Study on the Analysis of Business Chain and Evaluation of the Benefits of Standard Implementation in New Power System Based on the Whole-Chain Value Decomposition Approach

Pengwei Cong[1*], Rui Li[2], Ran Gao[3], Zhen Wei[4], Nuoling Sun[5], Xin Wei[6]

{corresponding author: imagecong@126.com[1*], lirui@sgeri.sgcc.com.cn[2], 1643657533@qq.com[3], ywzw89@sina.com[4], 13859058908@163.com[5], vx1n0330@qq.com[6]}

State Grid Energy Research Institute Co., Ltd, Beijing, China[1,2]
North China Electric Power University, Beijing, China[3]
State Grid Fujian Economic Research Institute, Fuzhou, China[4,5,6]

Abstract. The new power system is characterized by many fields, wide influence scope and long business chain, and it is difficult to evaluate the benefits of the implementation of standards for the new power system by traditional methods. Based on the analysis of the characteristics and development trend of the business chain of the new electric power system, this paper proposes the value decomposition method of the whole chain for evaluating the benefits of standards implementation, and accurately associates the technical standards and implementation benefits through the "business chain". The validity of the proposed model and method is verified through the calculation of examples of power grid enterprises, and the method proposed in this paper is effective in quantitatively evaluating the benefits of implementing new power system standards and find out the weak business areas of the implementation of the standards.

Keywords: New Power System; Technical Standard System; Implementation Benefits; Evaluation Model; Whole-Chain Value Decomposition Approach.

1 Introduction

The level of standardization is not only an important indicator of the core competitiveness of an enterprise, but also an important indicator of the core competitiveness of an industry or even a country [1]. At present, the development of China's power system has made great achievements, and has built the world's largest, highest voltage level, most advanced technology level, and the strongest resource allocation capacity of the power grid. In order to meet the needs of economic and social development of energy and electricity, it is necessary to continuously strengthen the standardization construction, form a scientific and applicable standard system in the planning and design of power grids, construction and operation, equipment management, etc., seize the technological commanding heights through the formulation of standards, and always lead the development of the power system with advanced and unified standards [2]. At the same time, how to measure the role and benefits of standardization has become a key element that needs attention [3].

MSIEID 2023, December 08-10, Guangzhou, People's Republic of China

DOI 10.4108/eai.8-12-2023.2344793

Literature [4-5] will be the internal structure of the system is decomposed into basic activities and related auxiliary activities, the use of value chain analysis to analyze the profitability of the implementation of technical standards of electric power enterprises, the method can use a systematic approach to the examination of the various activities of electric power enterprises and the interrelationships, so as to find a competitive advantage of the resources. Literature [6] in the establishment of the standardization of economic efficiency assessment index system based on the use of hierarchical analysis to determine the weights, and according to the data obtained from the questionnaire for fuzzy comprehensive evaluation. Literature [7] points out that the expert consulting evaluation method based on the indicator system is a kind of method to carry out the implementation of benefit evaluation by virtue of the subjective judgment of experts in the relevant fields, and this kind of method is commonly used in the field of technical standardization benefits and other evaluation studies that are difficult to quantitatively analyze. The above research methods are mostly based on a single standard implementation benefit evaluation as the research object, and the research on the standard systematic implementation benefit evaluation is still in the blank stage, and it is difficult to provide sufficient theoretical guidance for the existing research results of the electric power system which has complex business division of labor, numerous processes and procedures, and a huge system of technical standards.

On March 15, 2021, China made an important deployment of carbon peaking and carbon neutrality, proposing the construction of a new power system with new energy as the main body. In the past two years, the connotation of the new type of power system has been continuously deepened, and it is proposed to accelerate the construction of a new type of power system that adapts to the gradual increase in the proportion of new energy. In general, the new power system is more open and complex, emphasizing the interaction of the whole link of source, network, load and storage, focusing on multi-party scientific and technological innovation cooperation, and further highlighting the characteristics of the power system with a long business chain and a wide range of specialties [8]. Based on the analysis of the characteristics of the business chain and development trend of the new electric power system, this study establishes the whole chain value decomposition method to evaluate the benefits of the systematic implementation of technical standards of the new electric power system, including the business decomposition model, the standard contribution measurement model, and the comprehensive benefit calculation model considering the time lag effect, and finally, taking the grid company as an example, it carries out the empirical analysis of the evaluation model of the benefits of the implementation of the systematic implementation of technical standards to calculate the grid The contribution of technical standards to economic benefits.

2 Analysis of new power system business chain and development trend

The power industry is characterized by long business chains, technology-intensive, capital-intensive, strong public services and strict regulation. In terms of business chain, the power industry chain is a systematic and systematized concept.

From the perspective of the included fields and links, the power industry business chain involves "generation, transmission, distribution, use" of each link, but also the relationship between "source, network, load, storage" in a number of fields. From the perspective of product categories covered, the business chain of the power industry includes upstream basic raw materials, basic hardware and software, core basic components, including the midstream machine and equipment, components, tools and equipment, including downstream various types of grid operators, power producers, integrated energy service providers and other enterprises. Among them, the power grid is a bridge hub connecting power production and consumption, and is a network platform for energy conversion and utilization, optimal allocation and supply and demand docking. High-end power transmission and transformation, power distribution, intelligent operation and inspection and power dispatch and other grid business is to promote the power system "wind, water and fire" multi-energy complementary, "source network, storage" integration through the core of the key, can play a high-quality development of the power system industry chain. It can play the role of "main support" and "integration drive" for the high-quality development of the power system industry chain. The new power system business chain has the following development situation .

First, the new type of power system security development of openness and complexity characteristics are more significant. New type of power system massive distributed power supply extensive access, all kinds of energy storage resources and regulating resources a large number of construction, electric vehicles and integrated energy service providers, virtual power plants and other new market players, new forms of participation in the interaction, while the digital and physical systems are deeply integrated.

Secondly, the new electric power system emphasizes more on the deep synergistic interaction of the whole link of source, network, load and storage. The new type of power system mainly carries the green and low-carbon transformation of key industries such as industry, transportation and construction, and needs to give play to its core platform advantage of greening and low-carbonizing consumption, strengthen the synergistic matching of supply and demand, promote changes in the mode of energy consumption, enhance the terminal energy efficiency and electrification level, and promote the transformation of the mode of energy use to the intensive and efficient type.

Thirdly, the new type of power system pays more attention to strengthening the first driving force of technological innovation with multi-party cooperation mode. The new power system involves many fields and has a wide range of influence, requiring enterprises upstream and downstream of the industry chain to play to their strengths and take the initiative to change, and requiring the active support and participation of the government, the industry and the society to strengthen technological cooperation and sharing of results.

3 Evaluation method of standard implementation benefits based on the whole chain value decomposition method

Taking into full consideration of the characteristics of the new electric power system, which involves many fields, has a wide range of influence, and has a long business chain, the whole-chain value decomposition method is adopted to evaluate the benefits of the implementation of electric power technical standards. The whole-chain value decomposition method is based on the overall value chain of the enterprise's main business, through the decomposition, determination and stripping of the impact of the standard on the business benefits at all levels, and ultimately calculate the contribution rate of the implementation of technical standards to the enterprise's main business, so as to realize the comprehensive evaluation of the benefits of the systematic implementation of technical standards. The comprehensive evaluation model of the benefits of systematic implementation of technical standards includes three sub-models, namely, the decomposition model of main business based on weight allocation, the measurement model of the contribution of technical standards to the underlying business, and the comprehensive benefit calculation model considering the time lag effect.

3.1 Main business decomposition model based on weight allocation

The main function of the main business decomposition model based on weight allocation is to subdivide the main business of an enterprise into secondary and tertiary businesses according to the degree of importance or support of the lower business to the upper business, until it is decomposed to the specific business activities in which the technical standards play a direct role, i.e., the "bottom business". The degree of importance or support of the lower tier business to the upper tier business can be weighted based on the hierarchical analysis method and the Delphi (DELPHI) expert method.

Let's compare the degree of influence of the n factor $C_1, C_2, \cdots, C_n$ on the previous layer (e.g., the target layer) O , i.e., let's determine its share in O . For any two factors C_i and C_j , use a_{ij} to denote the ratio of the influence of C_i and C_j on O , and measure $a_{ij}\ (i, j = 1,2,\cdots,n)$ on a scale of 1-9. Thus, a two-by-two pairwise comparison matrix $A = (a_{ij})_{n\times n}$, also known as the judgment matrix, can be obtained, obviously:

$$a_{ij} > 0,\ a_{ji} = \frac{1}{a_{ij}}, a_{ii} = 1, (i, j = 1, 2, \cdots, n) \tag{1}$$

From the properties of positive reciprocal inverse matrices, it is sufficient to determine the elements of $\frac{n(n-1)}{2}$ in the upper (or lower) triangle of A . In a special case, if the elements of the judgment matrix A are transitive, i.e., satisfy

$$a_{ik}a_{kj} = a_{ij}(i, j, k = 1, 2, \cdots, n) \tag{2}$$

Consistency Ratio Indicator: $CR = \frac{CI}{RI}$, when $CR < 0.10$, the consistency of the judgment matrix is considered acceptable, then the eigenvectors corresponding to $\lambda_{\max}$ can be used as weight vectors for sorting. At this point

$$\lambda_{\max} \approx \sum_{i=1}^{n} \frac{(A \cdot W)_i}{nw_i} = \frac{1}{n}\sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij}w_j}{w_i} \tag{3}$$

where $(A \cdot W)_i$ denotes the i th component of $A \cdot W$.

The vector of total ranking weights of the elements on the k th layer on the target layer (the highest layer) is

$$W^{(k)} = P^{(k)} \cdot W^{(k-1)} = \left[P_1^{(k)}, P_2^{(k)}, \cdots, P_{n_{k-1}}^{(k)}\right] \cdot W^{(k-1)} \\ = \left(w_1^{(k)}, w_2^{(k)}, \cdots, w_{n_k}^{(k)}\right)^T \tag{4}$$

Maybe

$$w_i^{(k)} = \sum_{j=1}^{n_{k-1}} p_{ij}^{(k)} w_j^{(k-1)}, i = 1, 2, \cdots, n_k \tag{5}$$

For any $k > 2$ there is the general formula

$$W^{(k)} = P^{(k)} \cdot P^{(k-1)} \cdots \cdot P^{(3)} \cdot W^{(2)} (k > 2) \tag{6}$$

where W(4) is then the total ordering vector of the elements on the fourth business layer to the target layer.

3.2 The underlying business technology standard contribution measurement model

The main function of the bottom-level business technical standard contribution measurement model is to calculate the supporting role of the technical standard cluster corresponding to the bottom-level business unit on the business activity, with the main purpose of deducing the contribution of technical standard implementation to the overall main business benefits through the cascading contribution of technical standards in the bottom-level business. The contribution of technical standards in the bottom business needs to be calculated based on the data collection and investigation and analysis of the production process by combining two important factors, namely, the classification of technical standards and the driving elements of the bottom business. Since the driving factors of each specific underlying business are different, the calculation of the contribution of technical standards needs to be revised accordingly for different types of underlying businesses.

3.3 Model for calculating integrated benefits taking into account the time lag effect

The main function of the comprehensive benefit calculation model that takes into account the time-lag effect is to calculate the comprehensive benefits generated by technical standards for the main business, which needs to be comprehensively calculated in conjunction with the indicator system for the benefits of the implementation of the main business and the period of time in which the technical standards are in full play. Since it takes a certain period of time from the release of technical standards to the actual application of technical standards to generate implementation benefits, and the implementation benefits of standards are mainly generated in the second half of the full life cycle of the standards, it is necessary to deal with the time-lag effect of technical standards when calculating the implementation benefits of technical standards.

When counting clusters of standards, there are cases of standard turnover and life cycles that do not reach five years due to, for example, technological innovations or equipment improvements. Specific algorithms:

$$\eta_i = \frac{N_i}{N_{\text{base}}} \tag{7}$$

Where η_i is the time correction factor for criterion (cluster) i, N_i is the life cycle (in years) of criterion (cluster) i, N_{base} is the benefit evaluation cycle, and $N_{\text{base}} = 5$.

Combining the underlying business technical standard contribution calculation model and the grid main business weight allocation model can get the contribution of technical standards to the main business of the grid, and combining with the technical standard time lag effect, the contribution of technical standards to the implementation of the benefits can be obtained as shown in the following equation:

$$F_s = \sum_{k=1}^{K} f_k^{\text{ben-bus}} \left[\sum_{j=1}^{J} f_{jk}^{\text{bus-bus}} \left[\sum_{i=1}^{I} f_{ij}^{\text{bus-sta}} \cdot \eta_i \right] \right] \tag{8}$$

where F_s is the implementation benefit s, which is contributed by the first-level business k=1...K, and $f_k^{\text{ben-bus}}$ is the contribution of the first-level business k to the implementation benefit s; the first-level business k is contributed by its underlying business j=1...J, and $f_{jk}^{\text{bus-bus}}$ is the contribution of the underlying business j to the first-level business k; and the contribution of the standards in the underlying business j is obtained by multiplying the contribution of the corresponding science and technology standard (cluster) i by its time correction factor and then summing up to obtain the time correction factor , which can be calculated by Eq. (7). $f_{ij}^{\text{bus-sta}}$ The contribution of the standard in the bottom business j is obtained by multiplying its time correction factor η_i and then summing up, and the time correction factor η_i can be calculated by Eq. (7).

4 Case Study

In order to verify the correctness and effectiveness of the proposed new power system technical standard implementation benefit evaluation method, this paper carries out a case study on the example of power grid enterprises. The results of the calculation of the overall benefits of the systematic implementation of technical standards in power grid companies are shown in Table 1.

Table 1. Calculation results of the benefits of the implementation of the systematization of technical standards in power companies

typology	Level 1 indicators	Secondary indicators	unit	Systematic implementation of technical standards Benefits
Economic efficiencies	Corporate operating profit	Grid business profit	billions	2.411955
societies efficiencies	clean energy	Clean Energy Consumption of Electricity	Million kWh	14368.50
	Quality of electricity supply	City network supply voltage pass rate	%	0.010466
		Agricultural network supply voltage pass rate	%	0.099997
specialized field level (of achievement etc)	planning and design	Capacity-to-load ratio (500kV)	%	-0.006557

typology	Level 1 indicators	Secondary indicators	unit	Systematic implementation of technical standards Benefits
	marketing service	Electricity consumption information collection coverage	%	2.668480

From the contribution degree of technical standards of each main business, the contribution degree of planning and design profession is the highest (average value 11.8%), and the contribution degree of operation, maintenance and repair profession is lower (average value 9.47%), reflecting that the planning and design profession has higher dependence and standardization on technical standards. The overall contribution of technical standards of Grid Corporation is 11.97%, and the contribution of technical standards of the five professional business systems of planning and design, engineering and construction, scheduling and operation, operation and maintenance, and marketing service business is 13.95%, 12.19%, 12.61%, 10.33%, and 10.76%, respectively, reflecting that the standardization of Grid Corporation's planning and design business system is of higher benefit, and operation and maintenance The business system should further strengthen the systematic implementation and application of technical standards.

5 Conclusion

Aiming at the characteristics of the new power system, which involves many fields, has a wide range of influence, and has a long business chain, this paper proposes for the first time the "whole-chain value decomposition method" for the evaluation of the benefits of the systematic implementation of technical standards. According to the evaluation idea of "technical standard-business chain-implementation benefit", technical standards and implementation benefits are accurately related through the "business chain", thus solving the problem that traditional evaluation methods such as the ISO value chain method are unable to evaluate the large-scale business system of the new electric power system. This solves the problem that traditional evaluation methods such as ISO value chain method cannot evaluate the large-scale business system of new power system, and has good value of popularization and application.

Acknowledgments. This project is funded by The paper is funded by “Key Technological Project of SGCC(Project Number: SGFJJY00GHJS2200133) ”

References

[1]M. Muñoz and P. Montoya-Méndez: Identification of issues in the implementation of the ISO/IEC 29110 standard: comparison between the state of the art and the state of practice. 2021 10th International Conference On Software Process Improvement (CIMPS), Torreón, Coahuila, Mexico, pp. 90-97(2021).

[2]Zhao Sanshan, Xu Tangyun. Evaluation of technical standard implementation in large electric power enterprises. Operation and Management. Vol. 12, pp. 130-134 (2017).

[3]T. Tzolov: One Model For Implementation GDPR Based On ISO Standards. 2018 International Conference on Information Technologies (InfoTech), Varna, Bulgaria, pp. 1-3(2018).

[4]Qi Binfang, Song Mingshun,Fang Xinghua, Zheng Suli. An empirical study on the evaluation method of economic benefits of ISO standards. Standard Science. Vol. 11, pp. 11-15 (2012).
[5]Fu Qiang, Wang Yiyi, Wang Lijun, Liu Hui. A case study based on ISO standard economic benefit assessment method in China. Standard Science. Vol. 11, pp. 23-25 (2013).
[6]Yu Huifang, Zou Ge. Evaluation method for the implementation benefit of planning and design technical standards based on hierarchical analysis. China Equipment Engineering. Vol. 6, pp. 176-178 (2019).
[7]Lv Chao, Liang Cai, Zhang Pengyue, Li Weixia, Cheng Yue, Shi Ankang. Research on the evaluation method of technical standard implementation benefit of State Grid Corporation. China Standardization. Vol. 8, pp. 108-112 (2020).
[8]Zhang Zhigang, Kang Chongqing. Challenges and perspectives of constructing a new type of power system under the goal of carbon neutrality. Chinese Journal of Electrical Engineering. Vol. 42, pp. 2806-2819 (2022).