation method of the improvement degree of each reserve project on the power grid. The calculation expression of the index is:

$$u_{ki} = \pm \frac{r_{ki,a} - r_{ki,b}}{r_{ki,b}} * 100\% \tag{2}$$

In the formula, $r_{ki,b}$ and $r_{ki,a}$ are the index values of the $i-th$ index before and after the $k-th$ power grid reserve project is put into operation; u_{ki} is the degree of improvement of the first I indicator of the $k-th$ reserve project. Among them, if the larger the r, the more conducive to the development of the power grid, the improvement degree is "+"; If the smaller the more conducive to the development of the power grid, the degree of improvement is "-". The contribution of the indicator is calculated as:

$$s_{ki} = \frac{u_{ki}}{\sum_{i=1}^{m} |u_{ki}|} * 100\% \tag{3}$$

where m is the total number of reserve items; u_{ki} is the contribution value of the $i-th$ indicator of the $k-th$ grid reserve project. Through the calculation of the contribution degree of indicators, the dedimensionalization and standardization of each index can be realized, so that the indicators that cannot be directly compared due to different dimensions can be removed for the calculation of comprehensive contribution, so that the contribution of reserve project indicators is comparable.

4 Construction of the optimal sorting technology model of the reserve project by the improved particle swarm algorithm based on niche technology

The former particle swarm algorithm has been applied in many fields, but when dealing with complex models, the algorithm is easy to fall into the local optimal problem, namely the "early maturity problem". In this paper, aiming at the shortcomings of the particle swarm algorithm in dealing with complex problems, avoid the algorithm falling into the local optimum, introduce the niche technology to improve, and propose the improved particle swarm algorithm based on the niche technology.

In this paper, we introduce niche technology sharing mechanisms to reduce similar individual fitness to avoid local convergence and "early maturity" phenomenon. The sharing mechanism can be described as follows:

$$\begin{cases} d(i,j) = \sqrt{\sum_{k=1}^{n}(x_{ik} - x_{jk})^2} \\ Sh(i,j) = \begin{cases} 1 - (d(i,j)/\delta_r)^2, d(i,j) < \delta_r \\ 0, d(i,j) \geq \delta_r \end{cases} \\ Fit_i = \frac{1}{Sh_i} = \frac{1}{\sum_{j=1}^{N} Sh(i,j)} \end{cases} \tag{4}$$

where $d(i,j)$ represents the Euclidean distance between i and j; δ_r is the set niche radius. $Sh(i,j)$ is the shared distance between i and j, reflecting the degree of intimacy between i and j; N is the number of individuals in the territory of the child; $Sh(i,j)$ represents the degree of sharing of particles; Fit_i indicates the fitness of the particle.

In niche technology, its radius is an important factor. The size of the radius can reflect the diversity of the population, but the radius bias leads to low computational efficiency. Therefore, we adjust the value of the radius dynamically to improve its adaptability, and the adjustment method is as follows:

$$\delta_r = \delta_{rmin} + (\delta_{rmax} - \delta_{rmin})\frac{k}{I_{tera}} \tag{5}$$

Where is the current number of iterations; is the maximum number of iterations. At the beginning of the iteration, it smaller. The niche radius strengthens its overall ability to find optimal exploration, avoids the rabbit from falling into the local optimal problem, and gives it the larger niche radius, so as to strengthen its local optimal exploration ability.

5 Empirical analysis

5.1 Raw data collection

In this paper, a municipal power grid enterprise "fourteenth five-year" reserve planning database power grid project, to carry out empirical analysis and research. The reserve project data is collected and organized according to the project type and project planning and investment. The specific data are shown in Table 2 below:

Table 2. Raw data sheets.

Order number	Project name	Project type	Project planning investment (Wan Yuan)	New transformer capacity (ten thousand kVA)	New line length (km)
1	A certain 220 kV power grid optimization project(Project 1)	Improve power grid security	38274		150.6
2	A new 220 kV power transmission and transformation project(Project 2)	Meet the new load	10256	48	35.2
3	A new 220 kV power transmission and transformation project(Project 3)	Meet the new load	8654	48	15
4	A new 220 kV power transmission and transformation project(Project 4)	Meet the new load	7216	36	20
5	A new 220 kV power transmission and transformation project(Item 5)	Meet the new load	12514	48	35
6	A new 220 kV power transmission and transformation project(Project 6)	Meet the new load	18971	48	9.23
7	A 220 thousand substation main transformer expansion project(Project 7)	Meet the new load	13756	20	1.56
8	A 220 kV power grid grid optimization project(Project 8)	Strengthen the structure of the grid	11456		21
9	A new 220 kv power transmission and transformation project(Project 9)	Meet the new load	30012	48	52.1
10	A 220 kV photovoltaic delivery project(Project 10)	Improve the power supply delivery capacity	26450		60

5.2 Evaluation of the comprehensive contribution degree of the reserve projects

Based on the predicted power grid data before the construction of the reserve project and after the reserve project is put into operation, the improvement index and contribution index values of each reserve project are calculated. The specific results are shown in Table 3 and Table 4 below:

Table 3. Improvement degree of evaluation indexes of 4 reserve items.

Order number	project name	N-1 pass rate improvement level	Short-circuit current lift level	The risk of power outage is increased	Power supply delivery capacity improvement level	Equipment load rate balancing level	Equipment maximum load rate	Comprehensive line loss rate improvement level	Increase the efficiency of power supply	New energy emission reduction benefits
1	Project 1	0.065	-0.289	2.381	0	-3.928	42.702	0.011	0.09	0
2	Project 2	0.002	-0.2	-8.65	0	-1.918	20.985	0.001	0.19	0
3	Project 3	0.002	-0.065	4.172	0	-2.568	27.926	-0.002	0.28	0
4	Project 4	0.001	-0.24	-6.3	0	-3.421	37.218	0.006	0.30	0
5	Project 5	0.001	-0.216	8.412	0	-2.815	30.369	0	0.18	0
6	Project 6	0.002	-0.204	2.713	0	-3.102	29.123	0	0.18	0
7	Project 7	0	0	0	0	-4.322	41.656	0	0.49	0
8	Project 8	0.001	0	-0.253	0	-4.246	40.812	0	0.08	0
9	Project 9	0.003	-0.589	3.568	0	-2.679	25.765	0	0.12	0
10	Project 10	0.001	-0.092	9.899	0	-5.886	57.581	0	0.25	0

As shown in Table 3 above, the increase degree of short circuit current and load rate of equipment are negative indicators, and the smaller the value, the more favorable it is to the power grid development; while the increase degree of power outage risk and network loss rate are positive, which is conducive to the development of the power grid, while the value is negative, which is not conducive to the development of the power grid. The contribution degree calculation results of each index are shown in Table 4 below.

Table 4. Contribution of evaluation index of 4 reserve items.

order number	project name	N-1 pass rate improvement level	Short-circuit current lift level	The risk of power outage is increased	Power supply delivery capacity improvement level	Equipment load rate balancing level	Equipment maximum load rate	Comprehensive line loss rate improvement level	Increase the efficiency of power supply	New energy emission reduction benefits
1	Project 1	10.68	-6.13	1.58	0	-4.52	4.88	17.15	1	0
2	Project 2	0.31	-4.01	-5.78	0	-2.03	2.36	1.35	1.85	0
3	Project 3	0.31.	-1.38	2.81	0	-2.84	3.18	-3.42	3.03	0
4	Project 4	0.23	-5.10	-4.18	0	-3.87	4.26	6.48	3.23	0
5	Project 5	0.23	-4.62	5.61	0	-3.16	3.47	-0.275	1.89	0
6	Project 6	0.31.	-4.28	1.81	0	-3.42	3.47	-0.72	1.89	0
7	Project 7	0.11	0	0	0	-4.91	4.82	0.11	4.75	0
8	Project 8	0.11	0	0	0	-4.81	4.65	-0.65	0.65	0
9	Project 9	0.38	-12.68	2.52	0	-3.01	3.03	0	1.22	0
10	Project 10	0.11	-2.01	6.69	0	-6.79	6.58	0	2.65	0

Based on the calculation results of contribution, the objective weight was calculated by substituting the entropy weight method and the mean variance method, and 11 experts were organized to analyze, judge and weigh the indicators of the index system, and fill in the judgment matrix of the quantitative evaluation system of reserve items. The specific subjective and objective weight calculation results are shown in the following table 5:

Table 5. Calculation results of each index.

weight	N-1 pass rate improvement level	Short-circuit current lift level	The risk of power outage is increased	Power supply delivery capacity improvement level	Equipment load rate balancing level	Equipment maximum load rate	Comprehensive line loss rate improvement level	Increase the efficiency of power supply	New energy emission reduction benefits
Comprehensive weight	0.201	0.018	0.091	0.156	0.076	0.101	0.062	0.143	0.152

Table 5 is based on the judgment matrix of the quantitative evaluation system of the 11 expert reserve projects, and the subjective average weight of the 11 experts is calculated by using the analytic hierarchy method and the Delphi method.

Combined with the model principle, the dynamic adjustment ranking results of reserve items are shown in Table 6 below:

Table 6. Comparison of item preferred ranking results.

Order number	Project name	Planning library sorting	Sort them after model optimization
1	Project 1	2	3
2	Project 2	10	8
3	Project 3	5	4
4	Project 4	4	1
5	Project 5	6	6
6	Project 6	8	9
7	Project 7	3	5
8	Project 8	7	7
9	Project 9	1	2
10	Project 10	9	10

6 Conclusion

This paper considers the coupling relationship between each reserve project and the influence of each reserve project on the contribution of other reserve projects after it is put into operation, constructs the optimal ranking method of power grid reserve project based on the comprehensive evaluation of project contribution, and carries out empirical analysis and research based on the actual data of power grid enterprises in a certain city. The results prove that this method can effectively evaluate the comprehensive contribution degree of power grid reserve projects and compare the construction schedule, so as to further improve the investment benefit level of power grid enterprises.

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