



# Research on Intelligent Prediction of Power Transformation Operation Cost Based on Multi-dimensional Mixed Information

Ying Wang<sup>(✉)</sup>, Xuemei Zhu, Ye Ke, Jing Yu, and Yonghong Li

State Grid Fujian Power Economic Research Institute, Fuzhou 350000, China  
Yingwang21212@163.com

**Abstract.** Operation cost is an important link in the operation of power enterprises. In the process of intelligent prediction of power transformation operation cost, there is a problem of low accuracy. Therefore, an intelligent prediction method of power transformation operation cost based on multi-dimensional mixed information is designed. Evaluate the fixed cost of power grid, determine the budget amount in different budget periods, extract the life cycle of power grid substation equipment, establish the cost estimation relationship, use multi-dimensional mixed information to build the cost control model, refine the project category, and optimize the intelligent prediction mode of operation cost according to the different nature of each link cost. Test results: the average prediction accuracy of the intelligent prediction method of power grid substation operation cost in this paper and the other two intelligent prediction methods of power grid substation operation cost are 79.357%, 71.066% and 69.313% respectively, indicating that after using multi-dimensional mixed information, the application effect of the designed intelligent prediction method of power grid substation operation cost is more prominent.

**Keywords:** Multidimensional mixed information · Power grid · Substation · Operating costs · Fixed costs · Intelligent prediction

## 1 Introduction

With the accelerated development of power grid, the operation, maintenance, renewal and transformation of power grid assets are becoming more and more arduous. The traditional management method can not meet the needs of development under the new situation. Predicting the operation cost of power transformation has become the top priority of power grid enterprise management [1, 2]. Power industry is the most important basic energy industry in the growth of national economy. It is the first basic industry of national economy and the priority development focus in the economic development strategies of countries all over the world. The characteristics of large initial investment, high operation and maintenance costs and long service time of the main equipment of the power grid make it have broad prospects for the application of multi-dimensional

mixed information. With the rapid development of China's economy, the demand for power in the whole society continues to increase, and the expansion of power sales market stimulates the investment in power equipment. Analyzing the cost management of power grid enterprises from the perspective of multi-dimensional mixed information will help power grid enterprises get rid of the shackles of traditional cost concept and build a new cost management system. Power engineering project has the characteristics of large initial investment, relatively long construction time, long operation cycle and high operation and maintenance cost. Because all loads in the power grid system and generator units generate public costs under complex interactive transmission, and the interaction responsibility is difficult to distinguish. Transmission cost is divided into two important components: variable cost and fixed cost. While ensuring the safety and reliability of the power grid, improve the use efficiency of power grid assets, reduce the life cycle cost, and realize the lean, whole process and all-round management of power grid assets. Variable cost mainly includes loss cost, blocking cost and opportunity cost. The fixed cost mainly includes line construction cost, equipment purchase cost, management cost, maintenance cost, depreciation cost, etc. So as to build a new cost prediction system, improve the use efficiency of power grid assets, reduce costs, and realize lean, whole process and all-round management of power grid assets while ensuring the safety and reliability of power grid. Accordingly, the requirements for cost control and management of power engineering projects are also relatively high. Only when the public cost is shared can the stable operation of the power market be guaranteed. There is no direct one-to-one correspondence between the generation of these public costs and the specific load. The main performance is that we should consider not only the purchase and construction cost of the power engineering project, but also the operation and maintenance cost of the project. In other words, we should pay attention to the control of the total cost in the cost management and control of the power engineering project, and the goal should be the optimization of the total cost. The design of electricity price should consider a fair cost sharing, that is, each consumer should pay the corresponding part of the service cost. Moreover, this new type of price must be able to control consumption and power generation patterns at the same time, especially consumption patterns. At present, the traditional intelligent prediction model of power transformation operation cost emphasizes the division of stages and segmented management, that is, the decision-making, design, procurement, construction, installation, operation, decommissioning and disposal of power engineering projects are managed and implemented by different departments, so it is difficult to optimize the total cost of power engineering projects, Then it affects the achievement of performance objectives and sustainable development of power enterprises. Reference [3] proposes a distributed control method based on incremental cost consistency Firstly, based on the consistency theory, the incremental cost consistency algorithm is given to verify the cost optimization problem; Secondly, based on the optimal solution of the incremental cost consistency algorithm, a new distributed droop controller is designed. Under the condition of satisfying the balance of supply and demand, the control strategy makes the operating cost of the microgrid system optimal, the power can be reasonably distributed, and the frequency is stable at the rated value; Finally, the effectiveness of the proposed control strategy and algorithm is verified by simulation Reference [4] proposes a two-level optimal allocation method

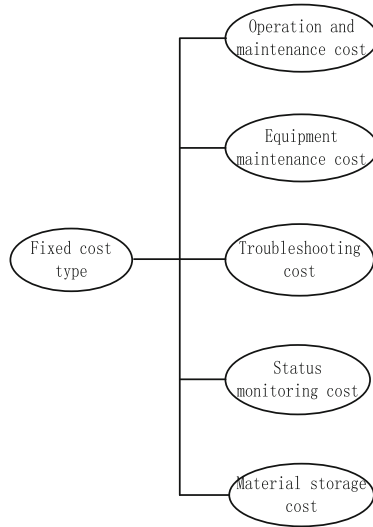
that takes into account the cost and benefit of energy storage system in the whole life cycle. Firstly, the model of life cycle cost and benefit is established to calculate various costs and benefits of energy storage; Then the genetic algorithm combined with simulated annealing algorithm is determined for the inner and outer layers; Finally, benchmark low voltage microgrid is used as an example to simulate the proposed optimization strategy. The simulation results show the feasibility and effectiveness of the method. The model can effectively manage the voltage, keep the voltage within a safe range, and reduce the cost through arbitrage. However, the above two literature methods have the problem of low prediction accuracy in the process of intelligent prediction of substation operation costs. Therefore, an intelligent forecasting method of substation operation cost based on multi-dimensional mixed information is designed. Evaluate the fixed cost of the power grid, determine the budget amount in different budget periods, extract the life cycle of the power grid substation equipment, establish the cost estimation relationship, establish the cost control model using multi-dimensional mixed information, refine the project category, and optimize the intelligent prediction mode of operation cost according to the different nature of the costs in each link.

## **2 Research on Intelligent Prediction of Power Transformation Operation Cost Based on Multi-dimensional Mixed Information**

### **2.1 Assess Grid Fixed Costs**

The cost of equipment operation and maintenance stage of power grid enterprises refers to the cost of all relevant activities such as operation, maintenance and overhaul in order to maintain its normal operation in the whole life cycle of assets. Most of the fixed costs are “operating capacity costs”, which are the costs that must be paid by enterprises in order to achieve production and operating capacity, such as depreciation expenses of fixed assets, house rent, wages and salaries of managers, etc., also known as binding fixed costs. Once the amount of such costs is determined, it is not easy to change and has a considerable degree of binding force. In order to simplify the treatment, only the emergency repair cost is considered in the fault disposal cost, and the condition monitoring cost and material reserve cost are not considered. Each cost item can be further subdivided into direct cost and indirect cost. Compared with the binding cost, discretionary fixed cost refers to the fixed cost formed by determining the budget amount of a plan period according to the enterprise’s operating financial resources before the beginning of the accounting year, such as development expenses, advertising expenses, etc. The cost composition is classified by activity type, as shown in Fig. 1:

As can be seen from Fig. 1, the fixed cost of power transformation operation can be divided into: operation and maintenance cost, equipment maintenance cost, fault disposal cost, condition monitoring cost and material reserve cost. The general procedure of power grid fixed cost analysis is to investigate the whole process of product operation process, identify and measure operation, and establish corresponding operation center. Collect the resource cost into the corresponding operation, and evaluate the effectiveness and value-added of the operation. However, in a certain period, it is similar to the binding fixed cost, so it is also a part of the fixed cost. Establish activity-based cost database,

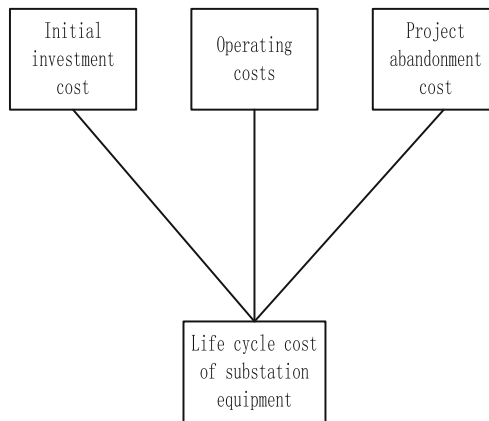


**Fig. 1.** Fixed cost types

select typical activities, and calculate activity-based cost driver coefficient. Calculate the activity-based cost consumed by products and summarize the output activity-based cost. Since the budget amount is only within the fixed budget period, it can also be determined qualitatively according to the specific budget period. This part of the cost is not binding, and the cost amount can be determined according to different situations. Evaluate the contribution of activity-based cost to output, determine cost efficiency, and collect value-added activities and non value-added activities. From the analysis of cost behavior, the cost is composed of fixed cost, variable cost and mixed cost. Direct cost refers to the material, labor and expense costs directly related to the operation of the cost object during the operation period, including internal and external (outsourcing) direct costs. Within a certain period or relevant scope, the part of the cost whose amount remains unchanged without being affected by the change of business volume is called fixed cost, such as depreciation of fixed assets, salary of managers and house rent. Indirect cost refers to the cost that is indirectly related to the operation period of the cost object, or is directly related but cannot be traced back to the specific object in an economic and reasonable way. It is divided into asset operation indirect cost and asset management indirect cost. However, from the perspective of unit business volume, the increase or decrease of business volume changes in the opposite direction with its fixed cost. After collecting direct costs and allocating indirect costs, they are summarized to form the cost of a certain type of operation of a single asset. The operation cost of a single asset is the total cost of various operations. Therefore, only in a certain period and relevant scope can the cost be fixed. If the business volume within this range changes, the fixed cost will change.

## 2.2 Extract the Life Cycle of Power Grid Substation Equipment

Equipment life cycle refers to the total length of time from the beginning of putting the equipment into use to the final withdrawal from use due to the complete loss of equipment function. The difference between project life cycle cost analysis and traditional economic evaluation is that it takes life cycle cost as the cost to measure the corresponding utility of the project. For power transformers, the use experience and test results show that after the equipment volume reaches a certain number, the overall statistics of the samples can still calculate the law: within the service life of the equipment, there is a certain law between the number of faults and the service time [5, 6]. The relationship curve between transformer operation time and defect failure rate shows the form of low in the middle and high on both sides. Therefore, the core of life cycle cost analysis is to identify the cost items at each stage of the life cycle, quantitatively estimate and analyze the cost according to a certain cost estimation model and method, and finally obtain the life cycle cost, and then make decisions on this basis. After determining the life cycle cost model of substation project divided by cost generation stage, it is necessary to further structure the cost of each part to the basic cost unit that can be used for specific calculation. The whole life cycle cost of substation project refers to the total cost incurred in the whole life cycle of substation, that is, from the construction of substation project to the scrapping of the project. The cost is divided by stages according to the whole life cycle. The cost is mainly composed of the following parts: as shown in Fig. 2:



**Fig. 2.** Phased cost of substation equipment life

It can be seen from Fig. 2 that the life stage costs of substation equipment are: initial investment cost, operation cost and project scrap cost. The purpose of life cycle cost decomposition is to decompose the components of life cycle cost to the required level, so as to establish the cost decomposition structure. The cost breakdown structure is a hierarchical tree structure. It includes all relevant cost units, neither omission nor repetition, from coarse to fine. It is broken down to the basic cost unit that can be estimated. Cost deconstruction shall be consistent with the classification principles of

power engineering industry and the financial classification principles of engineering projects. Each basic cost unit must have a precise definition and be independent of each other, so as to obtain cost estimation data from the financial department. In order to compare and make decisions on different schemes and management measures of equipment and system. A very effective method is to quantify them into comparable costs, that is, life cycle cost estimation. The cost estimation is usually carried out before the cost occurs. Therefore, the cost estimation relationship must be established. The basic cost unit obtained through cost deconstruction shall not omit important cost units or double calculate. The cost deconstruction shall follow certain principles: the deconstruction object shall include all relevant expenses incurred in the whole life cycle of the substation project. Solve various algorithm problems. This work is also called cost modeling. The life cycle of equipment and systems is very long, and the estimated costs occur in different years. Due to the different actual values of equal funds at different times, the calculated costs need to be converted or corrected before they can be used for comparison, measurement and analysis. Because the cost composition of substation project is very complex, in order to facilitate calculation and scheme evaluation, the cost structure can be appropriately simplified and the cost units that have a great impact on decision-making can be retained.

### 2.3 Constructing Cost Control Model with Multi-dimensional Mixed Information

Multidimensional mixed information includes corresponding data information, economic information, and multidimensional information. Because it involves a wide range of levels, it has a good effect when applied to the intelligent prediction of power transformation operation cost. The complexity of power system makes it impossible to accurately judge the actual path of power transmission in the power grid, so it is difficult to determine which equipment and degree of use each power user uses, resulting in a variety of fixed cost allocation methods and lack of unified standards. To implement activity-based cost management in equipment operation and maintenance stage, power grid enterprises first need to unify and standardize their operation characteristics and establish a set of standard operation library. The production scale index method is a method to estimate the equipment investment of similar projects with different production capacity by quoting the equipment investment of completed projects. Generally speaking, the cost will change with the change of production capacity or scale. Its calculation formula is:

$$R_2 = R_1 \left( \frac{L_2}{L_1} \right)^{-1} - \delta \quad (1)$$

In formula (1),  $R_1$  represents the actual engineering cost of similar projects,  $R_2$  represents the engineering cost required by the proposed project,  $L_2$  represents the production scale of the proposed project,  $L_1$  represents the production scale of similar projects, and  $Q$  represents the price conversion index. Moreover, due to the particularity of production and operation of power grid enterprises, the principle of fixed cost allocation of power grid enterprises is also different from that of general enterprises. Cost estimation is an important link in life cycle cost evaluation. Under the condition that the information about the project and its cost is very limited. Classify the operations according to

the main operation information such as operation equipment, operation parts, operators and operation items. Detailed items are set under the main item category to describe more detailed job information. The reasonable allocation of fixed costs of power grid enterprises should not only be consistent with the necessary production costs of power production, but also its regulation direction and regulation strength should be consistent with the requirements of the optimal allocation of resources [7]. The detailed project categories should include: equipment category, standard work code, operation directory, operation implementation unit, operator, operation content, voltage level, capacity, benchmark price, labor cost, machinery cost, equipment cost, comprehensive work day unit price, comprehensive work day quantity, expense classification, material code, material name Information such as material unit and material quantity. According to the data of similar projects or the limited information of the proposed project, simply and accurately estimate its various expenses or how to obtain the cost to be generated according to the paid cost, these are the problems that must be solved in cost estimation, and the accuracy of cost estimation is inseparable from the establishment of model. The initial investment cost estimation can be expressed as:

$$P = \sum_{\beta=1}^{\alpha} P_{\beta-1} \quad (2)$$

In formula (2),  $\alpha$  represents the operation and maintenance cost,  $\beta$  represents the discount rate or basic rate of return, and  $P$  represents the initial investment cost. According to the calculation results, in the process of establishing the standard operation database, we should also cooperate with the power grid to develop and establish a unified information system to match it, and formulate relevant management systems and standards. In the operation of equipment operation and maintenance stage, work order is a tool to implement its cost management. The fixed cost allocation of power grid enterprises should first follow the principle that the fixed cost should be reasonably allocated among all kinds of service objects according to the different conditions of service objects, such as different voltage levels and different power consumption characteristics, so that all kinds of service objects can bear the fixed cost fairly. The expression formula of construction project investment cost is:

$$G = \frac{\phi \times \varepsilon}{2} \times \frac{1}{\varepsilon} \quad (3)$$

In formula (3),  $\varepsilon$  represents the cost of unit construction quantities and  $\phi$  represents the total construction quantities. Work order management process: operators must first select standard operations in the standard operation library according to their operation needs. The system automatically generates operation documents such as standard operation cost, resource consumption and operation instructions. Operators operate according to the work order operation documents. The maximum demand is the maximum power consumption of the user. The variable cost is closely related to the user's power consumption, while the fixed cost is only related to the user's maximum power consumption. This is because although the frequency of the user's maximum demand is low, the system still needs to prepare the corresponding generation capacity and transmission and distribution capacity for its possible maximum power demand. After the operation is

completed, the operator performs the work order feedback operation, checks the actual operation amount and resource consumption with the original work order, and the work order system synchronously calculates the actual cost of the operation. Establishing a set of standardized work order format and operation standards is the key link in the implementation of work order management. Therefore, the maximum demand is the main factor affecting the fixed cost. For example, for large industrial users, since the maximum demand is much higher than that of ordinary residential users, power grid enterprises must prepare more installed capacity costs for them in order to meet the requirements of their maximum demand, including the construction of transmission and distribution lines and substations. Activity based cost management in equipment operation and maintenance stage is a system engineering with many projects and huge information content, which needs a perfect information system as a guarantee. A set of standard Activity-Based Cost database module can be established based on ERP system, which includes three sub modules: code table, price database and quota database, so as to realize the informatization of activity-based cost management. In the process of expanding reproduction and capital circulation, the appreciation of capital over time and the interest withdrawn from bank savings are the concrete embodiment of the time value of capital. The equipment purchase cost mainly consists of the original price of the equipment and the transportation and miscellaneous expenses of the equipment. The calculation formula of the equipment purchase cost is:

$$H = \sum \frac{Q \times (1 + \gamma)^2}{Q} \quad (4)$$

In formula (4),  $Q$  represents the original price of equipment,  $\gamma$  represents the freight and miscellaneous rate, and  $H$  represents the equipment purchase cost. For power grid enterprises, the operation and maintenance of equipment is mainly to ensure the safe and stable operation of the power grid, including operation and maintenance, equipment defect elimination, status supervision, temporary accident disposal, spare parts management and other operations. The quality standard is to maintain the safe and reliable operation of the power grid, eliminate all kinds of defects affecting the safe and economic operation in time, improve the economy of power grid equipment, reasonably control equipment maintenance, etc. The time value of funds means that certain funds have different values at different time points, that is, a sum of funds today, even without considering inflation, is more valuable than the same amount of funds obtained in the future. The installation engineering cost can be calculated according to the percentage of the equipment purchase price and the corresponding installation rate, or estimated according to the equipment weight and the corresponding installation cost and other index coefficients:

$$L = \frac{Q \times \eta}{\sum \gamma} \quad (5)$$

In formula (5),  $\eta$  represents the installation rate and  $L$  represents the installation cost. In the equipment operation and maintenance stage, a large number of operations can be identified. If the operation center is divided according to the operation activities, the work is relatively too complex. Therefore, the operations can be combined according

to the principle of homogeneity, the main operations can be determined, and then the operation center can be established. The equipment and projects we study have a long service life, the cost points are different, and the time value is also very different. If we simply superimpose the costs at these different time points, it will not be comparable.

#### 2.4 Optimize the Intelligent Prediction Mode of Operation Cost

According to the formulation principle of sales price, the operation cost is the basis of formulating sales price. The power supply cost mainly refers to the fixed cost of power grid enterprises. Therefore, it is necessary to analyze the composition of fixed cost of power grid enterprises. The fixed cost of power grid enterprises refers to the cost of providing preparation to ensure power supply to users at any time, while the variable cost refers to the cost of actual power supply. For power grid enterprises, the operation and maintenance of equipment is mainly to ensure the safe and stable operation of the power grid, including operation and maintenance, equipment defect elimination, status supervision, temporary accident disposal, spare parts management and other operations. However, the materials consumed jointly by several operations belong to indirect costs, which should be allocated in a reasonable and simple way and included in the cost of various production, operation and maintenance operations. When the consumption quota is correct, it is usually allocated according to the proportion of material quota consumption or material quota cost of the operation. The calculation formula is as follows:

$$W = \sum \frac{E}{Z} \quad (6)$$

In formula (6),  $E$  represents the actual total consumption of materials,  $Z$  represents the quota consumption of various operation materials, and  $W$  represents the distribution rate. The quality standard is to maintain the safe and reliable operation of the power grid, eliminate all kinds of defects affecting the safe and economic operation in time, improve the economy of power grid equipment, reasonably control equipment maintenance, etc. As the power industry is a capital intensive industry, its investment proportion is quite large, so the fixed cost of power grid enterprises is much larger than the variable cost. In the equipment operation and maintenance stage, a large number of operations can be identified. If the operation center is divided according to the operation activities, the work is relatively too complex. Therefore, the operations can be combined according to the principle of homogeneity, the main operations can be determined, and then the operation center can be established. According to the impact on decision-making, fixed costs can be divided into past capital investment and investment in power grid expansion and transformation prepared for future load growth, as well as debt service, depreciation, taxes, operation management and maintenance fees. Establish a standard operation library for the equipment operation and maintenance stage of power grid enterprises, which can subdivide the above operations, prepare a standard operation directory according to the type of equipment, and formulate detailed standard operation specifications. The contents of the standard operation library must form a work instruction document for operators' reference according to a unified format and standard. At the same time, fixed costs can also be divided according to links. Since fixed cost allocation

involves all links of distribution and transmission, according to the different nature of the costs of each link, fixed costs can be divided into fixed access costs, power grid use costs and auxiliary service costs. Fixed access cost is the fixed cost borne by power users, and the power grid company provides power supply services for them. It mainly includes network connection cost and management service cost. The contents of these guidance documents shall include all-round factors involved in on-site operation, such as standardized operation flow chart, preparation work, work requirements, tools and instruments, material list, dangerous point analysis and safety control measures, division of labor of operators, work content, process standard of work steps, acceptance standard, performance evaluation, etc. The cost of network connection mainly includes the cost of lines and equipment connected to the power grid. This part of the cost has one-to-one correspondence, and each user only needs to bear its own part. The calculation is mainly composed of the cost of network connection line and the cost of user network connection facilities in the substation where the connection point is located, which has nothing to do with the amount of transmission [8–10]. The operation cost is generally related to the capacity, scale and equipment performance characteristics of the substation project. The analogy method is usually used to compare the characteristic parameters of the new substation project with the parameters of the existing substation project, and estimate the cost of the new substation project according to the historical cost data of the Operation Substation project. At the same time, the parameter method can also be used for regression estimation. The estimation formula of operating cost can be expressed as:

$$F = \sum_y^x \sigma_x \times \frac{1}{k_y} \quad (7)$$

In formula (7),  $\sigma$  represents the planned annual consumption,  $k$  represents the unit price,  $x$  represents the planned annual maintenance, and  $y$  represents the cost coefficient of various cost parameters [11, 12]. For routine inspection and maintenance, major and minor repair and planned maintenance, the operation shall be carried out in strict accordance with the operation instruction documents. Unplanned maintenance, fault repair and other operations should be carried out in accordance with the operation instruction documents as far as possible. There is no one-to-one correspondence in the cost of management services, which should be borne by all users who enjoy transmission and distribution services. The use cost of power grid refers to the cost of power system construction, operation and maintenance. The annual operation loss cost is calculated as follows:

$$\varpi = \frac{h + t}{2} \times K \quad (8)$$

In Eq. (8),  $h$  represents demolition cost,  $t$  represents residual value and  $K$  represents electricity price. In view of this situation, we can properly classify and summarize those equipment operation and maintenance operations that are too detailed, select the more typical standard operations for cost calculation, then select the main influencing factors of activity cost for accounting, calculate the adjustment coefficient, and finally calculate the cost of single operation according to the adjustment coefficient [13, 14]. This part of the cost is closely related to the use degree of users, but the cost that users should bear cannot

be clearly defined like the cost of connecting to the network, so it can only be borne by all power grid users, resulting in the phenomenon of mutual subsidies [15]. In this way, the workload of formulating standard activity-based costing can be greatly simplified, the single standard cost can be distinguished, and higher flexibility and applicability can be obtained. After the formulation of standard Activity-Based Costing is completed, the standard Activity-Based Costing database is formed through collection and sorting to realize cost intelligent prediction.

### 3 Application Test

#### 3.1 Testing Environment

China's power system generally has two peak loads in the morning and evening. Therefore, the peak period can be 2 h in the morning and 2 h in the evening, 8 h in the night trough period, and the rest are divided into daytime periods. The specific period division can be adjusted and determined after considering the characteristics of the power system. Operating system platform software configuration: the database server operating system can use Microsoft Windows 2020 server version. If the database server management platform software configures that the database server management platform uses Oracle e database, the optional scheme is: the capacity of a single main transformer is 120 mva and the number is 4. Database server software configuration. Global database name: 1 cam; Tablespace Name: LCAM; Database user name: LCAM\_ user. The data comes from a provincial power grid company affiliated to the State Grid. 40 sets of operation cost data are selected. In order to eliminate the impact of different dimensions of substation parameters on the prediction speed and accuracy of the prediction model, it is necessary to normalize all sample data.

#### 3.2 Test Result

The intelligent prediction method of power transformation operation cost based on neural network and the intelligent prediction method of power transformation operation cost based on data mining are selected to compare with the intelligent prediction method of power transformation operation cost in this paper. Test the prediction accuracy of the three methods under different single transformer capacity. The test results are shown in Table 1, 2, 3, 4:

It can be seen from Table 1 that the average prediction accuracy of the intelligent prediction method of power grid substation operation cost in this paper and the other two intelligent prediction methods of power grid substation operation cost are 92.667%, 81.447% and 81.929% respectively. Compared with the other two intelligent prediction methods of power grid substation operation cost, the average prediction accuracy of the intelligent prediction method of power grid substation operation cost proposed in this paper is higher.

It can be seen from Table 2 that the average prediction accuracy of the intelligent prediction method of power grid substation operation cost in this paper and the other two intelligent prediction methods of power grid substation operation cost are 86.401%,

**Table 1.** Prediction accuracy of transformer capacity 120 mva (%)

Number of tests	Intelligent prediction method of power transformation operation cost based on neural network	Intelligent prediction method of power transformation operation cost based on data mining	Intelligent prediction method of power transformation operation cost designed
1	85.162	79.611	92.346
2	82.164	82.106	91.105
3	81.322	81.915	93.667
4	80.199	83.154	92.548
5	79.826	81.522	91.055
6	78.202	77.848	93.677
7	79.655	79.655	92.154
8	82.348	83.102	93.104
9	82.449	84.254	94.221
10	83.144	86.122	92.788

**Table 2.** Prediction accuracy of transformer capacity 180 MVA (%)

Number of tests	Intelligent prediction method of power transformation operation cost based on neural network	Intelligent prediction method of power transformation operation cost based on data mining	Intelligent prediction method of power transformation operation cost designed
1	79.648	77.841	85.666
2	76.477	76.912	84.364
3	79.633	76.337	87.223
4	78.548	74.515	86.452
5	78.102	76.902	85.914
6	79.616	77.454	84.906
7	81.217	73.161	85.465
8	82.945	72.955	88.416
9	80.799	73.154	87.149
10	79.540	72.464	88.455

79.653% and 75.170% respectively. Compared with the other two intelligent prediction methods of power grid substation operation cost, the average prediction accuracy of the

intelligent prediction method of power grid substation operation cost proposed in this paper is higher.

**Table 3.** Prediction accuracy of transformer capacity 240 MVA (%)

Number of tests	Intelligent prediction method of power transformation operation cost based on neural network	Intelligent prediction method of power transformation operation cost based on data mining	Intelligent prediction method of power transformation operation cost designed
1	65.316	64.119	76.164
2	64.822	63.784	74.512
3	65.919	62.006	73.604
4	64.378	63.147	72.649
5	63.978	62.922	73.468
6	66.121	63.781	74.915
7	67.106	64.352	74.658
8	68.241	65.464	75.355
9	69.316	66.223	76.461
10	65.752	65.464	74.512

It can be seen from Table 3 that the average prediction accuracy of the intelligent prediction method of power grid substation operation cost in this paper and the other two intelligent prediction methods of power grid substation operation cost are 74.630%, 66.95% and 64.126% respectively. Compared with the other two intelligent prediction methods of power grid substation operation cost, the average prediction accuracy of the intelligent prediction method of power grid substation operation cost proposed in this paper is higher.

It can be seen from Table 4 that the average prediction accuracy of the intelligent prediction method of power grid substation operation cost in this paper and the other two intelligent prediction methods of power grid substation operation cost are 63.732%, 57.070% and 56.028% respectively. Compared with the other two intelligent prediction methods of power grid substation operation cost, the average prediction accuracy of the intelligent prediction method of power grid substation operation cost proposed in this paper is higher.

**Table 4.** Prediction accuracy of transformer capacity 300 mva (%)

Number of tests	Intelligent prediction method of power transformation operation cost based on neural network	Intelligent prediction method of power transformation operation cost based on data mining	Intelligent prediction method of power transformation operation cost designed
1	61.324	58.641	63.947
2	59.878	59.316	64.518
3	62.316	55.828	63.228
4	58.499	54.161	62.945
5	59.677	55.319	63.701
6	56.322	52.348	62.533
7	52.878	55.227	63.944
8	53.945	54.313	62.586
9	52.146	55.649	64.512
10	53.712	59.481	65.401

## 4 Conclusion

The method of this design is to propose the selection process of main transformer capacity and number on the basis of considering the economic load rate of main transformer recovery cost. Evaluate the fixed cost of the power grid, determine the budget amount in different budget periods, extract the life cycle of the power grid substation equipment, establish the cost estimation relationship, establish the cost control model using multi-dimensional mixed information, refine the project category, and optimize the intelligent prediction mode of operation cost according to the different nature of the costs in each link. Induce the power users to make rational and correct choices according to their own power consumption, save energy consumption, transfer the peak load, and play a guiding role in the formulation and adjustment of electricity price. Therefore, it not only greatly simplifies the selection process of main transformer, but also ensures the reliability and economy of equipment operation. In the future development, the relevant advanced algorithms of deep learning are introduced to predict the operation cost of power grid substations, which makes the application effect of the intelligent prediction method of power grid substation operation cost more remarkable.

## References

1. Wang, Y.L., Wang, S., Zheng, Y., et al.: Calculation and allocation of operation and maintenance cost of power grid project based on elastic net **20** 165–172 (2020)
2. Wang, M.J., Liu, Y.B., Gao, H.J., et al.: A two-stage stochastic model predictive control strategy for active distribution network considering operation cost risk. *Adv. Power Syst. Hydroelectr. Eng.* **11**, 8–18 (2020)

3. Zhang, Z.X., Wen, C.B., Cai, P.C.: Distributed droop control of islanded microgrid based on incremental cost consistency **4**, 517–523 (2020)
4. Li, T., Xu, Y., Chen, J., et al.: Optimal configuration of energy storage for microgrid considering life cycle cost-benefit **3**, 46–51, 58 (2020)
5. Zhang, Y., Chen, Q.X., Xia, Q., et al.: Active distribution network cost allocation method based on distribution factor method. *Electr. Power* **4**, 13–21 (2020)
6. Wang, J.F., Kong, L.S., Fan, X.M., et al.: Optimal planning for soft open point integrated with ESS to improve the economy of active distribution network. *Electr. Power Constr.* **10**, 63–70 (2020)
7. Fang, Y., Chen, J., Tian, X.Z.: Capacity economical optimization of non-grid-connected wind/hydrogen hybrid micro power grid. *Comput. Simul.* **2**, 110–114 (2020)
8. Wang, S., Liu, X.Y., Liu, S., et al.: Human short-long term cognitive memory mechanism for visual monitoring in IoT-assisted smart cities. *IEEE Internet of Things J.* **9**, 7128–7139 (2021)
9. Liu, S., He, T.H., Dai, J.H.: A survey of CRF algorithm based knowledge extraction of elementary mathematics in Chinese. *Mob. Netw. Appl.* **26**, 1891–1903 (2021)
10. Liu, S., Wang, S., Liu, X.Y., et al.: Fuzzy detection aided real-time and robust visual tracking under complex environments. *IEEE Trans. Fuzzy Syst.* **1**, 90–102 (2021)
11. Qian, J., Wang, P.P., Cheng, G., et al.: Joint application of multi-object beetle antennae search algorithm and BAS-BP fuel cost forecast network on optimal active power dispatch problems. *Knowl.-Based Syst.* **226**, 107149.1–107149.21 (2021)
12. Li, W.J., Liu, Y.G., Liang, H.J., et al.: A new distributed energy management strategy for smart grid with stochastic wind power. *IEEE Trans. Ind. Electron.* **2**, 1311–1321 (2021)
13. Huang, H., Jia, R., Shi, X.Y., et al.: Feature selection and hyper parameters optimization for short-term wind power forecast. *Appl. Intell.: Int. J. Artif. Intell. Neural Netw. Complex Probl.-Solving Technol.* **10**, 6752–6770 (2021)
14. Jakoplic, A., Frankovic, D., Kirincic, V., et al.: Benefits of short-term photovoltaic power production forecasting to the power system. *Optim. Eng.* **1**, 9–27 (2021)
15. Zhang, Y., Li, Y.T., Zhang, G.Y.: Short-term wind power forecasting approach based on Seq2Seq model using NWP data. *Energy* **213**, 118371.1–118371.14 (2020)