Research on the Standardization of Power Grid Safety Production Cost Management

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Abstract. The annual expenditure on power grid safety production costs is substantial. In order to enhance cost management levels and improve investment efficiency, this paper standardizes the process of power grid safety production cost management and proposes a method for calculating standardized safety production costs in the power grid. Finally, using safety equipment testing as an example, the paper conducts cost standardization calculation and analysis. The results indicate that by establishing relevant standards for power grid safety production cost management, the standardization, scientificity, and accuracy of safety production cost management have been improved.

Keywords: Power Grid Safety Production Costs; Standard Work Item Repository; Expert Experience Method; Designated Average Method

1 Introduction

Power grid safety production involves various tasks related to safety equipment and facilities, improvement of firefighting and security measures, emergency construction, hazard identification and control, risk management, safety inspections, supervision and evaluation, safety promotion, education and training, labor protection, and occupational health. The expenses incurred from these activities are considered as power grid safety production costs.

In recent years, with the continuous improvement of safety production management requirements in power grid companies, the corresponding safety production costs have also increased year by year. Currently, there are issues with non-uniform standards and missing standards for safety production costs. To enhance the safety production cost management level, it is necessary to standardize the use of funds and establish standardized management processes.

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2 Standardized Process for Power Grid Safety Production Cost Management

2.1 Establishing a Standard Work Item Repository for Safety Production Costs

According to statistics, in the annual safety expenditure for the year 2023 in a certain province, the total investment for five categories of items - security services, security maintenance, safety evaluations, production of safety education videos, and safety equipment testing - accounts for a significant portion, amounting to 65.30% of the total initial safety expenditure. Considering this, these five categories are prioritized for compiling cost standards. The safety production costs related to these five categories are classified from professional categories to multi-level project divisions and then further subdivided into specific work items. The process is determined based on specific tasks for each work item, establishing a standardized work item repository. The standardized work item repository provides a clear outline of each work item's steps, content, and requirements to ensure proper execution and completion of the tasks[1-3].

2.2 Development of Safety Production Cost Standards and Calculation Regulations

In reference to the pricing basis used for power grid infrastructure construction, technological upgrades, major maintenance, marketing, and informatization projects, we conduct research and develop the “Safety Production Cost Standards and Calculation Regulations.” This primarily includes project categorization, cost composition, cost calculation rate standards, other expenses, and standards for cost allocation[4-5].

2.3 Preparation of Safety Production Cost Quotas and Corresponding Subcategory Quota Table

Based on the investigation, fundraising, and analysis of actual projects, calculations, and preparations are carried out using methods such as field measurements and analogical analysis. The corresponding subcategory quota table for safety production costs is developed based on the earlier compiled standard work item repository, quotas, and other achievements. It includes safety production work content and corresponding subcategory quota numbers. The table is mainly used to guide personnel involved in safety production projects on how to use safety production quotas, apply them appropriately, and improve the accuracy and efficiency of preparation[6-9].

3 Methodology for Calculating Power Grid Safety Production Cost Standards

The cost standards for the above five categories of projects are determined based on expert experience and relevant specification documents as references. Subsequently, calculations are conducted using historical engineering data and vendor quotations. The main methods employed include three-point estimation, statistical analysis, expert experience, benchmarking, and designated average method to comprehensively estimate the relevant cost standards.

Three-point estimation: It involves taking the weighted average of the maximum, minimum, and most likely values for a project. This method helps to mitigate the impact of biases from a single estimate on the overall project prediction. By adjusting the weights assigned to different estimated values, the overall accuracy of the prediction can be improved. The common formula for three-point estimation is as follows:

[Expected Cost] = (Optimistic Estimate + 4 * Most Likely Estimate + Pessimistic Estimate) / 6 (1)

In this formula, the Optimistic Estimate represents the lowest probable cost, the Most Likely Estimate represents the most probable cost, and the Pessimistic Estimate represents the highest probable cost.

Statistical Analysis Method: It is the most fundamental and commonly used approach for engineering quotas and cost standard estimation. It involves studying and analyzing the correlation and regularity of quantities related to the target object's scope, scale, and extent. It aims to understand and reveal the interrelationships, variability, and development trends of the subject matter. Generally, this method employs mathematical models to statistically analyze the sample data and information obtained from surveys, generating quantitative conclusions. The statistical analysis method is suitable for analyzing large sample sizes.

Expert Experience Method: By analyzing the actual work carried out in the current project and the actual incurred expenses from historical projects, and combining expert opinions, the calculation of project estimation data is conducted.

Reference and Benchmarking Method: By referring to similar projects and the actual execution of historical projects, a reasonable analysis of differences is performed to determine the data for calculation.

Designated Average Method: Averaging is the concept of evenly calculating a total number into parts, which includes simple averages and designated condition averages. The simple average is usually obtained by dividing the total by the number of parts. The designated condition average involves removing specified parts before averaging, which can include eliminating the highest or lowest values or removing a specified percentage. The variance minimization average involves setting the estimated value as X_m, and constructing the equation $\sigma^2 = \frac{\sum_{i=1}^{i=m}(X_{i1}-X_\alpha)}{N}$.

Then there exists a number X_α, which is averaged minimized variance, located between the value of min ($X_{11}, X_{21}, X_{31} \dots, X_{m1}$) and the value of max

$(X_{11}, X_{21}, X_{31} \dots, X_{m1})$, such that the value of σ^2 is minimized. The designated average method is suitable for both large and small sample size analyses[10-13].

4 Calculation and Analysis of Power Grid Safety Production Cost Standards

In the five categories related to power grid safety production, this paper takes safety equipment testing as an example to conduct cost standard calculation and analysis.

The cost standard calculation method for safety equipment testing mainly employs the Expert Experience Method and the Designated Average Method. Multiple rounds of fundraising and historical engineering data are carefully screened to remove obvious outliers, and the details are comprehensively analyzed and statistically summarized. Firstly, based on the expertise of experts in various cities and the actual implementation of testing centers in each city, the safety equipment testing data is comprehensively adjusted. Secondly, considering the current data from various testing centers, the cost standards are calculated using the Designated Average Method. X_{ij} denotes the associated costs caused by each testing center, where $i = 1,2 \dots \dots m$, represents m testing centers, and $j = 1,2 \dots \dots n$, denotes n associated costs. Taking the first cost as an example, the data from each testing center are as follows:$X_{11}, X_{21}, X_{31} \dots, X_{m1}$. We construct the equation using the method of designated variance minimization average $\sigma^2 = \frac{\sum_{i=1}^{i=m}(X_{i1} - X_{\alpha 1})}{N}$. Let the value of $X_{\alpha 1}$ in the range of the min $(X_{11}, X_{21}, X_{31} \dots, X_{m1})$ and the max $(X_{11}, X_{21}, X_{31} \dots, X_{m1})$, we assume that there exits a minimized value of σ^2, the step size is 0.01 RMBs. We denote the minimized value of σ^2 as $X_{\alpha 1}$.

Safety equipment testing mainly involves three major categories of objects: personal protective equipment, insulated safety equipment, and climbing equipment. The calculation is based on data from 16 testing centers, as shown in Table 1, Table 2, and Table 3. Among them:

$$\text{Cost typical price} = \text{labor cost} + \text{material cost} + \text{equipment cost} \tag{2}$$

Comprehensive unit price = cost standard base price + measures cost + indirect cost (overhead, management fee, profit) + taxes (3)

Table 1. Individual Protective Equipment Cost Standard Calculation

Testing Items	Cost Typical Price (RMB)	Comprehensive Unit Price (RMB)	Average Unit Price for Each Testing Center (RMB)	Deviation
Safety Helmet	163.21	291.81	291.67	0.05%
Safety Belt	149.20	290.85	289.06	0.62%
Safety Rope	81.82	161.51	155.66	3.76%
Connector	114.28	195.71	200.00	-2.14%

Speed Difference Self-Controller	112.66	237.83	236.36	0.62%
Guide Rail Self-Locking Device	112.79	206.25	217.44	-5.15%
Buffer	96.59	170.15	156.43	8.77%
Static Protective Clothing	731.46	1493.89	1500.00	-0.41%
Conductive Shoes (Antistatic Shoes)	104.99	200.19	200.00	0.10%
Personal Safety Line	75.85	159.24	152.01	4.76%

Table 2 is the cost standard calculation for insulated safety equipment. Due to space limitations, only the relevant expenses for 220 kV are listed in Table 2, while expenses for all other voltage levels, such as 10kV and below, 20kV, 35kV, 110kV, and 500kV, are not included.

Table 2. Insulated Safety Equipment Cost Standard Calculation

Testing Items	Cost Typical Price (RMB)	Comprehen-sive Unit Price (RMB)	Average Unit Price for Each Testing Center (RMB)	Devia-tion
220kVCapacitive Voltage Detector	294.20	468.36	455.73	2.77%
220kVPortable Short-Circuit Grounding Line	323.37	513.39	505.67	1.53%
220kV Insulation Pole	321.84	514.65	496.73	3.61%
Insulation Pole Static Bending	234.18	401.86	400.00	0.46%
Wired and Wireless Phase Comparator	353.62、231.59	569.8、374.44	543.50、350.00	4.84%、6.98%
Insulation Shield	135.17	257.66	239.04	7.79%
Insulation Barrier	177.46	306.05	296.63	3.18%
Insulation Rope	122.23	226.25	219.46	3.09%
Insulation Clamp	104.35	200.42	200.00	0.21%
Insulated Safety Helmet for Live Work	165.30	332.93	308.33	7.98%
Insulated Clothing	193.66	342.15	350.89	-2.49%
Shielding Clothing	599.26	1055.18	1081.56	-2.44%
Insulated Gloves and Boots (Shoes) for Live Work	107.40	216.37	200.00	8.19%

Insulated Mat (Blanket) for Live Work	107.35	203.6	200.00	1.80%
220kV Insulated Ladder for Live Work	373.82	621.49	600.00	3.58%
220kV Insulated Bottle Support	584.50	919.53	900.00	2.17%
220kV Insulated Soft Ladder	373.82	621.49	600.00	3.58%
Insulated Pulley for Live Work	103.36	201.52	200.00	0.76%
Auxiliary Type Insulated Gloves	54.72	102.15	99.52	2.65%
Auxiliary Type Insulated Boots (Shoes)	54.72	102.15	99.52	2.65%
Auxiliary Type Insulated Rubber Mat	124.71	217.13	216.60	0.24%

Table 3. High Climbing Equipment Cost Standard Calculation

Testing Items	Cost Typical Price (RMB)	Comprehensive Unit Price (RMB)	Average Unit Price for Each Testing Center (RMB)	Deviation
Foot Buckle	29.76	57.20	56.67	0.94%
Lifting Plate (Climbing Plate)	43.79	80.02	77.25	3.58%
Ladder (Bamboo, Wood)	169.37	300.70	300.00	0.23%
Ladder (Composite Material)	385.62	619.50	600.00	3.25%
Soft Ladder	169.37	300.70	300.00	0.23%
Quick-Assembly Scaffolding	318.00	520.64	500.00	4.13%
Maintenance Platform	1790.40	2736.86	2666.67	2.63%
Maintenance Platform	3131.65	3546.78	3500.00	1.34%

To verify the reasonableness of the cost estimation, a comparison was made between the actual contract costs and the calculated costs for 100 units of each type of equipment in 11 city companies, as shown in Table 4. There are several reasons for the discrepancies between the calculated and contract amounts, such as variations in labor costs among different cities, and so on. Overall, the estimation is considered to be relatively accurate.

Table 4. Comparison between Estimated Amount and Contract Amount

Contract Year	Total Contract Amount (in ten thousand RMB)	Total Estimated Amount (in ten thousand RMB)	Cost Deviation	Percentage of Cost Deviation
2022	1392.27	1259.22	-133.05	-9.6%

5 Conclusion

Through the research on standardizing power grid safety production cost management, the standardization, scientificity, and accuracy of safety production cost management have been enhanced. Standardizing cost management has promoted the improvement of safety production cost control capabilities and the level of lean management throughout the entire process. It effectively avoids significant cost discrepancies between similar safety items under the same work standards, reduces operating costs, improves feasibility study review efficiency, and mitigates internal control and external audit risks.

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