Hindawi
Advances in Multimedia
Volume 2023, Article ID 9843193, 1 page
https://doi.org/10.1155/2023/9843193

Retraction

Retracted: Double-Layer Optimal Configuration Method of Hybrid Energy Storage System Based on Chaotic Ant Colony Algorithm

Advances in Multimedia

Received 12 December 2023; Accepted 12 December 2023; Published 13 December 2023

This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] J. Y. Liu, X. Yang, J. G. Guo, D. Wang, H. Zhao, and Y. Lan, “Double-Layer Optimal Configuration Method of Hybrid Energy Storage System Based on Chaotic Ant Colony Algorithm,” *Advances in Multimedia*, vol. 2022, Article ID 6993143, 10 pages, 2022.

Hindawi
Advances in Multimedia
Volume 2022, Article ID 6993143, 10 pages
https://doi.org/10.1155/2022/6993143

Research Article

Double-Layer Optimal Configuration Method of Hybrid Energy Storage System Based on Chaotic Ant Colony Algorithm

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Received 4 August 2022; Revised 18 August 2022; Accepted 27 August 2022; Published 9 September 2022

Academic Editor: Tao Zhou

In order to stabilize the output fluctuation of wind power generation, this paper applies control strategy to control the action of the battery energy storage system according to the stability target, and quickly makes up for the system demand. In this paper, the optimal scheduling of new energy power system with energy storage is studied. This model predictive control is introduced into a certain system and optimized by model predictive control strategy so that the combination can match the predetermined expectations. Then, the model predictive control strategy is used to improve the schedulability of the wind farm. The objective function is to minimize the amount of action, and the composite output can track the scheduling instructions. Considering the cost, the way of storage and operation cost is optimized, and the penalty cost of wind abandonment is also reduced. Through rolling optimization and feedback correction, the model predictive control is optimized and solved, and finally, the action instructions of the storage system are obtained so that the storage output can effectively calm the wind. Power makes the combination schedulable. The optimized wind power/energy storage output is equivalent to the benign and dispatchable power supply of the power grid.

1. Introduction

Since the reform and opening up, China's energy development has gone through two stages. In the 1980s, due to the slow growth of China's oil and natural gas production, compressed oil burning was adopted. A series of policies such as replacing oil with coal have further strengthened the position of coal in China's energy supply system. China's energy development is mainly focused on solving the shortage of secondary energy supply, that is, the development of coal. Looking back at the several high tides of energy shortage in the 1980s, we can see that none of them was caused by the shortage of coal. Even the frequent power shortage is often closely related to the emergency of power coal. Under the condition that the supply cannot be fully and effectively known, the energy development policy of paying equal attention to conservation and development, and giving priority to conservation in the near future is proposed. The construction of the energy base centered on Shanxi, and the construction of Railways and ports focusing on coal transportation became the main contents of China's energy construction at that time. After entering the 1990s, China's economic system began to reform guided by the market economy, and the concept that energy supply is determined by the market has been strengthened. The large-scale import of oil from 1992 to early 1994 has not shaken the coal-based energy development strategy. However, people have doubts about whether the focus of China's energy supply should only be based on the domestic available resources, which has impacted the traditional thinking of China's energy development strategy. This is because, on the one hand, the coal market continues to be weak and the contradiction between power supply and demand is resolved. On the other hand, the short-term supply of high-quality energy has also been well balanced due to the increase in oil imports and the decrease in exports, as well as the rapid growth of natural gas production. Energy is indispensable in our daily life. Energy consumption can be used as a standard to measure the quality of life and living standard of human beings. Nowadays, the population is growing, energy demand is increasing, and energy consumption is also increasing. Fossil energies mean that their storage capacity is limited. It is impossible to achieve sustainable human development with fossil energy sources alone, and large-scale use of fossil energy sources will cause environmental pollution and negatively affect human life. Wind power generation, photo voltaic power generation, etc., are widely used as clean energy power generation worldwide with low power generation cost and considerable environmental benefits [1]. Due to the rapid economic development, my country's energy consumption is very serious, and its greenhouse gas emissions are among the top in the world. In order to cope with this problem, my country has begun to vigorously develop new energy, which has become a major part of my country's energy development strategy. It has developed rapidly, especially the wind one quite, and my country's wind power installed capacity ranks among the best [2].

It leads to huge losses; the distribution of wind energy resources in my country is inconsistent with the distribution of load centers, resulting in the prominent phenomenon of "power curtailment and wind curtailment" [3].

Energy storage technology has developed rapidly and is now quite mature. Its flexible charging and discharging characteristics make it more and more widely used and larger in scale. Many scholars have studied it [4]. China's cumulative installed capacity reached 33.1 GW, with 5.1%. Especially for electro chemical energy storage, the Chinese market reached 2,242.9 MW, and the cumulative installed capacity exceeded 2 GW was 1,381.9 MW, with 42%. China newly commissioned 533.3 MW, with 157% [5]. For vigorous development of clean energy, the energy structure of the power system has undergone tremendous changes. Nowadays, intermittent characteristics of wind power have brought difficulties to system. The storage system is flexible and fast in charging and discharging, and has excellent scheduling ability and load tracking ability. These advantages enable it to compensate for the fluctuating characteristics of wind power operation. In the system, we reduce wind abandonment and reduce the peak shaving rate of thermal power, which also prolongs the service life of thermal power.

In summary, such output has a smooth and dispatchable wind storage output, which is a benign power source for the power system. It can not only make it but also reduce the output of thermal power and reduce the emission of polluting gases. Even the environment of the Earth is very friendly, and it can also improve the economic benefits [6]. The application of large scale is the focus of our current research. One's way of storing system power generation systems has also become one of the important research contents [7].

2. State of the Art

From the perspective of power system development, with the rapid progress of new energy power generation technology (in this paper, new energy refers to the emerging renewable energy power generation technology represented by wind power and solar power generation, hereinafter referred to as new energy), the proportion of intermittent new energy power generation will be further increased. This brings a series of challenges to the safe and stable operation of the power grid [8]. Nuclear power has stable output and large moment of inertia, which is suitable for bearing power base load. At the same time, it provides the necessary moment of inertia for the system to play the power supply support role of the receiving end power grid. Thus, it is more conducive to the consumption of intermittent power sources such as wind power and solar power generation [9]. Therefore, it is urgent to further study the coordinated development strategy of nuclear power, new energy, and other power sources. The central significance of the new energy power system is to realize the real vertical and vertical complementation. With the help of the vertical network load energy storage coordination, the relevant technical means will reduce the use of one-time energy and increase the proportion of new energy in the power system [10]. Finally, we gradually make renewable energy to occupy the main position in the power resource structure. The new energy power generation system has the characteristics of randomness and fluctuation, and is greatly affected by temperature. The oscillation caused by new energy integration has an important impact on the safe operation of power system. Therefore, the higher the proportion of new energy, the more serious the oscillation problem [11]. The popularization of new energy will not only affect the safe and stable operation of the power system but also have a significant impact on the operation rate of the new energy power system. The main reason why we choose to transform the traditional coal-fired power generation system into a new energy power system is that the new energy system itself is renewable, repeatable, and available. The development and utilization of new energy such as wind energy, nuclear energy, solar energy, and hydro energy is an important part of the development of new energy at this stage [12].

From the perspective of production power generation, in order to realize wind power generation and photovoltaic consumption with obvious indirection and volatility, the power system must add some power sources that can be flexibly and rapidly adjusted as support points [13]. However, China's low-carbon flexible power supply, such as positive electricity and pumped storage, accounts for too much. Therefore, in this respect, it is necessary to further tap the potential and accelerate the construction and reconstruction of flexible power supply to match the development of new energy. And the load of the power system has been different from the conventional load of relative stability [14]. With the development of a large number of fluctuating loads such as air conditioning, it is necessary to strengthen the deep integration of digital technology and power grid technology [15]. The strong space-time difference of power generation makes it more and more difficult for the power system to maintain the space-time balance. This makes the problem of lack of flexible regulation resources increasingly prominent in China and also puts forward higher requirements for the traditional nuclear power with only base load. In the high proportion of new energy power system in the future, it is not necessary for nuclear power to participate in the peak shaving of power grid frequently [16]. Instead, the system flexibility is improved by promoting the flexibility transformation of thermal power and strengthening the application of energy storage and other technologies, and nuclear power is only used as a supplementary means when the peak shaving resources are seriously insufficient [17]. Of course, for the sake of safety and economy, nuclear power does not frequently participate in power grid peak shaving. This does not mean that it cannot undertake the peak shaving obligation. This requires giving full play to the role of the market in optimizing the allocation of resources. And we find the peak shaving value of the system in a market-oriented manner and allocate the cost among different power sources [18].

3. Methodology

3.1. Chaos Ant Colony Algorithm. Although the multifield research backgrounds, most of them are based on the evolution of probability theory as the iterative core. With the in-depth research on chaotic optimization in academic circles in recent years, the use of chaotic disturbance to solve some problems in ant colony optimization has been affirmed [19]. By analyzing the foraging behavior of ant colonies, Cole et al. proposed that the chaotic behavior of individual ants plays a decisive role in the adaptive selection of the ant colony as a whole, and refined the foraging behavior of ant colonies into three continuous processes: the first process describes the chaotic search behavior of individual ants. Ant individuals use pheromones as carriers of indirect information to guide themselves and other ants to search. At this time, there is no strong organizational ability among ants. Over time, its own behavior is affected by the accumulation of positive feedback. When the individual behavior is enough to affect the operation of the system, the ants gradually begin to cooperate; the third process rises from the individual behavior to the ant colony adaptive behavior, through which the ants continue to communicate with the surrounding neighbors. The optimal position information in the range is exchanged until most of the ants converge on the path formed by the optimal position, so as to complete the system optimization. Ant colony algorithm can be used to solve some problems that have not yet found an effective algorithm. Moreover, ant colony algorithm is also a metaheuristic algorithm, which is an algorithm framework. It can be applied to different problems based on its basic idea. Ant colony algorithm can be compared with other approximate algorithms, and these algorithms have great improvement flexibility according to different problems. Chaos ant colony optimization is the optimization method that introduces the chaotic optimization mechanism; based on other, it is the chaotic ant colony method based on the optimal position exchange strategy [20].

First, the system is initialized by using the unique ergodicity of chaotic behavior, and the chaotic variable is equivalent to a certain ant search path [21]; then, the ant colony optimization to perform a secondary in each iteration is recorded and only the pheromone is secreted on this path, where the pheromone update formula is optimized by formula (1) as follows:

$$\tau_{ij}(t+1) = \rho\tau_{ij}(t) + \Delta\tau_{ij} + \varepsilon F_{ij}. \tag{1}$$

Among them, s is the chaotic offset variable, F is the chaotic mapping formula, and the rest of the parameters are still the same as those in formula (1). We converge to the optimal path compared with the traditional solution accuracy.

We suppose there are m ants in the continuous search space R and the optimization function is abstracted, and each independent variable is finite-dimensional, and the ant i. Under the influence of group self-organization, the optimal position exchange strategy is satisfied; that is, the exchange is performed at the current position of the self, the historical optimal position of the self and its neighbors, and the abstraction is as shown in the following formula:

$$z_{\mathrm{id}}(t) = f\left(z_{\mathrm{id}}(t), z_{\mathrm{id}}(t-1), p_{\mathrm{id}}(t-1), y_i(t)\right). \tag{2}$$

In order to make the ants conduct chaotic search in the early stage of the algorithm, and let it be used as the cumulative independent variable $y(t)$ that affects the group search, the guiding effect of the independent variable on the behavior of the ants is gradually strengthened with the passage of the system state; at the same time, the introduction of $p_{id}(t-1) - z_{id}(t-1)$, so that the operator can satisfy the optimization theory so as to exchange the best positions between ant colonies [22]. To sum up, a chaos optimization model is proposed based on the R. V. Sole mathematical model, as shown in the following equation:

$$\begin{aligned} y_i(t) &= y_i(t-1)^{(1+r_i)}, \\ z_{\mathrm{id}}(t) &= z_{\mathrm{id}}(t-1) \\ &\quad \cdot \exp\left(\left(1-\exp\left(-a y_i(t)\right)\right)\left(3-\psi_d \cdot z_{\mathrm{id}}(t-1)\right)\right) \\ &\quad + \exp\left(-2a y_i(t) + b\right)\left(p_{\mathrm{id}}(t-1) - z_{\mathrm{id}}(t-1)\right). \end{aligned} \tag{3}$$

3.2. Principle of Model Predictive Control (MPC). The strategy for closed-loop optimization is a limited time domain. It uses the measured value to set an objective function for optimal control and solves to obtain only using the current moment, and continue to repeat the optimization process at the next moment [23].

The future output of the system is predicted. It is assumed that a series of dynamic coefficients. It is not only schedulable but also has the characteristics of fast response and flexibility. The characteristics of fast to stabilize the fluctuation farm and reduce the large amount curtailment caused by the fluctuation generation.

$$y(k) = \begin{cases} a_i \cdot \Delta u(k-i|k), (1 \le i \le P), \\ a_P \cdot \Delta u(k-i|k), (i \ge P), \end{cases} \quad (4)$$

where $\Delta u(k-i|k)$ represents the control variable in the process of $[k-i-1, k-i)$ known at time k. If the colleague has input at all times $k-i\,(i=1,2,\ldots,k)$, then according to the superposition principle:

$$y(k) = \sum_{i=0}^{P-1} a_i \cdot \Delta u(k-i|k) + a_P \cdot \Delta u(k-P|k). \quad (5)$$

Through the above expression, the N-step estimate $(N<P)$ of $y\ (k+j|\mathrm{k})$ is obtained as follows:

$$\hat{y}(k+j|k) = \sum_{i=0}^{P-1} a_i \cdot \Delta u(k+j-i|k) + a_P \cdot \Delta u(k+j-P|k), \\ j = 1,2,\ldots,N. \quad (6)$$

When the prediction model is constructed, since the input variables at the previous moment are already known in the expression, we can separate this part from the prediction model and generate the dynamic response of the input variables at the previous moment to the prediction system at the next moment. Generally, for data sets with more columns than rows or relatively simple problems, linear models are preferred. For complex problems with more rows than columns, we tend to use nonlinear models. Another factor to consider is training time. The training time of linear method is shorter than that of nonlinear method. The function part is listed separately, and the rewritten form is as follows:

$$\begin{aligned} \hat{y}(k+j|k) &= \sum_{i=0}^{j-1} a_i \cdot \Delta u(k+j-i|k) \\ &\quad + \sum_{i=j}^{P-1} a_i \cdot \Delta u(k+j-i|k) \\ &\quad + a_P \cdot \Delta u(k+j-P|k) j = 1,2,\ldots,N. \end{aligned} \quad (7)$$

In the above expression, the last two parts are the effects of past input values on the predicted future output variables, denoted as follows:

$$y_0(k+j|(k)) = \sum_{i=j}^{P-1} a_i \cdot \Delta u(k+j-i|k) + a_P \cdot \Delta u(k+j-P|k), \\ j = 1,2,\ldots,N. \quad (8)$$

3.3. Model Predictive Control-Based Wind/Storage Integrated Power Generation System Model. Power and energy balance equation for wind/storage integrated power generation system is

$$\begin{cases} P_{\mathrm{WB}}(k+1) = P_B(k) + P_W(k), \\ E_B(k+1) = E_B(k) - \eta \Delta T_B P_B(k), \end{cases} \quad (9)$$

where $P_{\mathrm{WB}}(k+1)$ is the output power of the wind farm with energy storage injected into the grid at time $k+1$; $P_B(k)$ is the charging and discharging power of one's way of storing system at time k. When $P_B(k)>0$, it emits power for one's way of storing system; when $P_B(k)<0$, it absorbs power for one's way of storing system. $P_W(k)$ represents the wind power, and $E_B(k)$ represents the energy surplus of one's way of storing system at time k. The ratio of the available energy to the rated capacity of one's way of storing battery is the state of charge.

Converting equation (10) into a state-space model is as follows:

$$\begin{cases} x(k+1) = Ax(k) + B_1 u(k) + B_2 d(k), \\ y(k) = Cx(k). \end{cases} \quad (10)$$

In the formula, the state quantity is

$$x(k) = \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} = \begin{bmatrix} P_{\mathrm{WB}}(k) \\ E_B(k) \end{bmatrix}. \quad (11)$$

The relationship between control input, system output, and power disturbance is as follows:

$$\begin{cases} u(k) = P_B(k), \\ y(k) = P_{\mathrm{WB}}(k), \\ d(k) = P_W(k). \end{cases} \quad (12)$$

Combined with the system, you can get

$$\begin{aligned} A &= \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}, \quad B_1 = \begin{bmatrix} 1 \\ -1\Delta T_B \end{bmatrix}, \\ B_2 &= \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \qquad C = \begin{bmatrix} 1 & 0 \end{bmatrix}. \end{aligned} \quad (13)$$

Technically and economically, one's way of storing system constraints is as follows:

(1) State of charge constraints

$$S_{\min} \le x_2 \frac{(k)}{C_B \le S_{\max}}, k = 1,2,\ldots,P. \quad (14)$$

(2) Charge and discharge power constraints

$$\begin{aligned} P_c(k) &= \min\left((S_{\max} - S(k-1)) \frac{C_B}{\eta \Delta t, P_{\max\_ch}} \right), \\ P_d(k) &= \min\left((S(k-1) - S_{\min}) \frac{C_B}{\eta \Delta t, P_{\max\_f}} \right). \end{aligned} \quad (15)$$

In the formula, $P_c(k)$ and $P_d(k)$ are the maximum chargeable and discharge power of one's way of storing system at the current moment and are the maximum charge $P_{\max_c \mathrm{h}}$ and $P_{\max\_\mathrm{f}}$ discharge power of the battery.

4. Result Analysis and Discussion

4.1. Analysis of Using Energy Storage System to Absorb Abandoned Wind Power. It is generally believed that energy storage can make renewable energy (wind power + solar energy)

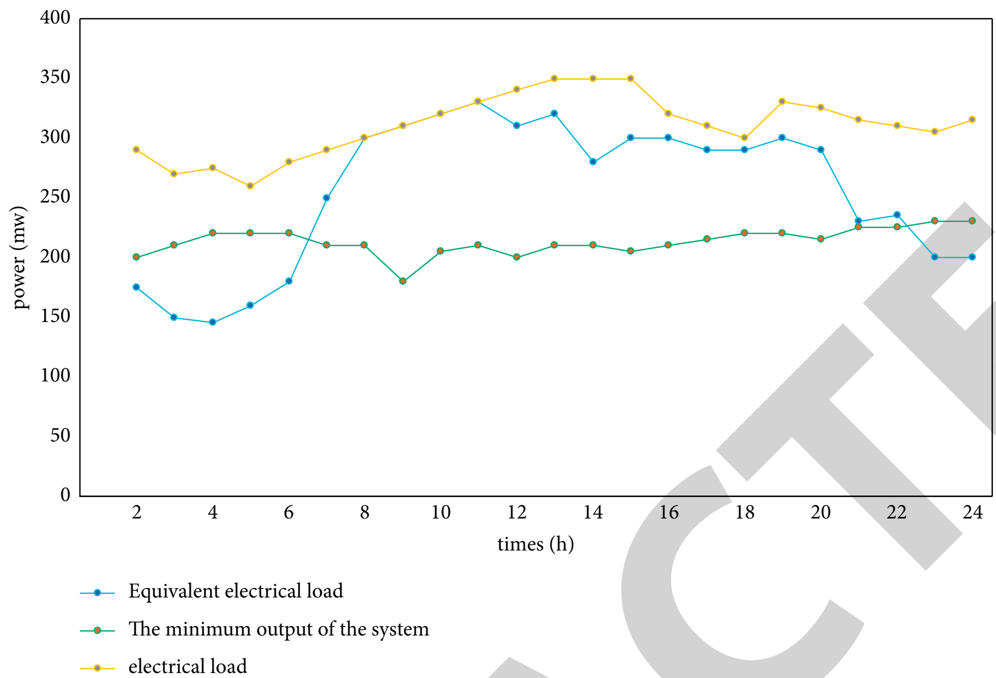

Figure 1: Principle of wind abandonment.

more attractive. It is generally believed that its greatest value is to enable the wind farm to output stable power. This is based on certain facts, but it can be achieved only when the fluctuation of varying power is small. In most cases, it is obviously not economical to rely on energy storage to achieve stable power output. Energy storage may only play a limited role in stable power output, but it is still very helpful for power grid system management. In particular, with the increasing proportion of renewable energy accepted by the power grid and the increasingly complex power grid structure, energy storage technology (especially battery technology) will develop rapidly and play a greater role. It is not only schedulable but also has the characteristics of rapid response and flexibility. It is characterized by rapid stabilization of fluctuating farms and reduction of large cuts caused by fluctuating power generation.

Generally speaking, the power grid load during the heating period in northern China is relatively high. Contrary to the characteristics of electric load, the peak period of heat load and wind power output usually occurs at night, and the trough period is during the day. The principle of wind curtailment is shown in Figure 1.

In Figure 1, the shaded part is the abandoned wind. This meets the minimum output requirement. At night, there is a lot of wind power generation, which reduces the equivalent electrical load, and the peak thermal load increases the minimum technical output of the thermal power unit, which makes the equivalent electrical load less than the minimum output of the probability of wind curtailment is high.

The wind power consumption for electric energy storage device, and the shaded part is the abandoned wind. After the introduction, the minimum output of the system remains unchanged, and the characteristic of energy storage is used to transfer energy to change the equivalent electric load curve of the system. During the day, the load is at the peak value, and the one is controlled to discharge. At night, the load is at the valley value. Controlling energy storage for charging, that is, the area of abandoned wind, is reduced compared with Figure 2.

This paper analyzes the output characteristics of wind power, describes the principle of wind power curtailment and peak regulation, introduces the impact of wind power grid connection, and then analyzes the operating characteristics. According to the energy classification, the basic characteristics technology is introduced through a table and a figure, and a detailed analysis:

(1) The output of wind farms is uncertain, which increases the difficulty, and it also has the characteristics of antipeak regulation. Its grid connection will increase consumption more difficult.

(2) By analyzing the principles of wind curtailment and peak regulation, it can be known that the feasible area of wind power operation is closely related to the peak regulation space, and the peak regulation space can determine the system's ability to accept wind power to a certain extent. Through simplified calculation, it can be known that different peak shaving measures need to be taken under different circumstances. When it can be taken, and when the power grid can no longer be stabilized by conventional units alone. When wind power is volatile, in-depth peak shaving measures need to be taken.

From it, it can be known in the category of power system, charging and discharging are usually flexible and fast, and one's way of storing system has the ability to dispatch and track the load. These advantages, it can compensate for the

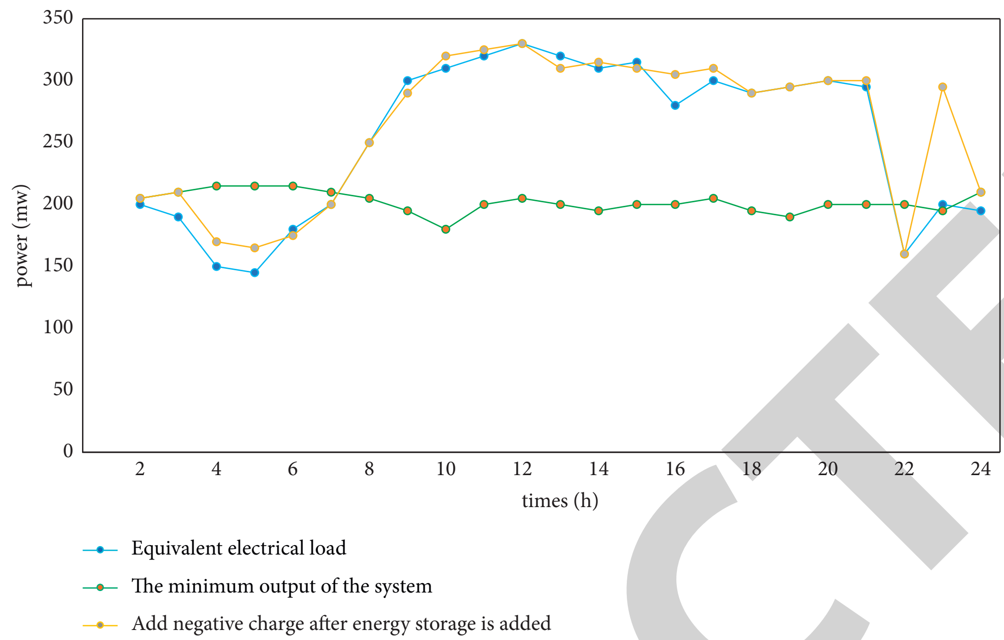

Figure 2: The principle of energy storage device to absorb wind power.

fluctuation characteristics of wind power operation, in the system, reduce wind abandonment, and reduce the peak shaving rate of thermal power, which also prolongs the service life of thermal power. It can achieve peak shaving and valley filling.

4.2. Comparative Analysis of Different Capacities of Energy Storage Configurations. In order to help promote clean heating in winter in northern China, electricity has been replaced by coal. At present, clean heating projects in Beijing, Tianjin, Liaoning, Jilin, and other northern regions have started. In this paper, the load characteristics of the reconstructed regional power grid are studied. Through network database investigation, the influence and optimization of coal to electricity on local load characteristics are analyzed. It is of great significance to the future demand-side management and control mode and the formulation of the next supporting power grid planning. The expected output of wind power can be formulated. In this paper, the average value of the four predicted values in every 60 min is taken as the dispatch command, and the dispatch command curve of one day is obtained. The scheduling instruction is shown in Figure 3.

The energy storage system in the wind farm is optimized through the model predictive, which can be close as possible to the expected output set in advance, and one's way of storing battery action is minimized as the control optimization goal. The model predicts that the control is optimized and solved through rolling optimization and feedback correction, and the action is obtained so that one's way of storing output can effectively suppress the fluctuation of wind power and that the combined output of the wind/storage integrated power generation system can be dispatched, and the wind, the accumulated output power, is smooth. Simulation calculation, the final wind/storage composite output of 96 nodes within 24 h, is shown in Figure 4.

It can make the combined output of the wind/storage system very close to the dispatch command. When one's way of storing capacity is configured as 60 MWh, the effect is better than that of 45 MWh and 30 MWh.

For 30 MWh, the deviation between the combined output of the wind/storage integrated power generation system and the dispatch command is 4.8039 MWh; when configured as 45 MWh, the deviation is 4.7803 MWh, which it is configured to. At 60 MWh, the deviation is 4.5114 MWh. The deviation is the smallest when one's way of storing configuration capacity is 60 MWh.

So does the capacity, the better the effect. On the whole, the synthetic output of the 60 MWh capacity configuration is closer to the dispatch command.

Figure 5 notes deviation between the wind storage combined output and the dispatch command.

We arrange the frequency of the absolute value of power deviation in Figure 5. The analysis shows that one's way of storing system with 30 MWh capacity configuration has a maximum power deviation of 30 MW, and the frequency of large power deviation is more, while one's way of storing system with 45 MWh and 60 MWh capacity configuration has a smaller deviation, and the frequency of small power deviation is more frequent.

The change diagram of the obtained from the simulation is shown in Figure 6.

The SOC fluctuation curve of one's way of storing system is shown in Figure 7.

The three graphs in Figure 6 are the change curves of the action quantities configuration capacities of 30 MWh, 45 MWh, and 60 MWh, respectively. Action change curves of one's way of storing systems with the three configurations

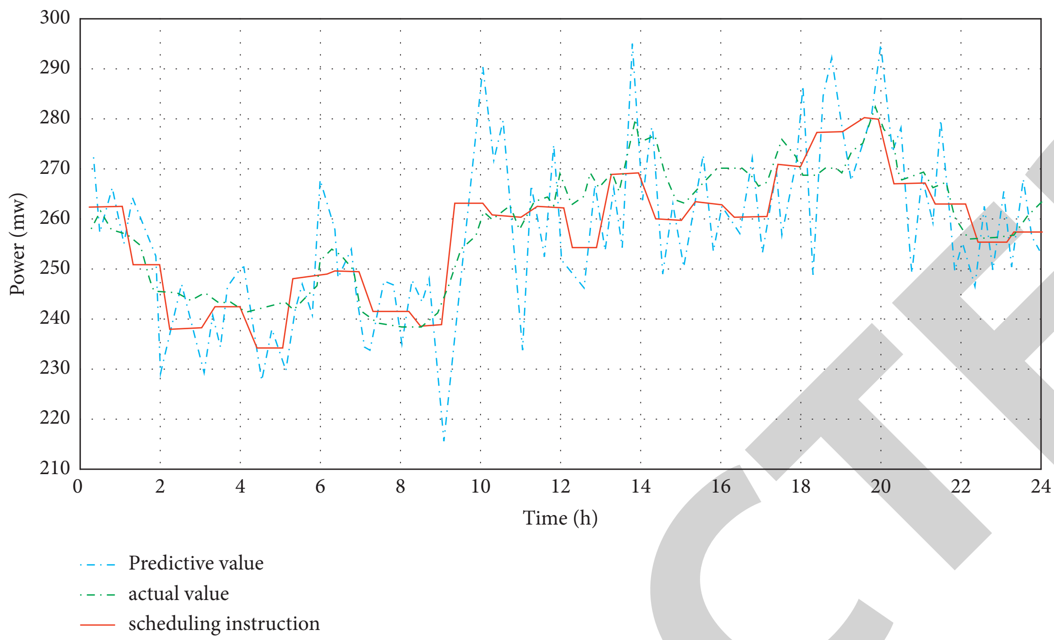

Figure 3: Schedule instruction curve.

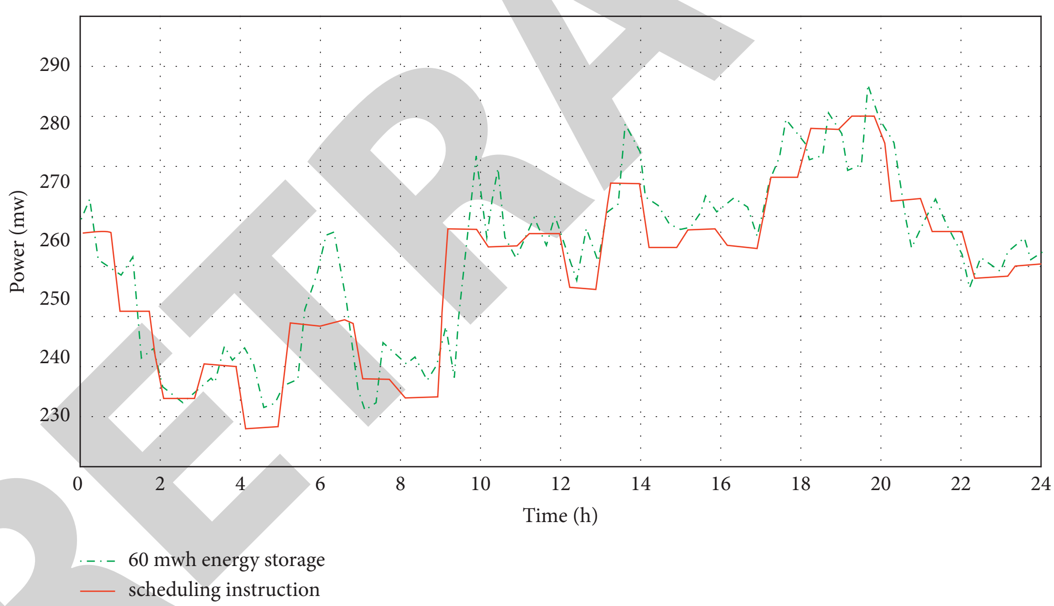

Figure 4: Effect diagram of wind/storage system composite output stabilization scheduling.

are all within the safe range. For an energy storage system with a configuration capacity of 60 MWh, almost all changes in its action amount are within 50% (10 MW) of the maximum rechargeable and discharge power.

Figure 7 shows the SOC fluctuation curves under configurations. When such configuration capacity is 30 MWh, the SOC fluctuation curve has a large amplitude and a high amplitude. The storage configuration capacity is 60 MWh, and the SOC fluctuation curve has a relatively gentle amplitude. In summary, the more stable the fluctuation, and the smaller the amplitude, so that the combined output of the wind/storage integrated power generation system can be as close as possible to the expected output.

There are many problems in the current centralized model test control center controller, such as large amount of calculation, weak robustness, and poor expansion ability. Model predictive control strategy is introduced to construct an MPC for improvement. The multi-agent distributed predictive control is carried out by taking each wind turbine as an independent agent. The cooperative control strategy of multi-agent distributed predictive control is formulated, and the effectiveness of the algorithm is verified by simulation experiments. Wind turbines are grouped according to the

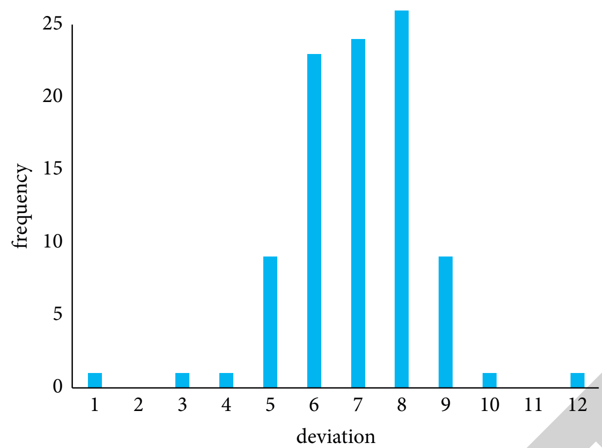

Figure 5: Statistical frequency distribution results of power deviation.

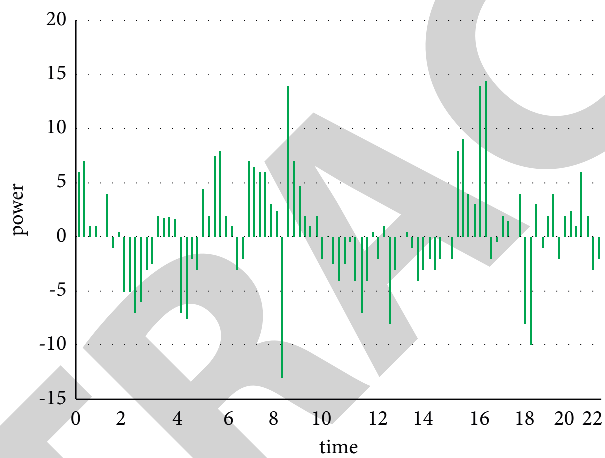

Figure 6: Action change diagram of energy storage system.

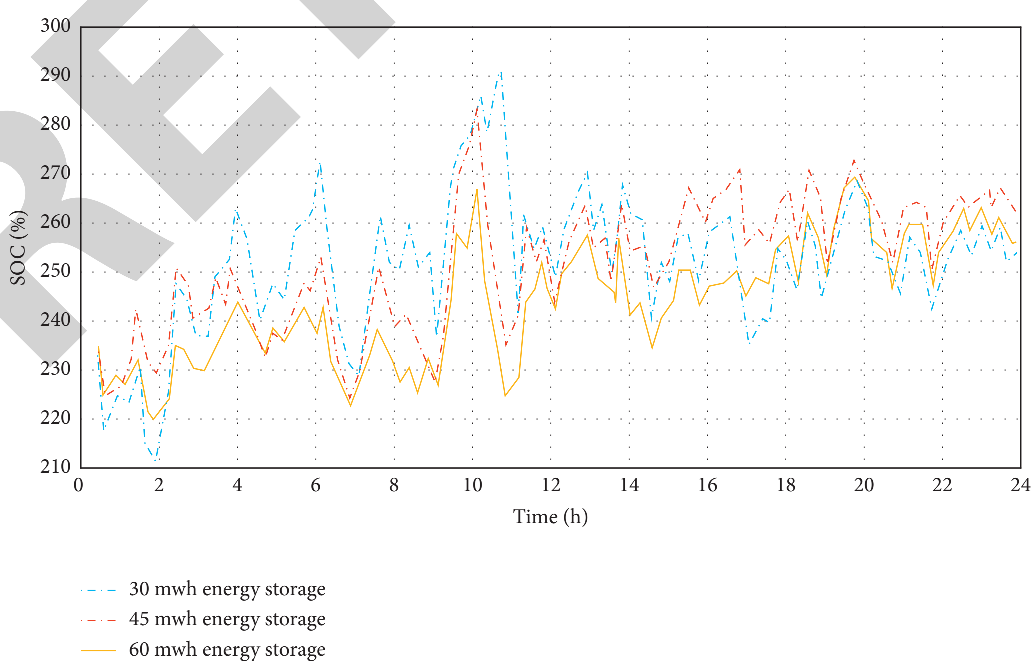

Figure 7: SOC fluctuation curve of energy storage system.

connection of power collection lines in the wind farm. The model not only makes the output of wind power/energy storage close to the dispatching command but also takes into account the power action constraint of the battery to ensure safe operation and optimize the objective function of the model. It also includes the minimum energy storage capacity and will have the operating cost of energy storage.

5. Conclusion

In this paper, the optimal scheduling of new energy power system with energy storage is studied. This model predictive control is introduced into a certain system and optimized by model predictive control strategy so that the combination can match the predetermined expectations. The objective of the control optimization is to output the minimum amount of action in the way of closing and one person storing the battery. The model predictive control is optimized and solved by rolling optimization and feedback correction, and the combined output of action commands of the energy storage integrated power generation system is schedulable. The optimized wind power/energy storage output will be the benign dispatching of the power grid. The control optimization objective is that the combined output force of wind power and energy storage can be close to the expected output prepared in advance and the action amount of energy storage battery is minimum. The model predictive control is optimized by rolling optimization and feedback correction, and the action command of the energy storage system is obtained. The energy storage output can effectively suppress the fluctuation of wind power. The combined output of the wind/storage integrated power generation system is schedulable, and the optimized wind storage output is equivalent to a benign schedulable power supply for the power grid. The optimal dispatching model of new energy power system with energy storage proposed in this paper plays an important role in improving the volatility and uncertainty caused by new energy grid connection. This model can not only reduce wind abandonment but also make the wind farm schedulable. It can also reduce the scheduling cost to a certain extent and improve the overall economy and reliability of the system.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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