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Research Article

Optimal Dispatching of New Energy Power Grid with High Penetration Rate under the Background of Big Data

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After decades of development, electricity has become an important driving force for national economic construction, and countries' dependence on electricity is also increasing. In order to solve the problems of environmental pollution and nonrenewable resources in the process of traditional energy power generation and further improve the utilization efficiency of electricity, countries have vigorously developed new energy grids. As a rapidly advancing developing country, my country has a huge demand for electricity. In addition, in recent years, my country's new energy power generation technology has advanced by leaps and bounds, and it has become an extremely important source of electricity, which is necessary. The purpose of this study is to improve the power grid dispatching and facilitate the people through the understanding of new energy sources with high penetration rate. This paper mainly uses the experimental method, the comparison method, and the investigation method and uses the big data technology to analyze the use of new energy and the optimal dispatch of the new energy grid. The experimental data show that the load changes in each time period are within 1. Through the continuous testing and optimization of the objective function, the dispatching of the high-penetration new energy grid has initially achieved scientific overall planning. The development of this research will help to realize the optimal configuration between traditional energy power generation and new energy power generation and realize the sustainable development of new energy power generation while reducing the loss of grid connection.

1. Introduction

After entering the new century, the scale of my country's power grid rapidly ranks first in the world. Both high-voltage grid technology and long-distance power transmission technology are in a leading position in the world. In this context, my country's requirements for the safety and low loss of power grid architecture are far higher than international standards. Under the current technical conditions, problems such as high failure rate of power grid equipment and difficulty in equipment maintenance have always restricted the further development of power grid architecture. In order to solve this problem, scholars have put forward a variety of beneficial ideas, and the optimal scheduling of high-penetration new energy power grids is one of the important areas.

There are many practical theoretical achievements in the research on optimal dispatching of high-penetration new energy power grids under the background of big data. Overseas scholars' research in this field mainly focuses on the application of high-permeability capacitors, such as new energy vehicle charging and smart city construction [1, 2]. There are also some scholars who have carried out theoretical discussions on the problems in the process of RES integration [3, 4]. Hao said that cluster planning has always been a research hotspot in the sense of cluster computing. The main focus of cluster planning research is to quickly and accurately obtain the operational resources required for computing tasks under the defined cluster resource conditions to achieve business goals [5]. Shen and Sun analyzed several power outages that caused serious losses in international history and analyzed the complexity of grid connection of new energy grids [6]. Shao adopted the modeling method to analyze the threat suppression caused by the harmonic source and demonstrated the scientific placement of the hybrid active power filter [7]. Zhang and Liu explored the scientific ratio between renewable energy generation capacity and investment income through empirical analysis of power grid data in northeast China and built an optimization model based on an integrated algorithm. In the analysis of the existing research results, it can be seen that there has been a deep research on the optimization of power grid efficiency, but there is a large gap in the field of optimization of high-penetration new energy power grids. Therefore, on the basis of the theory proposed by other scholars and the use of big data technology, this paper conducts an in-depth study on the optimal scheduling of high-penetration new energy power grids [8].

This paper mainly adopts the methods of literature analysis and comparative research. Firstly, the paper analyzes the basic theories of new energy and related energy and expounds the role of the data. Secondly, the operation of big data analysis technology is described. Then, the microgrid grid-connected penetration rate is selected as the most cutting-in point to carry out the experiment. Then, the power balance regulation mechanism of the power grid is analyzed. Finally, the optimal operation model of the high-permeability wind power grid-connected system is expounded, and the algorithm is used to test it. Compared with the existing research results, this study highlights the practical value of the model. In order to obtain scientific regulation suggestions, several horizontal comparison experiments were carried out to make the data foundation of the research more solid.

2. Related Work

2.1. Concept Explanation

2.1.1. New Energy Grid. The new energy power grid, simply understood, is a power grid based on new energy power. At this stage, the power supply of the new energy grid is greatly affected by changes in natural conditions, and it is not suitable for the main power supply. But it can be used as an additional power source to reduce the peak power consumption and reduce the load on the grid. It can significantly reduce grid investment and solve the problem of staggered peaks and valleys.

We can see from Figure 1 that China is the world leader in photovoltaic power generation, followed by Germany.

Since this century, wind power has received worldwide attention. The installed capacity and grid-connection capacity of wind power have increased rapidly. From 2015 to 2020, it has shown a stable development trend. The details are shown in Table 1.

If the penetration rate of wind energy connected to the grid is high, the thermal power unit will work under pressure to generate electricity, and the system utilization rate will decrease, which will have a negative impact on energy efficiency. It is particularly important to optimize the distribution. The system obtains the best economic profitability and the environment and improves the level of wind energy consumption [9, 10].

2.1.2. Grid-Connected Penetration Rate of Microgrid. Microgrid penetration rate is an important criterion to measure the value of microgrid grid connection at this stage, usually the proportion of incoming electricity generated between the microgrid and the distribution network to the total electricity of the distribution network. According to national standards, if the penetration rate reaches 10%, it can be defined as high penetration. In recent years, the field of new energy power generation has developed rapidly in various parts of my country. The proportion of many microgrids connected to the grid has reached this standard, forming a powerful supplement to the existing power distribution system [11, 12].

After testing, it is found that the grid-connected location of the microgrid has a direct relationship with the loss rate. The smaller the distance from the distribution network power supply, the smaller the voltage loss. On the contrary, it is bigger. The value of n is set to 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0, respectively, and the corresponding distribution network loss change rate is shown in Table 2.

It can be seen from Table 2 that the larger the value of n, the larger the value of change rate of network loss. In other words, the further the microgrid's intervention location is from the source location, the greater the losses. Therefore, the access location of the microgrid should be scientifically configured.

Big data objectively reflects the intercommunication and mutual exclusion of information attributes at different times, regions, and dimensions. Through big data analysis, the internal connection between things can be excavated, which has become an important way of data analysis at this stage.

2.2. Model Algorithm. Big data objectively reflects the intercommunication and mutual exclusion of information attributes at different times, regions, and dimensions. Through big data analysis, the internal connection between things can be excavated, which has become an important way of data analysis at this stage. However, due to the independent operation characteristics of power resources at this stage and a certain time difference between the access point and the load, big data analytics is the result of revising data science and researching new models in a data-intensive environment. There are two important technical aspects to this process: text analysis on the one hand and machine learning on the other.

Therefore, big data analysis is based on data generation mechanisms, extensive data collection and storage, and data formatting and cleaning. Based on the big data analysis model, with the support of the comprehensive big data analysis platform, use cloud computing technology to plan and analyze computer resources and finally study the pattern or process of regular data analysis behind big data.

The normalization processing method is

$$\xi = (\xi_m - \xi_{\min})(\xi_{\max} - \zeta_{\min}). \tag{1}$$

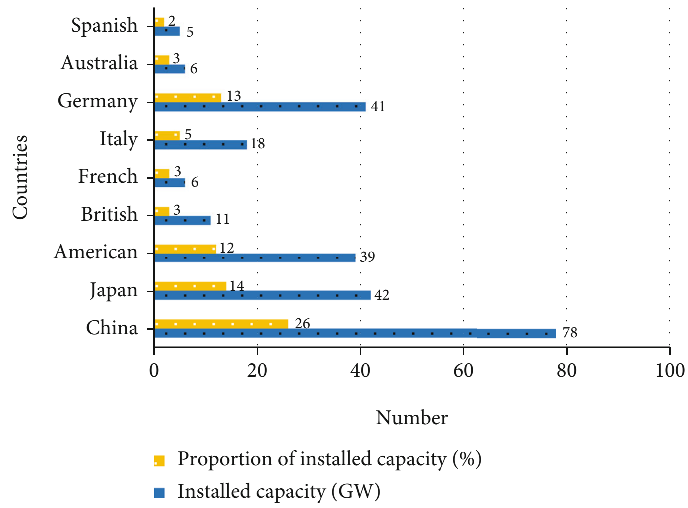

Figure 1: The basic situation of the top 9 countries in terms of cumulative installed capacity of photovoltaics in the world.

Table 1: Wind power installed capacity and new installed capacity.

	Installed capacity (GW)	New installed capacity
2015	44	7
2016	49	5
2017	53	4
2018	60	7
2019	65	5
2020	69	4
2021	72	3

Table 2: The influence of different positions of microgrid connected to the grid on the loss of distribution network.

n	Change rate of network loss	n	Change rate of network loss
0.1	0.036	0.6	0.215
0.2	0.070	0.7	0.252
0.3	0.107	0.8	0.287
0.4	0.141	0.9	0.324
0.5	0.182	1.0	0.366

In the formula, ξ is the data after normalization; ξ_m is the data before normalization; $\xi_{\min}$ is the minimum value in the same group of data; $\xi_{\max}$ is the maximum value in the same group of data.

In order to analyze and evaluate the effect of the model, the root mean square error (RMSE) is used as the model performance evaluation index, and the calculation formula is as follows:

$$F_{\text{RMSE}} = \frac{1}{M}\sum_{\kappa=1}^{m}\left(\frac{\delta_t(\kappa)-\delta_q(\kappa)}{D_\kappa}\right)^2. \tag{2}$$

3. Optimized Operation Model of High-Permeability Wind Power Grid-Connected System

3.1. Objective Function. According to the traditional daily power generation plan, many hydropower stations in the power grid in the northeast region formulate the power generation plan for the next day based on the actual load of the hydropower station, and each power station is required to strictly follow the plan [13, 14]. Although this reduces the waste of power storage and the control of the work process is relatively simple, it is not conducive to dealing with extreme situations of fluctuations in the new energy grid and reduces the fault tolerance of the distribution network for new energy power. Therefore, in order to further improve the control space between the distribution network and the new energy grid and achieve a dynamic balance between the two, in this study, the set generation plan is to add a certain percentage of reserve to the original quantity [15, 16]. The specific proportion is calculated by using a penalty function. This function is used to simulate and analyze the multiobjective optimization configuration under different scheduling strategies. In terms of monitoring methods, a mode of horizontal comparison with different management strategies under the same configuration conditions is adopted, and the effects of static and dynamic scheduling strategies on the regulation effect are summarized [17, 18].

3.2. Simulation Analysis of Multiobjective Optimization Configuration under Different Scheduling Strategies. After the experiment, the two management strategies are summed up and analyzed using big data technology. It can be found that the results do not show obvious differences, and there are still great difficulties in choosing the scheduling plan. Here, this study uses a newly constructed comprehensive evaluation system, adding the propensity ratio of power grid stakeholders to reliability and economic benefits in the

Table 3: Load value and photovoltaic power output value in each period.

Time period	PPV (kW)	Load	Time period	PPV (kW)	Load
3	0	0.755	15	343	0.935
6	0	0.776	18	28	0.949
9	226	0.898	21	0	1
12	503	0.961	24	0	0.802

measurement indicators and according to the new index system for evaluation and calculation and analysis again.

Load value and photovoltaic power output value in each period are shown in Table 3.

The calculation example system is optimized according to the voltage and reactive power optimization model. And the comparison between the total network loss value and the total voltage deviation value in each period and the initial state obtained after dynamic optimization is shown in Table 4.

As shown in Figure 2, we can see that compared with the initial power flow, after applying dynamic voltage and reactive power optimization models, the total voltage deviation and total loss in each period of the distribution network are significantly reduced, and the voltage state is more ideal. A numerical simulation example proves that the method and scheduling algorithm proposed in this paper are feasible and effective.

Table 4: Comparison of total network loss value deviation in each period.

Time period	Network loss after optimization	Initial network loss	Time period	Network loss after optimization	Initial network loss
3	107	221	15	57	234
6	113	229	18	103	236
9	75	237	21	106	237
12	46	238	24	102	232

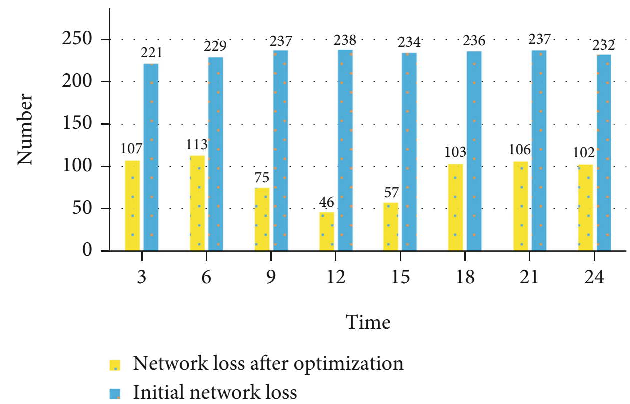

Figure 2: Comparison of total network loss value deviation in each period.

Table 5: Approximate prediction error range of different powers and time scales.

	24 h before	15 min within a day	30 s within a day
Wind power	23%~38%	<4%	<2%
Photovoltaic power	9%~18%	<5%	<2%
Random load	About 8%	<4%	<2%

4. Case Analysis

4.1. The Construction of the High-Penetration New Energy Grid Optimization. The construction of the high-penetration new energy grid optimization and dispatching platform is to realize the configuration and integration of various types of power resources such as wind power, photovoltaic power generation, and tidal energy under the background of big data. The application of big data enables the power grid to understand the operating status of the power system in real time, analyze it, and then adjust the corresponding power generation plan, reducing the impact on energy storage and transmission during peak power consumption periods. At the same time, intelligent technology is used to improve the collection, integration, and classification of various resource information. The new energy grid optimization dispatching platform based on big data is mainly aimed at areas with high penetration rate, using big data technology to build a complete, efficient, and perfect new energy grid optimization dispatching system.

The power balance of the power grid is an important prerequisite to ensure its safe and healthy operation, so it has also become an element that must not be ignored in the construction of the power grid. For safe, stable, and reliable operation, designers will establish a balance control mechanism when connecting the microgrid to the grid. In particular, when the new energy grid is connected to the distribution network, due to the unstable state of the former, it will bring great hidden dangers to the operation of the distribution network, so the power balance control is particularly important. It must be emphasized that at this stage, the scale of my country's power grid is gradually expanding, and the requirements for automatic regulation are increasing [19, 20]. In order to avoid additional burdens on the regulation system, it is necessary to adjust the power of the generator according to the actual needs of various places and the capacity of the power grid. Implement appropriate restrictions and develop a comprehensive and rigorous control plan [13, 14, 21].

The grid power balance regulation involved in this study is not a common device. It is usually in a standby state, and this device will only be activated when the power of the new energy grid is unstable. This emergency is the biggest difference between it and the commonly used service-oriented control system. From the current stage, the domestic regional power grids mainly adopt the short-term forecasting mode [19, 20] According to the power and regional power consumption requirements of various traditional power generation equipment in the network, the power generation plan for the next working day is formulated.

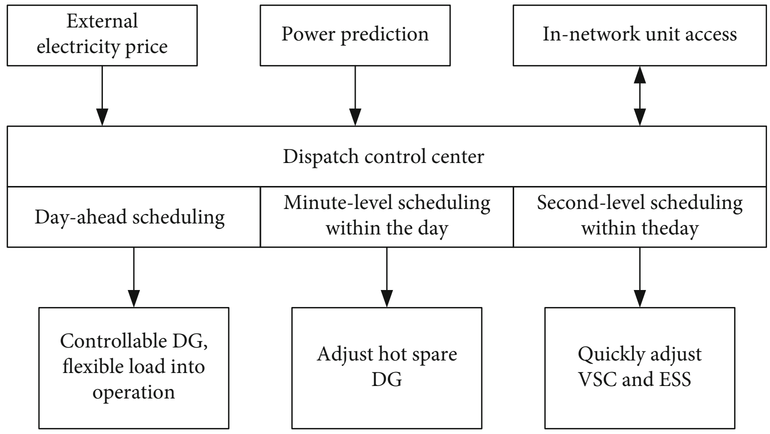

Figure 3: Multitimescale optimization scheduling framework.

Although such an approach is prudent and has a positive impact on reducing power losses, it does not provide clear data for long-term power compliance studies. In addition, the uncertainty of the new energy grid is unavoidable at this stage. When the amount of access is small, the uncertain interval will not have a significant impact on the distribution network, and as the amount of access increases, the impact will gradually increase. If a high proportion of the new energy grid is allocated in the short-term power generation plan, once an unexpected situation occurs, it will cause a great loss to the work of the distribution network [22–25].

4.2. Establishment of Analytical Regulation Models. In order to avoid this extreme situation, this study designed a new set of analytical regulation methods. This method is to connect distributed power sources into high-penetration units. Its main advantages are as follows. First, a certain amount of backup can be guaranteed when switching between low level and lack of capacity. The second is to adjust active power by introducing distributed power sources during peak load periods to reduce electricity bills and save costs. The third is to use big data technology to monitor and manage the power grid in real time and provide accurate and timely information support for the operation status of the power system. Through the Internet, the Internet of Things, and other means, build a huge and complete network system, to achieve all-round monitoring and management of wind power equipment and electricity users. Based on the prediction and analysis of application requirements and development trends in various fields in the power industry under big data technology, a multiobjective optimal dispatch model is established and algorithms are proposed to improve the efficiency and reliability of power grid operation and maintenance. Based on big data, the research on optimal scheduling of high-penetration power network is aimed at low energy consumption, cleanness, and environmental protection and maximizes the overall benefit of the power grid as a new energy generation method and power consumption structure. The optimal operation strategy is determined through reasonable configuration and planning control of large-capacity units, as well as load forecast analysis. After considering the influence factors such as the fluctuation of the fan speed, the calculation model of wind speed and voltage stability is established, and the corresponding algorithm is proposed to solve the problem in combination with the load characteristics.

The AGC unit in the distribution network is the unit that undertakes the balancing node for each distribution network partition. The biggest feature of this balancing unit is its instantaneous mechanism, which can adjust the power at the first time of triggering. Its working error range is shown in Table 5. From Table 5, it can be concluded that compared with the traditional control unit, the instantaneous unit designed by the study not only has a short response time but also has great advantages in error control.

The following is a horizontal comparison to observe the difference between the research and design of the DC distribution system dispatching and the traditional dispatching theory. The comparison method adopts the multitimescale scheduling comparison method. The specific time nodes are selected in three dimensions: day-ahead level, intraday minute level, and intraday second level. The basic framework is shown in Figure 3.

As can be seen from Figure 3, the key to the upgrade of this model is to use multiple timescales to formulate and adjust the power distribution scheme. The main reason for the use of multiple timescales for the formulation and adjustment of distribution schemes is that due to the high penetration of wind and photovoltaic power into the distribution network, fluctuations and uncertainties in their production affect the distribution network. The longer the prediction time, the larger the error, and the longer the prediction time, the higher the uncertainty.

5. Conclusion

For a long time in the past, when new energy grids were connected to the distribution network, most of them adopted the mode of on-demand power generation, ignoring the instable characteristics of new energy power generation. High-penetration power grid optimization scheduling is the product of power grid optimization in recent years. It relies on the development of the era of big data, analyzes the grid connection of new energy, and builds an optimal power flow model that satisfies multiobjective constraints. The current optimization and dispatching platform of the high-penetration power grid is mainly to realize all-round monitoring of wind power, photovoltaic power generation, and power systems, improve their operation status, and reduce risks. This paper mainly discusses the optimization strategy of high-penetration power dispatching system under the background of big data. Run model checking for system optimization through algorithmic demonstrations. The research on optimal scheduling of high-penetration distribution network is mainly to analyze the most critical factors affecting network loss and power consumption. With the support of big data algorithms, it is of practical significance to carry out a series of work such as analysis, calculation, and modeling. Experiments have shown that by further optimizing the access regulation, the dual goals of efficient utilization of new energy and risk reduction can be effectively achieved.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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