An Empirical Analysis of Asset Management Performance Evaluation Model for Power Grid Enterprises

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Abstract. According to the main business situation of the current enterprise management of power grid enterprises, we divided the identified key coordination points of business into five categories: the process of implementation, the timeliness of implementation, the accuracy of implementation, the compliance of implementation and the quality of implementation. Through the analysis of the basic characteristics and operation of the main business coordination points of the enterprise's asset management, the index system is constructed to evaluate the process, timeliness and accuracy of the key synergies of the enterprise's asset management to promote the coordination of the asset management system.

The Construction of Performance Evaluation Index System

The performance index system of the asset management business can be divided into the implementation process index, the implementation timeliness index, the implementation accuracy index, the implementation compliance index and the implementation quality index according to above coordination classification. These five categories of index can reflect the quality, time, flexibility, technology of grid enterprise asset management business. Based on the above thinking, we select the index system as shown in the table below.

Table 1. Evaluation Index System of Business Process Performance

Evaluation target	First level evaluation index	Second level evaluation index	Frequency	History demand	Concern
Performance Evaluation of Asset Management Business	Quality of service	High quality engineering rate of Power grid enterprise	0.5 year	5 Years	Quality Management
		Design excellence rate of power transformation engineering(750 kV and below)	1 year	5 Years	Design management
		Design excellence rate of Transmission line engineering(750 kV and below)	1 month	5 Years	Design management
		“N-1”pass rate of Power grid	1 year	5 Years	Power grid status
		residue rate of scrap assets	1 month	5 Years	Asset Life Cycle
	Business process	Project completion rate(750 kV and below;include pre start projects)	1 month	5 Years	Project Management

		Completion rate of bidding for engineering design(750 kV and below)	1 month	5 Years	Project Management
		Completion rate of material purchase contract	1 month	5 Years	Procurement contract management
		Signing rate of purchase (sale) electric contract	1 month	5 Years	Power Generation Services business
	Business timeliness	Implementation rate of material procurement standard	1 month	5 Years	Plan management
		Timely rate of contract signing	1 month	5 Years	Procurement contract management
		Timely rate of PMS account creation	1 month	5 Years	Asset Life Cycle
	Business accuracy	Rate of decrease in project settlement(10% or less is reasonable)	1 season	5 Years	Cost management
		Completion rate of information project investment plan	1 month	5 Years	Information Project Management
		Completion rate of information project plan	1 year	5 Years	Information Project Management
		Completion rate of supervision plan	1 month	5 Years	Quality supervision and management
		Completion rate of sampling plan	1 month	5 Years	Quality supervision and management
		Correct operation rate of relay protection	1 season	5 Years	Equipment level
		The passing rate of the day before the load forecasting	1 season	5 Years	Scheduling plan
		Monitoring accuracy rate of alarm information above provincial level	1 month	5 Years	Monitoring operation
	Business compliance	Balanced production index	1 season	5 Years	Project Management
		Application rate of general line design(750 kV and below)	1 month	5 Years	Design management
		Public bidding rate	1 month	5 Years	Procurement management
		Turnover ratio of current assets(Industry sector)	1 month	5 Years	Industry sector
		SEC comprehensive index	1 month	5 Years	Asset Life Cycle
		Total cost of maintenance	1 month	5 Years	Asset Life Cycle
		Total cost of operation and maintenance	1 month	5 Years	Asset Life Cycle
		Failure disposal cost	1 month	5 Years	Asset Life Cycle
		Original value of scrap assets	**1 month**	**5 Years**	**Asset Life Cycle**

The Model Construction and Empirical Analysis of Performance Evaluation

The grey triangular whitening weight function analysis method is adopted to evaluate and analyze the specific conditions of the selected indexes, and the results of the evaluation of different periods are compared and analyzed. The specific steps of the method are as follows:

(1) Determine the interval and specific function parameters

The gray classifications of the index system is divided into five grades: "high", "higher", "middle", "lower", "low". According to the value range of the index base value after the standardized treatment of the evaluation index, the grey range is set between 0-1. The specific correspondence is shown in table 2.

Table 2. Score dividing interval of assets operation index

interval	Low	lower	middle	higher	high
Grade defined value	[0，0.2]	[0.2，0.4]	[0.4，0.6]	[0.6，0.8]	[0.8，1]

According to the formula $\varepsilon_k = (k_s + k_{s+1})/2$, ε values corresponding to five gray levels are obtained:

$$\varepsilon_1 = (k_1 + k_2)/2 = 0.1, \varepsilon_2 = (k_2 + k_3)/2 = 0.3, \varepsilon_3 = (k_3 + k_4)/2 = 0.5, \varepsilon_4 = (k_4 + k_5)/2 = 0.7,$$
$$\varepsilon_5 = (k_5 + k_6)/2 = 0.9.$$

At the same time, the value domain is extended to the left and right sides, we get $k_0 = -0.2$，$k_7 = 1.2$.

Through the gray clustering trigonometric function and the standardized value of the evaluation index, the clustering trigonometric functions of each gray scale corresponding to the evaluation index are obtained respectively:

$$\vartheta_i^1(x) = \begin{cases} 0, & x_i \notin [k_0, k_3] \\ \dfrac{x_i - k_0}{\varepsilon_1 - k_0}, & x_i \in [k_0, \varepsilon_1] \\ \dfrac{k_3 - x_i}{k_3 - \varepsilon_1}, & x_i \in [\varepsilon_1, k_3] \end{cases} = \begin{cases} 0, & x_i \notin [-0.2, 0.4] \\ \dfrac{x_i + 0.2}{0.3}, & x_i \in [-0.2, 0.1] \\ \dfrac{0.4 - x_i}{0.3}, & x_i \in [0.1, 0.4] \end{cases}$$

$$\vartheta_i^2(x) = \begin{cases} 0, & x_i \notin [k_1, k_4] \\ \dfrac{x_i - k_1}{\varepsilon_2 - k_1}, & x_i \in [k_1, \varepsilon_2] \\ \dfrac{k_4 - x_i}{k_4 - \varepsilon_2}, & x_i \in [\varepsilon_2, k_4] \end{cases} = \begin{cases} 0, & x_i \notin [0, 0.6] \\ \dfrac{x_i}{0.3}, & x_i \in [0, 0.3] \\ \dfrac{0.6 - x_i}{0.3}, & x_i \in [0.3, 0.6] \end{cases}$$

$$\vartheta_i^3(x) = \begin{cases} 0, & x_i \notin [k_2, k_5] \\ \dfrac{x_i - k_2}{\varepsilon_3 - k_2}, & x_i \in [k_2, \varepsilon_3] \\ \dfrac{k_5 - x_i}{k_5 - \varepsilon_3}, & x_i \in [\varepsilon_3, k_5] \end{cases} = \begin{cases} 0, & x_i \notin [0.2, 0.8] \\ \dfrac{x_i - 0.2}{0.3}, & x_i \in [0.2, 0.5] \\ \dfrac{0.8 - x_i}{0.3}, & x_i \in [0.5, 0.8] \end{cases}$$

$$\vartheta_i^4(x) = \begin{cases} 0, & x_i \notin [k_3, k_6] \\ \dfrac{x_i - k_3}{\varepsilon_4 - k_3}, & x_i \in [k_3, \varepsilon_4] \\ \dfrac{k_6 - x_i}{k_6 - \varepsilon_4}, & x_i \in [\varepsilon_4, k_6] \end{cases} = \begin{cases} 0, & x_i \notin [0.4, 1] \\ \dfrac{x_i - 0.4}{0.3}, & x_i \in [0.4, 0.7] \\ \dfrac{1 - x_i}{0.3}, & x_i \in [0.7, 1] \end{cases}$$

$$\vartheta_i^5(x) = \begin{cases} 0, & x_i \notin [k_4, k_7] \\ \dfrac{x_i - k_4}{\varepsilon_5 - k_4}, & x_i \in [k_4, \varepsilon_5] \\ \dfrac{k_7 - x_i}{k_7 - \varepsilon_5}, & x_i \in [\varepsilon_5, k_7] \end{cases} = \begin{cases} 0, & x_i \notin [0.6, 1.2] \\ \dfrac{x_i - 0.6}{0.3}, & x_i \in [0.6, 0.9] \\ \dfrac{1.2 - x_i}{0.3}, & x_i \in [0.9, 1.2] \end{cases}$$

(2) The calculation of grey triangle weight vector

With respect to the weight v_i as the index x_i, the gray evaluation coefficient belonging to the m evaluation gray category is denoted as b_{im}, and the total evaluation number belonging to the different evaluation gray classification is denoted as b_i, so, $b_{im} = \sum_{j=1}^{m} \vartheta_m(x_{ij})$ $b_i = \sum_{m=1}^{m} b_{im}$

According to the formula mentioned above, the m triangle evaluation right of index x_i can be denoted as $a_{im} = b_{im}/b_i$ C, and then obtain the index gray triangle vector $x_i = (a_{i1}, a_{i2}, \cdots$.

(3) Determine the index weight

The establishment of the assets management performance evaluation index system model of power grid enterprises consists of two stages: the first is to determine the empowerment object, and the second is to determine the empowerment method.

The weight coefficient of the basic index is determined by the averaging method, and the weight coefficients of the second layers and third layers are determined by the combination of expert scoring and entropy weight. Then adjust the weight according to the performance evaluation, the assessment of responsible person, the peer benchmarking index system weight settings and other factors.

The expert scoring method combines qualitative sequencing with quantitative transformation. First of all, rank the dimensions and indicators subjectively by the raters. The basic idea is to assume that there are N indicators in the index system. According to the experts' collective discussion, the importance ranking of the N indexes is made, then the quantitative index is transformed into specific weight by means of quantitative transformation. The mathematical expression of qualitative ordering and quantitative transformation is: for the n sorting indicators, the evaluator's psychological sense of the index S_i is: $S_i = \frac{\ln(M+2-i)}{\ln(M+1)}$

Among them, M is the coefficient of transformation (that is, the maximum of the sorting), and the i is the sorting value of the index. In ranking the importance of dimensions and indicators, because the dimensions and indexes are generally not comparable, each indicator of importance ranking should be limited to the same dimension.

In the specific weight setting work, through expert scoring to build a judgment matrix by the use of AHP, set up the grid enterprise asset management performance evaluation model at all levels of dimensions and specific indicators weight.

(4) The calculation and classification of comprehensive evaluation results

The grey triangle weight vectors corresponding to each index are respectively multiplied with the corresponding gray value ε to obtain the grey clustering gray value of the index B.According to the result of weight of evaluation index multiplied by clustering gray value, we can get the comprehensive evaluation result of triangular whitening weight function: $T = GB$.

Through the above weight method, the calculated power grid enterprise asset management business performance evaluation model at all levels of dimensions and specific indicators weights are shown in table 3.

Table 3 Index weight setting results at all levels

First level evaluation index	Second level evaluation index	Weights of second level index	Basic evaluation index	Weights of third level index
Performance Evaluation of Asset Management Business	Business quality	0.1568	High quality engineering rate of Power grid enterprise	0.2
			Design excellence rate of power transformation engineering(750 kV and below)	0.2
			Design excellence rate of	0.2

			Transmission line engineering(750 kV and below)	
			"N-1"pass rate of Power grid	0.2
			residue rate of scrap assets	0.2
	Business process	0.094	Project completion rate(750 kV and below;include pre start projects)	0.25
			Completion rate of bidding for engineering design(750 kV and below)	0.25
			Completion rate of material purchase contract	0.25
			Signing rate of purchase (sale) electric contract	0.25
	Business timeliness	0.1812	Implementation rate of material procurement standard	0.33
			Timely rate of contract signing	0.33
			Timely rate of PMS account creation	0.33
	Business accuracy	0.2134	Rate of decrease in project settlement(10% or less is reasonable)	0.125
			Completion rate of information project investment plan	0.125
			Completion rate of information project plan	0.125
			Completion rate of supervision plan	0.125
			Completion rate of sampling plan	0.125
			Correct operation rate of relay protection	0.125
			The passing rate of the day before the load forecasting	0.125
			Monitoring accuracy rate of alarm information above provincial level	0.125
	Business compliance	0.3546	Balanced production index	0.111
			Application rate of general line design(750 kV and below)	0.111
			Public bidding rate	0.111
			Turnover ratio of current assets(Industry sector)	0.111
			SEC comprehensive index	0.111
			Total cost of maintenance	0.111
			Total cost of operation and maintenance	0.111
			Failure disposal cost	0.111
			Original value of scrap assets	0.111

The above index weight setting results can be seen in the table, in the five aspects of the performance of asset management business of power grid enterprises, the business accuracy and business compliance are relatively large, which is also consistent with the reality. In general, the business compliance is the prerequisite and basis for the normal operation of the enterprise's asset management business, so its role in asset management performance evaluation is the first. After the compliance is the accuracy of the business, it is directly related to the efficiency of the operation of the power grid business. In addition, the quality, process and timeliness are also key factors in business performance appraisal.

Empirical Analysis

A model test was conducted based on the five-year data of a grid enterprise in 2010-2014, the business performance of grid enterprises shows a general trend of growth. Among them, the grid enterprise asset management performance value in 2013 reached the peak in nearly five years. Although in 2014 there was a slight decline, the business process performance value in general to maintain a good growth trend. As shown in Figure 1.

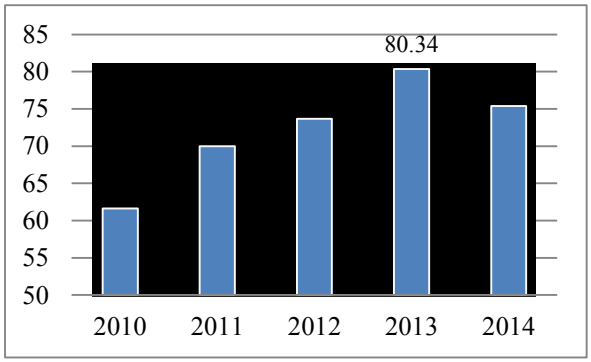

Figure 1 Asset management business performance value in 2010-2014

The reason for the peak performance in 2013 was that the process, compliance and quality were significantly improved, the performance value increased by 6.6842 over 2012. At the same time, business progress has reached the fastest in five years, the quality of business has also been steadily improved. The comprehensive promotion of the three indicators directly contributed to the greater performance of asset management performance compared with other years.

Conclusions

It was established the performance evaluation index system of asset management in this paper from the aspects of progress, timeliness, compliance, accuracy and quality，and established a method model based on gray triangle whitening weight function analysis to evaluate asset management performance. According to the classification of coordination key points, the business performance index system can be divided into process, timeliness index, accuracy index, compliance index and quality index. These five types of indicators can reflect the quality, time, flexibility and technical characteristics of the business process of grid enterprise asset management. By using the gray triangular whitening weight function analysis method, the specific situation of the selected indicators is evaluated and analyzed. By calculating the weights and performance values of the indicators at all levels, we can analyze the key influencing factors and the causes of the changes in the performance value of the asset management business in power grid enterprises, and propose reasonable measures and suggestions.

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