Eng Int Syst (2025) 2: 111–120

Engineering
Intelligent Systems

Algorithm of Scheduling Game Management Based on Big Data Integrated Energy Management and Control

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Currently, the information society is being transformed into an intelligent society. Various emerging technologies are being applied in various fields, and the application of big data (BD) in the energy field is also driving the transformation of the energy field to an intelligent industry. BD has five main characteristics: a huge amount of data, the general process of parallel processing when importing data into the database, diverse data types, little high-value data and real data sources. BD technology is used in the energy field to comprehensively consider the data of various types of energy, geographical environment, meteorological and other factors, for the purpose of energy collection, data analysis, energy processing and use. BD energy management and control not only make the energy production and management and control mode in the energy field enter a new era, but also further promote the development of the energy industry and optimize the energy scheduling algorithm. Comprehensive energy management and control involves collecting the data of the existing energy using equipment, monitoring the energy consumption data of each equipment in real time, and conducting a statistical analysis of this data, so as to obtain a more energy-saving air conditioning and equipment management strategy, ultimately achieving the goal of conserving energy and reducing operating and production costs. Game theory is derived from applied mathematics, and is used for better decision-making. The current scheduling algorithm is similar to the process scheduling in the computer field. In this paper, the traditional scheduling game management algorithm through the BD integrated energy management and control mode was analyzed. The traditional scheduling game management algorithm was optimized using several BD technologies, and the main steps of energy production, storage and use were improved through BD technology. Finally, model experiments were conducted on the new scheduling game management algorithm based on BD energy integrated management and control and on the traditional scheduling game management algorithm; then the differences in their performance indicators were compared. Compared with the traditional scheduling game management algorithm, the new scheduling game management algorithm had an average improvement of 38.5% in multiple performance indicators. At present, however, the research and building of BD technology infrastructure has not been well popularized, so the new algorithm proposed in this paper has limited application.

Keywords: scheduling game management; big data; energy control; energy report

1. INTRODUCTION

In recent years, the investment in and construction of comprehensive energy infrastructure has been increasing, which involves more and more types of energy. Due to the uneven distribution of various energy equipment, it is difficult to control this equipment by means of some previous technologies. However, the rise of BD technology has made it possible to build a centralized energy management and control system.

The development of information technology has brought new vitality to all walks of life, and an increasing number of researchers in the energy field have begun to study

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a new energy scheduling model combined with emerging technologies. By exploring the energy management and control system of home smart devices, a new type of energy management and control system for home smart devices with low energy loss was proposed using BD and related technologies, and an experimental study was conducted on the system[1]. The grid energy coordinated dispatch model based on intelligent management has higher performance[2]. By analyzing the penetration rate of renewable energy generation in the power system, the harm of this penetration rate to renewable energy generation was determined [3]. By exploring the usage patterns of highly integrated power systems in remote areas, the cloud distributed energy scheduling model was used to comprehensively regulate power in remote areas, proving the energy-saving and efficiency-enhancing capabilities of the model[4]. By exploring the multi-objective management and control schemes of hybrid energy and energy storage systems, hybrid renewable energy has various advantages [5]. By exploring new scheduling models for urban energy systems and analyzing the construction of smart cities, some requirements that the new scheduling models need to meet were identified [6]. The above represents research conducted by several researchers on the control of hybrid energy and electric energy.

Several researchers have also studied the management, control and scheduling models of these integrated energy sources. By studying the control modules in the micro-energy management and control model, a new predictive control module for energy feedback correction was experimentally analyzed. This module not only reduces pollution emissions in the energy production process, but also ensures economic growth[7]. By exploring the integrated dispatching model of distributed energy and microgrids, an optimized joint dispatching model based on new technologies is feasible[8]. By comparing energy scheduling models under various renewable energy environments, the multi-stage energy stochastic programming model has high applicability[9]. By analyzing the management and control model of electric energy storage in the unbalanced distribution network, the unbalanced distribution network can minimize energy loss and has energy-saving characteristics [10]. The management and control model of renewable energy dispatch and energy storage in hybrid energy networks is the latest research model [11]. The distributed energy management and control optimization scheduling model has economic optimality and high energy utilization rate[12]. At present, the computing power required by BD technology is still huge, and the cost of equipment with relevant requirements is also very high. Therefore, if this new energy scheduling model is to be further popularized, it is essential to reduce the computing power cost.

With the continuous development of BD technology, the management and control of comprehensive energy is gradually transforming a less efficient management mode to an intelligent management mode, and it is also providing continuous help for the further development of the energy industry. Energy production, analysis and distribution under the comprehensive energy regulation based on BD technology is also undergoing tremendous changes. However, due to the time required for further research and construction of infrastructure related to BD technology, the current intelligent transformation in the energy field is relatively limited in scope.

2. COMPREHENSIVE ENERGY MANAGEMENT AND CONTROL OF BD

The development of various information technologies in the current Internet field not only makes people's communication and life very convenient, but also requires numerous data processing tasks. How to store and process these huge data is a problem that has concerned relevant researchers for many years. However, with the introduction of BD technology, this problem has been solved. BD refers to a large data set that cannot be processed by conventional software in a short time, and BD technology generally refers to a technology that can quickly obtain high-value data from various types of huge data [13]. If BD technology is to be used effectively, it is necessary to count, analyze and process the data in the database using computers with high computing power. The data collected in BD generally have five characteristics: a very large amount of data, fast data collection and processing, a variety of data types, much low-value data in the collected data, and the authenticity of guaranteed data sources [14]. The generation of the current large amount of data is shown in Figure 1. BD technology can be used to obtain more in-depth and valuable information by analyzing massive data, and to make information predictions. The analysis of huge data is also a node where information technology has been applied in reality.

The development of BD technology has enabled related derivative technologies to advance further, becoming a new driving force for the sustainable and high-quality development of information-related fields.

Among various Internet or physical enterprises, BD technology has also become a key factor affecting the core competitiveness of enterprises. The high-level decision-making of enterprises is also transforming them from business-driven to data-analysis-driven mode. By using BD technology to analyze consumer data in large distributed databases of enterprises, the consumer demand be predicted and market dynamics can be grasped in a timely manner.

This paper studies the energy scheduling management algorithm. The progress of information technology has encouraged researchers in the energy field to pay attention to BD technology. Relevant researchers have proposed that BD technology can be used to collect equipment data in comprehensive energy, store them in a large distributed database, and then use BD algorithms to process these data. The aim is to create feasible regulation strategies for energy consumption equipment with the ultimate goal of saving energy. Comprehensive energy management and control is a technology that collects the consumption quantity of various energy sources and the energy use data of equipment in the current energy consuming department. It can achieve the real-time monitoring of the use of various energy sources and the analysis and processing of the collected data, so as to achieve the management and control of various energy-consuming equipment efficiently while saving energy as well. This technology controls the use of equipment through the centralized analysis of the data in multiple energy using equipment. Then, based on the analysis results, it controls the use of the equipment. The previous energy regulation system structure is shown in Figure 2.

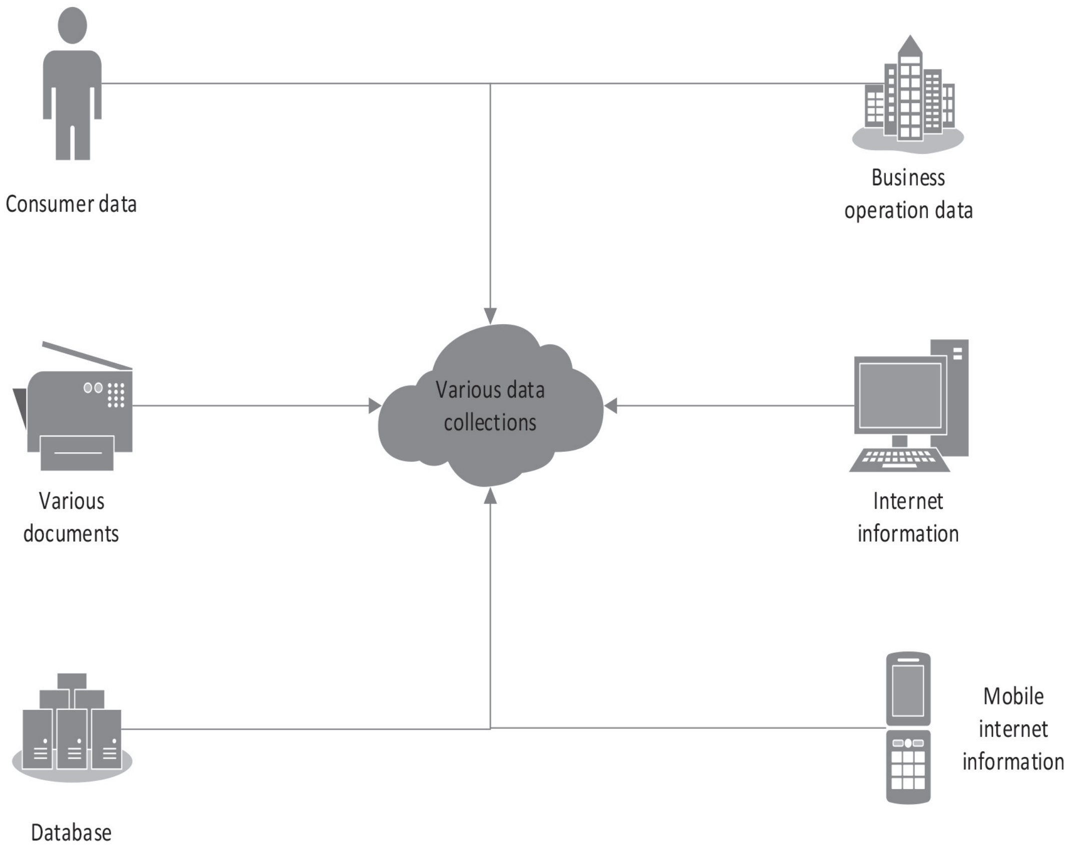

Figure 1 Schematic diagram of the process of generating large amounts of data.

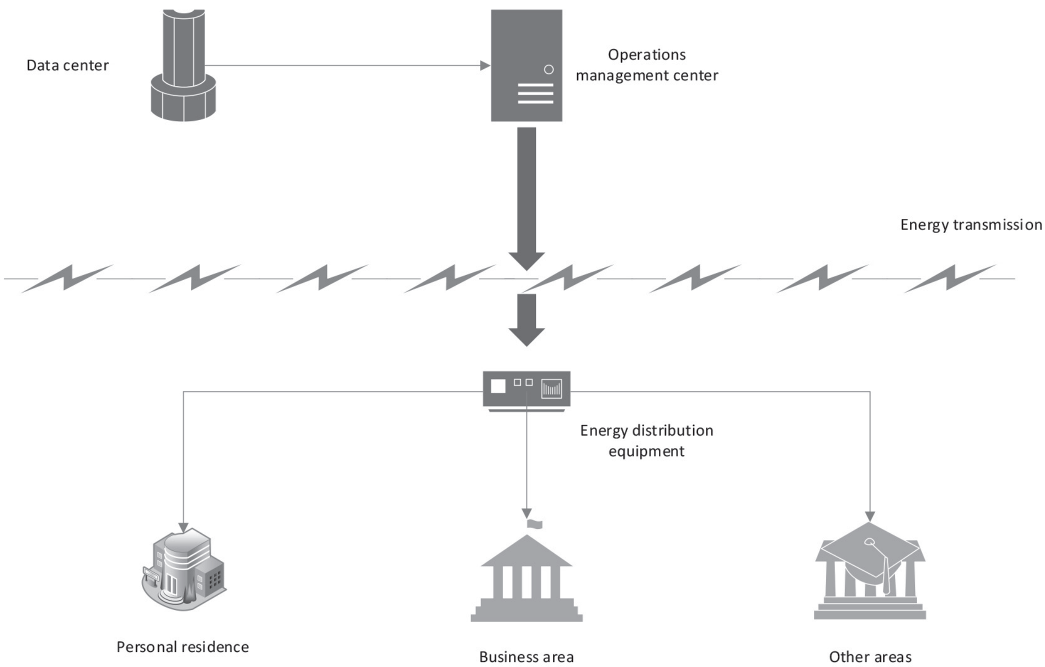

Figure 2 Schematic diagram of the structure of the previous energy regulation system.

The traditionaenergy management and control system design comprises three layers: the physical layer, the communication layer and the system layer. The physical layer includes the production equipment of various types of energy, such as wind power generation equipment, photovoltaic power generation equipment and distributed energy storage equipment, etc. In addition, the physical layer covers the energy consumption statistics devices in the supply equipment of various types of energy. Next is the communication layer, which is responsible for uploading various types of energy information generated and collected by the energy production equipment in the physical layer from different

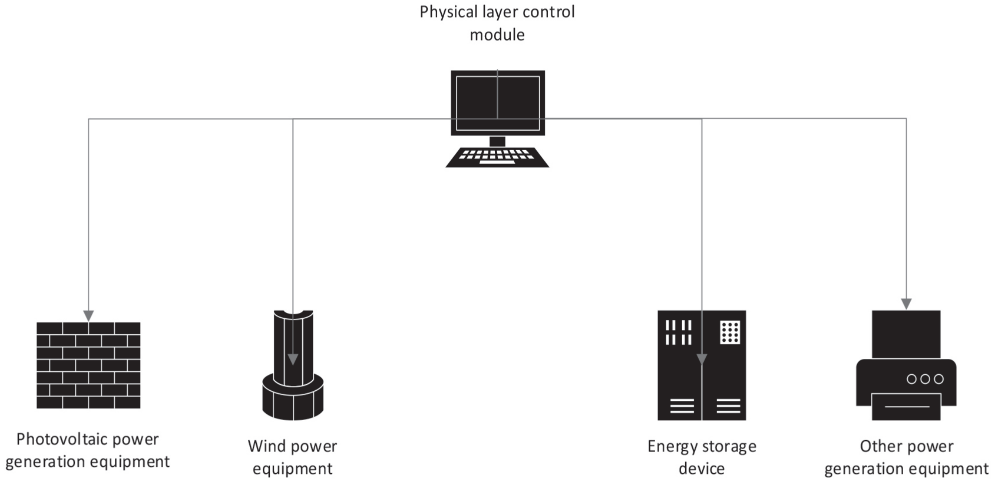

Figure 3 Schematic diagram of the physical layer structure of the comprehensive energy management and control model based on BD technology.

regions and stored on the database in the headquarters' energy management and control system. At the same time, this layer also needs to accurately transmit the control commands in the overall energy management and control system to the energy production or management equipment in specific regions. The last is the system layer, which consists of the database server and energy operation management server in the integrated energy management and control system of a region. It is responsible for the energy management and control of energy production, distribution and management in the region, and carries out the operation, maintenance and repair of various energy production or supply equipment in the region, and checks the accounting information related to energy use in the region. Meanwhile, the integrated energy management and control system in different regions can also exchange data. The comprehensive energy management and control model studied in this paper is used to analyze the data in energy production, management and supply in the region in a timely manner with the help of some algorithm models in BD in the system layer of the three-layer structure, so as to further improve the efficiency of energy management. At the same time, the new integrated energy management model proposed in this paper also provides a consistent data collection system and security system for relevant enterprises. Apart from achieving standardized data collection, it also ensures the authenticity, reliability and security of regional energy infrastructure, integrated system and data collection. The new integrated energy management module uses a modular design, and various supplementary modules can be added according to different needs in the future to provide more functions. The structure of the physical layer of the integrated energy management and control model based on BD technology is shown in Figure 3; the communication layer structure is shown in Figure 4; the system layer structure is shown in Figure 5.

3. ENERGY SCHEDULING GAME MANAGEMENT

In today's mixed management and regulation of multiple energy sources, the energy industry increasingly needs a new comprehensive energy scheduling game management model that needs to meet the need for more timely response to energy demand, to comprehensively evaluate the production and use of multiple types of energy, so as to update the scheduling management mode in real time. The model consists of two modules: task scheduling and game management. Task scheduling is an important part of the system layer in the integrated energy management and control model. Its performance directly affects the real-time performance of the entire integrated energy management and control module. The task scheduling mode can be divided into interruptible scheduling and non-interruptible scheduling according to different functions. The interruptible scheduling mode is the most basic requirement for many management systems as it achieves real-time information or operation interaction. In the interruptible scheduling mode, priority is assigned to each task scheduling. When scheduling a task with a lower priority, if a task scheduling with a higher priority occurs, the task scheduling with a lower priority is suspended, and the system instead handles the task scheduling with a higher priority. Until the task is completed, if there are no other tasks with a higher priority, the previous task scheduling can continue to be executed. Although this interruptible scheduling mode achieves the real-time interaction of the management system to a certain extent, it faces a big problem. That is, if a higher priority task scheduling occurs after the completion of the execution of the higher priority task scheduling, then the lower priority task scheduling faces the prospect that system resource allocation cannot be available all the time, resulting in a long waiting time for the scheduling of the low priority task. The non-interruptible scheduling is relatively simple. First, the system assigns priority to task scheduling, and the system executes task scheduling according to the time when the task was created. The task scheduling created first runs first. At this time, if a high priority task scheduling occurs, the low priority task scheduling cannot be interrupted. Although this mode has simplified the system program to a certain extent, if one of the task scheduling processes has problems, all subsequent task scheduling is not executed, so its reliability is also poor. The task scheduling operation process is shown in Figure 6.

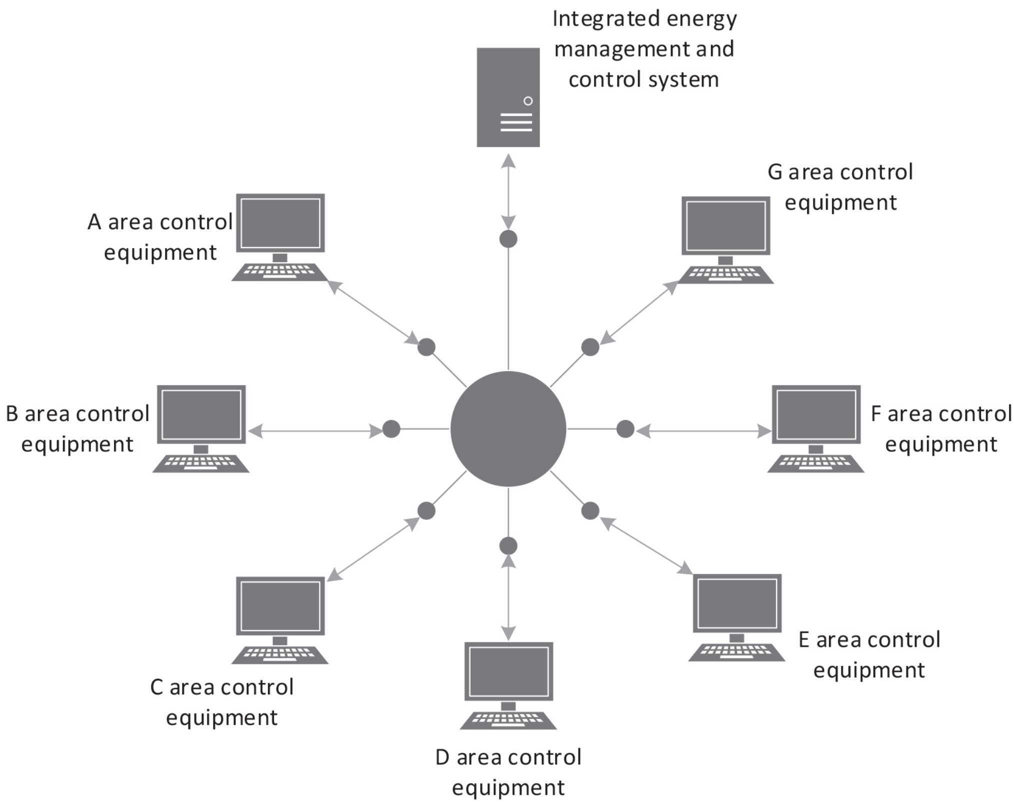

Figure 4 Schematic diagram of the communication layer structure of the comprehensive energy management and control model based on BD technology.

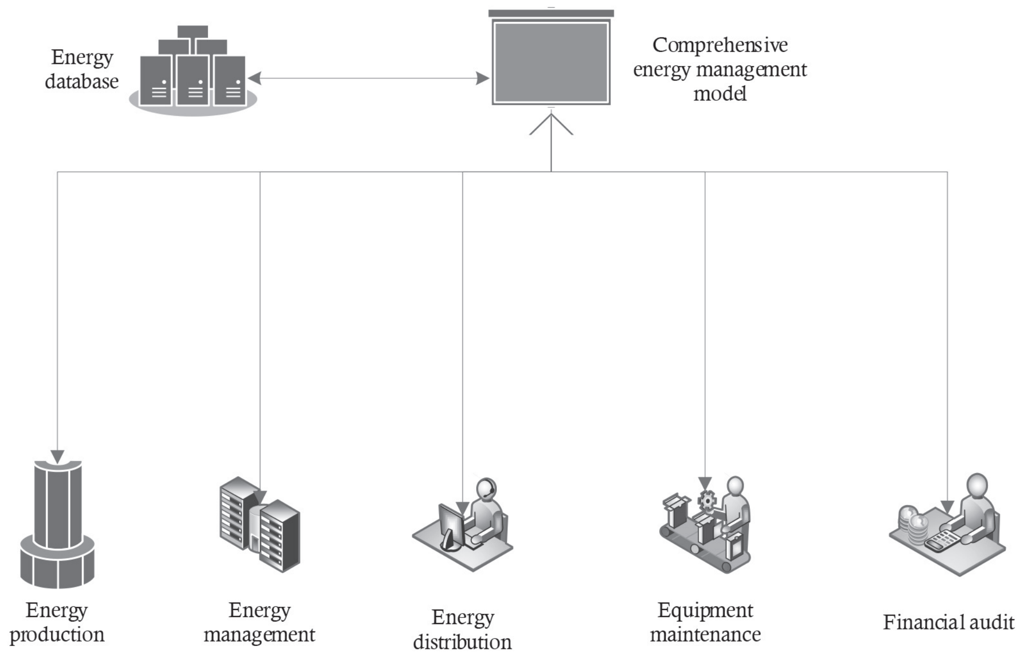

Figure 5 Schematic diagram of the system layer structure of the comprehensive energy management and control model based on BD technology.

In addition, game theory is a kind of theoretical technology used to study the nature of competition. Generally, a game is either a cooperative game or a non-cooperative game. A cooperative game includes a positive sum game, while a non-cooperative game includes negative sum game and zero-sum game. Generally speaking, the zero-sum game means that when both sides of the game obtain a certain profit in a fair competition environment, the other side must have the same loss. The sum of the gains and losses of both sides of the game is always zero, and the game can be ended only when one side of the game disappears. A negative sum game is one where there is fair competition, and the gains of both sides of the competition are always less than the losses. In addition, there is also a special game model, namely the Stackelberg game, where leaders can take the lead in making decisions in the competitive environment

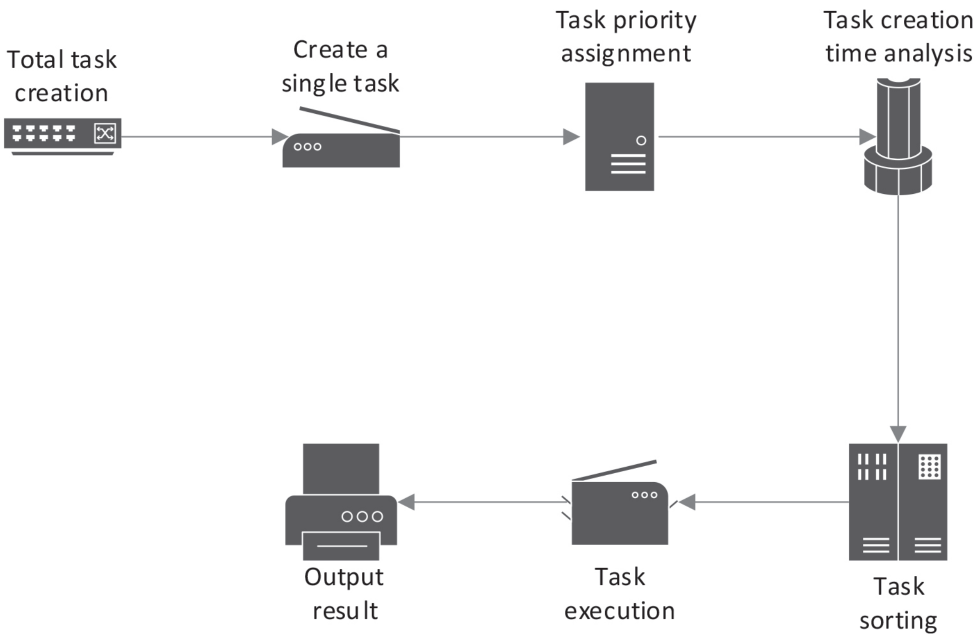

Figure 6 Schematic diagram of task scheduling operation process.

and seize a favorable position, while other followers need to make decisions after the leaders make decisions [15]. In the past, the energy scheduling management mode was a non-cooperative game mode. Each energy scheduling would seize limited resources, which would not only waste system resources, but would also reduce the operational efficiency of the whole system. This paper uses the Stackelberg game mode to build a new energy scheduling game management mode, which not only better meets some requirements of energy task scheduling in terms of time and security, but also greatly improve the performance utilization of the master server. This new energy scheduling game management mode puts the corresponding energy task scheduling in the right place to execute as much as possible, while ensuring the completion time of a single energy task and the total task completion time [16]. The master-slave scheduling structure is shown in Figure 7.

4. BD ALGORITHM

In recent years, during the establishment and continuous improvement of various energy production, supply and management platforms, the previous data processing mode has been used, leading to the collection of a large number of high-value data in the previous integrated energy management and control system, but the mining and analysis of these data has not occurred. Therefore, with the progress of various emerging technologies, researchers in the energy field have also begun to study how to better integrate some data processing technologies into the integrated energy management and control system, so as to achieve visual analysis and processing of a large amount of energy data [17]. The comprehensive energy scheduling game management mode based on BD proposed in this paper uses multiple operation models in statistics, information technology and economics to analyze and process the data collected for energy management and control so as to further optimize the energy scheduling management mode. Next, the algorithms used in this model are introduced.

This paper uses the clustering algorithm model in BD technology to establish a new comprehensive energy scheduling game management model. The clustering algorithm is a statistical algorithm model for analyzing and researching the problem of object classification. It can classify consumers from the database that stores the consumer information, and find the characteristics of each type of consumer.

First, the K-means clustering algorithm is used. x_i is used to represent specific sample data; n represents the number of sample data; μ represents the centroid points of clustering; j represents the number of centroid points. The class C to which each sample data belongs can be calculated using Formula (1).

$$C = \min_j (x_i - \mu)^2 \tag{1}$$

Then each centroid to the same type of data center point μ_j, is calculated as shown in Formula (2).

$$\mu_j = \frac{\sum_{i=1}^{n} x_i j}{\sum_{i=1}^{n} C} \tag{2}$$

Then qualitative operation is carried out for the whole training sample data, as shown in Formula (3).

$$J = \sum_{i=1}^{n} \sum_{j=1}^{k} r_{ij} (x_i - \mu)^2 \tag{3}$$

where J represents the minimum value of the centroid; k represents the number of clusters in the entire algorithm model; r represents the distance from the sample data to the centroid. The algorithm also uses several distance operation models, such as Minkowski distance, Euclidean distance, Manhattan distance and cosine distance operation.

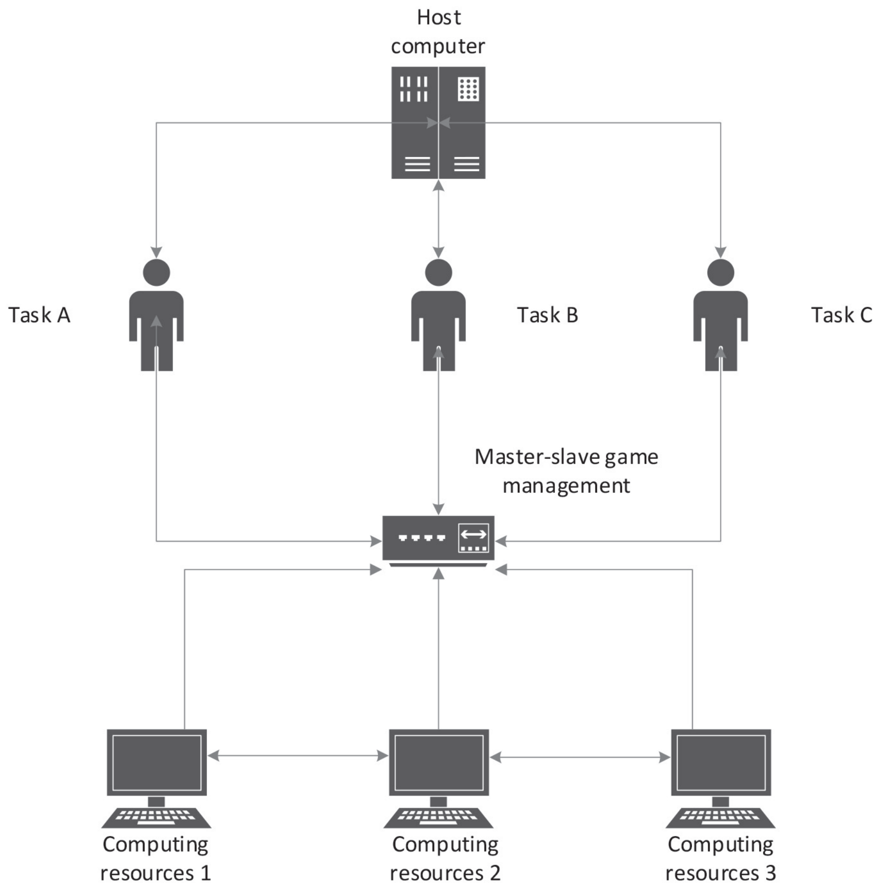

Figure 7 Schematic diagram of master-slave scheduling structure.

Generally, x and y are used to represent the two points to calculate the distance, and p represents the coefficient. Minkowski distance is a general expression of the formula for the distance between multiple points. Minkowski distance is calculated with Formula (4).

$$f(x, y) = \left(\sum_{i=1}^{n} (x_i - y_i)^p\right)^{\frac{1}{p}} \tag{4}$$

The Euclidean distance is calculated with Formula (5).

$$f(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \tag{5}$$

Manhattan distance is generally used to represent the sum of the absolute wheelbase of two points in the coordinate system. The formula for Manhattan distance is:

$$f(x, y) = \sum_{i=1}^{n} |x_i - y_i| \tag{6}$$

The operation of cosine distance is shown in Formula (7).

$$\cos\theta = \frac{\sum_{i=1}^{n} x_i y_i}{\sqrt{\sum_{i=1}^{n} x_i^2}\sqrt{\sum_{i=1}^{n} y_i^2}} \tag{7}$$

The algorithms above are used to construct the new comprehensive energy scheduling game management model proposed in this paper. These algorithms can help to reduce the number of calculation tasks in the original model, reduce the operation and management costs, and improve the energy utilization rate.

5. EXPERIMENT OF SCHEDULING GAME UNDER BD COMPREHENSIVE ENERGY MANAGEMENT AND CONTROL

The progress of new energy and BD technology has both accelerated the reform of the production and supply mode of various types of energy, and promoted the coordinated development of the energy supply side and the way consumers use energy. This paper has examined several deficiencies in the current comprehensive energy management and control and scheduling game management model: the two models are not comprehensive enough for the monitoring of the most basic energy production and energy supply equipment in the energy field, and the efficiency of fault determination and maintenance in the entire energy management and control system is low. To address these shortcomings, this paper proposed a new comprehensive energy management and control model and energy scheduling game management

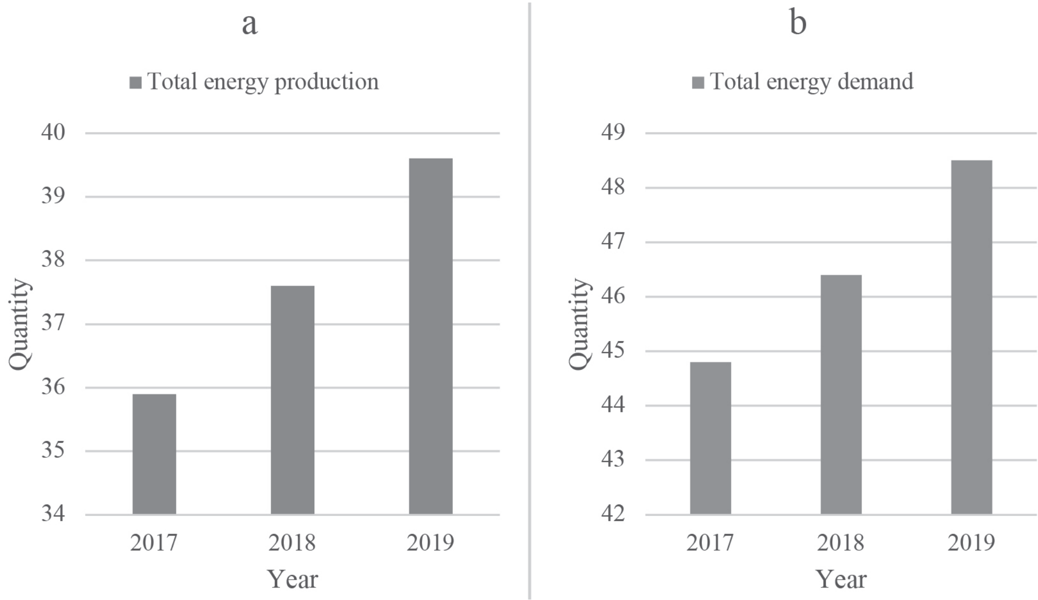

Figure 8 Schematic diagram of total energy production and total energy demand in a certain region from 2017 to 2019.

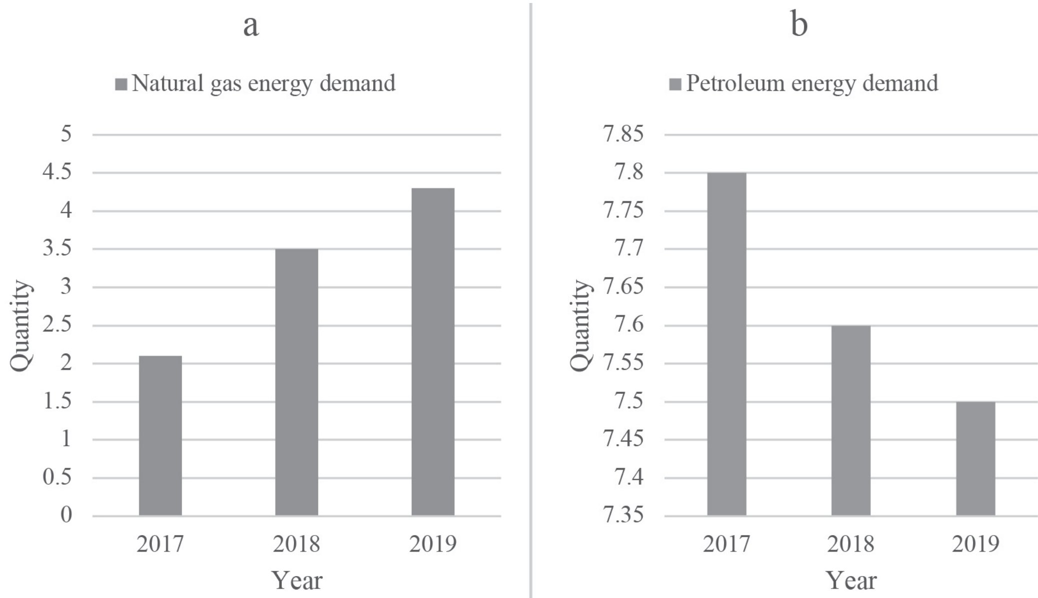

Figure 9 Schematic diagram of the trend of demand for natural gas and oil in the three years from 2017 to 2019.

mode based on BD technology, clarified the ultimate goal of comprehensive energy operation and maintenance, and further studied the comprehensive monitoring and more efficient troubleshooting mode of energy infrastructure. Finally, through a series of simulation experiments, the energy services under the energy scheduling game management mode were comprehensively evaluated, and the performance advantages of this new energy scheduling game management mode were determined.

First, the total energy production and demand of a region from 2017 to 2019 were analyzed, as shown in Figure 8. The figure 8a indicates the total energy production, and the figure 8b shows the total energy demand. The unit of energy quantity is 100 million tons of standard coal.

The analysis of total energy production and total energy demand in the three years in Figure 8, clearly shows that the energy supply in the energy industry in recent years was far less than the total energy demand, and although the total energy production increased significantly in the three years, there was still a large gap between meeting the total energy demand. Therefore, the intelligent transformation of the energy industry is imminent. Various emerging technologies can not only improve the energy production efficiency, but also analyze the energy use scenarios at the energy supply side and intelligently regulate the distribution and use of energy, thus effectively reducing the total energy demand.

Then the change in the demand for natural gas and oil in the three years from 2017 to 2019 was analyzed, as shown in Figure 9. The Figure 9a represents the demand for natural gas energy in the past three years, and the figure 9b represents the demand for oil energy in the past three years. The unit of energy demand is 100 million tons of standard coal.

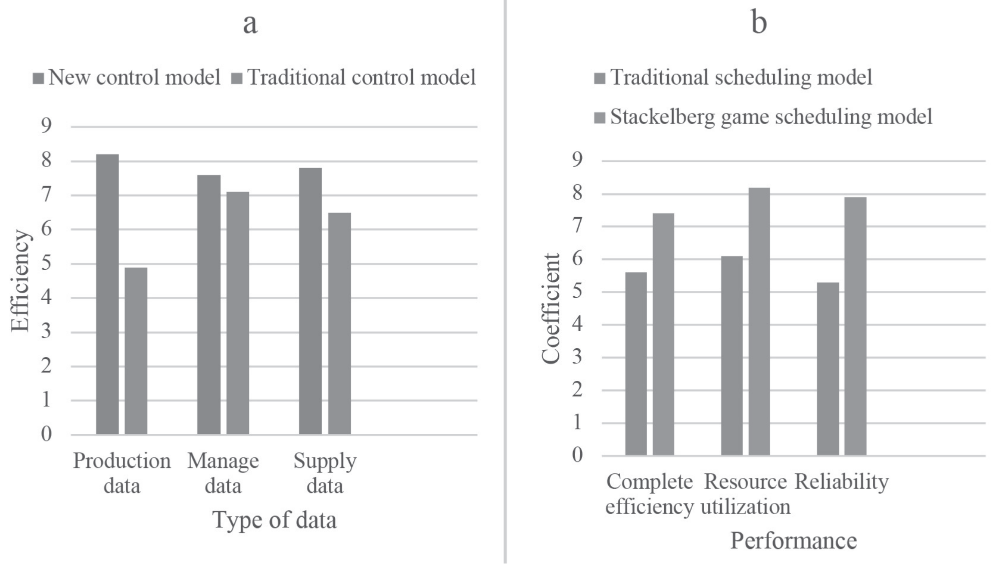

Figure 10 Schematic diagram of the simulation experiment analysis results of the performance of the integrated energy management and control model and the energy scheduling game management model.

Based on the analysis of the change in demand for natural gas and oil energy in the three years from 2017 to 2019 (Figure 9), it can be seen that the demand for natural gas energy was steadily increasing, mainly because residents needed to use natural gas for daily cooking and heating. However, the demand for petroleum energy was constantly decreasing. On the one hand, the rising price of petroleum energy led an increasing number of people to reduce its use. Furthermore, the advancement of new energy technologies with low prices and easy use prompted people to further abandon petroleum energy.

Finally, the performance of the integrated energy management and control model and the energy scheduling game management model proposed in this paper was simulated and analyzed, as shown in Figure 10. Figure 10a indicates the performance indicators of the integrated energy management and control model, and the figure 10b shows the performance indicators of the energy scheduling game management model.

Through the analysis of the two groups of data in Figure 10, it can be determined that the new comprehensive energy management and control model and energy task Stackelberg game management model proposed in this paper were greatly improved compared with the previous system. The average performance of the comprehensive energy management and control model was about 31.4% higher than that of the traditional energy management and control model, and the average performance of the energy task Stackelberg game management model was about 38.5% higher than that of the previous energy task scheduling game management model. Among them, the greater improvement in the comprehensive energy management and control model was in the processing of data at the energy production end, while the greater improvement in the energy task scheduling game management model was the reliability of the system

6. CONCLUSIONS

At present, the industrial structure in the energy field is being continuously optimized. From some basic business models in energy production and use to the management system in the energy field, they are all moving towards intelligent transformation. Before incorporating some emerging technologies into the integrated energy scheduling game management model, the final goal of energy production and service should be analyzed first, and the scope of energy services should be further expanded based on intelligent upgrading. Firstly, this paper analyzed the comprehensive energy management and control model, and integrated several BD technologies with the previous comprehensive energy management and control model, which not only improved the analysis ability of the comprehensive energy management and control model for the data of energy loss, but also established different models to explore personalized energy conservation schemes. On the other hand, the traditional energy production and supply equipment is progressing to become more comprehensive following the development of BD. In a BD environment, these devices also have the ability to collect and transmit data, which can make the outcome of the integrated energy scheduling game management mode closer to the expected goal. The scheduling game management mode under the comprehensive energy management and control mode based on BD proposed in this paper improves the intelligent level of the energy industry as well as the energy production and service mode, making the comprehensive energy services more integrated and convenient for unified management. As a result, the energy sector has also taken a significant step in the direction of intelligence.

Funding

This work is supported by the Key Project of Humanities and Social Sciences in Higher Education Institutions in Anhui Province: Research on the Path of Rural Revitalization in Our Province Empowered by Live E-commerce under the Background of Digital Economy (Project No: 2024AH053350), Quality Engineering Project of Anhui Province: Teaching Innovation Team for Marketing Major (Project No: 2022cxtd113), Key Quality Engineering Projects of Anhui Province: Research on modular teaching reform of the course

"Introduction to Logistics Management" based on the flipped classroom concept(Project No: 2021jyxm0555) and Key Projects of Philosophy and Social Sciences of Anhui Province: Research on the Integration and Development of Business Forms in Rural Revitalization of Anhui Province (Project No: 2022AH052804). Key Research Project of Humanities and Social Sciences in Anhui Provincial Universities: Research on the Measurement of Green Development Efficiency and Influencing Factors of the Agricultural Products Circulation Industry in the Yangtze River Delta Region(Project No: 2024AH052511).

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