Design of Real-time Electricity Cost Informatization Calculation System Based on Big Data Mining Algorithm

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Abstract. With the development of the Internet, the original electricity expenditure statistical methods include incomplete statistics, incorrect amount calculation, unclear payment records, and inaccurate time estimation. For this issue, a real-time information calculation system of power consumption cost based on big data mining algorithm is proposed. The big data mining algorithm is introduced to build the operation process of the real-time cost information calculation system. According to the composition of the power consumption cost, the power consumption cost is analyzed in terms of the total power to be borne by the transmission load, the conservation of the power consumption cost. According to the analysis results of power consumption cost, the real-time power consumption cost is calculated through the unit price of single power component at the node, the total transmission cost of the node, the total unit power cost of the load node and the total power sales revenue at the load. Experimental results: the electricity bill calculation result of the designed system as follows: The difference between the maximum load cost and the minimum load cost is 19000 yuan / MWh; The difference between the maximum circuit loss cost and the minimum circuit loss cost is 21500 yuan / MWh. The designed system can sense the load, circuit loss, and other changes of power grid generation in real time, and has higher sensitivity.

1. Introduction
With the development of the Internet, information technology, artificial intelligence, cloud computing and other technologies, the original way of looking up the table is to count the electricity expenses of residents, units and factories. There are some problems, such as incomplete statistics, wrong calculation of payment amount, unclear payment records, inaccurate time estimation and so on [1-4]. On this basis, the cost of electricity consumption method is proposed abroad, which solves the problems of unclear initial cost and complicated calculation process in traditional methods of power cost investigation and statistics. However, it is necessary to calculate the present value of tax deduction, cost present value, fixed assets limit and generation limit. Therefore, in reference [5], based on the basic information of power generation system costs, operation and maintenance costs, financial costs, depreciation costs and tax costs, the power generation cost model and comprehensive cost model are established to calculate the power generation cost. In reference [6], the economic evaluation method of OECD power generation project is used to analyze the cost structure of per capita power, determine the main input of per capita power cost, and calculate the per capita power cost.
2. Design of real-time electricity cost information computing system based on big data mining algorithm

The design of the real-time electricity cost calculation system will consider the main functions of the real-time electricity cost calculation system, build the design process of the real-time electricity cost calculation system, and use big data mining algorithms to design the software of the real-time electricity cost information calculation system [7-8].

2.1. Construction of real-time electricity cost information calculation system operation process

The big data mining algorithm will be used to mine the electricity cost the system database. At this time, it is only necessary to calculate the cost of electricity based on the file analysis in the system database. Based on this, the designed system operation flow chart is as Figure 1.

![Figure 1 System operation flow chart](image)

According to the system operation flow chart shown in Figure 1, the design of real-time electricity cost information calculation system can be completed.

2.2. Mining electricity cost information based on big data mining algorithm

The mining process is as Figure 2.

![Figure 2 Data mining process of degree electricity cost informatization](image)
As shown in Figure 2, the data mining process of the degree electricity cost informatization needs to go through four steps: data cleaning and integration, data selection and conversion, mining cost informatization data, and displaying data mining results.

2.3. Analysis of electricity cost
Assume that there are \( N \) power sources and \( W \) load paths in a resident's home, thereby forming a residential power grid. In this electricity network, when residents use electricity, a load \( i \) will be generated. At this time, assuming that the power of the load \( i \) is provided by the power source \( n_i \) \((n_i \in N)\), the voltage power \( U_i \) and current power \( I_i \) provided by the power source \( n_i \) are the total power that the load \( i \) needs to bear \( W_i \) is:

\[
W_i = \sum_{n_i=1}^{N} U_i \cdot H_i \cdot I_i \quad (1)
\]

In formula (1), \( H_i \) represents the distribution coefficient matrix of load current and power supply current. Based on the above analysis results, it can be found that the cost of electricity per kilowatt-hour is conserved. For this reason, suppose that the selling price of each load node \( j \) of the grid is \((j = 1, 2, \cdots, N)\). At this time, only considering the selling price of electricity per kilowatt-hour and the loss of electricity sold by the substation, the obtained electricity cost per kilowatt hour uses the principle of conservation of current:

\[
P_{n_i} \cdot \text{Re}(W_i) = \sum_{i=1}^{N} \xi_j \cdot \text{Re}(U_i \cdot H_i \cdot I_i) \quad (2)
\]

In formula (2), \( \text{Re}(\cdot) \) represents the real part of the plural; \( P_{n_i} \) represents the part of the power purchase cost of the power supply \( n_i \) that consists of the price of electricity and the network loss. According to formula (2), to obtain the partial cost \( P_{l,k} \) consisting of the selling price and network loss of all power purchase nodes, then:

\[
P_{l,k} = \frac{\text{Re}(U_i \cdot H_i \cdot I_i)}{\text{Re}(W_i)} \cdot \xi_j \quad (3)
\]

It can be seen from formula (3) that the electricity selling cost of the substation is affected by the load of the substation grid and the electricity selling price of the electric power bureau.

2.4. Real time power cost calculation by informatization
1. The unit price of a single power component at the node. Assuming that the power component injection node is \( l \) and the power injected into node \( l \) is \( P_l \), the unit price \( \xi_l \) of the power component at node \( l \) is:

\[
\xi_l = \frac{P_l}{P_l - P_{l,k}} \cdot \xi_k \quad (4)
\]

In formula (4), the unit price \( \xi_k \) of the electricity component at node \( k \).

2. The total transmission cost of the node. According to the calculation result of equation (4), the total transmission cost of the node is calculated by weighting multiple power components on the node \( l \). For this reason, suppose that the variable of the number of power components of the power supply \( n \) is \( q \), where \( n \in N \) represents any power supply, \( 1 \leq q \leq N \); the variable of the number of power supplies is \( m \), and \( 1 \leq m \leq N \), then the total transmission cost \( l \) of the node \( \xi_{l2} \) is:
In formula (5), \( U_{lk}(q,n) \) represents the \( q \) power component injected by the power supply \( n \) into the node \( l \).

3. The total cost of electricity per load node. Based on the total power \( W_i \) that the load \( i \) needs to bear based on the formula (1), the weighted average method is used to calculate the total cost \( \xi_i \) of the unit power of the load node \( i \). The calculation formula is as follows:

\[
\xi_i = \frac{\sum_{N=1}^{q} \xi_i^N P_i^N}{\sum_{N=1}^{q} P_i^N} \quad (6)
\]

In formula (6), \( P_i^N \) represents the power component provided by the power supply \( N \) in the load node \( i \).

4. Revenue from electricity sales at the load point. Assuming that during the grid transmission process, the electricity at the load is \( P \), then the electricity sales revenue at the load is \( \xi_S \):

\[
\xi_S = P \cdot \xi \quad (7)
\]

Combining the above equations (4) ~ (7), the real-time electricity cost \( \xi \) obtained is:

\[
\xi = \xi_{IZ} + \xi_i + \xi_S \quad (8)
\]

3. System test

3.1. Experiment preparation

The IEEE33 distribution network selected for this experiment is as Figure 3. According to the distribution network shown in Figure 3, the designed installation location of the cost per kilowatt-hour calculation system is shown by the solid circle in Figure 3.
Based on the IEEE33 distribution network shown in Figure 3, a cost calculation system for kilowatt-hours was deployed, and the Windows XP operating system was used to control the operation of the three groups of systems selected in this experiment. At this time, in the IEEE33 distribution network shown in Figure 3, during the transmission process, the active power component and the component loss on the line are as Table 1.

Table 1 Active power components provided by power grid transmission and their losses on lines (MVA)

| Power supply 1 | Power supply 2 | Power supply 3 |
|---------------|---------------|---------------|
| 1             | 35.176        | 65.679        | 24.145        |
| 5             | 25.643        | 46.367        | 17.991        |
| 6             | 29.410        | 54.680        | 15.910        |

Loss of component on line

| 7-4 | 4.096 | 15.832 | 3.123 |
|-----|-------|--------|-------|
| 5-8 | -1.013| -0.046 | 1.225 |
| 6-9 | -0.228| -1.286 | 1.772 |
| 2-8 | -1.542| -0.594 | 3.49  |
| 3-9 | -0.713| -0.018 | 3.031 |
| 1-2 | 0.779 | -1.629 | 2.496 |
| 1-3 | 0.954 | -0.152 | 1.528 |

Note: "-" means loss component.

3.2. Experimental results

3.2.1. Experimental results of the first group

The experimental results are as Figure 4.

Figure 4 Sensitivity of power cost calculation for load change system
As can be seen from Figure 4, in the case of continuous decline of power generation load of the power grid, the calculated power consumption cost of the two groups of conventional systems has not changed significantly. The difference between the maximum load cost and the minimum load cost is 19000 yuan / MWh.

3.2.2. Results of the second group
The experimental results are as Figure 5.

![Figure 5](image_url)

Figure 5 Sensitivity of power consumption cost calculated by circuit loss variation system

As can be seen from Figure 5, when the circuit loss of power grid generation increases, the calculated power cost of the two groups of conventional systems does not change significantly. The difference between the maximum circuit loss cost and the minimum circuit loss cost is 21500 yuan / MWh.

4. Conclusion
In order to solve the problems of incomplete statistics, wrong amount calculation, incorrect payment records, inaccurate time estimation and so on, this paper proposes the design of a real-time electricity cost information computing system based on big data mining algorithms, and introduces big data mining algorithms to further mine electricity cost information and improve the sensitivity of the system to calculate the electricity cost.

Acknowledgment
The study was supported by “Development and application of positive balance method real time power cost technology system based on information platform (Grant No. 2020BDE92013)”.

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