Research on the Comparison Method of Power Grid Engineering Reserve Projects under the Transmission and Distribution Price Reform

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Abstract. In the context of transmission and distribution price (TDP) reform, the "TDP" policy of "permitted cost plus reasonable revenue" replaces the price principle of "purchase and sale price difference", and the "TDP" is approved separately under the premise of respecting the commodity properties of electricity, which constrains the investment capacity of power grid enterprises to a certain extent. At the same time, after the reform of "TDP", the power grid is increasingly concerned about the effectiveness of investment in reserve projects, and it is especially important to use a systematic scientific method to study the quantitative evaluation and preferential ranking of power grid reserve projects to achieve accurate investment. This paper establishes the evaluation system of power grid engineering reserve projects (PGERP) from the whole process of investment and efficiency system of power grid project construction in the new power system construction. Firstly, we analyze the reliability, economy, coordination and efficiency of each reserve project to improve the overall grid effectiveness assessment, apply the entropy weighting method to evaluate the indexes and combine with the technique for order preference by similarity to an ideal solution method (TOPSIS) to establish a quantitative model to select the optimal ranking scheme of the grid engineering reserve project; secondly, considering the initial dynamic investment scale of the reserve project, we calculate the comprehensive contribution rate of the unit investment of the grid reserve project. Again, the optimal ranking method is carried out to realize the optimal ranking method of the "PGERP". Finally, selecting the 110kv transmission and substation projects in Zhejiang Province to carry out the empirical study of the optimal ranking, to verify the practical application effect and the scientific and reasonable nature of the selection method, so that the unit investment of the power grid enterprises can effectively support the investment plan and construction plan while obtaining the maximum benefit.

Keywords: transmission and distribution price reform; reserve projects; entropy-TOPSIS model; grid construction

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1. Introduction

In 2015, the State Council issued the "Opinions on Further Deepening the Reform of the Electricity System", which opened the curtain on a new round of power system reform that has attracted much attention in China. To further break the monopoly of the power grid enterprises, China adopted a series of comprehensive reform measures for transmission and distribution prices, and the power grid enterprises said goodbye to the main profit model of earning the difference in electricity prices, and changed to "permitted cost + reasonable income" to improve the effectiveness of releasing the dividends of electricity reform[1] . Although the stability of their profitability has been strengthened to a certain extent, and the degree and scope of regulation has been enhanced, the cost structure of grid enterprises has been changed to a large extent, affecting their operating income and cash flow. Because of the special nature of power grid projects, which take a long time and require a huge number of investments, the transmission and transformation tariff reform has brought a lot of economic pressure to the implementation of power grid projects. In the background of the transmission tariff reform, power grid enterprises are eager to make investment activities to improve their profit growth rate, but some enterprises lack of detailed investment planning, so there are major problems in the investment decision, not only to a certain extent affect the rationality of the internal use of funds, making enterprise resources can not be reasonably allocated, but also make the enterprise are difficult to achieve both economic and social benefits.

In order to achieve long-term stable development of power grid enterprises, enterprises not only need to combine the background of transmission and transformation tariff reform, establish a perfect budget management system, promote the transformation of enterprise production and operation mode, and meet the rigid investment demand, but also need to implement the corresponding responsibility system to achieve the best possible investment return. Therefore, it is particularly important to use a systematic and scientific approach to study the quantitative evaluation and preferential ranking of the "PGERP" to achieve accurate investment, so as to strengthen and standardize power co-ordination planning and power grid investment supervision, realize the optimization of internal investment structure, and guarantee the realization of power grid enterprise business objectives.

There have been more studies on the comprehensive evaluation and preference ranking of grid reserve projects at home and abroad. In the evaluation of reserve projects, Xu,R.N (1992)[2] brings fuzzy mathematics into the comprehensive evaluation of multiple schemes and transforms the discussion at the qualitative level into a study at the quantitative level, and Lin,Y (2014), Mu,YZ (2015), Wu,H.L (2019)[3]-[5] also extend this approach; Wang,T (2016)[6] proposes quantitative reliability assessment indexes for grid reliability and economic evaluation, and planning scheme investment value index; Newbum et al. (2016)[7] establish unique data sets to evaluate projects from economic and institutional perspectives. Yao Feng et al. (2018)[8] solved the comprehensive weights using improved hierarchical analysis and entropy weight method, and based on the scores of overall planning scheme investment benefit evaluation, the grid planning scheme was comprehensively evaluated; Yao Qi et al. (2021)[9] constructed a quantitative evaluation model for the transmission link engineering reserve project, and solved the transmission grid portfolio weight optimization model using particle swarm optimization algorithm based on quadratic interpolation .

In the research field of the optimal ranking of grid reserve projects, QianZ (2004)[10] used quantitative research methods to build a comprehensive evaluation and ranking model for the economics of reserve projects from the economic perspective of the projects, ARAUJOSV (2010)[11] used the probability distribution method to comprehensively evaluate multiple grid projects, and also chose the static ranking method to compare the projects; Li Canbing et al. (2013), Song (2013), and Peng Dingwu (2013)[12]-[14] proposed the network coordination degree assessment model, the auxiliary decision-making index system for grid infrastructure projects, and the two-stage method for optimal ranking of grid construction projects to derive the optimal construction order of projects, respectively. Zhao Juan et al. (2018)[15] selected hierarchical analysis method for assigning weights to each evaluation index, and also constructed a comprehensive evaluation model for ranking grid reserve projects. Yu Song (2018)[16] Three sequential rankings based on the first principle of project attribute priority, the system comprehensive index evaluation system and the project time and space sequential constraints are conducted, and the final results of the optimal ranking of medium voltage distribution grid projects are given.

In view of the current situation of domestic and foreign research, there have been more studies on the evaluation of input-output efficiency of power grid projects, which can provide important reference for similar projects. However, in the face of the current investment management requirements of power grid enterprises under the "TDP" reform, as well as the characteristics of large number and variety of reserve projects, there are shortcomings in the previous studies: on one hand, influenced by the traditional thinking and production model, weaken the analysis of economic and efficiency effectiveness, without fully considering the coordination and reliability; on the other hand, the evaluation and optimization management of power grid construction reserve projects lack of comprehensive scientific methods and standards, less taking a scientific quantitative approach to multiple power grid investment reserve projects for its effective multi-dimensional evaluation. In addition, the research process ignores the overall development trend of the grid, and lacks consideration for the role and effectiveness of individual projects on the whole grid after they are put into operation, thus making it difficult to meet the technical support conditions needed to maximize the unit investment benefits of the grid project reserve.

Based on this, this paper establishes a multidimensional evaluation index system for the "PGERP" based on the optimized entropy weight TOPSIS model, and takes into account the characteristics of the change of project investment income under the "TDP" reform and the impact of project construction on the overall coordination of power grid. Firstly, we analyze the reliability, economy, coordination and efficiency of each reserve project to improve the overall grid effectiveness assessment, and apply the entropy weighting method to calculate the weighting of each indicator; secondly, we apply the TOPSIS method to calculate the relative posting progress of each reserve project and rank them once; finally, we consider the preliminary investment cost of the reserve project, calculate the comprehensive contribution rate of each unit investment and rank them finally. The results of the two rankings are used as the basis to realize the optimal ranking method for the "PGERP".

2. Grid engineering reserve project evaluation index system

2.1 Basic framework of index system

The quantitative evaluation index system of the "PGERP" is the basis of reserve project preference ranking. According to the characteristics of the "PGERP", considering the actual situation of power system transmission and substation engineering projects, data collection and the difficulty of prediction, this paper selects and chooses indicators from the perspective of solving power grid problems, and establishes the "PGERP" based on the principles of systemic, independence, accessibility, guidance and comparability in terms of power grid reliability, coordination, economy and efficiency.The quantitative evaluation index system of the project is shown in Table 1.

Table 1 Quantitative evaluation index system of power grid engineering reserve projects

Primary Indicators	Secondary indicators	Indicator Properties	Calculation means
Reliability indicators	Capacity share	Weighting calculation	Statistical Analysis
	Line length as a percentage	Weighting calculation	Statistical Analysis
Coherence indicators	Maximum equipment load factor	Weighting calculation	Tide calculation
	Load Capacity Ratio	Calibration	Statistical calibration
Economic indicators	Average line loss rate	Weighting calculation	Tide calculation
	Load factor	Weighting calculation	Tide calculation
Beneficial indicators	Electricity efficiency	Weighting calculation	Statistical calculation
	Equipment Utilization	Weighting calculation	Tide calculation

2.2 Definition and quantitative model of reserve project evaluation index

2.2.1 Reliability indicators

1) Capacity share

Grid capacity is the total load allowed to be carried by the grid, i.e. the maximum amount of charge carried by all circuits in an area. The capacity share is the ratio of the capacity of the reserve project to the capacity of the transmission line to which the reserve project belongs, and the expansion of capacity and lines improves the reliability of power supply for the regional grid.

$$V = \frac{V_k}{V_L} \times 100\% \tag{1}$$

In the above equation (1), the V is the capacity share, and V_k is the capacity of the reserve project, and V_L is the capacity of the transmission line to which the reserve project belongs.

2) The proportion of line length

Transmission line length is the length of the line for remote transmission of electric power. In this paper, the line length ratio is selected as one of the reliability evaluation indicators, which is the ratio of the line length of the reserve project to the length of the transmission line belonging to the reserve project.

$$L = \frac{L_k}{L_{all}} \times 100\% \tag{2}$$

In the above equation (2), the L is the percentage of line length, andL_k is the length of the reserve project line, andL_{all} is the length of transmission lines belonging to the reserve project.

2.2.2 Coordination indicators

1) Maximum equipment load factor

In this paper, the maximum equipment load factor index is set for measuring the coordination of reserve projects. The power transmission of the reserve projects of power projects put into operation under the maximum operation mode of the planned power grid is derived from the tide calculation.

$$\begin{cases} \delta_T = \dfrac{P_T}{S_T} \\ \delta_L = \dfrac{P_L}{P_E} \end{cases} \tag{3}$$

In the above equation (3), δ_T is the maximum transformer load factor.P_T is the maximum transformer load in the maximum operating mode in the year of commissioning.S_T is the rated capacity of the transformer.δ_L is the maximum load factor of the line.P_L for the maximum active power on the line.P_E is the economic transmission power of the line.

2) Load capacity ratio (calibration index)

The capacity-to-load ratio is a construction index used for transmission and substation infrastructure projects, referring to the power supply capacity of the transformer in a certain power supply area for the maximum load at the same voltage.

$$R_S = \frac{S_T}{P_{max}} \tag{4}$$

In the above equation (4), the R_S is the capacity-load ratio of a voltage level, and S_T is the main substation capacity of the voltage level and P_{max} is the highest annual forecast (or current situation) load of the voltage level.

2.2.3 Economic indicators

Under the new situation of the "TDP" reform, the government regulation is stricter on the effective assets. The effective assets are approved based on the investment effectiveness, so more attention should be paid to the investment efficiency and effectiveness. In this paper, line loss rate and load factor are cited to evaluate the economy of power grid investment input and output.

1) Line loss rate

In practical application, the statistical line loss is the difference between power supply and power sales. Since the statistical line loss of different feeders varies greatly in magnitude, the statistical line loss rate is usually used as the evaluation index of the line loss of the power system.

$$P_{loss} = \frac{P_g - P_s}{P_g} \times 100\% \tag{5}$$

In the above equation (5), the P_{loss} is the line loss rate, and P_g is the amount of electricity supplied, and P_s is the amount of electricity sold.

2) Load factor

The load factor is the ratio of the average load over a specified period of time to the maximum load designed for the grid. The load factor is used to measure the variation of the load over a certain period of time and thus to assess the economic utilization of the transformer.

$$\beta = \frac{P_{ave}}{P_{max}} \times 100\% \tag{6}$$

In the above equation (6), β is the load factor, andP_{ave} is the average load during the specified time period, and P_{max} is the maximum load during the specified time period.

2.2.4 Beneficial indicators

1) Electricity efficiency

Power efficiency is the product of the increased transmission volume of substations and lines and the unit power tariff of that voltage level after the reserve project is put into operation, and this paper uses this indicator to evaluate the efficiency of the reserve project put into operation.

$$\begin{cases} C_{kT} = \sum_{i=1}^{m} P_{Tmaxki} T_{Tmaxki} c_T \\ C_{kL} = \sum_{j=1}^{n} P_{Lmaxkj} T_{Lmaxkj} c_L \end{cases} \tag{7}$$

In the above equation (7), C_{kT} and C_{kL} are respectively the power benefits of the total commissioned transformers and lines of project .m is the number of transformers to be built. j represents the lines.n is the number of lines to be built.P_{Tmaxki} and P_{Lmaxkj} are the active power of transformer and line in project k.T_{Tmaxki} and T_{Lmaxkj} are the maximum annual utilization hours of transformers and lines in project k respectively.c_T andc_L are the unit power tariffs of transformers and lines of the voltage level respectively.

2) Equipment utilization

Based on the current research results on the utilization rate of power grid equipment, this paper takes the utilization rate of transformers in years as the statistical time as the evaluation index of equipment utilization.

$$\eta = \frac{E_a}{C \times T_a} \tag{8}$$

In the above equation (8), the η is the annual utilization rate of the transformer;E_a is the actual power of the transformer for one year of operation, such as the actual power delivered and the actual power changed; C is the transformer capacity; T_a is the actual time of transformer operation in one year.

3. Quantitative evaluation and preferential ranking method for power grid engineering reserve projects

3.1 Entropy weighting method to determine the weights

In the process of the "PGERP" preference ranking, assigning weights to each evaluation index is a very important part. Compared with the traditional fuzzy hierarchical analysis method and expert scoring method, the advantage of entropy weighting method is to collect quantitative data for processing, and its basic logic is to determine the objective weights according to the size of the variability of each evaluation index, and the importance of each evaluation index is reflected by the index weight in the form of quantity. Therefore, it can avoid the intervention of the accuracy of the evaluation results due to the assignment deviation caused by subjective factors, and the final comprehensive evaluation results can be more practical and scientific to be applied to the reserve selection scenario of power grid projects and provide technical support to the investment decision. The specific steps are as follows:

1) Create the initial index matrix for forwarding.

First, determine the number of evaluation programs mand the number of evaluation indicators n, discriminate the positive and negative indicators from the n evaluation indicators, and adopt this formula:$(\mathrm{Max}-\mathrm{X})/(\mathrm{Max}-\mathrm{Min})$ for forwarding of the inverse indicators. The Max and Min denote the maximum and minimum values of the same evaluation indicators, and X is the value of the judged reverse indicator quantity. The initial index matrix of forwarding is formed, as shown in the following equation (9):

$$V=\begin{bmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{m1} & \cdots & v_{mn} \end{bmatrix} \quad (9)$$

wherev_{ij} （$i=1, 2, \ldots, m; j=1, 2, \ldots, n$) is the initial data-positive indicator value for the evaluation scheme i and evaluation indicator j.

2) Calculation of characteristic weight, as shown in the following equation (10):

$$P_{ij}=\frac{v_{ij}}{\sum_{i=1}^{m} v_{ij}} \quad (10)$$

3)Calculate the entropy value of the evaluation index j.

$$E_j=-k\sum_{i=1}^{m} P_{ij}\ln(P_{ij}) \quad (11)$$

As shown in the above equation (11), $k=\frac{1}{\ln(m)}$, $k>0$, $E_j>0$;E_j is thej entropy value of the evaluation index j .

4)Determining the objective weight of indicators - entropy weight

In general, the greater the weight of the indicator, the greater the amount of information it provides in the comprehensive evaluation, which is due to its large degree of indicator variability and small entropy value. And in the same case, the smaller the weight of the indicator, the greater its entropy value. So the entropy value is used to calculate the objective weights of evaluation indicators, and the main basis is the degree of variation of each indicator.

$$\mathrm{w_j} = \frac{1 - \mathrm{E_j}}{\sum_{\mathrm{j}=1}^{\mathrm{n}} \left(1 - \mathrm{E_j}\right)} \tag{12}$$

As shown in the above equation (12), $\mathrm{w_j}$ is the normalized firstj entropy weight of the first evaluation index.

3.2 Comprehensive evaluation of reserve project preferences based on TOPSIS method

TOPSIS method is mostly applied in the field of multi-objective decision making, taking the idealized solution as the benchmark and ranking the existing evaluation solutions based on their closeness to the idealized solution, so as to evaluate the relative advantages and disadvantages, which can avoid information distortion to a large extent and has the advantages of simpler calculation and more intuitive results. The specific evaluation process of applying TOPSIS to select the reserve project construction plan is as follows:

1) Assign weights to the initial index matrix to form a weighted decision matrix, as shown in the following equation (13), (14):

$$Z = w_j \cdot \left(v_{ij}\right)_{m\times n} = \left(Z_{ij}\right)_{m\times n} \tag{13}$$

$$\mathrm{Z} = w_j \cdot \begin{bmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{m1} & \cdots & v_{mn} \end{bmatrix} \tag{14}$$

2)Determine the positive ideal solution (Z+) and negative ideal solution (Z-) vectors of the weighted decision matrix Z.

$$Z^{+} = (maxZ_{i1}, maxZ_{i2}, maxZ_{i3} \cdots maxZ_{\mathrm{in}}) \tag{15}$$

$$Z^{-} = (minZ_{i1}, minZ_{i2}, minZ_{i3} \cdots minZ_{\mathrm{in}}) \tag{16}$$

As shown in the above equation (15), (16), $\mathrm{maxZ_{ij}}$ consists of the value for which each indicator data is the largest, and $\mathrm{minZ_{ij}}$ consists of the value for which each indicator data is the smallest.

3) Calculate the Euclidean distance of each reserve item from the positive and negative optimal solutions,as shown in the following equation (17), (18):

$$D_i^+ = \sqrt{\sum_{j=1}^{n}\left(\max Z_{ij} - z_{ij}\right)^2} \quad (17)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n}\left(\min Z_{ij} - z_{ij}\right)^2} \quad (18)$$

4) Calculate the relative closeness of each reserve project to the optimal solution, and rank the reserve projects

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (19)$$

As shown in the above equation (19), the closeness C_i reflects the relative advantages and disadvantages of the existing solutions, and the larger the closeness means that the solution is more feasible.

3.3 Calculation of the integrated contribution rate per unit of investment for reserve projects

In this paper, we analyze the reliability, economy, coordination, and efficiency dimensions of each reserve project in the new power system construction of the power grid engineering system construction of the whole process of investment and accountability system on the whole power grid effectiveness assessment improvement, and take the ratio of the relative posting progress of the reserve project to the measured investment amount as the comprehensive contribution rate of unit investment.

$$S_k = \frac{C_i}{f_k} \times 100\% \quad (20)$$

As shown in the above equation (20), S_k is the combined contribution rate of the unit investment of the reserve project k, and f_k is the measured investment amount of the reserve project k.The reserve projects are ranked from the largest to the smallest according to the integrated contribution rate of unit investment, and the ranking result is the preferred project.

4. Analysis of calculation cases

In order to verify the practical application effect as well as the scientific and reasonable nature of the "PGERP" selection method, this paper selects "Hangzhou Chun 'an Maoyan 110 kV power transmission and transformation project (hereinafter referred to as "Maoyan Project"), Hangzhou Tonglu Linchang 110kV Transmission and Transformation Project (hereinafter referred to as "Linchang Project"), Hangzhou City Chunlan 110kV Transmission and Transformation Project (hereinafter referred to as "Chunlan Project"), Hangzhou Yuhang Jindu 110kV Substation 3rd Main Transformer Expansion Project (hereinafter referred to as "Jindu Project(expansion)"), Hangzhou Fuyang Liyuan 110 kV Transmission and Transformation

Project (hereinafter referred to as "Liyuan Project") from the planning project database based on the new 110 kV expansion project of Hangzhou Power Supply Company, a total of five projects planned for commissioning in 2021 are studied empirically.

4.1 Calculation of evaluation index weights of power grid engineering reserve projects based on entropy power method

In this paper, the data of the quantitative evaluation indexes of each reserve project in the table are substituted into the calculation method given above, and after all the positive and negative standardization, the entropy weighting method is applied to determine the weights of the quantitative evaluation indexes of each reserve project, and the contribution percentage played by each index to the evaluation system is clarified, and the results are shown in the following Table 2.

Table 2 Reserve project evaluation index weights

Primary indicators	Weighting (%)	Secondary indicators	Information entropy value e	Information utility value d	Weighting (%)
Reliability	26.720	Capacity share	0.800	0.200	9.370
		Line length as a percentage	0.630	0.370	17.350
Coherence	22.042	Maximum load factor of apparent power	0.812	0.188	8.827
		Load Capacity Ratio	0.718	0.282	13.215
Economical	17.430	Average line loss rate	0.837	0.163	7.658
		Load factor	0.791	0.209	9.772
Benefitability	33.808	Electricity efficiency	0.474	0.526	24.649
		Equipment Utilization	0.804	0.196	9.159

From the entropy weighting method calculation results, in the reserve project evaluation indexes, the weight of each primary indicator is not much different, and the weight of economic indicators is low, which means that the relative importance of the evaluation indexes of the grid reserve projects selected in this paper is close, and the influence of subjective factors on the evaluation of the five reserve projects is small, further indicating the reasonableness of the selection of indicators. The secondary indicators with the largest weights are power efficiency, line length and capacity ratio, all of which have weights of more than 0.1, among which power efficiency has the largest weight. Because it is particularly important under the comprehensive promotion of quality and efficiency improvement and market power trading mechanism. This is because as a reliability indicator, the line length of transmission and substation projects is an important factor to connect power plants, substations and users to form the power system, which has a role to play in improving the reliability of power supply in the power grid. The load capacity ratio is the third weight, because in the construction process of power grid projects, the load capacity ratio will increase the investment in the pre-construction of power grid, and if the load capacity ratio is too small, the adaptability of power grid and power supply will be affected to a certain extent, so in order to have reasonable planning, the quantitative value of the load capacity ratio is a key influence factor to make it more reasonable. Therefore, the quantitative value of the load factor is the key influence factor to make it more reliable, so that the grid is not too strong or cannot keep up with the load development.

4.2 Reserve project selection method based on TOPSIS method and integrated contribution rate of unit investment

Based on the index weights calculated by entropy weighting method, applied TOPSIS method to conduct comprehensive evaluation of the "PGERP", and got the ranking results of the five power grid engineering reserve schemes selected in this paper in terms of closeness: Maoyan Project < Chunlan Project < Liyuan Project < Jindu Project (expansion) < Linchang Project.

Considering the cost-benefit perspective to avoid the influence of inconsistent investment scale of each reserve project on the ranking results, this paper further calculates the integrated contribution rate per unit of investment to re-rank the projects. The final results of the best decision ranking are as follows: Maoyan Project < Chunlan Project < Liyuan Project < Linchang Project < Jindu Project (expansion). As shown in the following Table 3, after considering the investment scale of each reserve project, the ranking result of the forestry project exceeds that of the Jindu Project (expansion), which has the lowest initial dynamic investment and higher relative posting schedule, and becomes the most preferable investment project.

Table 3 Ranking of evaluation results of reserve projects

Reserve project name	Positive ideal solution distance	Negative ideal solution distance	Relative posting progress	Sorting	Initial dynamic investment cost (RMB million)	Integrated contribution rate of unit investment (%)	Sorting
Chunlan Project	0.617	0.327	0.347	4	80.590	0.004	4
Jindu Project (expansion)	0.607	0.464	0.433	2	22.710	0.019	1
Linchang Project	0.397	0.650	0.621	1	53.830	0.012	2
Liyuan Project	0.627	0.361	0.365	3	61.725	0.006	3
Maoyan Project	0.738	0.352	0.323	5	117.559	0.003	5

1) Jindu Project (expansion) is to meet the demand for electricity supply load in Liangzhu Street, Yuhang District, Hangzhou, enhance the power supply capacity of the grid and improve the reliability level, and is selected in preference based on the calculation results because of its more prominent and balanced contribution to the power efficiency, equipment utilization and power supply capacity of the grid.

2) After the completion of Linchang Project, the new substation capacity of 63,000 (KVA), the

total line length of 3.46 KM, its completion of the contribution to the grid capacity, line expansion ratio in terms of outstanding.

3) Liyuan Project is mainly for the load of Dazheng block of Fuchun Street and Chunjian Township. To meet the needs of the load growth in the area, the load rate is higher after completion, and at the same time its line loss rate is also higher.

4) Chunlan Project is designed to meet the demand for power supply in the north unit of Xiasha University City, improve the reliability of regional power supply and optimize the power grid structure, and its average line loss rate and power efficiency are good. However, its low equipment utilization rate and high initial dynamic investment cost lead to its low overall ranking result.

5) Maoyan Project was the last selection for improving the power grid structure in the northwest region of Chun'an County because of its relatively small line length and the large initial dynamic investment cost of the new line.

5. Conclusion

A series of related methods of "TDP" reform have put forward newer and stricter requirements for power grid enterprises' investment. From the "source" control before investment to the establishment and improvement of incentive mechanisms suitable for China's power grid enterprises' investment environment, the quantitative evaluation and preferential ranking of the "PGERP" are the link between power grid planning and investment plans. In order to ensure the accuracy and efficiency of power grid investment, power grid enterprises are committed to researching and exploring ways to effectively screen out grid reserve projects from a large number of different targeted grid reserve projects that can improve the overall performance of the grid, eliminate grid defects, improve the efficiency of the grid enterprise projects at the same time, and gradually strengthen the project effectiveness concerns and supervision.

Based on the previous reasons, this paper proposes a quantitative evaluation method and preferential ranking of the "PGERP" under the background of "TDP" reform, so as to meet the requirements of precise investment in power grid and provide practical basis for the development of power grid enterprises along the direction of power system reform. The research results of this paper are summarized as follows:

1) This paper starts from the characteristics of the "PGERP", considers the impact of the project on the power grid after it is put into operation, builds a comprehensive evaluation index system of the reserve project based on power grid effectiveness in terms of power grid reliability, coordination, economy and efficiency, and clarifies the definition of each index in the index system as well as the quantitative calculation model and method of the index, which lays the foundation for the calculation method of integrated contribution rate of unit investment based on power grid effectiveness.

2) Based on the comprehensive collection of relevant data and information on the evaluation of the "PGERP" and the study of quantifying the evaluation index values of relevant reserve projects, this paper constructs an optimal ranking method for the "PGERP". The entropy weight of each evaluation factor is determined according to the entropy weight method, and the TOPSIS

method is applied to obtain the ranking of the closeness of the five investment schemes of the "PGERP", and the comprehensive contribution rate per unit investment of each "PGERP" is further obtained, which is used as the basis for the optimal ranking of the "PGERP".

3) In this paper, the 110kv transmission and substation project planning library in Zhejiang Province is selected to conduct an empirical study on the preferential ranking of the planned commissioning projects. The research results show that the method of this paper can effectively and accurately evaluate and select the "PGERP". The selection results not only consider the constraints of investment capacity and investment efficiency, but also consider the impact of the projects on the overall coordination of power grid construction. The method of this paper can also improve the accuracy of project arrangement. While selecting the projects with relatively high output, it avoids the problems that the project arrangement cannot meet the actual demand of the power grid and the low efficiency of the project commissioning, .so as to achieve coordinated and high-quality development of the grid.

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