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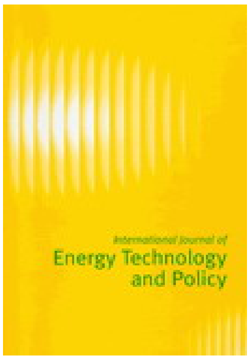

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Multi-objective capacity optimisation method for renewable energy generation systems based on artificial bee colony algorithm

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Abstract: In order to reduce energy loss and improve charging and discharging efficiency, a multi-objective capacity optimisation method for renewable energy power generation systems based on artificial bee colony algorithm is proposed. Firstly, build models for wind power, optoelectronics, and batteries. Secondly, a multi-objective capacity optimisation objective function for renewable energy generation systems is constructed from three aspects: the daily cost borne by power users, the volatility of wind and solar energy, and the energy loss of storage batteries, and constraint conditions are set. Finally, artificial bee colony algorithm is used to continuously search for new honey sources, in order to obtain the optimal solution of the optimisation objective function and achieve multi-objective capacity optimisation of the power generation system. The experimental results show that this method can effectively reduce the energy loss, the daily energy loss is about 0.1 kWh, and the charging and discharging efficiency is always above 91%.

Keywords: artificial bee colony algorithm; renewable energy; power generation system; multiple objectives; capacity planning.

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1 Introduction

With the continuous growth of global energy demand, renewable energy power generation systems have become one of the important means to solve energy problems and reduce environmental pollution (Brumana et al., 2022). Although traditional fossil fuels have advantages such as stability and controllability, the large amount of greenhouse gases such as carbon dioxide generated during their extraction and utilisation have brought serious pollution and damage to the environment. The renewable energy power generation system, on the other hand, mainly relies on natural energy sources such as solar energy, wind energy, and hydropower. It not only achieves zero emissions and low-carbon environmental protection, but also has many advantages such as wide resource distribution, strong renewability, etc. It will play an increasingly important role in the future energy system (Zhao et al., 2022; Elkadeem et al., 2021). However, due to the influence of weather, geography and other factors, the renewable energy generation system has instability and volatility in its power generation capacity, which brings many challenges to its practical application. For example, when the generation capacity of renewable energy generation systems is surplus, it will lead to energy waste and a decrease in the system's economic efficiency. When its power generation capacity is insufficient, it will affect the normal operation of the system and the quality of power supply (Bedadi and Gebremichael, 2021). Therefore, how to optimise the capacity planning of renewable energy generation systems, improve their economy and reliability, has become a hot topic of current research.

Liu and Liu (2021) propose a power generation system capacity optimisation method based on Modelica non-causal modelling. This method uses Modelica non-causal modelling to dynamically describe the random parameters of the power generation system, and optimises the capacity of the wind and solar energy storage power generation system layer by layer. Build an objective function with the goal of minimising the penalty cost for power fluctuations, and use operations planning algorithms to solve the objective function. However, the optimised method has a high energy loss and reduces practical application performance. Xu et al. (2021) propose a power generation system capacity optimisation method based on wavelet packet energy function. This method uses wavelet packet adaptive algorithm to decompose renewable energy generation power into low-frequency and high-frequency components, and serves as the expected power for renewable energy grid connection and power instructions for energy storage systems, respectively. By adding a wavelet packet energy spectrum function, the optimal boundary point interval between high-frequency and sub high-frequency power instructions for energy storage suppression was determined. Based on a detailed analysis of the economic performance of power generation, a capacity optimisation model for the power generation system is constructed to optimise the capacity of the power generation system. However, the power fluctuation of the power generation system is strong after the optimisation of this method. Zhang et al. (022b) propose a power generation system capacity optimisation method based on chaotic genetic algorithm. This method constructs a power generation system capacity optimisation model based on the maximum consumption of the power generation system, with the goal of minimising the peak valley load difference and maximising the grid connection profit. Using chaotic genetic algorithm to solve the optimisation model, the optimal solution for optimising power generation capacity is obtained. However, the efficiency of the power generation system fluctuates significantly after optimisation using this method.

In order to reduce energy loss and power fluctuations in power generation systems, a multi-objective capacity optimisation method for renewable energy generation systems based on artificial bee colony algorithm is proposed.

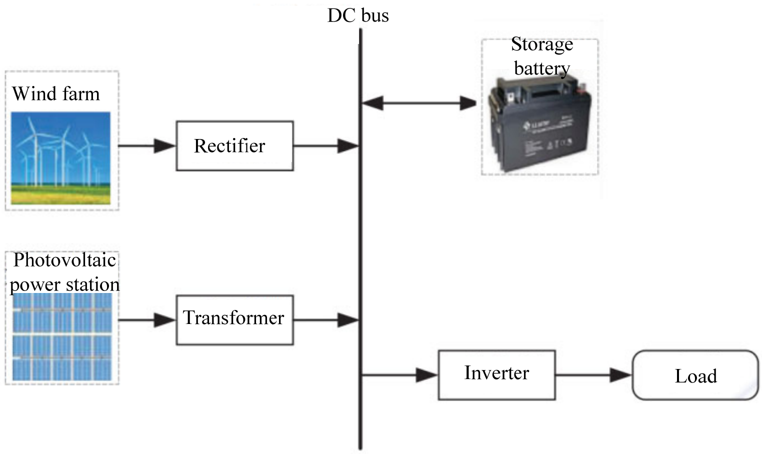
2 Analysis of the structure and principle of renewable energy power generation system

The renewable energy power generation system analysed in this analysis is mainly composed of wind farms, photovoltaic power stations, energy storage units, and busbar transformers. The topology structure of their connections is shown in Figure 1.

In the structure shown in Figure 1, the battery utilises the principle of electrochemical energy storage to directly store electrical energy. When the output power of wind and photovoltaic power generation systems exceeds the load demand, excess electrical energy will be stored in batteries. On the contrary, when the output power of wind and photovoltaic power generation systems is less than the load demand, the battery will release the stored energy to supplement the insufficient load demand. In this way, batteries can play an important role in the operation of the power system, achieving the storage and regulation of electrical energy. This method can not only improve the stability and reliability of the power system, but also effectively utilise renewable energy, reduce dependence on traditional fossil fuels, and achieve sustainable development (Zhang et al., 2021, 2022a; Verastegui et al., 2021).

In order to fully understand the situation of each component in the renewable energy power generation system and improve the effectiveness of multi-objective capacity optimisation of the power generation system, the mathematical models of each component are constructed.

Figure 1 Topological structure of renewable energy power generation system (see online version for colours)



When optimising the multi-objective capacity of renewable energy generation systems, wind power models, photovoltaic models, and battery models each have unique performance advantages. Wind power models can maximise the utilisation of wind energy resources and determine the optimal configuration and capacity of wind power generation devices by considering factors such as geographical location and meteorological conditions. The photovoltaic model uses solar energy as its energy source, which has universality and wide applicability. It can flexibly arrange photovoltaic modules to capture solar energy and provide stable power output. The battery model serves as an energy storage device with energy storage and regulation capabilities, which can balance grid demand, reduce energy waste, and improve the efficiency of the energy system. By comprehensively using these three models, the renewable energy power generation system can make full use of Renewable resource, achieve multi-objective capacity optimisation, and improve the reliability, resource utilisation efficiency and sustainability of the system.

2.1 Wind power model

The effectiveness of wind power generation is influenced by the actual wind speed at the hub and the actual operating characteristics of the wind turbine. Therefore, the calculation formula for wind power output is constructed as follows:

$$P_W = \begin{cases} 0, & v < v_{ci} \parallel v \geq v_{co} \\ P_{WR} \cdot \dfrac{v^3 - v_{ci}^3}{v_r^3 - v_{ci}^3}, & v_{ci} \leq v < v_r \\ P_{WR}, & v_r \leq v \leq v_{co} \end{cases} \tag{1}$$

In the formula, v represents the actual wind speed, v_{ci} represents the cut-in wind speed, v_{co} represents the cut-out wind speed, and v_r represents the rated wind speed (Zhang, 2022).

2.2 Photoelectric model

The effectiveness of photovoltaic power generation is influenced by the actual radiation illuminance and the operating temperature of photovoltaic modules. The calculation formula for photovoltaic power generation output is:

$$P_{PV} = P_{PVR} \cdot \frac{I_T}{I_{stc}} \cdot \left[1 - \varepsilon \cdot \left(T_{PV} - T_{stc}\right)\right] \tag{2}$$

In the formula, P_{PV} represents the actual output power of photovoltaic power generation, P_{PVR} represents the rated power of photovoltaic power generation, I_T represents the irradiance of the inclined plane, I_{stc} represents the standard irradiance, ε represents the temperature correction coefficient, T_{PV} represents the actual operating temperature of the photovoltaic module, and T_{stc} represents the standard condition temperature (Hajialigol et al., 2021).

In the actual working process of photovoltaic units, there are many factors that affect temperature. In order to obtain accurate actual temperature results, the following equation is used for calculation:

$$T_{PV} = T_{amb} + \left(T_{com} - T_{ref}\right) \cdot \frac{I_T}{I_{ref}} \tag{3}$$

In the formula, T_{amb} represents the ambient temperature, T_{com} represents the rated operating temperature, T_{ref} represents the reference temperature, and I_{ref} represents the reference irradiance.

2.3 Battery model

The battery model and its operational constraints are:

$$E_{bat}(t) = E_{bat}(t-1) + P_{bat.c}(t) \cdot \eta_{bat.c} \cdot \Delta t \tag{4}$$

$$E_{bat}(t) = E_{bat}(t-1) - \frac{P_{bat.d}(t)}{\eta_{bat.d}} \cdot \Delta t \tag{5}$$

$$\left(1 - \sigma_{DOD}\right) \cdot E_{bat.\max} \le E_{bat}(t) \le E_{bat.\max} \tag{6}$$

In the formula, $E_{bat}(t-1)$ and $E_{bat}(t)$ represent the capacity of the battery before and after charging and discharging, $E_{bat.\max}$ represents the maximum capacity of the battery, $P_{bat.c}(t)$ and $P_{bat.d}(t)$ represent the charging and discharging power of the battery, $\eta_{bat.c}$ and $\eta_{bat.d}$ represent the charging and discharging efficiency of the battery, and σ_{DOD} represents the discharge depth of the battery (Ding et al., 2021).

3 Multi-objective capacity optimisation of renewable energy generation system based on artificial bee colony algorithm

After completing the construction of the above model, a comprehensive understanding of the performance of renewable energy power generation systems was gained. In order to achieve multi-objective capacity optimisation of renewable energy generation systems, the decision variables are the daily cost borne by power users, the volatility of wind and solar energy, and the energy storage loss of batteries. The constraints are the power balance constraints, battery constraints, and interconnection line exchange power constraints of the renewable energy generation system, Construct a multi-objective capacity optimisation function for renewable energy generation systems under the above conditions.

In the multi-objective capacity optimisation of renewable energy power generation system based on artificial bee colony algorithm, it is reasonable to take the comprehensive efficiency of wind and solar energy, energy loss and charging and discharging efficiency as the objective function. Maximising the comprehensive efficiency of wind and solar energy can improve the effective utilisation of wind and solar energy resources in the system. Minimising energy loss can reduce waste in energy conversion and transmission processes. Maximising the charging and discharging efficiency can realise efficient energy storage and release of the battery system. Assuming that power balance constraints, battery constraints and tie line exchange power constraints are met, multi-objective optimisation of renewable energy power generation system can be achieved by optimising the objective function, improving the energy conversion efficiency of the system, reducing energy loss, and optimising the charging and discharging efficiency of the battery to achieve efficient operation of the system.

3.1 Multi-objective capacity optimisation objective function

On the premise of ensuring the normal operation of the power generation system, it is necessary to minimise the daily costs borne by power users (Li et al., 2021). In order to accurately calculate costs, the expenses borne by power users are converted into three parts: the initial cost of renewable energy generation system, maintenance cost, and electricity purchase and sales cost per day. The calculation formula is:

$$f_1 = C_{pv1} + C_{w1} + C_{ess1} + C_{pv2} + C_{w2} + C_{ess2} + C_g \tag{7}$$

In the formula, f_1 represents the daily economic cost borne by each household, C_{pv1} represents the initial investment cost of the daily photovoltaic unit, C_{w1} represents the initial investment cost of the daily wind turbine unit, C_{ess1} represents the investment cost of the daily energy storage battery, C_{pv2} represents the maintenance cost of the daily photovoltaic unit, C_{w2} represents the maintenance cost of the daily wind turbine unit, C_{ess2} represents the maintenance cost of the daily battery, and C_g represents the total cost of purchasing and selling electricity.

In the process of electric energy scheduling, batteries are prone to energy loss and resource waste. Therefore, based on the normal operation of renewable energy generation systems, multi-objective optimisation of energy storage capacity should also be carried out to minimise energy loss. The calculation formula for battery energy loss is:

$$f_2 = \sum_{t=1}^{T} \left[P_{bat.c}(t) \frac{1-\eta_{bat.c}}{\eta_{bat.c}} \Delta t + P_{bat.d}(t)\left(1-\eta_{bat.d}\right)\Delta t \right] \tag{8}$$

In the formula, T represents the number of sampling points within a day, and Δt represents the interval between sampling points (Tabatabaei et al., 2022).

The fluctuation of the comprehensive power of wind and solar energy is represented by the square of the difference in power change before and after mixed energy storage stabilisation and the original power. The specific expression is:

$$\begin{cases} f_3 = \dfrac{\sum_{t=1}^{T} \left[P_{DG}(t) - P_{DG}(t-1)\right]^2}{\sum_{t=1}^{T} P_{DG}(t)} \\ P(t) = P_v(t) + P_w(t) \\ P_{DG}(t) = P(t) + P_b(t) + P_c(t) \end{cases} \tag{9}$$

In the formula, f_3 represents the fluctuation level of the comprehensive power of wind and solar energy, $P_{DG}(t)$ represents the comprehensive power of wind and solar energy after mixed energy storage compensation, $P(t)$ represents the comprehensive power of wind and solar energy, and $P_v(t)$ and $P_w(t)$ respectively represent the photovoltaic power and wind power.

3.2 Constraint condition

After completing the construction of multiple objective functions for energy storage optimisation, construct constraints for the objective functions. Firstly, implement power balance constraints for renewable energy generation systems. During the operation of renewable energy generation systems, it is necessary to ensure that the power generated by each component is in a balanced state.

$$P_1 L = P_v + P_w + P_b + P_g \tag{10}$$

In the formula, P_g represents the interaction power between the user and the power grid at time t.

Secondly, constrain the battery. In order to ensure the normal operation of the power generation system, the charging and discharging power of the battery should be within a certain range at any time. In addition, the state of charge (SOC) of a battery represents the ratio of remaining energy to rated capacity. In order to extend the energy storage life of the battery, it is necessary to ensure that the (SOC is within the allowable range.

$$\begin{aligned} P_{b,\min} \le P_b(t) \le P_{b,\max} \\ P_{c,\min} \le P_c(t) \le P_{c,\max} \end{aligned} \tag{11}$$

$$\begin{cases} SOC_{b,\min} \le SOC_b(t) \le SOC_{b,\max} \\ SOC_{c,\min} \le SOC_c(t) \le SOC_{c,\max} \end{cases} \tag{12}$$

Thirdly, perform power constraints on the exchange of interconnection lines. The interaction power on the contact line should be within the exchange limits allowed for the operation of the power generation system, in order to ensure the stable operation of the renewable energy power generation system.

$$P_{g,\min} \le P_g(t) \le P_{g,\max} \tag{13}$$

Finally, perform power constraints on wind and solar energy. The power generated by photovoltaic and wind turbines needs to be within a certain upper and lower power range.

$$\begin{cases} P_{v,\min} \le P_v(t) \le P_{v,\max} \\ P_{w,\min} \le P_w(t) \le P_{w,\max} \end{cases} \tag{14}$$

3.3 Solving multi-objective optimisation functions based on artificial bee colony algorithm

After completing the construction of the multi-objective capacity optimisation objective function for renewable energy generation systems, the objective function is solved. At present, the commonly used swarm intelligence optimisation algorithms include artificial bee colony algorithm, genetic algorithm, particle swarm optimisation algorithm, etc. The artificial bee colony algorithm is relatively simple, with good global search ability and strong robustness.

The artificial bee colony algorithm has significant advantages in solving the objective function of multi-objective capacity optimisation in renewable energy generation systems. First of all, it is suitable for solving multi-objective optimisation problems, and can effectively balance power generation efficiency, cost and carbon footprint and other goals. Secondly, the artificial bee colony algorithm has strong global search ability, which can find potential optimal solutions throughout the entire search space and avoid falling into local optima. In addition, the algorithm has adaptability and robustness, and can flexibly adjust search strategies based on problems and environmental changes to cope with the complexity and uncertainty of the problem. Finally, artificial bee colony algorithm is suitable for parallel computing, which can search for multiple solutions in parallel and share updated information, thereby improving solution speed and efficiency. Therefore, the artificial bee colony algorithm is the choice of multi-objective capacity optimisation objective functions for renewable energy generation systems, which can achieve efficient and high-performance solution results.

Artificial bee colony algorithm is developed to solve multivariable function optimisation problems, derived from the honey picking behaviour of bee colonies, characterised by simple operation and high global search ability. The main process of solving multi-objective capacity optimisation functions for renewable energy generation systems using artificial bee colony algorithm is as follows:

3.3.1 Collecting bees to find new sources of honey

The process of solving optimisation problems can be seen as a search process in the D-dimensional space. The location of each honey source represents a possible solution to the problem. The relationship between bee picking and honey source is one-to-one correspondence, and the bee picking relative to the second honey source searches for a new honey source according to the following formula:

$$x_d^i = x_{id} + \phi_{id}\left(x_{id} - x_{kd}\right) \tag{15}$$

In the formula, x_{id} represents the value of the d^{th} variable in the i^{th} honey source, and ϕ_{id} represents a random number within the range of [–1, 1].

3.3.2 Observing bees searching for new honey sources based on the honey sources they collect

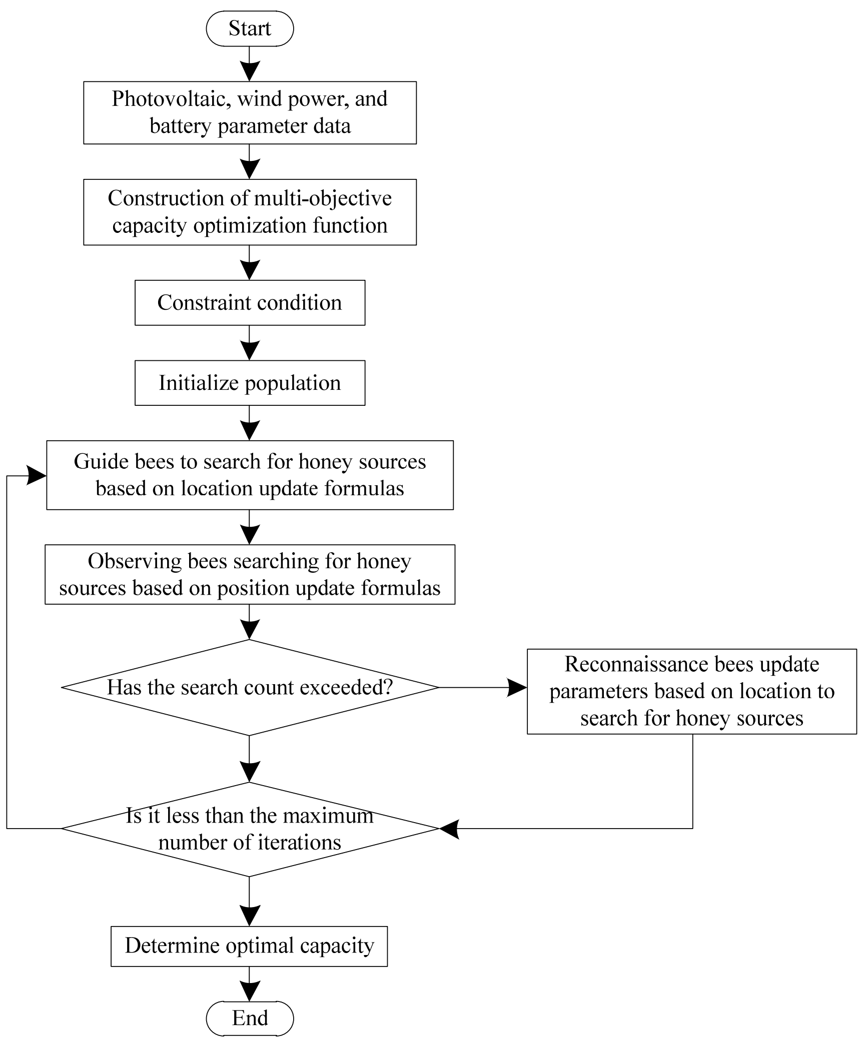
Each observing bee selects a honey source based on probability, and the calculation formula for probability is:

$$P_i = \frac{F_i}{\sum_{j=1}^{N} F_j} \tag{16}$$

In the formula, both F_i and F_j represent the fitness values of possible solutions.

For the selected honey source, observe the bee to search for new possible solutions according to formula (14).

Figure 2 Multi-objective capacity optimisation process for renewable energy generation system based on artificial bee colony algorithm



Dynamically adjusting the search space based on the distribution of the optimal solution can accelerate convergence and more effectively explore the optimal solution by narrowing the search space or focusing on potential solution areas. When all honey bees and observation bees search the entire search space, if the fitness value of a honey source does not improve within the given step, the honey source is discarded, and the corresponding honey bee is a reconnaissance bee. The reconnaissance bee continues to search for a new honey source using the following formula:

$$x_{id} = x_d^{\min} + \omega\left(x_d^{\max} - x_d^{\min}\right) \tag{17}$$

In the formula, ω represents a random number, while $x_d^{\min}$ and $x_d^{\max}$ represent the minimum and maximum values of the variable, respectively.

When bees search for new honey sources, the formula for updating their position determines whether they can quickly find a more suitable honey source. In this study, a global factor was introduced into the formula for updating the position to expand the search range:

$$x'_{id} = x_{id} + \phi_{id}\left(x_{md} - x_{kd}\right) + \varphi\left(x_{best,d} - x_{id}\right) \tag{18}$$

In the formula, φ represents the influencing factor, and $x_{best,d}$ represents the honey source with the highest abundance in the entire honey source.

In this study, the artificial bee colony optimisation algorithm utilised the advantage of information sharing between different seals and introduced a global factor ($x_{best,d} - x_{id}$) in position update, enhancing the directionality and purposefulness of bee search for honey sources. The distance between the current position and the optimal honey source position was adjusted by the step size of the influence factor φ. The multi-objective capacity optimisation process of the power generation system is shown in Figure 2.

Through the above calculations, based on wind, solar, and battery models, calculate the daily cost borne by power users, the fluctuation of wind and solar energy, and the energy loss of batteries, and construct a multi-objective capacity optimisation objective function for the power generation system. After setting the constraint conditions of the objective function, the artificial bee colony algorithm is used to calculate the optimal solution, thereby completing the multi-objective capacity optimisation of the renewable energy generation system.

4 Experimentation

4.1 Experimental environment and data

Taking a renewable energy power generation system as the research object, typical daily photovoltaic and wind power data were selected, with a sampling period of 15 minutes. The rated output power of wind power generation was 22 kW, and the rated output power of photovoltaic power generation was 18 kW. The typical daily photovoltaic and wind power generation power and load power consumption are shown in Figure 3.

The parameters of photovoltaic and wind power generation are shown in Table 1.

The battery parameters are shown in Table 2.

Figure 3 Typical daily photovoltaic and wind power generation power and load electricity consumption data

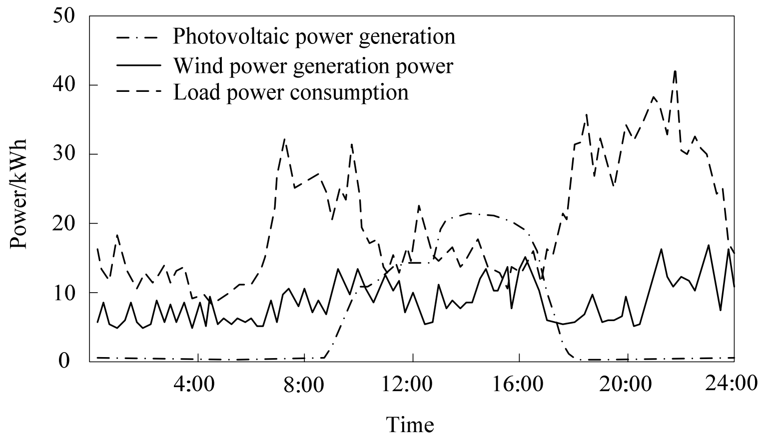


Table 1 Photovoltaic and wind power generation parameters

Parameter	*Unit*	*Photovoltaics*	*Wind power generation*
Rated output power	kW	18	22
Conversion efficiency	%	15-20	30–50
Area/rotor diameter	m^2/m	1.6/4	-
Rated speed	rpm	-	200–600
Cutting wind speed	m/s	-	3–5
Rated wind speed	m/s	-	10–15
Cut out wind speed	m/s	-	25–30

Table 2 Relevant parameters of battery

Project	*Parameter*
Power cost coefficient/(yuan/kW)	2,700
Capacity cost coefficient/(yuan/kWh)	4,500
Operation and maintenance coefficient/(yuan/kW)	155
Charging and discharging efficiency/%	90
State of charge/%	20~80

4.2 Experimental scheme

In order to fully prove the practical application performance of the optimisation method in this paper, the method in this paper is compared with the methods in Xu et al. (2021) and Zhang et al. (2022b), with the wind and solar comprehensive efficiency, energy loss, and charge and discharge efficiency as indicators.

- Fluctuation of wind and solar integrated power: Wind and solar integrated power refers to the fluctuation degree of the total power generated by solar panels and wind turbines, and the lower the fluctuation degree, the stronger the optimisation performance.

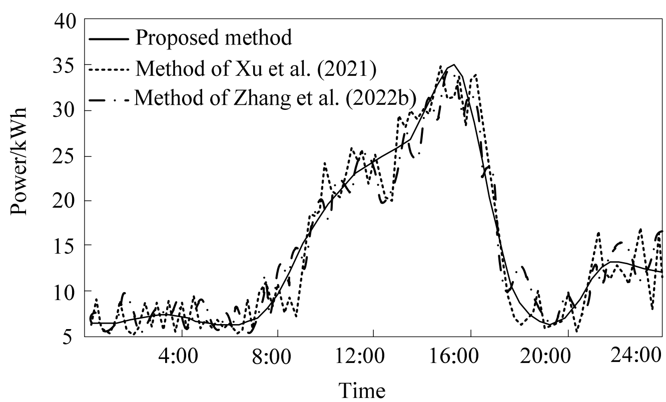
- Energy loss: Energy loss mainly includes line loss, generator loss, transformer loss, inverter loss, and other equipment losses. The lower the energy loss, the better the optimisation effect.
- Charging and discharging efficiency of the power generation system: Charging and discharging efficiency refers to the energy conversion efficiency of the power generation system during the charging and discharging process. The higher the charging and discharging efficiency, the higher the utilisation rate of the power generation system.

4.3 Experimental results

4.3.1 Fluctuation of wind and solar comprehensive power

The fluctuation of wind and solar comprehensive power is caused by the changes and instability of solar and wind resources. With changes in weather conditions, the fluctuation of wind and solar comprehensive power can also occur. In addition, factors such as equipment loss, grid load, and management may also lead to fluctuations in wind and solar comprehensive power. In order to maximise the utilisation of renewable energy and ensure stable power supply, this method is compared and validated with the methods in Xu et al. (2021) and Zhang et al. (2022b), using the fluctuation of wind and solar comprehensive power as an indicator. The comparison results are shown in Figure 4.

Figure 4 Fluctuation of wind and solar integrated power

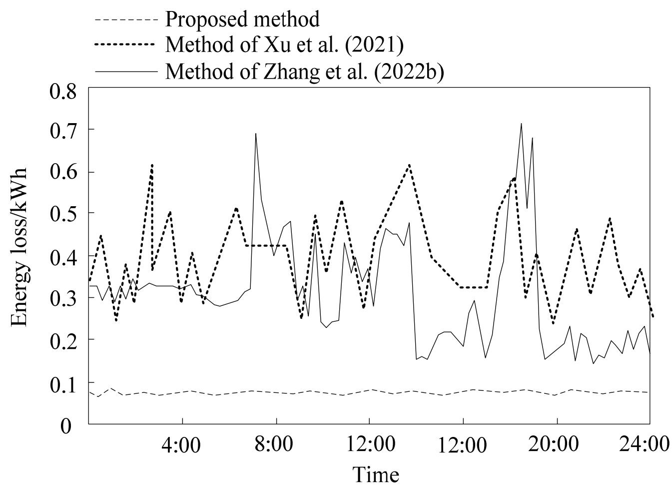


From the results shown in Figure 4, it can be seen that the trend of changes in the comprehensive power of wind and solar power under the optimisation of the three methods is basically consistent. However, the power fluctuation of the method in this paper is relatively small over time, and the fluctuation of the comprehensive power of wind and solar power of the methods in reference Xu et al. (2021) and Zhang et al. (2022b) is relatively large. Therefore, it indicates that the method proposed in this paper can effectively suppress power fluctuations in renewable energy power generation systems and improve the operational performance of the power generation system.

4.3.2 Energy loss

Energy loss means waste of energy and an increase in emissions, which is not conducive to sustainable development. Reducing energy loss can also improve the reliability and economy of power generation systems. Energy loss can lead to issues such as voltage reduction and line overload during power transmission, thereby affecting the stability and quality of power supply. At the same time, energy loss will also increase the cost of electricity and reduce the economic benefits of the power generation system. Therefore, taking the energy loss of the power generation system as an indicator, the method proposed in this paper is also compared and validated with two literature methods. The daily energy loss results of the three methods are shown in Figure 5.

Figure 5 Daily energy loss



Observing the daily energy loss results shown in Figure 5, it can be seen that over time, the energy losses of the three methods show significant changes. Among them, the energy loss of the method in this paper is basically stable at around 0.1 kWh, while the energy loss results of the methods in Xu et al. (2021) and Zhang et al. (2022b) are higher and have poor stability. The energy loss of Zhang et al. (2022b) method is the highest among the three methods, reaching over 0.7 kWh.

4.3.3 Charge-discharge efficiency

The higher the charging and discharging efficiency of the power generation system, the better, because high efficiency means less energy waste and less environmental pollution. High efficiency can also help reduce energy costs and improve system reliability. Therefore, based on the charging and discharging efficiency as an indicator, the method proposed in this paper is compared and validated with the methods in Xu et al. (2021) and Zhang et al. (2022b). The charging and discharging efficiency results of the power generation system under three methods are shown in Table 3.

From Table 3, it can be seen that the charging and discharging efficiency of the method in this article is the highest among the three methods, consistently maintaining over 91%. However, the charging and discharging efficiency of the methods in reference Xu et al. (2021) and Zhang et al. (2022b) is lower than that of the method in this article. The charging and discharging efficiency of the method in Xu et al. (2021) is always above 73%, while the charging and discharging efficiency of the method in Zhang et al. (2022b) is always above 81%. Therefore, it indicates that the method proposed in this paper can improve the charging and discharging efficiency of power generation systems.

Table 3 Comparison results of charging and discharging efficiency

Number of experiments	*Charge-discharge efficiency/%*		
	Proposed method	*Xu et al. (2021) method*	*Zhang et al. (2022b) method*
1	92.3	73.5	81.8
2	91.5	73.2	82.1
3	93.0	73.8	81.5
4	91.8	72.7	82.0
5	92.6	73.4	81.9
6	92.0	73.1	82.3
7	93.2	73.7	81.7
8	91.9	73.0	82.2
9	92.7	73.6	81.6
10	92.1	73.3	82.4

5 Conclusions

In order to improve the capacity optimisation effect of renewable energy power generation systems, a multi-objective capacity optimisation method for renewable energy power generation systems based on artificial bee colony algorithm is proposed. The performance of the method was verified from both theoretical and experimental perspectives. This method has high charging and discharging efficiency and low energy loss in the multi-objective capacity optimisation process of renewable energy generation systems. Specifically, compared with the method based on wavelet packet energy function, the charging and discharging efficiency of this method is significantly improved, always maintaining above 91. Compared with the optimisation method based on chaotic genetic algorithm, the energy loss of our method is significantly reduced, and the energy loss of our method is basically stable at around 0.1 kWh.

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