Research on the Evaluation Method of Technical Standard Implementation Benefits in State Grid Corporation

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Abstract. By studying the traditional evaluation methods of the implementation benefits of the technical standards, this paper analyzes the advantages and disadvantages of different traditional evaluation methods. According to the analysis results and the operation of State Grid's technical standards, evaluation methods of the implementation of the technical standards in line with the national grid were put forward. This provides the basis for the systematic implementation benefits evaluation of the technical standards of the national grid company.

1. Introduction
Technology standard refers to the standards that are established for the coordination of technical matters. The goal of establishment and revision of technology standard for an enterprise is to improve the production technology and thus realize the benefit maximization. By evaluating the implementation benefit of technology standard, the most suitable standard can be selected so that the benefit can be maximized. Therefore, it is of great importance to establish an effective evaluation method for technology standard implementation benefit.

Evaluation of technology standard implementation benefit involves prediction, analysis and calculation of comprehensive benefits yielded by implementing technology standard [1], [2]. Standard implementation benefit is an important tool to measure the effect of standardization activities [3], and also is an epitome of the management level of modern enterprises. Technology standard implementation benefit can be considered as a system. Then the system evaluation method can be employed to evaluate technology standard implementation benefit. The system evaluation method can be divided into three categories: index system based expert consultation evaluation method, economic model based evaluation method, and multivariate statistics based evaluation method [4]-[7]. This paper is based on the actual technology standard system construction, and investigates the economic benefits yielded by its technology standard. The research in this paper lays a foundation to standard establishment and planning for enterprises in the same industry, and provides a decision reference for these enterprises to invest technology standardization.
2. System Evaluation Methods

2.1. Index system based expert consultation evaluation method

Index system based expert consultation evaluation method takes advantage of subjective judgments of experts from related fields to evaluate implementation benefits. In nature, this method belongs to the class of qualitative comparison methods. Such a class often is applicable to the case where technology standard implementation benefits cannot be evaluated by quantitative methods. This class of evaluation methods includes the correlation coefficient method, the analogy method, and the rating method. The correlation coefficient method estimates the contribution of implementation benefits through expert rating. The analogy method takes the similarly evaluated projects as references, and evaluates the projects at hand based on the analogy analysis. As for the rating method, experts from related fields rate the evaluation objects by their expertise and predefined rating requirements.

The expert rating methods is intuitive and easy to operate. Thus, it is suitable for quantitative/qualitative analysis of technology standard implementation benefits. The disadvantages of this method are as follows:

- The relation of input and output is ignored, lowering the guidance value in practice. In addition, it is hard to identify the key problem during the implementation process of this method, which makes it difficult to promote the improvement of the methodology.
- This method has a stronger subjective nature and relatively lower accuracy. In practice, the rationality of this method is also limited by the problem of how to define and select the expert from related fields.

2.2. Economic model based evaluation method

The economic model based evaluation method is a typical class of quantitative methods. The methods to evaluate the economic model includes the input-output analysis, the production function method, and the index-formula method. For the input-output analysis, the input-output theoretical model is used to study the input-output relation among related economic systems. Then a comparison of parameters for the input and output value leads to the labor-saving quantity, based on which technology standard implantation benefits are analyzed.

The feature of the economic model based evaluation method lies in relatively strong practicability and objectiveness, and has a higher level of accuracy in the economic benefit evaluation. The limitation of this method is, even though the process of technology standardization for different industries is similar in part, the same input-output model is hard to applicable to every industry due to their differences in technology and production. Meanwhile, in the practical evaluation, such single-quantification based methods are not practical.

2.3. Multivariate Statistics based Evaluation Method

The multivariate statistic based evaluation method is based on the multivariate statistic theory and objectively statistical data. This methods include the factor analysis, principal component analysis, discriminant analysis, and cluster analysis.

2.3.1. Factor analysis

Factor analysis attempts to explain the correlation among variables by underlying factors, which to some extent reflect the important information of original variables and their correlation. The variables rely on the factors while subject to random errors.

The use of factor analysis includes the following steps: 1) the data normalization; 2) the representation of the normalized data by matrix; 3) calculation of eigenvalues and the corresponding eigenvectors; 4) calculation of variance; 5) the identification of principal factors: when the set of factors, \( N \), contains \( n \) factors the total amount of whose data information is not lower than 80%, these factors can be selected to reflect evaluation indices. 6) the rotation of factors: when the practical meaning of the selected \( n \) factors is small or hard to determined, these factors are rotated to gain the
practical meaning; 7) the scoring of principal factors by the linear combination of original indices. 8) The comprehensive scoring: the contributions of principal factors to covariance are weighted, and the linear combination of principal factors leads to the index function of the comprehensive evaluation; 9) The Sorting of the results: The analysis results are sorted in the order of high to low comprehensive scorings.

2.3.2. Principal Component Analysis
Principal component analysis reflects data on scattered variables in the comprehensive index, that is, the inherent structure of original data is reflected by the principal components. Based the order-reduced idea, this method realizes the change in the number of indices from large to small, and the shift of indices from scatter and to concentration. In the practical calculation, \( n \) principal components can be selected as \( x_1, x_2, \ldots, x_n \), the contributions of which to variance are weighted. The comprehensive evaluation system is then established by the function method, leading to the scorings of every principal components. Finally, the studied objects are scored, based on which the sorting and comparison are performed.

2.3.3. Discriminant and Cluster Analysis
Discriminant analysis summarizes the law for the classification of objectives on a basis of sample information, and establishes discriminant criterion. Then the new samples can be classified by the summarized discriminant criterion. The evaluation study is often conducted with the combination of discriminant and cluster analysis.

Cluster analysis solves the classification problem by classifying statistical samples from the quantitative analysis perspective. This method can also combines with discriminant analysis, forming a framework for the comprehensive evaluation. Compared with the expert based evaluation method, cluster analysis does not involve expert scorings, and thus improves the accuracy of the data. Besides, this method is based on a complete theory, and capable of evaluating multiple factors quantitatively. In addition, this method can achieve a good evaluation performance for the evaluation studies including fuzzy and uncertain factors.

The multivariate statistics based evaluation method has a feature of high practicability and strong objectiveness, and thus is suitable to accurately examine the economic benefit evaluation of technology standards. However, this method has a shortcoming. Due to an overemphasis on the objectiveness of correlation indices, practicability of indices can be deteriorated, which makes the evaluation results fail to unveil the economic meaning, lowers the evaluation performance and even leads to an invalid evaluation result.

3. Comparisons of traditional evaluation methods
The aforementioned evaluation methods promote the evaluation study of technology standards, while they have shortcomings due to constraints. Comparisons of their advantages and disadvantages are given in Table 1

Table 1. Comparisons of traditional evaluation methods of technology standard implementation benefits

| No. | Evaluation methods | Advantages | Disadvantages |
|-----|--------------------|------------|---------------|
| 1   | Index system based expert consultation evaluation method | Strong intuition, easy operation, and suitable to applied to quantitative and qualitative analysis | (1) The input-output relation is ignored, and the guidance value in practice is relatively low. (2) Strong subjective, low accuracy |
2 Economic model based evaluation method
Strong practicability and objectiveness, high accuracy for the economic benefit evaluation
Applicability for the quantitative analysis is low. A single input-output model is not applied to every industry.

3 Multivariate Statistics based Evaluation Method
Strong practicability and objectiveness; accuracy for examining the evaluation performance
Overemphasis on the correlation indices; Low practicability for indices; Low or invalid evaluation value

- At present, the domestic and foreign research on the evaluation methods focuses on the establishment of standard systems, the evaluation of standard implementation benefits, and so on. Since this domain is explored considerably and extensively, a few important achievements have been made. However, these methods have the following drawbacks:
  - The range of studies is greatly limited. Most of the studies take the implementation benefit evaluation of one single standard as the research object, while the research on the implementation benefit evaluation of a standard system is few.
  - The indices for the evaluation of standard implementation benefits lack systematicness. Domestically, the evaluation system is initially established in some specific areas of power grids. However, this system covers a few areas. Moreover, the setting of the indices is relatively simple, and the indices are hard to be quantified. The qualitative evaluation of the indices is affected by subjective.
  - The effectiveness of the evaluation method selection and the accuracy of the evaluation results are hard to ensured. The main methods that are applied for the benefit evaluation include principal component analysis, etc.. These methods have their respective advantages, disadvantages, and application scope, as well as the different degree of impacts by different factors. If the inappropriate selection of evaluation methods easily decreases their effectiveness levels.

Currently, a large amount of work has be done by State Grid Corporation in the framework of the standard system and standard revision. This paper combines with the status of the technology standard system implementation, analyses the economic basis of technology standards in State Grid Corporation, proposes an evaluation system of technology standard implementation benefits, and verifies the effectiveness of the proposed system on the practical power grid. This paper provides a support for standard practice.

4. The status of standard system in State Grid Corporation
To meet the need of the power grid development, State Grid Corporation is based on the power production process and establishes the “1+9” mode based technology standard system featuring systematicness, coordination, adaption and openness [8]. In this technology standard system, “1” represents the main system of technology standards in State Grid Corporation. “9” represents 9 subsystems of technology standards to accommodate ultra-high voltage AC/DC, smart grid, life cycle asset management, and the big five core business, as shown in Table 2.

| Subsystems of technology standards | The supporting objects |
|-----------------------------------|------------------------|
| Technology standard subsystem of core business | 5 core business: Grand planning, grand construction, grand maintenance, and grand marketing |
| Technology standard subsystems of ultra-high voltage and smart | ultra-high voltage AC/DC, smart grid |
Technology standard subsystems of life cycle asset management

The establishment of technology standards in State Grid Corporation constantly follows the principle of unity, integrity, hierarchy, coordination, clarity, and scalability. Here, uniformity is reflected in unified planning, centralized management, division of responsibility, unified validation, and unified release. Integrity is reflected in the technology standard system with various kinds, scientific classification, and complete supporting systems. Hierarchy is reflected in the fact that application scope of technology standards covers all business levels. Coordination is reflected in the fact that standard systems with all business links in a power grid coordinate with each other.

Clarity is reflected in the fact that categories are divided according to the inherent nature of technology standards to avoid the repeated establishment of these technology standards. Scalability is reflected in adaptation to the business scope of State Grid Corporation and the trend of the science development. According to the aforementioned principles, State Grid Corporation establishes a technology standard system with a full coverage of business scopes, a closed connection between business links, and a clear classification of business categories. Combined with the practical power production, corporation standards, industry standards, nation standards, international standards are filtered, analyzed, and classified. Thus, their scientificity and sustainability are refined, and their architecture optimized. By 2018, the technology standard system of State Grid Corporation contains 1717 corporation standards, 4402 industry standards for 24 industries, 3519 nation standards, and 1250 international standards. The architecture of this system is shown in Figure 1.

![Block diagram of the technology standard system in State Grid Corporation](image)

**Figure 1.** The block diagram of the technology standard system in State Grid Corporation

From Fig. 1, the hierarchical structure is adopted in the technology standard system. It mainly consists of two levels: the first level includes the basic standards of technologies; the second level includes technology standards of corporations in the order of the production process. The core business of State Grid Corporation is grid planning, construction, operation, maintenance and marketing. These five business that cover the full business cycle, are clearly divided and closely connected. The internal business flows in every business are complete and complex. Therefore, most sub-business in these five business should be covered in the evaluation of technology standard implementation benefits.

5. **The evaluation of technology standard implementation benefits in State Grid Corporation**

The proposed evaluation method is based on the value chain of the core business in State Grid Corporation, the basic-level business development of corporations, and the application of technology standards in the production line, as well as the technical facts. A survey facing worker in the production line is conducted in the form of questionnaire in terms of standard contributions. The obtained data on standard contributions is combined with the business feature of State Grid Corporation, and then the index system is designed from the perspectives of planning, construction, operation, maintenance, and marketing. When the contributions of technology standards to the core business are identified, numerical analysis is employed to calculate standard implementation benefits.
Finally, the comprehensive analysis results on the evaluation of standard implementation benefits are obtained. The following two problems should be concentrated on:

- The design of the index system [9]. To evaluate the benefits, the goal of the benefit evaluation should be fully considered to design the corresponding index system for data collection and calculation. In addition, due to the difference of the standard’s influence on different industries, the industry features should be considered in the design of the index system. The feasibility and costs of data collection also need to be addressed to avoid the index systems with difficulty and/or huge costs in the data collection.

- Separation of technology standard implementation benefits [10]. The social and economic benefits produced by corporations arise from the combined actions of scientific innovation, integrated management, standard application, personal training. As a result, the social and economic benefits should be separated from the standard contributions. The separation methods have two types: The first type is based on data calculation. This type needs to analyze the mechanism of the actions of all factors and obtain the corresponding results, which is extremely hard. The second one is based on the questionnaire filled in by experts, by which the shared ratio of standard contributions is obtained. Then the survey data is processed to attain the final level of the standard contributions.

6. Conclusion
This paper comprehensively analyses the domestic and international evaluation methods for technology standard implementation benefits. Furthermore, by exploiting the technical facts of State Grid Corporation, a survey is conducted in the form of questionnaire to acquire data on the levels of standard contributions directly from workers in the production line. With the standard contributions and business features, the index system is designed with the consideration of grid planning, construction, maintenance, and marketing. Then technology standard implementation benefits are calculated by numerical analysis.

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