Proceedings of the 3rd International Conference on Mechatronics and Smart Systems
DOI: 10.54254/2755-2721/117/2025.20148

Analysis of Power Load Composition and Study on Countermeasures for Orderly Use of Electricity

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Abstract: The electric power industry is the foundational industry of national economic construction and is closely associated with people's lives. The development and improvement of the economy have led to this. Moreover, society has increasingly higher demands for the reliability of power supply and the qualification rate of voltage. Power load control technology is a comprehensive use of modern management, automatic control, computer application and other disciplines to carry out power marketing management, power marketing monitoring, business copy and collection, data collection and other activities of a technology, and substation as a local industrial and agricultural production, life power supply base, the rationality of its design will directly affect the local economic development. To build a new type of power system, achieve the goal of carbon peaking and carbon neutrality, realize the flexible interaction of the new type of power system load, and meet the requirements of the digital transformation of power load management, this paper examines the architecture of the new type of power load management system from the perspective of the concept of the new type of power load management system. Then it focuses on the analysis of several key information and communication technologies, including cloud computing technology and artificial intelligence technology, which support the new power load management system in the power load management system, and introduces the composition of the load management system and the application algorithm, and finally puts forward the future development of the new power.

Keywords: electric power, Power load control technology, cloud computing technology, China

1. Introduction

With the swift development of the economy and the continuous enhancement of people's living standards, the demand for electricity keeps growing. On July 21, the data released by the China National Energy Administration indicated that by the end of June 2024, the cumulative installed power generation capacity of the country was approximately 3.07 billion kilowatts, an increase of 14.1% compared with the same period last year. Among all types of power generation approaches, the installed capacity of solar power generation reached approximately 710 million kilowatts, an increase of 51.6%. The installed capacity of wind power was about 470 million kilowatts, rising by 19.9 percent year on year. In terms of the average utilization hours of power generation equipment, from January to June 2024, the cumulative average utilization hours of power generation equipment

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DOI: 10.54254/2755-2721/117/2025.20148

in the country was 1666 hours, a decrease of 71 hours compared with the same period last year[1]. At the same time, the large-scale access of new energy and the construction of smart grid have brought new challenges to the operation and management of the power system. In this case, it is of great significance to analyze the composition of power load and formulate the countermeasures for orderly power consumption to ensure the safe and stable operation of power system and improve the efficiency of energy utilization. Through the analysis of the power load composition, the characteristics and demands of different types of loads are understood, which provides the basis for the formulation of orderly power consumption countermeasures. It is conducive to enhancing the reliability and stability of the power system, reducing energy consumption and environmental pollution, and promoting the sustainable development of the economy and society. This paper will combine the literature to study the analysis of power load composition and the study of orderly power consumption strategy, including load characteristics analysis, load forecasting, orderly power consumption strategy formulation and so on.

2. New power management information communication support technology

2.1. Overview

The new power management information communication supporting technology is the key to load management and orderly power consumption. These technologies, such as the Internet of Things, big data, cloud computing, artificial intelligence, and so on, offer robust technical support for the intelligent management of power systems.

2.2. Application of Internet of Things technology in power load management

Based on the literature, the application of Internet of Things technology in power load management is mainly introduced in the following three categories:

The first is sensor technology, the application of this technology in power compliance management is mainly reflected in the installation of sensors on power equipment to monitor the change of power load in real time; The second is the use of wireless communication technology, the sensor collected data transmission to the management center communication technology; The third is to analyze and process the collected data, extract useful information, and provide decision-making basis for load management data analysis technology.

2.3. Application of big data and cloud computing technology in power load management

The application of big data and cloud computing technology in power load management plays an important role in modern life. It is mainly reflected in three data processing methods. The first data storage and management realizes the storage and management of massive power load data through the use of cloud computing technology. The second is data analysis and mining, using big data analysis technology to conduct in-depth analysis and mining of power load data to find the law and trend of load changes. The third is forecast and decision support. Based on the data analysis results, power load prediction is carried out to provide decision support for the development of orderly power consumption countermeasures.

2.4. Features of cloud computing

Cloud computing has a large scale, and Cloud computing supplies consumers with an abundance of resources. These resources cannot be produced in a vacuum. Therefore, there has to be a place to store these resources. Take Google as an example. It already has over one million servers supporting the "cloud" it possesses. Moreover, IT giants such as Amazon, Microsoft, and IBM have

DOI: 10.54254/2755-2721/117/2025.20148

hundreds of thousands of servers backing their own cloud computing. In general, enterprise-class private cloud has hundreds or thousands of servers. Another feature of cloud computing is that cloud computing is virtual, and virtualization technology is the basis of cloud technology. Cloud computing allows users to use various services on the terminal anytime and anywhere. Then, the user doesn't need to know where their service is operating. Thus, it can be stated that the entire cloud service is completely transparent to the user. And to ensure the high security of the data, the platform will adopt various technologies to guarantee the security of the data and provide users with highly reliable and highly fault-tolerant services, such as multiple copies of the data, or service migration and other techniques. The application of cloud computing is very wide, which benefits from its strong interoperability, not only to offer services for a certain application, the cloud platform must to be able to offer various services to various users.

For instance, it gives user B matching resources for other jobs even as it gives user A computing resources for scientific research projects. The resource pool of the platform can be dynamically adjusted instead of having a fixed size. In this manner, a resource node will be idle As a part of the platform resource pool, it can be used to provide resources to other users. When the In case the node is utilized for other purposes, the platform management can be taken out again to provide. Services that are personalized for users. In addition, cloud computing is cost-effective, when users use the platform, all services can be deployed on the platform, in the case of constant work efficiency, the maintenance cost of the server is greatly reduced, thus improving the input-output ratio.[2]

2.5. Application of artificial intelligence technology in power load management

2.5.1. Load prediction

The artificial intelligence algorithm is used to predict the power load accurately and improve the accuracy and reliability of the load prediction. Load forecasting has always been an important component of power system planning and operation. Over the past few decades, the demands of market competition and the integration of renewable energy have drawn more attention to probabilistic load forecasting methods. These methods can reflect the uncertainty of the forecast through the forecast interval, thereby benefiting the decision-making activities in the operation of the system.

2.5.2. Load regulation

As shown in Figure 1, through intelligent control algorithm, real-time regulation of power load is carried out to achieve orderly electricity consumption. The main feature of HVDC transmission system is to improve the power flow control of AC network, which can transfer energy between two remote ends and also support AC system.[3]

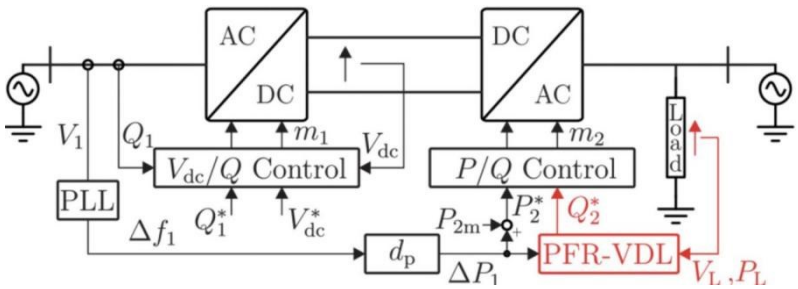


Figure 1: Steps of load regulation

DOI: 10.54254/2755-2721/117/2025.20148

2.5.3. Fault diagnosis

Using artificial intelligence technology, fault diagnosis and prediction of power equipment can improve the reliability and stability of power system. The availability of synchronous data measurement devices and data loggers paves the way for learning-based approaches such as machine learning (ML) models for fault diagnosis of power systems, leading to considerable research into data-driven monitoring, control, and maintenance of power systems. A number of ML-based power system fault detection, classification and location research results. Various models, including stepwise regression algorithms, K-nearest neighbor KNN, support vector machines, neural networks, naive Bayes, decision trees, Gaussian process regression and integrated methods have been proposed for power system fault diagnosis[4].

2.6. Stepwise regression algorithm

The stepwise regression algorithm is mainly divided into two core steps: the first is forward selection, using the initial model as empty, and the algorithm adds variables to the model one by one in order until the model gain reaches the preset standard. The second is reverse elimination, which uses the starting model to include all candidate variables, and then removes the variables that contribute least to the current model in turn until the remaining variables combine optimally. Of course, these two core steps can be selected at the same time. Combined with the above two strategies, new variables can be added or insignificant variables can be deleted, and continuous iteration can be performed until a stable state is reached.

3. Implementation of power load management system

3.1. System organization

First of all, the power load management system consists of the main station, communication channel and terminal equipment. The most important part is the master station, which is the core of the power load management system and is responsible for data collection, processing, analysis and decision-making. Then the whole system needs to be connected in series using the communication channel, which is the bridge connecting the master station and the terminal equipment, responsible for data transmission and communication. Finally, the terminal device, which is installed on the power user side, is responsible for collecting power load data and uploading it to the main station.[5]

3.2. Channel and communication

3.2.1. Communication mode

The power load management system adopts a variety of communication methods, such as wireless communication, wired communication and so on. The next generation of wireless technology capable of meeting this demand, namely the fifth generation (5G) technology, should be capable of delivering 1,000 times the capacity. Additionally, due to the newly developed data-hungry applications and the vast expansion of wireless networks, in the years after 2030, the sixth generation (6G) communications will represent a major upgrade compared to the fifth generation (5G) networks, which are anticipated to operate within the bands ranging from 100 GHz to 3 THz. To meet the escalating demand of wireless operators, an efficient wireless access approach that can enhance the throughput of wireless areas without expanding the bandwidth or the size of cells is necessary. Radio-frequency orbital angular momentum vortex waves (now called OAM waves) have attracted much attention in recent years to solve the above problems. Due to their orthogonality, OAM waves

DOI: 10.54254/2755-2721/117/2025.20148

of different modes can be reused in the same frequency channel, which can greatly increase the channel capacity [6].

3.2.2. Communication protocol

In order to ensure the reliability and security of data transmission, the power load management system adopts a unified communication protocol. Power Line Communications (PLC) technology offers reliable and cost-efficient communication solutions for a variety of applications like smart buildings, smart cities, and Industry 4.0. The advancement of broadband PLC technology enables higher data transfer rates and supports more protocols for smart building applications. Moreover, the technology is particularly appropriate for continuous power quality monitoring, electric vehicle charging, as well as microgrid and distribution generation applications. The deployment of broadband power line (BPL) networks is anticipated to keep growing due to the escalating demand for energy efficiency and emission reduction and the rapid development of machine learning as an essential tool for data analysis and pattern recognition. In the domain of communication systems, especially in areas such as error-correcting codes and communication protocols, the utilization of machine learning-based approaches has resulted in significant enhancements. Error correction code based on machine learning: English traditional error correction code uses predefined algorithms and rules to detect and correct errors. In contrast, error-correcting code based on machine learning is designed to detect and correct errors by learning from training datasets. This method can better correct errors in noisy and complex communication environment. Error correction codes based on machine learning can be developed by employing various machine learning algorithms, such as deep learning, support vector machines, and random forests. These approaches render error-correcting codes more flexible, scalable, and adaptable to new communication environments and challenges. Communication protocols based on machine learning: Communication protocols founded on machine learning make data exchange more efficient and compatible through the analysis of network traffic and communication processes. Machine learning algorithms are capable of using machine learning optimize operations in communication protocols, such as flow control, error control, timing, and network routing. Communication protocols are enabled to respond more quickly and efficiently through this modifying network conditions and user requirements. Machine learning-based methods play a role in helping enhance the reliability and efficiency of communication systems. Further research and applications in this area will lead to the development of more efficient and reliable communication systems, such as energy management, monitoring and automation systems. In addition, new complex communication environments can be developed with error-correcting codes and protocols that can be quickly adapted using machine learning-based approaches [7]

3.2.3. Data encryption

Encrypt the transmitted data to prevent data from being stolen and tampered with. With the rapid development of cloud computing, Internet of Things and other technologies, a large amount of personal data is generated worldwide. These are constantly being collected and analyzed by companies personal data, providing them with professional services and generating significant economic benefits, enabling users and businesses to reap huge profits from the information society. Sadly, in the past few years, businesses have not implemented data protection measures, such as storing Personal data breaches are on the rise due to the use of plaintext data stored on centralized servers. Therefore, it is vital that private data is shared and stored in a secure manner. As a decentralized ledger database, blockchain can provide a trusted data storage and sharing environment due to its decentralization and hard to tamper with data. Currently, many researchers are already using blockchain in various fields, including data storage, iot, healthcare, transactions, and payments.

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3.3. Terminal equipment

Terminal equipment is a device that inputs programs and data to a computer or receives processing results from a computer output through a communication facility. Terminal equipment is usually set up in a convenient place that can use communication facilities to connect with distant computers, which is mainly composed of communication interface control devices and special or selected input and output devices. A system in which a large number of dispersed terminal devices are connected to a computer through a communication facility is called an on-line system. When it is necessary to input and output a small amount of frequent information to the computer, or when it is necessary to query and retrieve the computer information base, the flexible keyboard display terminal device is often used. The terminal equipment of the power load management system includes intelligent meters, load control terminals, etc. The terminal equipment has the functions of data acquisition, communication and control, which can realize the real-time monitoring and control of the power load.

4. Technology application

4.1. Data detection

Data detection is divided into data acquisition, data processing and data storage. The method of data acquisition is to collect the power load data through the terminal equipment, including voltage, current, power and other parameters. Typically, the data collected in network systems can reflect or be utilized to detect security threats. We define this kind of data as data related to cybersecurity. The research and analysis of security-related data can assist in detecting cyber attacks and intrusions, making it feasible to further assess the level of security of the entire network system. Obviously, the first step in detecting cyber attacks and intrusions is to gather security-related data.[8]. However, in the context of big data and 5G, there are some challenges with the collection of these security-related data. After collecting a large amount of data, the data should be processed, and the collected data should be processed and analyzed to extract useful information. The processed data is stored in a database for subsequent query and analysis.

4.2. Load regulation

Load control requires load forecasting first, which can provide basis for load control based on historical data and real-time data. After the prediction, a reasonable load control strategy, such as off-peak electricity consumption, peak-valley electricity price, etc., can be developed to achieve orderly electricity consumption. Finally, the power load is controlled in real time by the terminal equipment, and the load control strategy is implemented[9].

4.3. Application of 5G technology in power load management

5G technology has high-speed communication, and 5G technology has the characteristics of high speed and low delay, which can meet the requirements of power load management system for data transmission. 5G technology supports large-scale device connectivity and can achieve management and control of massive terminal devices.

5G technology can realize network slicing, provide dedicated network channels for power load management systems, and ensure the reliability and security of data transmission.[10]

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5. Conclusion

This paper mainly analyzes the development status of the new power load management system, and carries out corresponding analysis and research from three aspects: cloud computing technology, artificial intelligence technology, system structure composition and technology application. Through the analysis of power load composition and the study of orderly power consumption countermeasures, A set of power load management systems based on new power management information communication support technology is proposed. The system can realize the real-time monitoring, analysis and control of power load, and provides a strong support for the formulation of orderly power consumption countermeasures. In this study, the accuracy of data collection and load forecasting need to be further improved. This paper does not carry out empirical research, and future research can be combined with empirical research methods to further study and apply artificial intelligence, big data and other technologies to improve the intelligent level of power load management system. At the same time, strengthen the cooperation with power enterprises and users, and jointly promote the orderly use of electricity.

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