Research on Evaluation System of Comprehensive Effects of Implementation of Technological Innovation Projects in Power Grid Enterprises

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ABSTRACT
The implementation of scientific and technological projects has become an important source of support for the innovative development and strategic deepening of power grid enterprises. At this stage, the lack of a corresponding review method system for the comprehensive effects of the implementation of technological innovation projects in power grid enterprises cannot effectively support the enterprises to sum up the highlights of project results and tap development bottlenecks in a timely manner. Based on this, this article combines the implementation process of power grid enterprises' scientific and technological innovation projects and the focus of assessment and evaluation, scientifically and rationally constructs a system of assessment indicators and assessment methods, and provides reference and guidance for further improving the implementation effect of scientific and technological innovation projects of power grid enterprises and improving the level of project management efficiency.

Keywords: *Power Grid Enterprises, Scientific and Technological Innovation Projects, Comprehensive Effects of Implementation, Review System*

1. INTRODUCTION

At present, scientific and technological innovation has become an important driving force for my country's social development. Strengthening the efficient operation of scientific and technological research and development and scientific and technological projects is an important guarantee for improving my country's scientific and technological competitiveness and promoting human civilization [1]. Under the new situation, with the tightening of external supervision and supervision of power grid enterprises, the endogenous requirements for precise investment, quality improvement and efficiency have continued to increase, and it is of great significance to strengthen the implementation of lean management and control of scientific and technological innovation projects and optimize and improve the system construction. Post-review is an important part of the whole process of the project, and it is also an important link for systematically summarizing the highlights and advanced experience of the project, and digging into the bottleneck of the problem and the direction of improvement.

The power grid science and technology project is a knowledge-intensive, technology-intensive, and talent-intensive investment project that can solve key technical problems in power grid construction, safe production, and operation and management [2]. In order to deepen the implementation of the "dual carbon" development guidelines, closely focus on the development drive of "double innovation", center on the strategic development direction of building a "new power system", and strengthen the selection of strategic, characteristic, and representative evaluation objects, this article starts from the whole process of the project. , The use of funds, the comprehensive economics of input and output, the degree of completion of project results, the advancement of project results, the value of project promotion prospects, etc., we have built a comprehensive evaluation index system for the implementation of scientific and technological innovation projects, and combined the actual needs of power grid companies, and A suitable review method model was constructed to provide guidance for grid companies to improve the comprehensive effect of implementing scientific and technological innovation projects.

2. RESEARCH ON THE CONSTRUCTION OF EVALUATION INDEX SYSTEM AND INDEX MEASUREMENT METHODS

2.1 Index System Construction

Combining the key points of the evaluation of the implementation effect of technological innovation

projects of power grid enterprises, the evaluation indicators are constructed from 6 dimensions including the whole process of the project, the use of project funds, the comprehensive economics of project input and output, the degree of completion of project achievements, the advancement of project innovation, and the value of project promotion prospects. System, as shown in table 1 below:

Table 1. Evaluation index system table

Review dimensions	Evaluation index	Unit of measurement
Evaluation of the whole process of the project	Compliance of the preliminary project approval process	By level
	Project process organization, timeliness and standardization	By level
	Project acceptance status	By level
Evaluation of the use of project funds	Project fund availability rate	%
	Project fund expenditure ratio	%
Comprehensive economic evaluation of project input and output	Project achievement conversion rate	%
	Demonstration project put into production ratio	%
	Project internal rate of return	%
Project achievement completion evaluation	Completion rate of technical and economic indicators	%
	Completion rate of thesis and monograph	%
	Patent soft work completion rate	%
	Standard specification completion rate	%
	Application for patent authorization rate	%
	Completion rate of talent training target	%
Evaluation of the advancement of project innovation	Project research and development innovation	By level
	The advanced nature of the project achievement field	By level
	Project awards	By level
Project promotion prospect value evaluation	Regional economic contribution	Yuan/ten thousand yuan
	Drive employment contribution	Person/ten thousand yuan
	"Dual Carbon" Development Contribution	Tons/ten thousand yuan

2.2 Index Measurement Method

2.2.1 Compliance of the Project Initiation Process in the Early Stage of the Project

This indicator is used to evaluate the compliance of the project's early-stage project declaration procedures and the timeliness of submission time. According to the indicator data results, it is divided into the following four levels: ①Full compliance: 10 points; ②Basic compliance: 6-9 points; ③ Partially compliant: 10 points Compliance: 1-5 points; ④ Non-compliance: 0 points.

2.2.2 Timeliness and Standardization of Project Process Organization

This indicator is used to evaluate the timeliness of the mid-term related meetings of the project and the implementation of relevant requirements. According to the indicator data results, it is divided into the following four levels: the following four levels of scoring: ① Fully timely specification: 10 points; ②Basic timely specification: 6-9 points; ③ Partially timely specification: 1-5 points; ④ Irregularity: 0 points.

2.2.3 Project Acceptance Status

This indicator is used to evaluate the one-time acceptance of the project. According to the indicator data results, it is divided into the following four levels: divided into the following three levels: ① Pass the acceptance: 10 points; ② Agree to complete the question and pass the reconsideration: 6-9 points; ③ Fail the acceptance and reconsideration: 0 points.

2.2.4 Project Fund Availability Rate

Project fund availability rate=number of funds available/number of approved funds*100%, divided into the following two levels according to the indicator data results: ①fund availability rate ≥100%: 10 points; ②

fund availability rate <100% or not in place in time: 0 point.

2.2.5 Project Fund Expenditure Ratio

Capital expenditure ratio=(expenditure funds/budget investment)*100%, divided into the following three levels according to the index data results: ①The capital expenditure ratio is 95%-100% or within 10% of the approved funds: 10 points; ②The capital expenditure ratio is 80 %-95% or 10%-20% beyond the approved funds: 6-9 points; ③The capital expenditure ratio is below 80% or exceeds the approved funds by more than 20%: 0-4 points.

2.2.6 Conversion Rate of Project Results

Project achievement conversion rate = total project achievement conversion income/ total project capital investment * 100%, according to the index data results are divided into the following three levels: ① project achievement conversion rate ≥ 100%: 10 points; ② project achievement conversion rate 50%-100 %: 6-9 points; ③Project achievement conversion rate <50%: 0-5 points.

2.2.7 Demonstration project put into production ratio

Demonstration project commissioning ratio = (sum of estimated income during each year of operation/demonstration project investment) * 100%, according to the index data results are divided into the following three levels: ① commissioning ratio ≥ 100%: 10 points; ② commissioning ratio 50%- 100%: 6-9 points; ③ put into production ratio <50%: 0-5 points.

2.2.8 Project Internal Rate Of Return

The calculation formula of the project internal rate of return (FIRR) is as follows:

$$\sum_{t=1}^{n}(CI-CO)_t(1+FIRR)^{-t}=0 \quad (1)$$

Among them, CI: the cash inflow of each year of the project CO: the cash outflow of each year of the project n: the calculation period of the project FIRR: the internal rate of return of the project. According to the index data results, it is divided into the following two levels: ①The project internal rate of return is greater than or equal to the feasibility study expectation: 10 points; ②The internal rate of return of the project is lower than expected in the feasibility study: 0 points;

2.2.9 Completion Rate of Technical and Economic Indicators

Technical and economic completion rate = actual number of technical and economic indicators completed/total number of indicators required by the task book * 100%, divided into the following two levels according to the index data results: ① completion rate of technical and economic indicators ≥ 100%: 10 points; ② completion of technical and economic indicators Rate <100%: 0 points;

2.2.10 Completion Rate of Theses and Monographs

The completion rate of thesis monographs consists of two parts: ①thesis completion rate=the number of actual completed papers/total assignment requirements*100%; ② the completion rate of the monograph=the actual number of monographs completed/total assignment requirements* 100%. According to the index data results, it is divided into the following two levels: the completion rate of thesis monograph ≥100%: 10 points; ② the completion rate of the thesis monograph <100%: 0 points.

2.2.11 Completion Rate of Patent Soft Work

The completion rate of patent soft work consists of two parts: ①Patent completion rate=number of actual completed patents/total number of assignment requirements*100%; ② Completion rate of software works=number of actual completed software works/total number of assignment requirements*100%. According to the index data results, it is divided into the following two levels: ①The completion rate of patent softening ≥100%: 10 points; ②The completion rate of patent softening <100%: 0 points.

2.2.12 Completion Rate of Standard Specifications

Completion rate of standard specifications=number of technical standards formulated/total number of tasks required*100%, divided into the following two levels according to the index data results: ①Completion rate of standard specifications ≥100%: 10 points; ② Completion rate of standard specifications <100%: 0 point.

2.2.13 Grant Rate of Patent Applications

Patent application authorization rate=number of authorized patents/total number of patent applications*100%, divided into the following four levels according to the index data results: ①Patent application authorization rate ≥60%: 10 points; ②

Patent application authorization rate 40%-60%: 7 -9 points; ③ Patent application authorization rate 20%-40%: 5-6 points; ④ Patent application authorization rate 0%-20%: 0-4 points.

2.2.14 Completion Rate of Talent Training Target

Completion rate of talent training = actual number of people trained/total required by assignment*100%, divided into the following two levels according to the index data results: ①Completion rate of talent training ≥100%: 10 points; ②Completion rate of talent training <100%: 0 points .

2.2.15 Project Research and Development Innovation

This indicator is used to evaluate the innovation of the overall implementation plan and technical methods. According to the indicator data results, it is divided into the following three levels: ① Very innovative: 10 points; ② Comparative innovation: 6-9 points; ③ Innovativeness: 0-5 points .

2.2.16 Advancement in the Field of Project Results

This indicator is used to evaluate the advanced level of project results in related fields. According to the indicator data results, it is divided into the following four levels: ①very advanced: 10 points; ②relatively advanced: 6-9 points; ③basically advanced: 3-5 points; ④ Average level: 0-2 points.

2.2.17 Project Awards

This indicator is used to evaluate the level of project achievements participating in the awards, and is divided into the following four levels according to the indicator data results: divided into the following four levels: ① national level: 10 points; ②provincial level, industry level: 6-9 points; ③company Grade: 3-4 points; ④ Other grades: 0-2 points.

2.2.18 Contribution to Regional Economy

Regional economic contribution = total annual tax payment / total investment in project promotion, divided into the following three levels according to the index data results: ① very significant: 10 points; ② relatively significant: 6-9 points; ③ low contribution: 0-5 points .

2.2.19 Drive Employment Contribution

Contribution to employment promotion = employment promotion/total investment in project promotion, according to the index data results are divided into the following three levels: ① very significant: 10 points; ② relatively significant: 6-9 points; ③ low contribution: 0-5 points.

2.2.20 Contribution of "Dual Carbon" Development

"Dual-carbon" development contribution = (increased regional clean energy consumption and equivalent carbon reduction + fossil energy consumption reduction, equivalent carbon consumption + fossil energy utilization rate increased, equivalent carbon consumption) / investment amount, based on indicator data results Divided into the following three levels: ① very significant: 10 points; ② relatively significant: 6-9 points; ③ low contribution: 0-5 points.

3. REVIEW METHOD MODEL CONSTRUCTION

3.1 Determination of Indicator Weights

This post-review index weight calculation adopts the principle of comprehensive weight determination. On the one hand, it relies on expert experience and uses the analytic hierarchy process to determine the subjective weight; on the other hand, it relies on the calculation of the indicator data value and uses the entropy weight method to determine the objective weight, and finally combines The calculation result of subjective weight and objective weight forms the calculation result of comprehensive weight, comprehensive weight weight=0.8*subjective weight+0.2*objective weight. The idea of determining the index weight is shown in Figure 1 below:

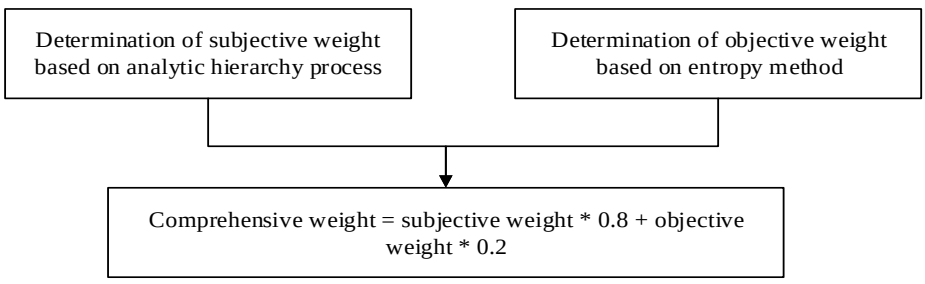

Figure 1. Comprehensive weight determination and determination

3.1.1 Determine the subjective weight of indicators based on Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a decision-making method that decomposes the elements that are always related to decision-making into goals, guidelines, and plans, and then conducts qualitative and quantitative analysis on this basis[3]. The specific implementation steps are as follows:

First, a binary comparison judgment matrix is constructed from the importance scaling theory: A

$$A=\left(a_{ij}\right)_{n\times n}\left(i,j=1,2,\cdots,n\right) \tag{2}$$

Then the judgment matrix is normalized, and the calculation formula is:

$$\bar{a}_{ij}=a_{ij}/\sum_{k=1}^{n}a_{kj}\left(i,j=1,2,\cdots,n\right) \tag{3}$$

The weights are calculated as:

$$w_i=\bar{w}_i/\sum_{i=1}^{n}\bar{w}_i\left(i=1,2,\cdots,n\right) \tag{4}$$

Finally, the consistency is judged, if the consistency test, the result is valid. Do not to adjust the result.

3.1.2 Determine the objective weight of indicators based on the entropy weight method

The objective weights of the post-review indicators are mainly determined in combination with the entropy weight method [4]. As an objective comprehensive evaluation method, the entropy method mainly determines the weight of each indicator based on the amount of information passed to the decision maker. First, determine the original data matrix. Assuming that there are m schemes or evaluation samples in an evaluation problem, and each sample has n evaluation indicators or targets [5-6], the initial matrix that can be obtained is as follows:

$$X=\begin{pmatrix}x_{11} & x_{12}\cdots & x_{1n}\\ x_{21} & x_{22}\cdots & x_{2n}\\ \vdots & \vdots & \vdots\\ x_{m1} & x_{m2}\cdots & x_{mn}\end{pmatrix} \tag{5}$$

Among them, x_{ij} is the value of the $j-th$ index of the $i-th$ sample.

Then, standardize the original matrix to determine the information entropy and entropy weight. The information entropy of the $j-th$ index is:

$$h_j=-\frac{1}{\ln(m)}\sum_{i=1}^{m}p_{ij}\ln p_{ij} \tag{6}$$

Where：

$$p_{ij}=\frac{x_{ij}}{\sum_{i=1}^{m}x_{ij}} \tag{7}$$

Therefore, the weight of the $j-th$ index is as follows:

$$w_j=(1-h_j)\Big/\sum_{j=1}^{n}(1-h_j) \tag{8}$$

3.2 TOPSIS Comprehensive Evaluation Method

TOPSIS method is a multi-attribute decision-making method, which determines the comprehensive evaluation value of the evaluated object by calculating the relative distance between the index vector of each evaluation object and the positive ideal solution and the negative ideal solution [7-8]. Sorting is based on the relative distance between the index vector of the evaluation object and the positive ideal solution and the negative ideal solution. If the evaluation object is close to the positive ideal solution and farthest away from the negative ideal solution [9-10], it is the best; otherwise, it is not optimal.

4. EMPIRICAL ANALYSIS

Eight county-level units under a provincial power grid company are selected as the research objects, combined with statistical analysis of data, to carry out empirical analysis.

Table 2. Table of raw statistics

Evaluation index	Index Score							
	A	B	C	D	E	F	G	H
Compliance of the preliminary project approval process	10	10	10	10	10	10	10	10
Project process organization, timeliness and standardization	10	8	8	10	6	8	10	8
Project acceptance status	6	6	10	8	0	8	6	0
Project fund availability rate	10	10	10	10	10	10	10	10
Project fund expenditure ratio	10	8	8	6	2	4	4	2
Project achievement conversion rate	8	6	6	8	6	6	6	6
Demonstration project put into production ratio	10	6	8	4	10	8	0	2
Project internal rate of return	9	8	9	10	6	8	9	8
Completion rate of technical and economic indicators	6	4	4	4	6	8	10	8
Completion rate of thesis and monograph	6	6	10	8	0	8	6	0
Patent soft work completion rate	10	10	10	10	10	10	10	10
Standard specification completion rate	10	10	10	10	10	10	10	10
Application for patent authorization rate	10	6	8	4	10	8	0	2
Completion rate of talent training target	6	6	10	8	0	8	6	0
Project research and development innovation	10	8	8	10	6	8	10	8
The advanced nature of the project achievement field	9	8	9	10	6	8	9	8
Project awards	6	6	10	8	0	8	6	0
Regional economic contribution	10	10	10	10	10	10	10	10
Drive employment contribution	9	8	9	10	6	8	9	8
"Dual Carbon" Development Contribution	6	4	4	4	6	8	10	8

The comprehensive weight is calculated by the analytic hierarchy process and the entropy method, and the following results are obtained:

Table 3. Comprehensive weight calculation results

Review dimensions	Evaluation index	Comprehensive index weight
Evaluation of the whole process of the project	Compliance of the preliminary project approval process	0.05
	Project process organization, timeliness and standardization	0.15
	Project acceptance status	0.15
Evaluation of the use of project funds	Project fund availability rate	0.1
	Project fund expenditure ratio	0.05
Comprehensive economic evaluation of project input and output	Project achievement conversion rate	0.04
	Demonstration project put into production ratio	0.03
	Project internal rate of return	0.03

Review dimensions	Evaluation index	Comprehensive index weight
Project achievement completion evaluation	Completion rate of technical and economic indicators	0.025
	Completion rate of thesis and monograph	0.025
	Patent soft work completion rate	0.025
	Standard specification completion rate	0.025
	Application for patent authorization rate	0.025
	Completion rate of talent training target	0.025
Evaluation of the advancement of project innovation	Project research and development innovation	0.03
	The advanced nature of the project achievement field	0.03
	Project awards	0.04
Project promotion prospect value evaluation	Regional economic contribution	0.05
	Drive employment contribution	0.05
	"Dual Carbon" Development Contribution	0.05

According to the basic principles of the TOPSIS method, the results of calculating the relative posting progress of the indicators are shown in the following table:

Table 4. Calculation of relative posting progress

Unit	A	B	C	D	E	F	G	H
Relative post progress	0.5860	0.4971	0.7644	0.6648	0.1807	0.6597	0.5220	0.1848

According to the principle of the TOPSIS method, it is sorted according to the size of the posting progress. The larger the closeness value, the better the comprehensive effect of the unit's scientific and technological innovation project implementation; conversely, the smaller the closeness value, the worse the comprehensive effect of implementation. Therefore, Company C is the unit with the best overall effect of implementing scientific and technological innovation projects in 2020.

5. CONCLUSION

This paper constructs a comprehensive evaluation method system for the implementation of scientific and technological innovation projects in power grid enterprises, and combines empirical analysis to verify its effectiveness. This review method system can effectively guide power grid companies to carry out comprehensive review work for the implementation of science and technology projects, and further provide project management efficiency levels.

REFERENCES

[1] Wu Liangzheng, Lin Xiuhao, Liang Yanni. Research on technical and economic evaluation model of power grid technology projects. China Electric Power Enterprise Management, 2020(09): 80-81.

[2] Hu Ji, Chen Wen. Performance evaluation method and system of power grid technology projects. Times Finance, 2017(35):234-235.

[3] Li Naiqiang. Research on performance evaluation of key development zones based on analytic hierarchy process. Surveying and Spatial Geographic Information, 2021, 44(08): 101-105.

[4] Deng Yanguo, Wang Bing, Cao Zhijie, Zhang Qiuqiao. Distribution network spatial load forecasting based on entropy weight method and GRA-ELM. Electric Power Engineering Technology, 2021, 40(04): 136-141.

[5] Zeng Yan, Kan Weimin, Hu Ju. Research on the Implementation Effect and Benefit Evaluation Index System of Science and Technology Projects in Power Grid Enterprises. China Electric Power Education, 2014(15): 189-190+215.

[6] Chaithanya Seetha and Reddy V. Naga Bhaskar and Kiranmayi R. Performance evaluation of PMSG-based LFAC system for offshore wind power. International Journal of Ambient Energy, 2021, 42(14) : 1643-1648.

[7] de Almeida Liliane et al. A methodology for identifying results and impacts in technological innovation projects. Technology in Society, 2021, 66

[8] Ozdemir Fatih and Ar Ilker Murat and Baki Birdogan. A decision model approach for determining social innovation potential of technological projects. Journal of Multi‐Criteria Decision Analysis, 2021, 28(1-2): 112-125.

[9] Roberto Daniel Hernández-García and David Güemes-Castorena and Idalia Estefania Ponce-Jaramillo. A real option based model for the valuation of patent protected technological innovation projects. World Patent Information, 2018, 53: 24-38.

[10] Zhang Zhen Wen et al. Comprehensive evaluation of integrated solar combined cycle system regarding fuel-savability under unified framework. Applied Thermal Engineering, 2021, 199.