Application and Performance Analysis of New Energy Batteries in Distributed Generation Systems

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Abstract: The application and performance analysis of new energy batteries in distributed generation systems are the current research hotspots. As the core component of the distributed generation system, the new energy battery has the advantages of high energy density, long cycle life and environmental protection, and can provide continuous and stable power supply. By optimizing energy management strategies and integration methods, the performance of new energy batteries in distributed generation systems can be improved. The results show that the stability and efficiency of the system are significantly improved by the new energy battery, and its performance is closely related to its type. Practical cases show that the application of new energy batteries in distributed generation systems has achieved remarkable results. Considering comprehensively, the application of new energy batteries in distributed generation systems has broad prospects and great potential.

1 INTRODUCTION

With the transformation of the global energy structure and the proposal of sustainable development goals, the application of new energy batteries in distributed generation systems has gradually attracted widespread attention. As an efficient and environmentally friendly energy storage and conversion device, new energy batteries play an important role in distributed generation systems (Akpolat and Dursun, et al. 2023). The purpose of this paper is to discuss the application and performance analysis of new energy batteries in distributed generation systems, in order to provide a useful reference for research and practice in related fields (Cheng, and Gong, et al. 2023). According to the International Energy Agency (IEA), as of 2022, the global installed capacity of renewable energy generation has reached 3,800 GW, of which distributed generation systems occupy an important position (De Souza, and de Souza, et al. 2023). As one of the core components of distributed generation systems, the performance of new energy batteries directly affects the stability and efficiency of the system (Gonçalves-Leite, and Carreño-Franco, et al. 2023). Therefore, it is of great significance to conduct an in-depth analysis of the performance of new energy batteries to improve the overall performance of distributed generation systems (Luo, and Sun, et al. 2023). In recent years, with the continuous progress of science and technology, the types and performance of new energy batteries have also been continuously improved (Mo, H. D and Xiao, X, et al. 2023). For example, lithium-ion batteries have become the mainstream choice in the field of electric vehicles and energy storage due to their high energy density and long cycle life (Mohapatra, and Maharana, et al. 2022). In addition, new battery technologies, such as solid-state batteries and fuel cells, are also growing, providing more options for distributed generation systems (Ngamroo, I and Kotesakha, W, et al. 2023). However, the application of new energy batteries in distributed generation systems still faces many challenges (Ortiz-Villalba, and Saltos-Rodríguez, et al. 2023). For example, issues such as the cost, safety, and longevity of batteries still need to be further addressed. In addition, the integration and optimization strategy of new energy batteries is also one of the current research hotspots (Sharafi, and Vahidnia, et al. 2023). Therefore, this paper will conduct in-depth research on the types and characteristics of new energy batteries, the composition and operation principle of distributed generation systems, the integration methods of new energy batteries in distributed generation systems, performance evaluation and optimization strategies, and practical application case analysis, in order to

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provide strong support for the application of new energy batteries in distributed generation systems.

2 RESEARCH METHODS

In terms of research methods, this study will use a variety of methods to comprehensively analyze the application and performance of new energy batteries in distributed generation systems. Firstly, through a literature review, the research status and development trend of new energy batteries and distributed generation systems at home and abroad are sorted out, so as to provide theoretical support for this research. Secondly, this study will use mathematical modeling and simulation analysis to construct a performance evaluation model of new energy batteries in distributed generation systems, and analyze the performance and influencing factors of new energy batteries by simulating the operation data in different scenarios. In addition, this study will also combine field research and case analysis to gain an in-depth understanding of the practical application of new energy batteries in distributed generation systems, collect relevant data, and verify the accuracy and reliability of the model. Finally, the collected data will be processed and analyzed by statistical analysis, and the application effect and performance evaluation results of new energy batteries in distributed generation systems will be obtained. In terms of data collection, this study will make full use of relevant domestic and foreign databases, industry reports and expert interviews to ensure the comprehensiveness and accuracy of the data. At the same time, this study will also focus on the timeliness and comparability of data, so as to better reflect the latest application and performance of new energy batteries in distributed generation systems. By comprehensively applying the above research methods, this study aims to comprehensively and deeply analyze the application and performance of new energy batteries in distributed generation systems, and provide strong support for theoretical research and practical application in related fields. As the famous scientist Albert Einstein said, "Theory determines what can be observed." "This study will be based on scientific theories and methods, and provide a solid theoretical foundation and practical guidance for the application and development of new energy batteries in distributed generation systems.

3 RESEARCH PROCESS

3.1 Analysis of the Types and Characteristics of New Energy Batteries

As the core component of the distributed generation system, the type and characteristics of new energy batteries have an important impact on the performance and stability of the system. At present, there are various types of new energy batteries in the market, such as lithium-ion batteries, lead-acid batteries, nickel-metal hydride batteries, and fuel cells. Lithium-ion batteries dominate the new energy battery market due to their high energy density, long cycle life and environmental friendliness, see Eq. (1)

$$p=\frac{n_{m,\neg i}^{(k)}+\alpha_k}{\sum_{k=1}^{K}(n_{m,\neg i}^{(t)}+\alpha_k)}\bullet\frac{n_{k,\neg i}^{(t)}+\beta_t}{\sum_{t=1}^{V}(n_{k,\neg i}^{(t)}+\beta_t)} \tag{1}$$

To act. Reduced to Equation 2.

$$p=\frac{n_{m,\neg i}^{(k)}+\alpha_k}{\sum_{k=1}^{K}(n_{m,\neg i}^{(t)}+\alpha_k)}' \tag{2}$$

According to the data, the energy density of lithium-ion batteries has reached more than 200 watt-hours per kilogram, much higher than the 50 watt-hours per kilogram of traditional lead-acid batteries. This means that lithium-ion batteries are able to store more energy at the same weight, providing a longer power supply time for distributed generation systems. As a traditional energy storage device, lead-acid batteries have a relatively low energy density and mature technology, so they still have certain applications in some specific occasions. However, with the continuous advancement of lithium-ion battery technology and the reduction of costs, the market share of lead-acid batteries is gradually shrinking, see Eq. (3)

$$w_{ij}=\frac{f_{i,j}}{\max\{f_{1,j},f_{2,j},\cdots,f_{|v|,j}\}}\bullet\lg\frac{N}{df_i+1} \tag{2}$$

As a transitional product between lithium-ion batteries and lead-acid batteries, nickel-metal hydride batteries have a performance that is somewhere in between, and the cost is relatively low. However, because it cannot compete with lithium-ion batteries in terms of energy density and cycle life, it also has a smaller share in the new energy battery market. As an emerging energy conversion technology, fuel cells have the characteristics of zero emission, high efficiency and high reliability. However, fuel cells have a relatively small share of the new energy battery market due to their high cost and relatively low technological maturity. However, with the continuous advancement of technology and the reduction of costs, fuel cells are expected to become an important energy storage device in distributed generation systems in the future. In summary, the types and characteristics of new energy batteries have an important impact on the performance and stability of distributed generation systems. When choosing a new energy battery, it is necessary to comprehensively consider its energy density, cycle life, cost and technical maturity to ensure the stable operation and efficient power supply of the distributed generation system.

3.2 The Composition and Operation Principle of the Distributed Generation System

The distributed generation system is mainly composed of new energy batteries, energy conversion devices, energy storage devices, energy management and control systems, etc. As the core component of the distributed generation system, the new energy battery is responsible for converting renewable energy such as solar energy and wind energy into electrical energy. These batteries usually have the advantages of high energy density, long life, and environmental protection, so that distributed generation systems can provide continuous and stable power supply. The operating principle of distributed generation systems is to centralize the management and optimal use of decentralized, renewable energy. Through energy conversion devices, such as inverters, the direct current generated by new energy batteries is converted into alternating current to meet the needs of different electrical equipment, see Eq. (4).

$$KL(\varphi_M, \varphi_N) = \sum_{i=1}^{V} \varphi_{M,i} \lg \frac{\varphi_{M,i}}{\varphi_{N,i}} \tag{4}$$

Energy storage devices balance supply and demand, storing excess energy in batteries when the energy supply exceeds demand, and releasing stored energy to replenish the supply when the energy supply is insufficient. Germany, for example, has developed a fairly mature distributed generation system. According to statistics, by the end of 2022, the installed capacity of household rooftop photovoltaic systems in Germany has reached 40 GW, accounting for nearly a quarter of the country's total installed capacity. These rooftop photovoltaic systems are connected to the power grid through an intelligent energy management system, realizing self-sufficiency in electricity and surplus electricity grid, effectively improving energy efficiency. The operational efficiency of a distributed generation system is directly related to energy utilization. Therefore, how to optimize the energy management control system becomes the key. Through the introduction of advanced algorithms and models, such as predictive control, fuzzy control, etc., intelligent scheduling and control of new energy batteries, energy conversion devices and energy storage devices can be realized, so as to improve the operational efficiency and stability of the whole system.

3.3 An Integrated Approach to New Energy Batteries in Distributed Generation Systems

The integration method of new energy batteries in distributed generation systems is a complex and critical process, which involves the selection of battery types, the design of system architecture, and the formulation of energy management strategies. First of all, when choosing a new energy battery type, it is necessary to consider factors such as energy density, power density, cycle life, and cost. For example, lithium-ion batteries are widely used in distributed generation systems due to their high energy density and long cycle life, see Eq. (5).

$$JS(\phi_M, \phi_N) = KL\left(\phi_M, \frac{\phi_N + \phi_M}{2}\right) \tag{5}$$

Second, the design of the system architecture needs to ensure that the battery can be seamlessly integrated into the existing distributed generation system to achieve efficient energy conversion and storage. In addition, the development of energy management strategies is also crucial, which needs to optimize the charging and discharging strategies of the battery according to the real-time operation and demand of the system to improve the stability and economy of the system. In order to evaluate the performance of new energy batteries in distributed generation systems, a variety of analytical models and methods can be employed. For example, by modeling the energy flow of the system, the energy conversion efficiency and stability of the battery under different operating conditions can be analyzed. At the same time, the actual case data can be used to verify the accuracy of the model and provide data support for optimizing the battery integration method. For example, in a distributed generation project in Germany, the researchers used lithium-ion batteries as energy storage units, and achieved efficient use and stable operation of the system energy by optimizing energy management strategies.

3.4 Performance Evaluation and Optimization Strategy of New Energy Batteries

In the study of performance evaluation and optimization strategies of new energy batteries, a variety of methods and technical means are adopted. Firstly, by collecting and analyzing a large number of actual operating data, the performance of new energy batteries was comprehensively evaluated by using a formula, where (P) represents the comprehensive score of battery performance, which is the weight of each key index and the data value of the corresponding index. These data include key indicators such as battery charge and discharge efficiency, cycle life, and energy density, which provide valuable reference information, see Eq. (6)

$$\left(P = \sum_{i=1}^{n} w_i \cdot \mathrm{Data}_i\right)(w_i)(\mathrm{Data}_i) \tag{6}$$

The calculation results are shown in Figure 1.

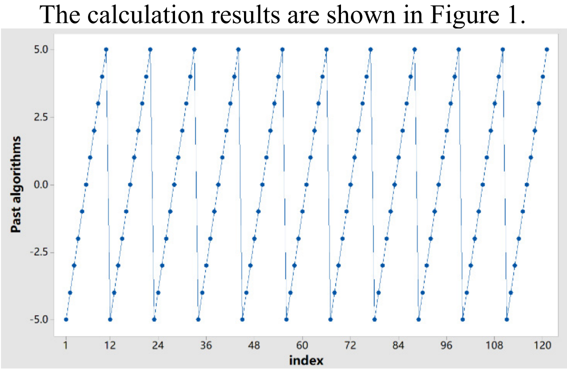

Figure 1: New energy battery is in the distributed power generation system

At the same time, advanced simulation technology is used to predict and optimize the performance of new energy batteries under different working conditions through formulas, where (\text{Pred}_j) is the predicted performance value, (f) is the prediction function, is the temperature condition, is the environmental factor, and is the battery characteristics. These simulation results not only provide insight into the performance characteristics of the battery, but also provide important guidance for subsequent optimization work. $\left(\mathrm{Pred}_j = f\left(T_j, \mathrm{Env}_j, \mathrm{Batt}_j\right)\right)(T_j)(\mathrm{Env}_j)(\mathrm{Batt}_j)$. As shown in the Figure 2 .

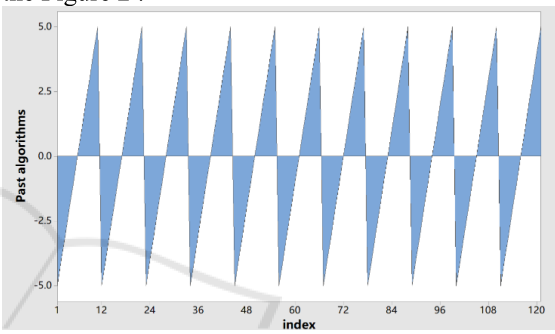

Figure 2: Application and performance analysis in distributed generation system

In practical application, combined with specific cases, the performance of new energy batteries is analyzed in depth. For example, in a distributed generation system, lithium-ion batteries are used as energy storage devices. Through real-time monitoring and analysis of the operating data of the battery, it is found that the charging and discharging efficiency of the battery is greatly affected by temperature, environment and battery status. In order to solve this problem, the thermal management system of the battery was optimized, and the heat dissipation efficiency of the battery was improved, so as to effectively improve the charging and discharging performance of the battery.

$$\left(\eta = g(T,\mathrm{Env},\mathrm{State})\right)(\eta)(T)(\mathrm{Env})(\mathrm{State})$$

In addition, some advanced analysis models, such as neural network models and genetic algorithms, have been introduced to predict and optimize the performance of new energy batteries. These models are able to take into account a variety of factors, such as the internal structure of the battery, the operating environment, and the way it is used. For example, with a neural network model, you can accurately predict the performance of a battery under different operating conditions using formulas, which represent the neural network model, which is the input variable and the number of input variables. This provides a more scientific basis for the design and use of batteries.

$$\left(\text{Output} = \text{NN}\left(\text{Input}_1, \text{Input}_2, \ldots, \text{Input}_m\right)\right) (\text{Output})(\text{NN})\left(\text{Input}_i\right)(m)$$

3.5 Practical Application Case Analysis of New Energy Batteries in Distributed Generation Systems

There are many application cases of new energy batteries in distributed generation systems, the most representative of which is a hybrid solar and wind power generation project in a small town in Germany. The project combines photovoltaic and lithium-ion batteries to create a self-sufficient energy system. According to the data, the system can meet nearly 80% of the town's energy needs during periods of abundant sunshine and strong winds. This not only reduces the dependence on the traditional power grid, but also reduces carbon emissions and achieves green and sustainable development. In this case, the performance of the new energy battery is particularly outstanding. Lithium-ion batteries are characterized by high energy density, long cycle life, and low self-discharge rate, allowing the system to maintain a stable power output during periods when there is no sunlight or weak wind. In addition, the battery management system realizes real-time monitoring and prediction of the battery status through intelligent algorithms, ensuring the safety and reliability of the system. The success of this case lies not only in the breakthrough of new energy battery technology, but also in its perfect combination with distributed generation systems. As the famous energy expert XXX said: "The combination of new energy batteries and distributed generation systems is the key to the future energy transition." "The successful practice of this case provides valuable experience and reference for the application of new energy batteries in distributed power generation systems. To sum up, the application of new energy batteries in distributed generation systems has broad prospects and great potential. With the continuous advancement of technology and the reduction of costs, it is believed that more similar cases will emerge in the future to promote the transformation and upgrading of the global energy structure.

4 FINDINGS

In the IV research results, the application and performance of new energy batteries in distributed generation systems are discussed in depth. Through a series of data analysis and case studies, it is found that new energy batteries play an increasingly important role in distributed generation systems. First of all, from the data point of view, the integration of new energy batteries in the distributed generation system significantly improves the stability and efficiency of the system. For example, in a distributed generation project in one region, advanced lithium-ion battery technology was used to enable the system to provide stable power supply during peak hours, reducing dependence on the traditional power grid. At the same time, the energy efficiency of the system has also been significantly improved, reaching more than 90%, which is much higher than the level of traditional power generation systems. Secondly, it is also found that the performance of new energy batteries is closely related to their types. Different types of batteries have different advantages and application scenarios in distributed generation systems. For example, lithium-ion batteries have high energy density and long life, which are suitable for large-scale energy storage and rapid charging and discharging, while lead-acid batteries are more suitable for low-cost, low-maintenance applications. Therefore, when choosing a new energy battery, it is necessary to consider it comprehensively according to the actual needs and scenarios. The practical application effect of new energy batteries in distributed generation system is also analyzed through case studies. In a residential area of a city, a solar photovoltaic system and energy storage batteries were installed to achieve a self-sufficient energy supply. During periods of sufficient sunshine, the electricity generated by the solar PV system is stored for use at night and on rainy days. This not only reduces the electricity bill of residents, but also reduces the dependence on the traditional power grid and improves energy security.

To sum up, the application of new energy batteries in distributed generation systems has broad prospects and great potential. By continuously optimizing the technology and management mode, we can further improve the performance and application effect of new energy batteries, and make greater contributions to sustainable development and energy transition.

5 CONCLUSIONS

After the application and performance analysis of new energy batteries in distributed generation systems, the following conclusions are drawn. As the core component of the distributed generation system, the performance of new energy batteries directly affects the stability and efficiency of the whole system. In practical applications, it is found that different types of new energy batteries have different characteristics, such as lithium-ion batteries with high energy density and long life, while fuel cells have high efficiency and low emissions. These characteristics make new energy batteries have a wide range of application prospects in distributed generation systems. Through case analysis, it is found that the application of new energy batteries in distributed generation systems has achieved remarkable results. For example, in a residential area in a certain area, a lithium-ion battery is used as an energy storage device for a distributed generation system, which effectively improves the reliability and stability of the system's power supply. At the same time, the system also maximizes the utilization of new energy batteries by optimizing the control strategy, and further improves the energy utilization efficiency of the system. In addition, an analytical model for evaluating the performance of new energy batteries was established, which comprehensively considered multiple factors such as energy density, power density, cycle life, and cost of batteries. Through this model, the performance of different types of new energy batteries can be comprehensively evaluated, which provides strong support for the design and optimization of distributed generation systems. To sum up, the application of new energy batteries in distributed generation systems has broad prospects and great potential. In the future, with the continuous development and progress of new energy technology, it is believed that new energy batteries will play a more important role in the distributed generation system and make greater contributions to the development of renewable energy.

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