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Optimization Strategy of New Energy Distributed Energy Storage Cluster Based on Intelligent Manufacturing

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Abstract: With the rapid development and widespread use of new energy, distributed energy storage technology has become an important method to address the fluctuations and instability of new energy. The development of intelligent manufacturing technology provides new ideas and methods for the optimization of new energy distributed energy storage clusters. Therefore, this article aims to explore the optimization strategy of new energy distributed energy storage clusters based on intelligent manufacturing, with a view to providing reference and reference for research and practice in the field of new energy storage. This paper discusses the application of distributed energy storage systems and intelligent manufacturing in the optimization strategy of new energy distributed energy storage clusters, proposes a distributed optimal scheduling technology, and conducts experimental research on the optimization of new energy distributed energy storage systems. The experimental results in this paper show that when the installed capacity ratio is 70%, the distributed energy storage system achieves the goals of the highest energy utilization rate, the lowest carbon emission rate, and the lowest total annual cost, and achieves dual improvements in economic and environmental benefits.

1. Introduction

With the development and application of new energy technologies, distributed energy storage technology has become an important means to solve power grid scheduling and supply and demand balance issues. The application of intelligent manufacturing technology can improve the operational efficiency of energy storage systems, reduce costs, and achieve intelligent management and control of energy storage systems. Therefore, this paper intends to study the optimal control method of distributed energy storage clusters for new energy for intelligent manufacturing, in order to improve the comprehensive performance of energy storage clusters, enhance their economic benefits, and promote the development and application of new energy technology. Develop reasonable energy management strategies by collecting and analyzing various data in the energy storage system, such as energy storage, supply and demand, to maximize the energy storage and release capabilities of the energy storage system.

Zhang Y. proposed a distributed clustering storage optimization method for large-scale real-time data. Based on this, a replica generation and preservation method based on copy cost and the impact of intermediate data generation on copy distribution is proposed. For data centers, in order to conduct large-scale data migration, sensitive data and frequent access need to be considered as a migration factor. To solve the problem of large-scale data storage, he proposed an optimization algorithm based on particle swarm optimization, and introduced a new optimization algorithm into large-scale data storage, thereby achieving distributed and clustered storage of large-scale data [1]. Zhong W. proposed an energy storage control method based on online energy storage for energy storage characteristics in distributed energy storage systems. Research a new type of energy storage sharing mode, that is, through the reconfiguration of physical energy storage resources, to achieve effective utilization of physical energy storage resources. Lyapunov optimization method is used to optimize the energy storage and sharing system online. Then, in order to ensure the real-time performance of the system, an offline optimal parameter selection method is proposed. In order to meet users' needs for information security, Zhong W. adopted a distributed algorithm based on interactive multipliers. In a distributed energy system, users only need to manage their virtual energy in a local area, without providing private information to other users. During the simulation process, real real-time data on electricity prices, loads, renewable energy, etc. were collected [2]. Z Shao introduced an optimal combination and sharing strategy for fuel cells/wind turbines/battery packs, as well as a demand response for microgrids to improve their profitability in market participation. In order to regulate contract electricity and reduce unbalanced energy sources, people regard the regulated market as 3 to 7 hours ahead of the delivery date, at which time the electricity provided can be updated [3].

In order to solve the volatility and instability of new energy, this paper proposes a new energy distributed energy storage cluster optimization strategy based on intelligent manufacturing. The volatility and instability of new energy is one of the main factors restricting its large-scale application. Adopting the optimization strategy of distributed energy storage clusters for new energy based on intelligent manufacturing can achieve full utilization and better management of new energy, thereby improving the efficiency and stability of new energy utilization.

2. New Energy Distributed Energy Storage Method for Intelligent Manufacturing

2.1 Distributed Energy Storage System

Distributed energy storage system refers to a system that distributes multiple small energy storage units in different locations and connects them through a network to form an overall energy storage system [4-5]. Compared with traditional large-scale energy storage systems, distributed energy storage systems have higher flexibility, reliability, and scalability. It can better adapt to complex energy environments and achieve better utilization and management of energy [6-7].

The distributed energy storage system mainly consists of the following parts:

Energy Storage Unit: Distributed energy storage systems are composed of multiple small energy storage units, each of which can be a battery, supercapacitor, capacitor, etc.

Communication network: Each energy storage unit in a distributed energy storage system is interconnected through a communication network to achieve information transmission and control command issuance [8-9].

Control system: The control system in a distributed energy storage system can achieve functions such as charge and discharge control, capacity management, and fault diagnosis for energy storage units.

Monitoring system: In a distributed energy storage system, the monitoring system can monitor the parameters of the energy storage unit such as electricity, voltage, and current in real time, thereby ensuring the safe and normal operation of the energy storage system.

Data management system: The data management system in a distributed energy storage system can achieve data collection, storage, analysis, and application of the energy storage system.

Distributed energy storage systems can be applied to various scenarios, such as smart grids, building energy management, electric vehicle charging, and other fields, with broad application prospects.

2.2 Application of Intelligent Manufacturing in the Optimization Strategy of New Energy Distributed Energy Storage Clusters

Intelligent manufacturing is widely used in the optimization strategy of new energy distributed energy storage clusters, mainly reflected in the following aspects:

Data collection and monitoring: Intelligent manufacturing technology can achieve real-time data collection and monitoring of various energy storage units in a new energy distributed energy storage cluster, including parameters such as electricity, voltage, and current, thereby achieving real-time monitoring and analysis of the state of the energy storage system [10-11].

Intelligent control and optimization: Based on the results of data collection and monitoring, intelligent manufacturing technology can achieve intelligent control and optimization of new energy distributed energy storage clusters, including charging and discharging control, capacity management, fault diagnosis, and other functions of energy storage units, to achieve efficient utilization and better management of energy storage systems.

Prediction and scheduling: Intelligent manufacturing technology can predict and schedule new energy distributed energy storage clusters through big data analysis and machine learning algorithms, including predicting and scheduling the electricity, load, market demand, etc. of the energy storage system, to achieve efficient operation and flexible adjustment of the energy storage system [12-13].

Information sharing and collaboration: Intelligent manufacturing technology can achieve information sharing and collaboration for each energy storage unit in a new energy distributed energy storage cluster, including sharing and collaboration for the state, energy, load, etc. of the energy storage unit, thereby achieving unified management and optimization of the energy storage system.

In summary, intelligent manufacturing technology has significant application value in the optimization strategy of new energy distributed energy storage clusters, which can achieve efficient utilization and better management of energy storage systems, and promote the development and application of new energy storage technology.

2.3 Distributed Optimal Scheduling

Distributed optimal scheduling refers to decomposing a large optimization problem into multiple small problems, solving them on different processors, and then combining the results of each processor to obtain the final optimization results. Distributed optimal scheduling has been widely used in distributed computing, machine learning, artificial intelligence, and other fields [14-15].

This paper presents a marginal cost compatible algorithm for first order discrete systems. The marginal cost is selected as a compatible variable and a distribution algorithm is used to solve the optimization problem.

From the conventional calculation method, it can be seen that the cost function of the generator is a quadratic function:

$$V_o(Q_{Ho}) = s_o + n_oQ_{Ho} + v_oQ_{Ho}^2,\ o \in D_H \tag{1}$$

$V_o(Q_{Ho})$ is the fuel cost, Q_{Ho} is the power generation capacity of the generator, s_o, n_o, and v_o are the fuel cost functions of the o th generator, and D_H is the generator set.

The goal of the economic scheduling problem is to meet generator generation constraints and minimize the total cost of M generator systems:

$$\sum_{o=1}^{M} Q_{Ho} - \sum_{o=1}^{M} Q_{F_o} = 0 \tag{2}$$

$$Q_{Ho,min} \le Q_{Ho} \le Q_{Ho,max} \tag{3}$$

Q_{F_o} is the local load demand, and $Q_{Ho,min}$ and $Q_{Ho,max}$ are the minimum and maximum output power of the generator.

Distributed optimal scheduling can also be applied to the optimal scheduling of distributed energy storage systems. For example, in a distributed storage system, optimal scheduling methods are used to allocate multiple storage cells individually, achieving charge and discharge control and management for each storage cell, improving the operational efficiency and stability of the system.

3. Experimental Research on Optimization of New Energy Distributed Energy Storage System

3.1 Infrastructure of New Energy Distributed Energy Storage System

The basic structure of the new energy distributed energy storage system mainly includes: energy storage equipment: including various types of energy storage equipment such as lithium ion batteries, sodium sulfur batteries, and nano iron batteries, which are used to store electrical energy in the power grid in case of emergency. Grid interface: used to connect the energy storage system to the grid, enabling the energy storage system to receive electrical energy from the grid and output the stored electrical energy to the grid. Control system: used to monitor and control energy storage equipment, including monitoring of parameters such as electricity, voltage, and current, as well as charging and discharging control, fault diagnosis, and other functions. Communication system: used to realize communication between energy storage system and other systems, including communication with power grid, intelligent control system, and remote monitoring system. Intelligent control system: Based on technologies such as artificial intelligence and the Internet of Things, it realizes intelligent control and management of energy storage systems, including energy management, charge and discharge control, and fault diagnosis. Remote monitoring system: Realize remote monitoring and management of energy storage systems through Internet of Things technology, including real-time monitoring and management of the status, operation, energy storage, and release of energy storage equipment. Energy trading system: Based on blockchain technology, it realizes energy trading in energy storage systems, promotes the application and development of new energy technologies, and improves the economic and environmental benefits of energy storage systems. The infrastructure of a new energy distributed energy storage system is composed of multiple components, and through the synergy of these components, effective solutions to grid scheduling and supply and demand balance can be achieved.

In terms of installed capacity, if the installed capacity of a distributed energy storage system is too small, its advantages and economic benefits in terms of energy conservation and emission reduction are not significant. Based on practical engineering experience, when selecting the proportion, this article starts from 30%, and selects a total of 7 proportion values of 40%, 50%, and 90% of the peak cooling load for installation. From the perspective of system economy, this article compares and analyzes systems of various installed scales.

3.2 Comparison Between Distributed Energy Storage Optimization System and Traditional Energy Storage System

This article takes an enterprise as an example to study two different storage methods: distributed energy storage optimization system and traditional energy storage system, and analyzes the advantages of distributed energy storage optimization system. Table 1 shows the carbon emissions, energy consumption, and energy efficiency of the two models. Compared to conventional storage methods, its total CO2 emissions decreased from 191800 tons to 159100 tons, a decrease of 17%; Energy consumption expenditure decreased by 22% from 19.7827 million yuan to 15.3568 million yuan. Practice has proven that after optimization, the system has significant energy-saving and emission reduction effects, and also achieved good economic results, which proves that the proposed scheme is feasible.

Table 1: Comparison of carbon emissions, energy consumption costs, and energy efficiency between the two methods

Operation mode	Distributed energy storage optimization system	Traditional energy storage system
Total carbon emissions (10000 tons)	19.18	15.91
Total energy storage (100 million kwh)	3.0	3.0
Energy consumption cost (10000 yuan)	1978.27	1535.68
energy efficiency	0.69	0.83

3.3 Optimal Installation Mode of Distributed Energy Storage System

(1) Energy efficiency of the system under different installed ratios

Figure 1 is a comparison of energy utilization rates between distributed energy storage systems and traditional energy storage systems under different installed capacity ratios. As can be seen from the column chart, because the primary energy consumption of the system has a trend of decreasing first and then increasing, as the installed scale increases, the total energy efficiency of the distributed energy storage system presents a trend of increasing first and then decreasing. When the assembly rate increases to 70%, the energy efficiency of the entire system reaches a peak of 83.1%. Then, by increasing the assembly rate, the energy efficiency decreases to 77.3%. The overall energy efficiency of traditional systems is only 69.2%, lower than that of distributed energy storage systems with each installed capacity.

(2) Total carbon emissions of the system under different installed ratios

As shown in Figure 2, it is a comparison diagram of the total carbon emissions of distributed energy storage systems and traditional energy storage systems under different installed ratios. As can be seen from the figure, with the increase in the proportion of installed capacity, the annual total CO2 emissions of distributed storage systems will undergo a process of first decreasing and then increasing. With the installed capacity increasing from 30% to 80%, the total carbon emissions gradually decreased from the highest of 191000 tons to the lowest of 1591000 tons, and then increased to 160700 tons. The annual CO2 emissions of conventional systems are up to 19.18 tons, exceeding the carbon emissions of distributed energy storage devices with different installed capacities.

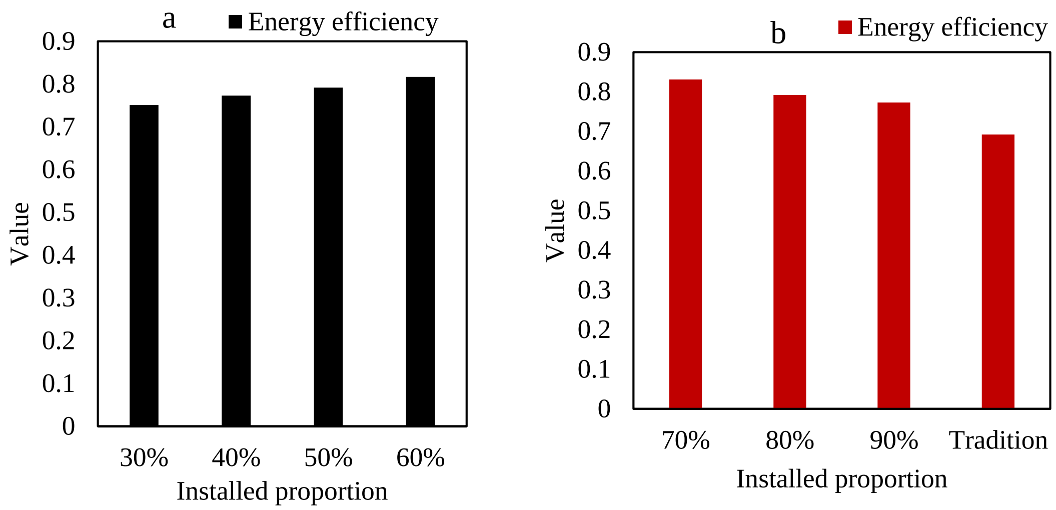

Figure 1: Energy utilization efficiency of the system under different installed ratios

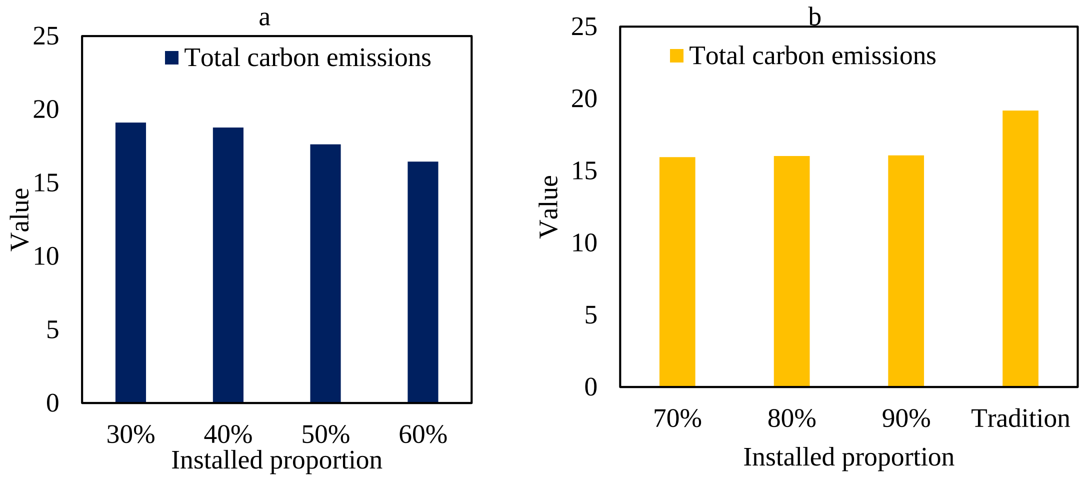

Figure 2: Total carbon emissions of the system under different installed ratios

(3) Annual total cost of the system under different installed ratios

As shown in Figure 3, it is a comparative diagram of the annual investment costs and operation and maintenance costs of distributed energy storage systems and traditional energy storage systems under different installed ratios. When the installed capacity is large, its annual investment will increase with the increase of unit area, but its operation and maintenance costs will first decrease and then increase. After synthesis, the total annual cost of the system experienced a process of first decreasing and then increasing. During the process of increasing the installation rate of the system from 30% to 70%, the total annual cost of the system decreased to the lowest value of 223.12 million yuan. Subsequently, as the installation rate increased, the total annual cost of the system began to gradually increase. However, the annual investment cost of conventional systems is 33.67 million yuan, which is far less than distributed energy storage systems allocated according to different installed capacities; However, due to the low energy efficiency and high annual operating and maintenance costs of traditional systems, the annual cost of traditional systems is higher than that of individual distributed energy storage devices.

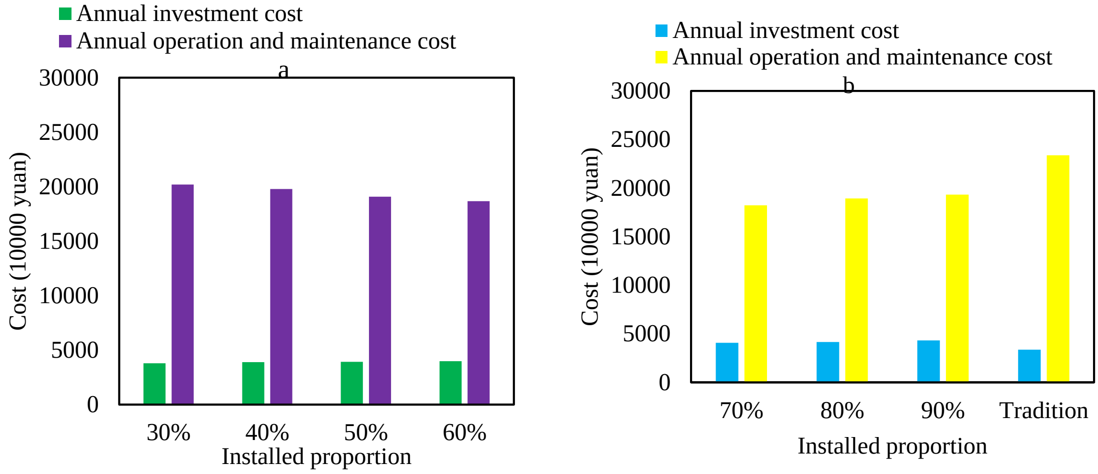

Figure 3: Annual total cost of the system under different installation ratios

In summary, when the installed ratio is 70%, the distributed energy storage system achieves the highest energy utilization rate, the lowest carbon emission rate, and the lowest total annual cost, while improving economic and environmental benefits.

4. Conclusions

This paper studies the optimization strategy of new energy distributed energy storage cluster based on intelligent manufacturing, proposes the framework and implementation method of the optimization strategy of new energy distributed energy storage cluster based on intelligent manufacturing, and conducts experimental verification. On this basis, carrying out optimization design of distributed energy storage clusters for new energy can effectively improve the operational efficiency and stability of energy storage clusters, save energy storage fees, and promote efficient utilization and management of new energy. Specifically, this optimization strategy can achieve multi-objective optimal scheduling of energy storage systems, including optimization of energy balance, battery life extension, charging efficiency, and other aspects, thereby improving the efficiency and performance of energy storage systems. The optimization strategy of new energy distributed energy storage cluster based on intelligent manufacturing has broad application prospects and potential, and has important reference and reference value in research and practice in the field of new energy storage.

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