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The Analysis of a Power Information Management System Based on Machine Learning Algorithm

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ABSTRACT

With the deepening reform of the power market, great progress has been made in informatization. Blockchain can improve the reliability of power management system (PMS) data processing. PMS informatization has become the basis for improving the quality and efficiency of project management and maximizing the social and economic benefits of the project. Due to the requirement of safe and stable power production, PMS attaches great importance to the application and implementation of information in power management, but does not attach enough importance to the informatization of power production management. Therefore, this article analyzes the current situation, characteristics, and existing problems of PMS through a machine learning algorithm, then constructs the design principles, and finally proposes the optimization path of PMS according to the principles. The information collection ability and system control ability of the optimized PMS were better than the original PMS. The information collection ability was 14.2% higher than the original, and the system control ability was 9.8% higher than the original. In general, both blockchain and machine learning can improve the data reliability of PMS.

KEYWORDS

blockchain technology, machine learning, Power information management system, privacy, service security

1. INTRODUCTION

PMS is an important part of the local basic economy. With the rapid development of the market environment, it has become normal for power enterprises to use information management automation to solve the contradiction between the shortage and waste of information resources. Power equipment information management is the management of information generated from all activities throughout the entire lifecycle of power equipment. It is the management of the operational information of

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power equipment that is monitored online. We can divide the management of monitoring information into several modes, such as fault management, operation management, and planned maintenance. Blockchain can improve the reliability of electrical system data processing. In other words, the establishment and existence of modern information management systems to meet the needs of PMS has become an inevitable trend to improve the market competitiveness of energy enterprises and information work. Therefore, it is very important to study the methods and strategies of PMS information automation.

PMS can improve the operation ability of power information management. Ramya (2019) described data collection with reference to grid intrusion attacks, and tested and evaluated different machine learning strategies. Yang, Fang, Feng, and Li (2019) developed a novel energy management system method to achieve a flexible time frame energy management system schedule and an energy management system based on optimal power flow in a single time interval; thereby, promoting the most advanced microgrid technology. Rathor Sumit (2020) reviewed the framework, objectives, architecture, benefits, and challenges of the energy management system, and made a comprehensive analysis of different stakeholders and participants involved. Li Zhiyi (2019) proposed a set of interoperable blockchains embedded with self-executing smart contracts to manage the energy and capital flows between trading microgrids in a trusted way. Sitharthan (2019) has developed a new automatic control strategy to manage the power supply from the wind power generation system to the load, aiming to develop a pitch angle control based on fuzzy logic and a static transfer switch. Smys (2020) put forward the idea of power management in intelligent street lighting and effectively controlled power consumption by comparing light intensity and weather conditions. Cimen Halil (2020) introduced an efficient energy management system for residential microgrid. Firstly, using the method based on multitask deep neural network to analyze smart meter data and extract consumers' household appliance level information. The above studies all describe the role of power information management, but there are still some deficiencies in PMS operation.

Machine learning algorithms are widely used in power industry. Cheng Lefeng (2019) discussed the development of machine learning under big data thinking and provided a prospect for the future development of machine learning in intelligent power information management systems. He Yuqing (2018) improved the utilization rate of distribution network equipment from the supply side and the demand side, which can greatly reduce the investment required by the distribution network on the premise of reliable power supply and good power quality. Ke Jia (2020) proposed a passive intelligent PMS for parallel multi-photovoltaic systems based on improved adaptive boost algorithm, which can effectively distinguish the island operations of traditional passive monitoring methods in PMS. Aribowo Widi (2021) proposed Archimedes optimization algorithm to improve the performance of the feedforward neural network and apply PMS stabilizers. Sharma Mandeep (2019) discussed the implementation of adaptive neuro fuzzy inference system method for load frequency control of three zone inequality thermal power generation systems. Al Badawi Rashid (2018) proposed a monitoring controller based on fuzzy logic to ensure that the battery power and energy do not exceed its design limit and maintain a stable power flow. The above studies all describe the impact of machine learning on the power industry, but there are still some deficiencies in optimizing information management.

It is a long-term challenge for the power industry to ensure the reasonable allocation of energy resources, realize the self-optimization of resources and the automatic allocation of power resources. Blockchain technology can effectively help power enterprises to automate data management. By using information technology, PMS can realize information management, greatly improve the level of PMS information management and automation, and improve the efficiency of PMS information collection. It can also improve the accuracy and timeliness of information processing. At the same time, the development of management methods also provides opportunities for the management automation of energy enterprises.

This article analyzes the management level and management information sharing ability of PMS through machine learning algorithms, and adjusts and optimizes the construction of PMS

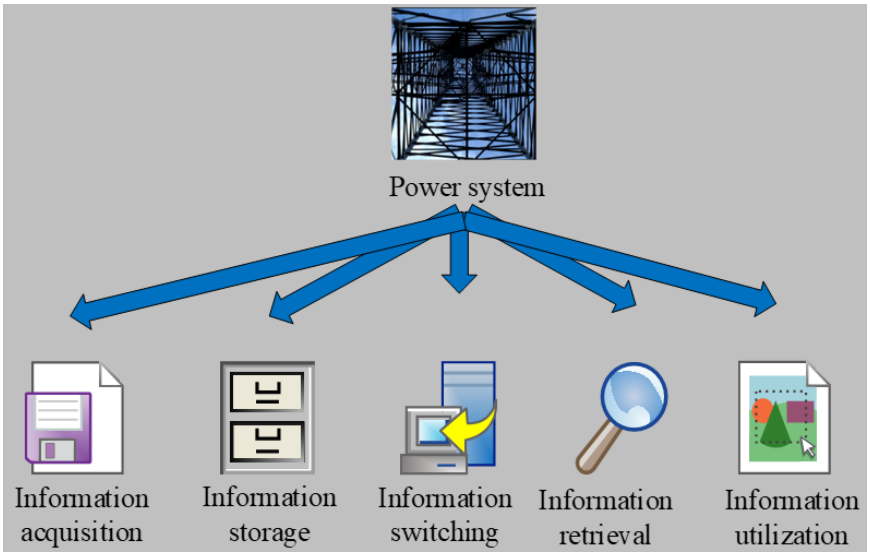
system based on the analyzed data to improve its operational capability. This article uses machine learning algorithms to analyze the regression function values and relative error values of PMS. The difference between the optimized PMS and the original PMS in terms of information technology level is becoming increasingly significant and gradually promoting enterprise system innovation and increasing corresponding capital investment.

2. ELEMENTS OF PMS MANAGEMENT

2.1 Characteristics of PMS Informatization

At present, the power information infrastructure has gradually started to operate, and information network, information security, office automation, Internet information portal, and other systems have been established and put into use (Butt, 2021). Information technology is gradually integrated into the management, science and technology, economic activities, and decision-making of electric power enterprises. Electric power informatization is developing towards a more convenient, safe, efficient, and scientific direction. The focus is to improve the overall level of enterprise production or management and pay attention to the actual impact of information system investment and its production efficiency. Power management informatization is characterized by information acquisition automation, information storage informatization, network information exchange, information retrieval tools, and information science utilization, as shown in Figure 1. Electric power management informatization not only means replacing manual information processing with information equipment, but also means that systems with a high amount of information have many incomparable advantages compared with manual operation. A portion of the information is obtained through the front-end real-time monitoring system, which generates a relatively large amount of data due to real-time monitoring. The other part of the information is the inspection data obtained by security personnel through regular inspections. The data collected by sensors in the front-end real-time monitoring system and the data obtained through regular inspections in the corresponding tables in the database is stored. This allows for a comprehensive query of device information. It should focus on research, information exchange and processing, information acquisition, and information use and improve the quality of information available by increasing the amount of information on power resources.

Figure 1. Informatization characteristics of power management system



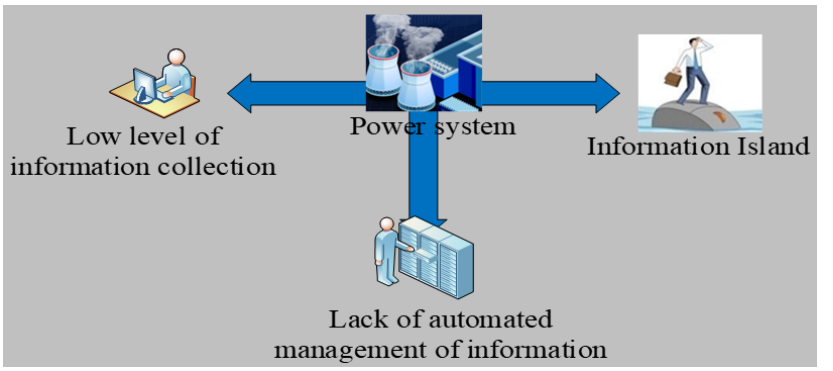
2.2 Current Situation of Power Information Management

The status quo of PMS information management includes software vulnerabilities and governance imbalance (Shahzad & Umair, 2020). Software vulnerability involves organically connecting and integrating subsystems of PMS into one system, so that each terminal of the system is distributed among subsidiaries, thus allowing interaction between final performance data and points. With regard to PMS management software, due to the decentralization of management authority of each branch, the exchange of PMS information cannot be carried out in time and an effective and complete information management system has not been established. The problems existing in information management need to increase relevant management functions according to the development of PMS to achieve an automated, information rich, and high-speed software management model. Unbalanced management means different economic development levels in floating areas, leading to different levels of power resource distribution. The imbalance of power management level leads to the backwardness of the whole PMS and the modernization of the local area. This restricts the overall optimization of PMS configuration, which is not conducive to the overall operation of PMS and the overall configuration of PMS resources. Therefore, the power information system cannot operate normally, which limits the role of power management and the potential cost-effectiveness of the system.

2.3 Problems in PMS

The main problem of PMS is that the management level is relatively low due to backward technology, as shown in Figure 2. Although many systems have been widely applied in various enterprises, they do not fully meet the needs of enterprises, so the equipment management system still needs further improvement. The system developed in this project can intelligently verify the information of power equipment. It can not only overcome many shortcomings, such as low data accuracy and high collection intensity caused by manual on-site collection, but also manage equipment information resources in real-time and with accuracy. Firstly, the level of information collection in PMS is low. The collection of PMS information is still mainly passive, and the degree of automation of PMS is low. This is due to the low closeness of PMS, and the information about PMS being too scattered to collect. Due to the limitation of PMS information software functions, it is usually impossible to effectively filter unnecessary information, which brings pressure to the data storage in the PMS database. Second, PMS lacks automatic management. In terms of information transmission, insufficient system transmission means that advanced management equipment is used, but PMS cannot effectively use it in information mode (Jayachandran, 2021). Another problem is the isolation of PMS information and the low degree of information of PMS; because these systems are mainly responsible by departments, the interaction between them is weak. Due to the unclear functions of each governing body, the information system in PMS no longer adopts the manual control mode, thus reducing the connection between them.

Figure 2. Problems in power management system



3. OPTIMIZED DESIGN OF PMS MANAGEMENT

3.1 The Application of Blockchain in PMS

Blockchain can solve the number of system participants, diversity of data information, and other problems through consensus mechanism, smart treaty, and other technologies. By using blockchain technology to identify the correlation between various defects in equipment, it is possible to predict another possible defect when one type of defect occurs in the equipment, and take corresponding precautions before these defects occur. This can prevent problems, reduce maintenance costs, and improve work efficiency, avoiding unnecessary losses caused by frequent equipment maintenance stops. The decentralized trust and data sharing system established by all participants in the system helps to strengthen the synergy and cooperation and promote enterprises to achieve more efficient collaboration. In addition, blockchain can provide reliable support for energy production information, power distribution information, and other data, and fully optimize business processes. Based on the multi-chain technology, the multi-chain model can be used to overcome the data acquisition obstacles, and a multi-component comprehensive energy distribution mechanism can be established by mining the chain information and big data. It can adjust enterprise demand, energy supply, and load reserve, so as to speed up power supply and strengthen comprehensive cooperation to ensure dynamic and stable balance of power.

3.2 Design Principles of an Electric Power Information System

The electric power information system adopts the method of combining scientific and practical management concepts with advanced software technology. Considering the application requirements and the flexibility and feasibility of the system, the submission, approval, process management, progress management, acceptance, document processing, report, and statistical results of the information system can be managed scientifically. It can improve the application efficiency, quality control, progress control, project acceptance, document use, etc., of the management system. The system allows the creation and consolidation of various reporting functions, saving time and increasing productivity. The system principles include practicability, security, flexibility, and convenience, as shown in Figure 3. The principle of practicality is to complete project declaration, management, and approval to provide detailed disposal functions. The design of the power equipment information management system adopts a multi-layer and multi-module design concept. In the power equipment information management system, the application presentation layer is the display of the system's user interface, query results, power equipment operation status, fault alarms, and other information. The implementation of the business processing layer is its key and most difficult point. This layer is mainly used for dividing the user interface, clarifying the relationship between the tasks completed by each intermediate layer and data layer, maximizing system scalability and overall performance, and maintaining the connected systems. The data layer is used to store various information data that supports the operation of the management system. The security principle is that the system provides security by using user permissions and encrypting data. The principle of flexibility is to implement system functions in an enterprise-defined manner and adapt them to changing requirements. The principle of convenience is to use the data dictionary according to the needs of PMS, and quickly fill in the project content by double clicking or entering the code.

3.3 Optimization Approach of an Electric Power Information System

According to the actual needs of the company, it can integrate advanced system concepts, deepen each stage of distribution network management, create integrated solutions, and realize the digitalization of the distribution network. This provides customers with more advanced services (Molla & Tesfahun, 2019). Therefore, effective use of the information management system is the most important way to ensure the best service. Information management is achieved through the following aspects, as shown in Figure 4.

Figure 3. Design principles of an electric power information system

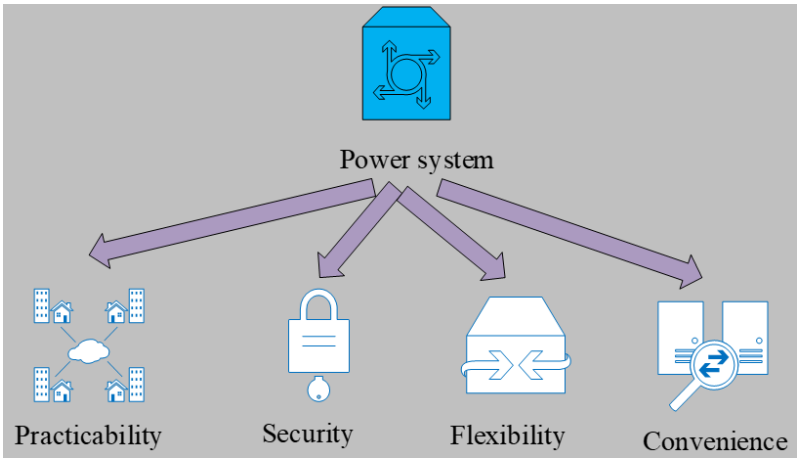
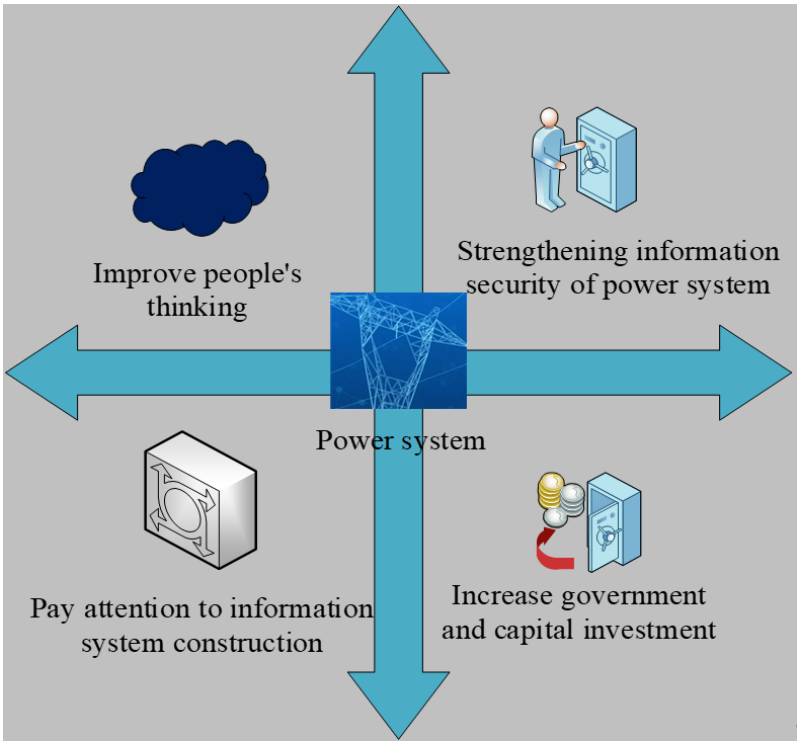


Figure 4. Optimization approach of a power information system



3.3.1 Pay Attention to Information System Construction

The relevant personnel of electric power enterprises must develop the design of communication protocols, terminals, and network structures. The goal of power companies is to promote the allocation of resources among various internal departments. Firstly, the efficiency of the electric power information system must be improved. Relevant power management personnel need to

change data according to their unified standards (Luo & Fengji, 2018). In addition, it is essential to continue to simplify the information channels of the network to improve the efficiency of information resource processing. The second step is to improve the interface structure. In order to improve the efficiency of the power industry information management system, enterprise employees should pay attention to the use of data and information in the work process and establish an interactive website. Additionally, they should monitor the corresponding middleware, databases, servers, network devices, and other resources associated with the business system, including independent monitoring of IT infrastructure resources. In addition to daily inspections and monitoring, in the installation, debugging, troubleshooting, security testing, preventive testing, backup and recovery, software changes, and other areas of information networks, application systems, and other equipment that have been officially put into production and operation, the work ticket system should be implemented, and work tickets should be filled out. They should also improve the accuracy of the power industry information and promote the development of the power industry information management.

3.3.2 Increase Government and Capital Investment

Public investment and capital investment are the guarantee of management automation. With the development of technology, automatic control systems become more magnified and complex. In order to effectively use the information system of power companies, it is necessary to reorganize the personnel structure of power companies, so that they have more human and financial resources. In addition, the debugging cost of many management automation systems is still high, which requires a lot of policy support and capital investment. Therefore, government support is the key factor to ensure the success of power management automation.

3.3.3 Improve People's Thinking

Improving managers' understanding of management systems is an effective force to promote the automation of management systems. If the information management system wants to play a role, it must become the focus of the senior management. If people resist the system, then no matter how good the system is, it can only be a decoration. With the development of information management automation, the quality and knowledge of managers is becoming more demanding. Therefore, it is necessary to strengthen the training of all factory personnel and improve the technical level and knowledge level of operators, which is an important guarantee for the effective operation of the system. Practice also shows that the development of PMS in the new era requires a lot of skills and knowledge of managers. In the process of implementing automatic information management systems, managers must have certain knowledge and skills. Therefore, training system staff is a necessary way to promote the effective operation of the system. Developing PMS in the new era requires more knowledge and technology.

3.3.4 Strengthen PMS Information Security

In the process of information management automation, it is necessary to study the information security problem in the power field, because information security is an important factor limiting the development of information management automation. In order to ensure the information security of the energy system, it can start from the following aspects. First, it can clarify the security strategy of power information management, improve both the standardization level of power industry and the risk tolerance of power enterprises. Second, it should formulate an organizational strategy for energy system information security and strengthen internal management and organization. It is necessary to improve the security awareness of all staff and share the responsibility of information security measures between departments and individuals.

4. MACHINE LEARNING ALGORITHM IN A POWER INFORMATION MANAGEMENT SYSTEM

In order to study the specific implementation effect of a power information management system, this paper systematically analyzes the power load forecasting in PMS through a machine learning algorithm, and optimizes the system management through the analysis results. The system technical architecture mainly includes four components: portal presentation, infrastructure, support platform, and data collection. Resource management includes the full lifecycle management of device resources, defining the entire process business management process of device software, and hardware resources. Resource management defines resources and defines their classification and scope. We are currently applying multi-dimensional comprehensive queries, intelligent reminders, and statistical analysis to resources. Firstly, the reconstructed state space that is good at analyzing the state vector in the system is:

$$A_i = \left(a_i, a_{i+\alpha}, \cdots, a_{i+(m-1)\alpha}\right)^S \tag{1}$$

In the formula, m is the embedded function and α is the delay time of the vector. Then, the estimation function of a power information system is analyzed as follows:

$$f(b) = \lambda \bullet \beta\left(b\right) + q \tag{2}$$

In the formula, b is the learning sample in the system, and q is the offset vector. Then, optimize the management system by using the optimization function to obtain the objective function as follows:

$$\min W = \frac{1}{2}\left\|\lambda\right\|^2 + C\sum_{i=1}^{n}\left(\mu_1 + \mu_2\right) \tag{3}$$

The constraint conditions of the objective function are:

$$\begin{cases} \mu_1, \mu_2 \geq 0 \\ -a_i + \lambda\beta\left(b\right) + q \leq \delta + \mu_1 \\ a_i - \lambda\beta\left(b\right) - q \leq \delta + \mu_2 \end{cases} \tag{4}$$

μ_1, μ_2 are the relaxation factors of PMS, and C is the penalty factor. Then, the support vector machine algorithm is used to analyze the objective function, and the regression function of PMS is:

$$f\left(b\right) = \sum_{i=1}^{n}\left(\chi_i - \chi_i^{'}\right)\left[\beta\left(b_i\right), \beta\left(b\right)\right] + q \tag{5}$$

$$f\left(b\right) = \sum_{i=1}^{n}\left(\chi_i - \chi_i^{'}\right)k\left(b_i, b\right) + q \tag{6}$$

Formula (6) is the kernel function to solve the problem of power management system. Finally, the PMS management system is evaluated according to the prediction model. The average relative error and root mean square error of the system are:

$$R_1 = \frac{1}{m}\sum_{i=1}^{m}\left|\frac{b_i - \bar{b}_i}{b_i}\right| \times 100\% \tag{7}$$

$$R_2 = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(\frac{b_i - \bar{b}_i}{b_i}\right)^2} \tag{8}$$

5. EXPERIMENTAL ANALYSIS OF PMS INFORMATIZATION

In order to study the information implementation effect of PMS, this paper analyzes the management level and management information sharing ability of PMS through a machine learning algorithm, and adjusts and optimizes the construction of a PMS system according to the analyzed data, so as to improve the operation ability of PMS. First, this paper investigated the recognition degree of employees of three electric power enterprises in a region to PMS informatization. One hundred employees were selected from each enterprise, and the recognition degree was divided into five levels, including Level 1, Level 2, Level 3, Level 4 and Level 5, from low to high. The specific investigation is shown in Table 1.

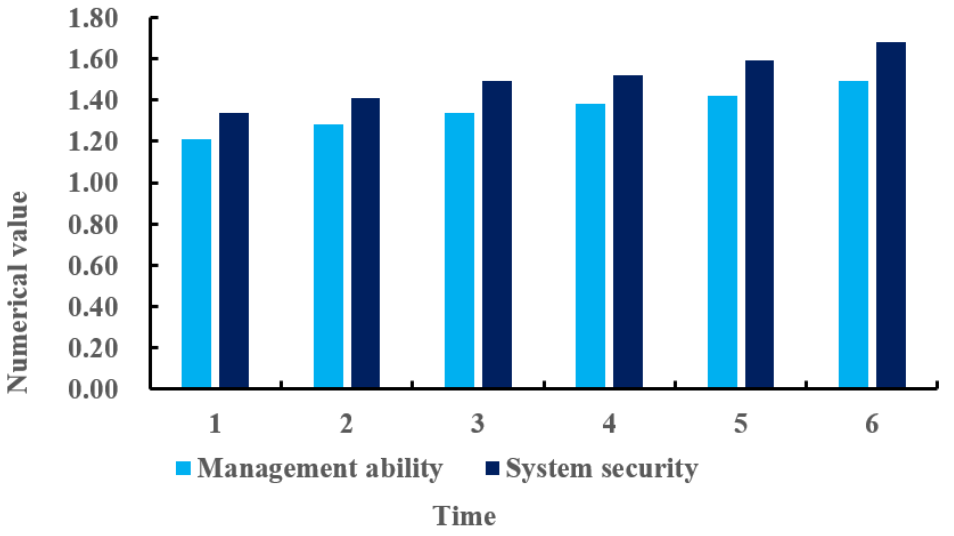
According to the data in Table 1, there are 5 employees in Enterprise 1, 6 employees in Enterprise 2, 7 employees in Enterprise 3, 39 employees in Enterprise 1, 41 employees in Enterprise 2, and 35 employees in Enterprise 3. Among the three enterprises, Enterprise 3 has the largest number of people with an identity of 1, and Enterprise 2 has the largest number of people with an identity of 5. On the whole, 6% of the total respondents had an identity of 1, and 12.7% had an identity of 2. About 17.7% of the respondents had an identity of 3, 25.3% had an identity of 4, and 38.3% had an identity of 5. The employees with the highest degree of recognition believe that PMS informatization can improve the flow of information between departments, and that improving the communication between departments can promote the uniform distribution of power resources. The employees with the lowest degree of recognition feel that PMS informatization would threaten their position in the enterprise. Then, this paper analyzes the management capability of the optimized PMS informatization and the security of the system, and investigates a total of six weeks. The specific changes are shown in Figure 5.

According to the histogram depicted in Figure 5, the management capability of PMS and the security of the system are gradually increasing after optimization. The initial value of management capability is 1.21, and it reached 1.49 in the sixth week. The whole process is improved by 0.28. The initial value of system security is 1.34, reaching 1.68 in the sixth week, and the whole process is improved by 0.34. The improvement of PMS management ability and system security after optimization shows that informatization can promote the management and distribution of power resources by strengthening the information communication ability between various departments. The personnel management and training between various departments have improved a lot compared with that before optimization, and the enterprise has also attracted a lot of policy and financial support, laying the foundation for the improvement of the system. Then, this paper uses a machine learning

Table 1. Recognition of employees of three power enterprises for PMS informatization

	Level 1	Level 2	Level 3	Level 4	Level 5
Enterprise 1	5	14	20	22	39
Enterprise 2	6	9	15	29	41
Enterprise 3	7	15	18	25	35
Total	18	38	53	76	115

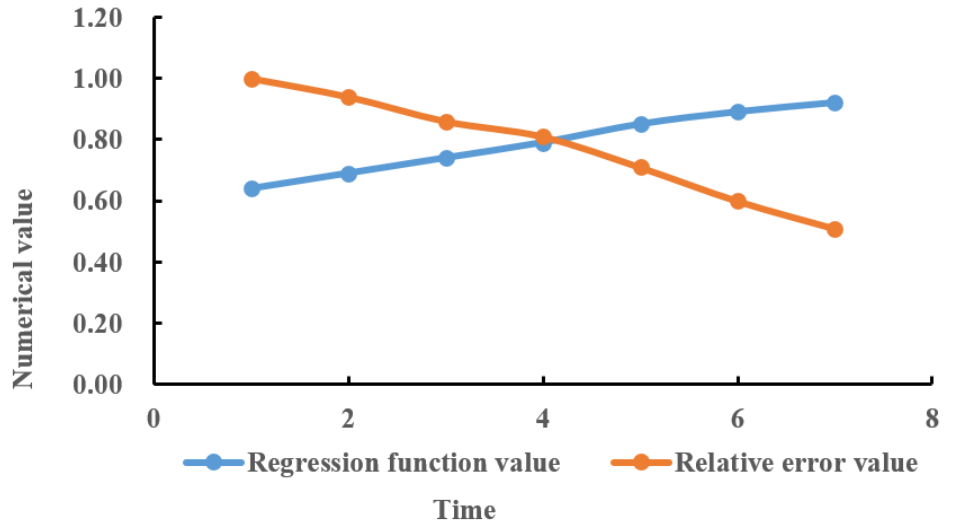
Figure 5. PMS informatization management capability and system security



algorithm to analyze the regression function value and relative error value of PMS, and investigates the changes of their data in a week, as shown in Figure 6.

According to the curve depicted in Figure 6, the regression function value of PMS increases with time, while the relative error value decreases with time. The mean value of the regression function value is about 0.79, and the mean value of the relative error value is about 0.78. In the whole process, the regression function value increased by 0.28 and the relative error value decreased by 0.49. The increase of regression function value indicates that the management under PMS tends to be information-based and the management quality is relatively high. The decline of the relative error value shows that the difference between the optimized PMS and the original PMS in the level

Figure 6. Change of Regression function value and relative error value of PMS



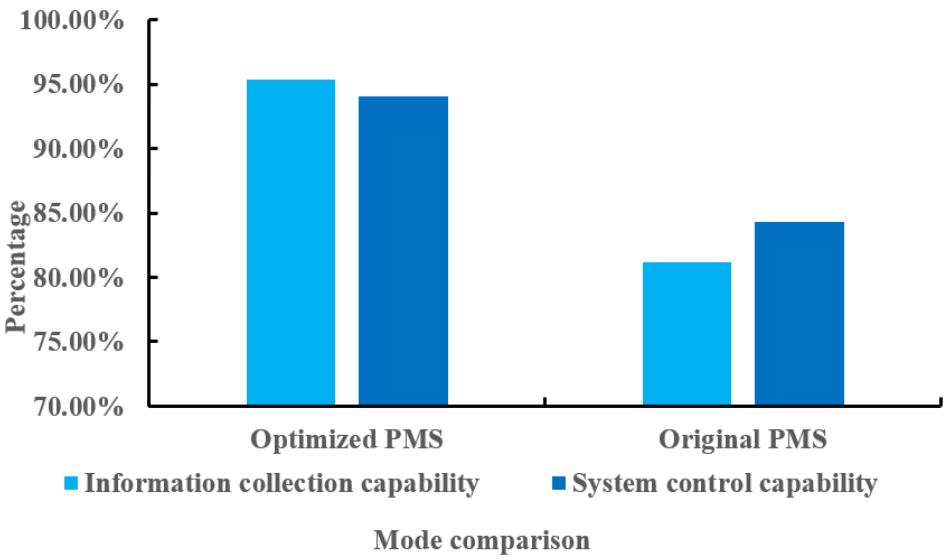
of informatization is getting bigger and bigger, and gradually promotes enterprises to carry out systematic innovation and increase the corresponding capital investment. Finally, this paper compares and analyzes the information collection capability and system control effect under the optimized PMS and the original PMS, as shown in Figure 7.

According to the comparison results in Figure 7, the information collection capability and system control capability of the optimized PMS are better than the original PMS, and the information collection capability is 14.2% higher than the original PMS. The control ability of the system is 9.8% higher than the original one. The optimized PMS pays more attention to the ideological training of employees, and the flow of information is more smooth. The information island formed among various departments has also been broken. In addition, the increase of enterprise capital investment has also helped the enterprise to introduce a large number of technical talents, providing support for the normal operation of PMS.

6. CONCLUSION

The research of power management systems is very important to promote the long-term development of energy enterprises and improve their efficiency. Relevant personnel should fully understand the characteristics and problems of power management informatization, and establish a power information management model through design and optimization. Blockchain technology improves the reliability of power management information and ensures the normal transmission of power data. In addition, the implementation of PMS requires a large amount of capital investment and support. By strengthening the construction of information platform structure, the scientific allocation and optimal utilization of power resources can be improved, so as to improve the level of PMS informatization and lay a foundation for system automation. The power information management system based on machine learning algorithms will overcome the shortcomings of manual on-site verification, such as high workload, poor data accuracy, and classification. It can also manage equipment information resources in a timely and accurate manner, achieve information sharing, and greatly improve management efficiency.

Figure 7. Comparison of Information collection capability and system control effect between optimized PMS and original PMS



After optimization, the management capability and system security of PMS are gradually improving. The initial value of management ability is 1.21, reaching 1.49 in the sixth week. The entire process has been improved by 0.28. The initial value of system security was 1.34, reaching 1.68 in the sixth week, and the entire process was improved by 0.34. The improved PMS management capabilities and system security after optimization indicate that informatization can promote the management and allocation of power resources by strengthening information communication capabilities among departments.

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