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The Influence of Ant Colony Algorithm on the Power Distribution Scheme of Thermal Power Plants

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Abstract. The power distribution scheme of thermal power plants can balance the power flow voltage and current in the station area to ensure the stability of power grid operation, and the changes in power distribution scheme such as new energy, dwarf, wind power, wind power, etc., to ensure the quality of power supply of the whole power grid, but in the process of thermal power grid distribution, there are interference factors such as a large amount of data, difficulty in data analysis, and stability of new energy power generation, which affect the effectiveness of the entire distribution scheme In the mediation process of new energy sources such as photovoltaics, the stability of voltage and current is improved, kept between 90% ~ 95%, and the current of the power grid is effectively constrained to avoid the problem of excessive current and voltage, and the accuracy of power distribution is improved, and the improvement rate reaches 10~20%. Compared with the previous algorithms, it is found that the algorithm can shorten the power distribution time of thermal power plants and keep it between 5~6 seconds. Therefore, the ant colony algorithm can optimize the power distribution scheme of thermal power plants and support the grid connection of new energy.

Key words. Thermal Power Plant, Power Distribution, Ant Colony Algorithm, Energy Balance.

1. Introduction

The power distribution system of thermal power plant is one of the most basic energy supply systems in modern society, and the stability and security of its power grid operation are essential [1], [2]. The power distribution scheme of thermal power plants is the planning of the operation of its distribution system, and it is also an important prerequisite for the scheduling of thermal power plants, so as to improve the quality of new energy power supply [3], [4], especially the voltage and current connected to the grid. Therefore, the thermal power grid distribution scheme is an important part of the stable operation of the power grid. Ant colony algorithm is an optimization algorithm that simulates the behavior of real ant colonies, which can solve complex system optimization problems and play an important role in the process of power generation allocation and scheduling, but its application in the optimal scheduling of power distribution system of thermal power plants is controversial [5]. Due to the increasing number of sensors in thermal power grids and the continuous advancement and improvement of embedded technologies in photovoltaic and wind energy, the distribution schemes of thermal power plants are becoming more complex and involve more data [6]. The perception, self-regulation and easy monitoring capabilities of the thermal power grid distribution scheme can improve the stability of thermal power grid distribution and maintain the power flow balance between different stations. Some scholars have analyzed the thermal power grid distribution scheme, and found that the grid connection of photovoltaic energy and wind energy will affect the stability of the entire distribution network, and the power generation of wind energy and photovoltaic itself also has randomness, which is affected by factors such as natural environment and climate, so the main goal of the thermal power grid distribution scheme is to carry out the balanced processing of monitoring data and the analysis of factors, and some intelligent methods such as The K-clustering method and the random search method of the police force thermal power grid distribution scheme can not identify the problem anomalies and fault points, and the wide application of the military algorithm in the power system and its own iterative computing advantages are suitable for the analysis of the distribution scheme of the thermal power grid at the theoretical level, but some scholars believe that the topological variability of the distribution scheme of the State Grid is large, and the limited data processing capacity cannot realize the demand for continuous expansion and increase in the scale of the power grid [7], [8], so it is the focus of the current research to verify whether the ant colony algorithm is effective and the degree of optimization of the thermal power grid distribution scheme is the focus of the current research. Then, the overall situation and comprehensive analysis of the thermal power grid are judged to form the clustering points of the thermal power grid, and then the eigenvalue analysis of each clustering point is carried out to find out the optimal set of the thermal power grid operation scheme and compare it with other sets, and finally, the thermal power grid distribution scheme is proposed, and finally, the integrity and logic of the thermal power grid distribution scheme are verified, and the final solution strategies and methods are proposed, so as to provide support for the stability of the thermal power grid distribution scheme and the integration and connection of photovoltaic energy [9].

In this paper, the swarm algorithm is used as the support for analysis, the data of the power grid are collected first, and then the iterative relationship is comprehensively judged and the effective results are finally output, so as to improve the effectiveness of the whole analysis, aiming to promote the stability of thermal power grid adjustment, which is supported by the theoretical level.

2. Mathematical Description of the Problem of Thermal Grid Distribution Scheme

The problem of grid connection is not only the regulation of the whole unit and the regulation of wind power and photovoltaic power grid, but also the comprehensive result of external interference factors, so it is necessary to better identify the process of grid connection of thermal power grid, reduce its energy consumption, and improve its comprehensiveness is a complex process, which requires intelligent algorithms as an aid to finding the key points, so as to save the data points of the rocket grid connection, improve the power flow and voltage stability in the future, so it is necessary to describe the problems in the grid connection of the thermal power grid mathematically, brighten the nodes and problems involved, and find the best solution through intelligent search and iterative analysis.

A. Balance of Current and Voltage in the Power Grid

The optimal scheduling of the distribution system of thermal power plants refers to the scheduling and optimization of current, load and power flow in the power grid under the premise of meeting the power supply demand, so as to improve the quality of power supply, reduce the cost of renewable energy grid connection, enhance the stability of photovoltaic power generation and thermal power generation, and improve the reliability of the scheme. Hypothesis 1: The power flow stabilizes in a positive direction, the interaction between the voltage changes up and down $V_a(t)$, the amount of photovoltaic renewable energy incorporated is m_1, and the total mass of renewable energy incorporated is m_2. The power flow simulation is a sinusoidal slope, and the relationship between the power flow and the voltage and current is:

$$y(t) = A\sin(\omega t) + A \to V_a(t) \tag{1}$$

where the voltage change is V, the current change is $I = 2V\pi R(R$ the radius of the voltage change), the correlation degree is l, $y(t)$ is the instantaneous voltage, then the degree of change of the power flow is $\omega = \frac{2\pi v}{l}$, and the grid-connected process of renewable energy is shown in Figure 1.

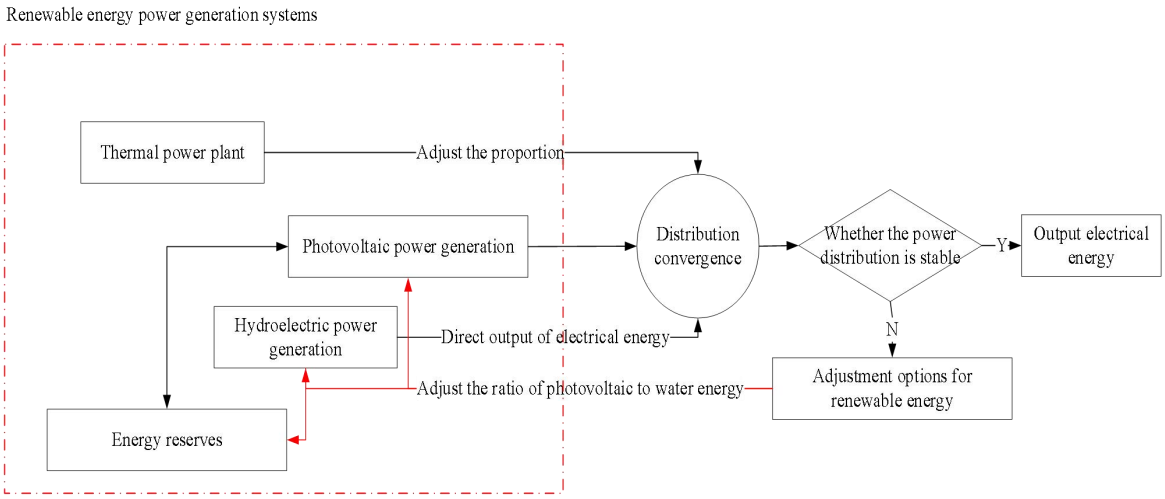


Figure 1. The Process of Generating Electricity from Renewable Energy

The power distribution scheme of thermal power plants is affected by many factors such as power generation, transmission, distribution, and load during operation. Therefore, the optimal scheduling method of the thermal power plant distribution system needs to consider the influence of multiple factors, and at the same time, it is necessary to ensure the safety and stability of the system operation.

The optimal scheduling method of thermal power plant distribution system based on ant colony algorithm applies the above principles to abstract the equipment, load and energy in the thermal power plant distribution system into pheromones, evaluate the quality of nodes according to the pheromone concentration of each node in the system, and selects the strategy of the optimal node for optimization. The application method of ant colony algorithm in the power distribution system of a thermal power plant will be introduced below. In the process of grid connection throughout the grid, the proportion of renewable energy such as photovoltaic and wind power generation is gradually increasing, which also increases the instability of the whole grid regulation. How to balance the relationship between the proportion of photovoltaic energy and the stability of the power grid is the focus of current research, in which the power flow and voltage are the key indicators in the process of grid connection, how to find the key points that affect the power flow and voltage of the entire

power grid, and timely adjust the load and power are the main points of balancing and balancing the power grid its cleanliness.

B. Grid-connected Regulation of Renewable Energy by Ant Colony Algorithm

Power flow equilibrium after grid connection, the grid connection analysis of renewable energy grids can be analyzed according to the principle of power flow balance:

$$k_1 x_1(t) - F_a(t) = m_1 \cdot x_1^{"} \cdot (t) \tag{2}$$

Among them are the power flow of thermal power grid, the $F_a(t)$ power flow of renewable energy grid connection, and the $m_1 x_1^{"}(t)$ balanced power flow after grid connection.

After grid connection, the voltage stability is analyzed, and the corresponding voltage balance is constructed according to the way of voltage difference, and the formula is as follows:

$$_a \cdot (\ ) - \ _i \cdot \ _i(\ ) - \ _i \cdot v_{i+1}(\ ) = \ _i \cdot \ _{i+i}^{"}(t) \tag{3}$$

Among them, $k_i v_i(t)$ it is the voltage of the photovoltaic power grid and $k_i v_{i+1}(t)$ the voltage of the wind power grid. Due to the influence of random factors such as weather, policy, etc., the change in voltage is:

$$v_1(t) + v_2(t) = y(t) \tag{4}$$

The ant colony algorithm can find a general solution for the balance adjustment after grid connection:

$$v_2(t) = \frac{[c_1 \cdot \cos(\omega_n \cdot t) + c_2 \cdot \sin(\omega_n \cdot t)]}{n} + \frac{k_i \cdot A}{\sum k_i} \tag{5}$$

The voltage regulation factor of different lines is k_i, then the voltage variation of renewable energy is as follows:

$$\frac{k_1 \cdot A - A \cdot m_i \cdot \omega^2}{\sum k_i - \sum m_i \cdot \omega^2} \cdot \sin(\omega \cdot t) \tag{6}$$

Since different factors cause voltage changes, the average value of the voltage is analyzed, and the results are as follows:

$$\omega_n^2 = \frac{\sum k_i \cdot \omega^2}{\sum m_i} \tag{7}$$

Voltage stability is also a requirement after grid connection, so stability adjustment is mainly carried out for stability analysis in different time periods, and the results are as follows.

$\Delta v_i(0) = 0, \Delta v_{i+1}(0) = 0$ Rule:

$$c_i = -\frac{k_1 A}{\sum k_i} \tag{8}$$

Among them is the stability of power flow after grid connection, such as the stability of photovoltaic and wind power grid connections. In addition, the stability of the entire power grid was analyzed, and the results were as follows.

$$\sum c_i = -\frac{\omega}{\omega_n} \times \frac{k_1 \cdot A - A \cdot m_1 \cdot \omega^2}{\sum k_i - \sum m_i \cdot \omega^2} \tag{9}$$

The stability analysis of the entire power grid is the $\sum c_i$ grid-connected stability of the entire power grid.

C. Power Load Scheduling

Power load scheduling refers to adjusting the power generation and power supply plan according to load changes, and the ant colony algorithm finds the renewable energy point with the highest power flow fluctuation by collecting power flow changes, and adjusting the surrounding voltage to balance the power flow of the entire power grid, so load scheduling is also an important part of the scheme adjustment, as follows.

$$c(t) = k_3 \cdot v_2(t) \tag{10}$$

The relationship between the change of load and the power flow is as follows:

$$\sum c_i(t) = c_i(t) \cdot \tan\theta(t) \tag{11}$$

The stability monitoring of the distribution load of the thermal power plant is carried out, and the indicators and operation of power flow, voltage and current are evaluated according to the operating conditions. At the same time, the ant colony algorithm simplifies the complex and changeable state data, and continuously adjusts the parameters to realize the selection of power distribution schemes for thermal power plants. The integration rate between photovoltaics, wind power grids and thermal power generation is $\theta(t)$ that the optimal load regulation analysis is as follows:

$$\tan\theta(t) = A \cdot \omega \cdot \cos(\omega \cdot \mathrm{t}) \tag{12}$$

The adjustment of the temporary load is as follows:

$$c_i(t) = \frac{\sum k_i}{k_{i+1}} \cdot c(t) \tag{13}$$

The balance between the scenario and the load is as follows:

$$M(t) = c_i(t) \tag{14}$$

Scheduling optimization formula for the available load of the simultaneous formula:

$$M(t) = A \cdot R \cdot \omega(k_i) \cdot \cos(\omega t) \cdot \begin{vmatrix} c_i & \omega_n & A \\ k_i & m_i & 1 \\ 0.53 & 0 & \sin(t) \end{vmatrix} \tag{15}$$

Among them, the R optimal starting scheme, the best load distribution, and the best shutdown scheme for the generator set are determined for the scheduling parameters of different loads. In the process of load regulation, the corresponding scheme is selected according to the level of voltage, power flow and current changes, and finally the purpose of balancing power flow and controlling voltage and current is achieved.

D. Proportion of Renewable Energy in the Distribution of Thermal Power Plants

A large number of survey results show that the stability of the distribution network of thermal power plants is the key indicator, increasing the proportion of renewable energy, and reducing energy consumption are auxiliary indicators, so the energy consumption of the distribution network should be calculated, as follows:

(1) Ratio of photovoltaic and wind energy consumption

$$\sum c_i = c_i(t)\cdot\alpha + c_j(t)\cdot\beta \tag{16}$$

Among them are the energy consumption of photovoltaics, the $c_j(t)\cdot\beta$ energy consumption of wind power, and the $\sum c_i$ total energy consumption of the two.

(2) The ratio of energy consumption of renewable energy to thermal power generation

$$\sum c_i = \sum c_i(t)\cdot\alpha + c_j(t)\cdot\beta\cdot\lambda + \sum c_m(t)\cdot(1-\lambda) \tag{17}$$

Among them, λ is the proportion of renewable energy, $\sum c_m(t)$ is consumption of thermal power generation.

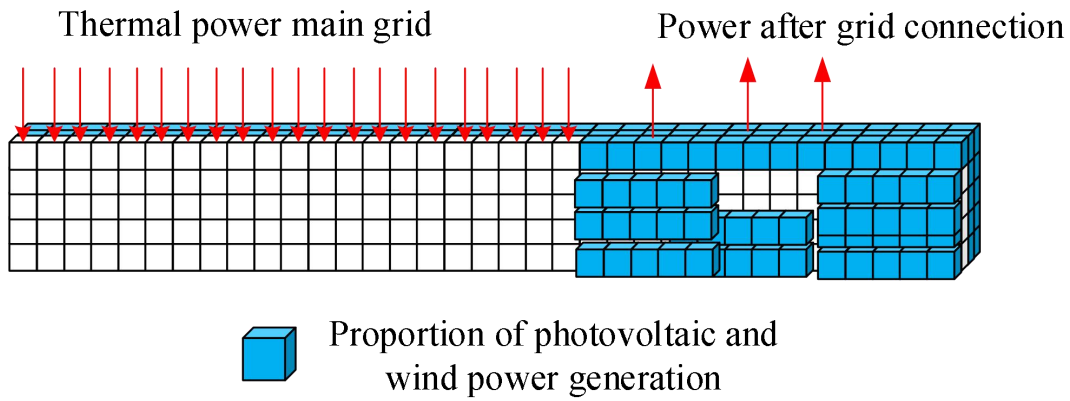


Figure 2. Energy Output after Renewable Energy is Connected to the Grid

Figure 2 shows how the ant colony algorithm reveals the relationship between renewable energy and thermal energy, adjusts the power flow voltage and load, and adjusts the proportion of renewable energy and thermal power to achieve the overall optimization of energy consumption.

E. Chaos Improvement and Optimization of Power Distribution Scheme Based on Ant Colony Algorithm

The power system optimization problem is a system engineering, which includes complex optimization problems, such as reactive power optimization, economic load distribution optimization, grid distribution optimization, and power unit input optimization. As an intelligent algorithm, the chaotic algorithm has high requirements for the initial conditions, and fractal is the main concept of the algorithm. Chaos is intended to have self-similarity in different scale ranges in the internal environment of the system. The self-similarity property can be symmetrical across scales, so that there are hidden and ordered patterns with structure and regularity, called chaotic sequences. There are chaotic attractors in chaotic systems, which are point attractors, limit ring attractors, and singular attractors. Attractors are fixed properties within a system that are attracted to a cycle and remain in a certain state. The above three attractors constrain each other to maintain static equilibrium within the system. In this paper, the ant colony algorithm is improved based on chaos theory, and the improved algorithm is applied to the optimal distribution of power distribution in thermal power plants. The research strategy in this paper is to solve the problem of optimal distribution of power distribution in power plants, and the ant colony algorithm cannot set the initial path and initial pheromone according to the empirical rules, so it is necessary to combine other technologies to improve the search efficiency and make the algorithm not fall into a local minima state.

The chaotic sequence often used in chaotic algorithms is the logistic sequence, which can be described by equation (18):

$$a^{(i+1)} = \mu\cdot a^{(i)}\cdot\left(1-a^{(i)}\right) \tag{18}$$

In Eq. (18) above, $a^{(i+1)}$ denotes the sequence; μ represents a constant, and the value range can be greater than 1.

After the path establishment process, all ants are comprehensively evaluated to select the optimal solution by comprehensive evaluation of the pheromones in the journey, and the chaos theory is proposed to improve the optimal ant, so that the search radius of the optimal ants is reduced within the radius search range corresponding to the optimal solution, so as to reduce the number of iterations. According to the above requirements, the

sigmoid function is used to optimize the value r in the scheme:

$$r = 1 - \frac{1}{1 + \exp(-0.3t + 5)} \tag{19}$$

In equation (19), the number of iterations in the ant colony algorithm is t.

When chaos theory is applied to the process of searching for the optimal solution for each generation, the calculation results can be obtained according to equation (19), and the search radius increases with the increase of search algebra. The optimal solution obtained by using the ant colony algorithm based on chaos theory can be described as:

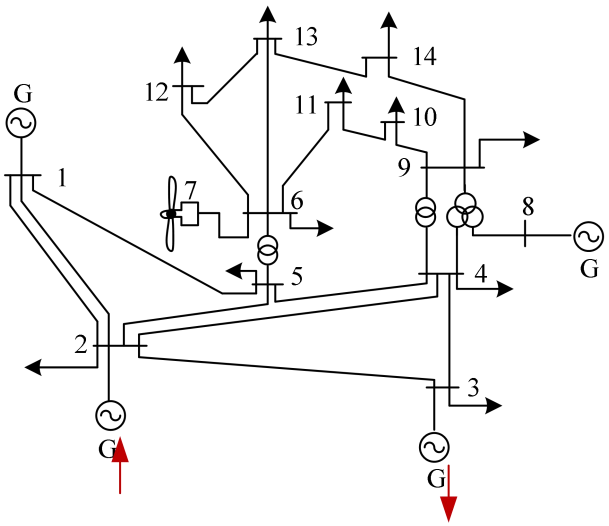
$$\begin{cases} P_i' = P_i + \eta \cdot x(m) \\ \eta = \eta \cdot x_i \end{cases} \tag{20}$$

In equation (20), P_i' represents the computational solution after chaos optimization; P_i represents the global optimal solution after decoding; The number of chaotic optimization iterations is m; The global optimal solution before decoding is $x(m)$.

3. Actual Case Analysis

A. Construction of the Fire Network

IEEE 14 was used as the experimental object, and the simulation environment was constructed. Among them, the power grid is divided into two branches by the main bus, respectively used for wind power and photovoltaic power generation, and the main line is used for thermal power generation. The power grid is 220V, the current is 12A, the power is based on the load in the main network, and the branch equipment is numbered, the main line is Li, the voltage is Vi, and the current is Ai. At the same time, relays and rectifiers are set up on the main network to maintain the power flow and voltage stability in the line. The indicators of the power distribution scheme are the stability and balance of voltage, current, and power flow, as well as the lowest overall energy consumption, and the additional parameter is the proportion of renewable energy (Figure 3).



1 - Load node, 2 - Load node, 3 - Load node, 4 - Load node, 5 - Transformer node, 6 - Load node, 7 - Wind farm node, 8 - Load node, 9 - Load node, 10 - Load node, 11 - Load node,12 - load node, 13 - load node, 14 - load node

Figure 3. Wiring Diagram of the Power System of the IEEE 14 Bus Including Wind Power Plant

B. Optimization Results of Thermal Power Distribution Network after Grid Connection

Therefore, an in-depth analysis of the grid-connected thermal power distribution network can effectively verify the optimization results of the thermal power distribution network with the group algorithm. The analysis results of the thermal power distribution network should be analyzed under the influence of random factors in the analysis process. The analysis results of the power flow and the distribution of voltage under the conditions should be judged under the influence of random factors. The final value of the calculation results should be used as the benchmark for power flow and voltage, and the final value of the calculation results should be analyzed for the nodes in the entire test power grid, and the power flow optimization of each node should be judged and used as the optimization results after grid connection, as follows:

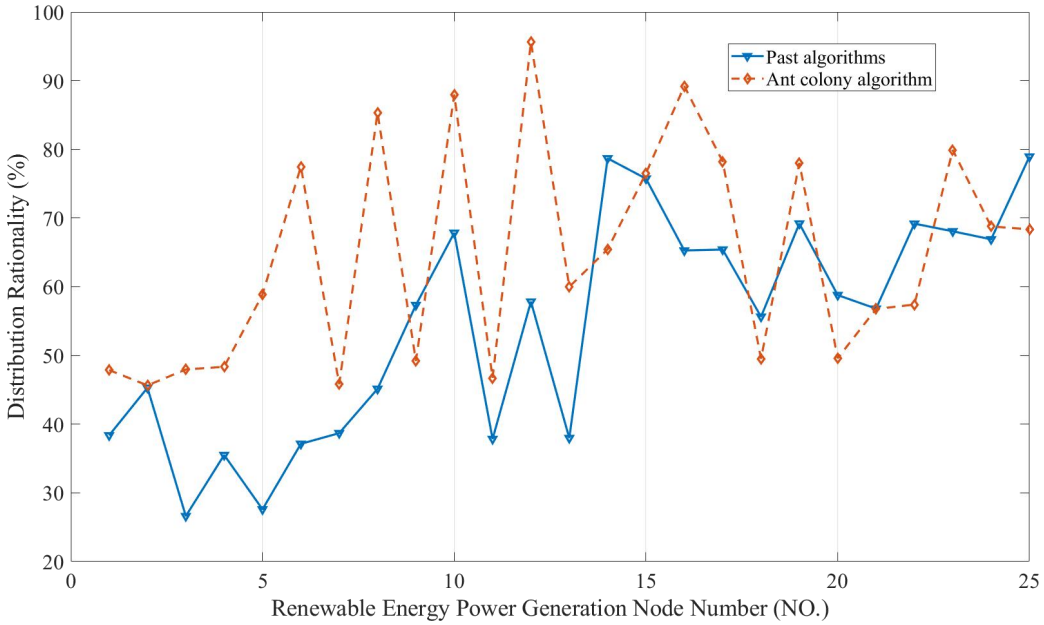


Figure 4. Two Algorithms for Power Distribution

Based on the results in Figure 4, it can be seen that the colony calculation method requires 8 jumps to find the optimal route, compared to 12 jumps in the previous algorithm. Both methods passed the 25-node test. However, since the ant colony algorithm makes use of the geography, power generation and energy storage metrics of the distributed grid, it will simplify the calculation process of the entire node. The ant colony calculation method selects the renewable energy power generation node with the highest transfer probability from the adjacent nodes for planning, and the line length covering the power grid is significantly expanded. Therefore, the ant colony algorithm improves the rationality of the distribution scheme by reducing the complexity of the power generation node and the length of the transmission line.

C. Energy Consumption

Under the condition that the overall power flow remains unchanged, the total energy consumption in the process of grid connection and the energy consumption distribution uniformity of renewable energy such as photovoltaic and wind power are comprehensively judged to ensure the uniform energy consumption of each node. Through repeated testing and monitoring, the final change in energy consumption can be obtained, as shown in Figure 5 below.

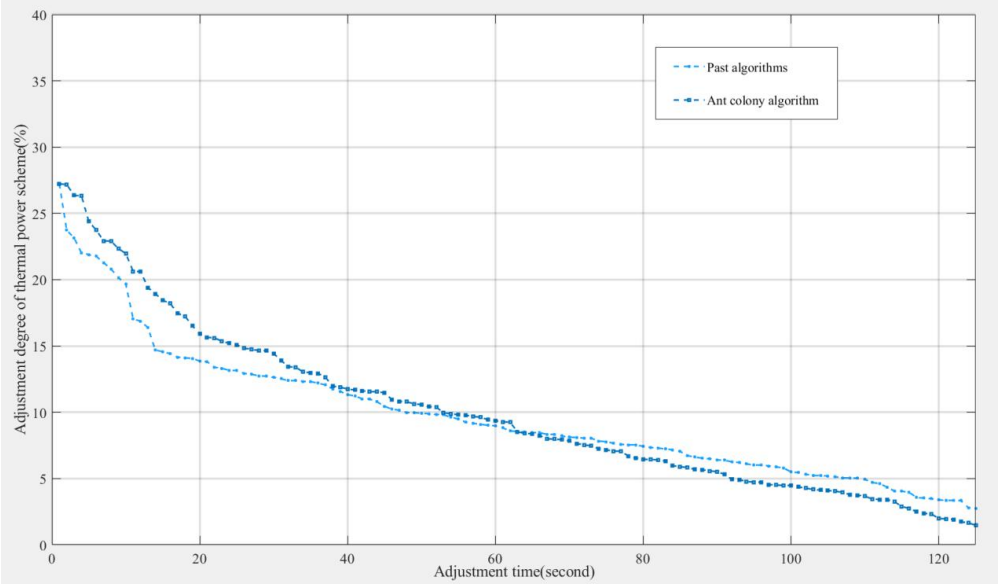


Figure 5. The Degree of Adjustment of Thermal Power Configuration Schemes of Different Methods

According to Figure 5, it can be observed that the longer the two algorithms run, the closer their total energy efficiency will be to equilibrium. Compared with previous algorithms, this algorithm has obvious advantages in terms of energy consumption. At the beginning of the thermal power generation scheme, the grid-connected results of photovoltaic and wind power generation were relatively stable, the overall energy consumption was low, and there was no large power flow voltage fluctuation after the thermal power generation main grid was connected, and

the power generation energy consumption of the grid was reduced. The main reason for the above results is that the group algorithm will judge the optimal value, identify some abnormal voltages, and balance the voltage and current through the power flow regulation of the entire renewable energy network, so as to ensure the stability of the grid after integration. Moreover, the integration of renewable energy and thermal power grids can effectively reduce the cost of thermal power grid distribution, as shown in Table 1.

Table 1. Comparison Statistics of Power Distribution Schemes

SCENARIO TYPE	COMPREHENSIVE FEE (10,000 YUAN)	FOSSIL FUELS (100 TONS).
Basic distribution plan	876.5	72.7
Improve the distribution plan	690.5	53.8

The application of photovoltaic and wind power energy in the entire power grid can reduce petrochemical resources, and indirectly reduce transportation costs and personnel costs, so the overall distribution cost is greatly reduced, in the case analysis of this article, the four units have a great advantage in terms of capacity, and their overall load is 80% of the previous power generation, so 20% of the energy is saved. According to the ratio factor of 0.46, the total cost is about 30%, and the overall grid load of thermal power generation is greatly reduced. It can be seen that the integration of renewable energy such as photovoltaic and wind power into the grid can save the cost of thermal power generation, increase the cost of thermal power generation, and keep the entire power grid green.

D. Regulation Time of Lifa Power Grid

In the traditional thermal power generation regulation process, the generator set should be regulated, and the generator set will affect the power generation of the entire motor after its frequent adjustment after operation, and the virus of renewable energy is transmitted again through the battery, which has the effect of fast adjustment and stable output.

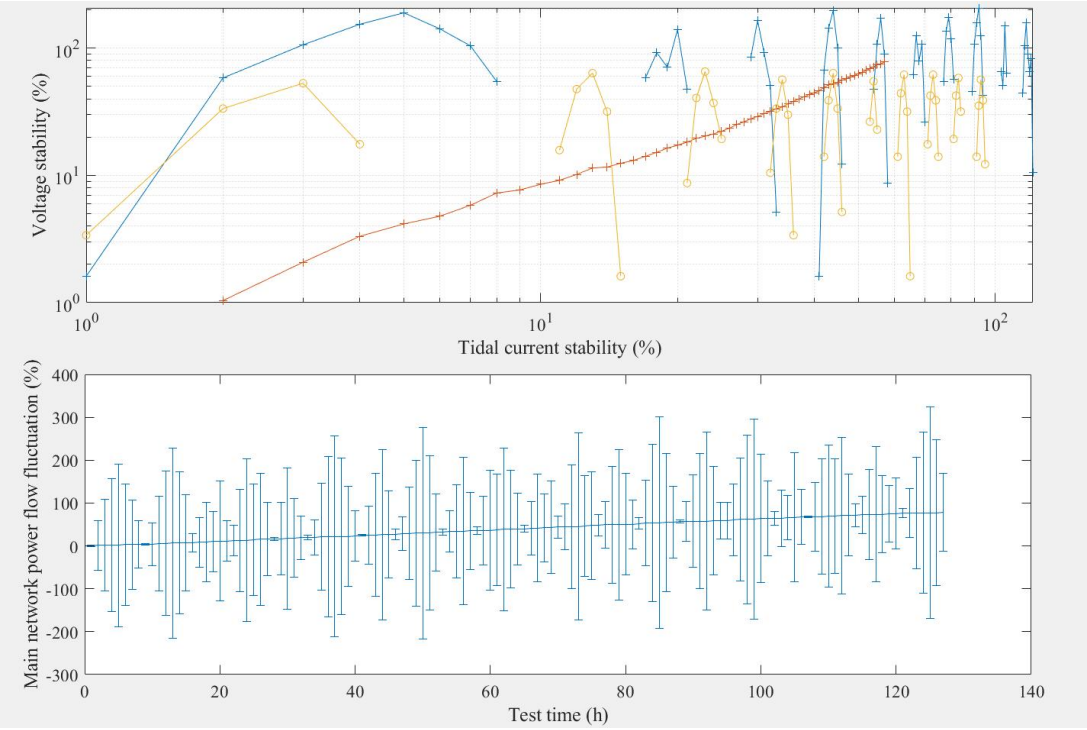


Figure 6. The Degree to Which Different Methods Reduce the Nodes of the Power Distribution Scheme

The above fluctuation analysis results show that photovoltaic power generation and thermal power generation show fluctuation changes, while the fluctuation changes of thermal power grid are relatively rare, indicating that thermal power generation is still the main aspect of allocation, but in terms of fluctuation changes in the whole power grid, its volatility shows regular changes, indicating that the known algorithm can comprehensively select the energy storage equipment in the distributed power grid, and allocate the key points or wind power generation nodes with a high proportion, so as to ensure the stability of renewable energy after grid connection and reduce the comprehensive energy consumption of the entire power grid. From the analysis results in Figure 6, it can be seen that the grid connection of renewable energy such as photovoltaic and wind power generation can improve the power generation effect and make the power generation efficiency consistent with the past, and the power generation time is relatively short in the whole power generation process, which can meet the requirements of the distribution network for power flow

stability adjustment efficiency, and the specific shortening time is shown in Table 2.

Table 2. Situation of Thermal Power Generation

FORM OF POWER GENERATION		DISTRIBUTION EFFICIENCY(100 MILLION KW/H)		TIME(S)
	8:00~14:00	14:00~23:00	23:00~8:00	
Thermal power generation	519.8	572.7	623.6	4.52
Photovoltaic, wind power generation	478.9	554.1	668.3	2.34

As can be seen from Table 2, the electricity results of photovoltaic and wind power generation are 47.89 billion KW/h, 55.41 billion KW/h and 66.83 billion KW/h respectively, which are significantly lower than the good thermal power generation capacity, but close to the national average power generation of 48.01 billion kWh, 55.50 billion kWh and 66.81 billion kWh respectively. For thermal power generation, relatively speaking, there are more pollutants, mainly carbon dioxide, sulfur dioxide and dust particulate matter, the specific proportion is shown in Figure 7 below.

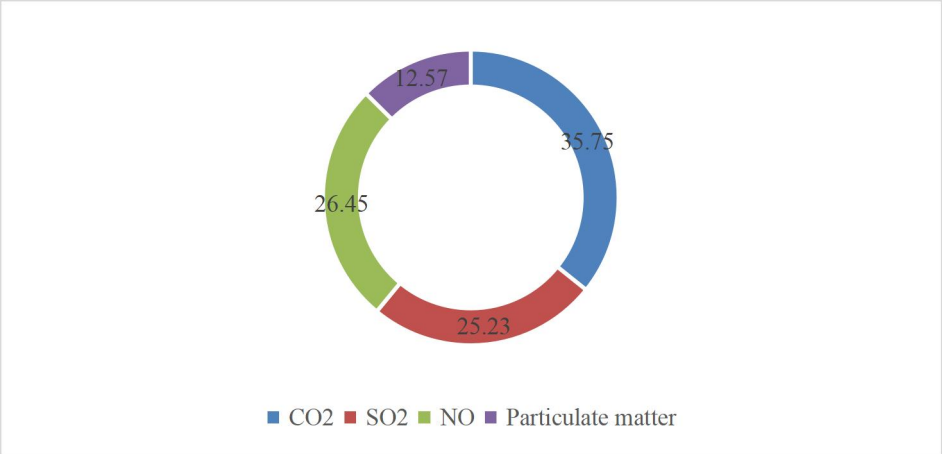


Figure 7. Pollutant Emissions from Thermal Power Generation

As can be seen from Figure 6, the pollutant emissions of thermal power generation are dominated by carbon dioxide and sulfur dioxide, which are particulate matter and carbon monoxide, so the increase in the proportion of renewable energy in thermal power generation can reduce pollutant emissions and improve the cleanliness of energy. The ant colony algorithm can realize the optimization of power distribution in thermal power plants, which can not only balance regional power flow, voltage and current, but also meet the requirements of rapid power distribution of the power grid. Under the influence of policy, weather and other interference factors, the rapid adjustment of the entire power grid is realized. Through the above test and analysis, the genetic algorithm can better analyze the distribution efficiency and cost of the entire distribution network, find the key current and voltage balance lines, and evenly distribute the energy storage equipment in the wind power, so as to enhance the integrity of the entire energy storage equipment, maximize the energy supply of the energy storage equipment, maintain the total energy balance of the thermal power grid, and reduce the motor load of the thermal power grid, so as to save the later cost and the overall cost support. At the same time, it is necessary to judge the sustainability of photovoltaic and wind power generation, and the specific results are shown in Figure 8.

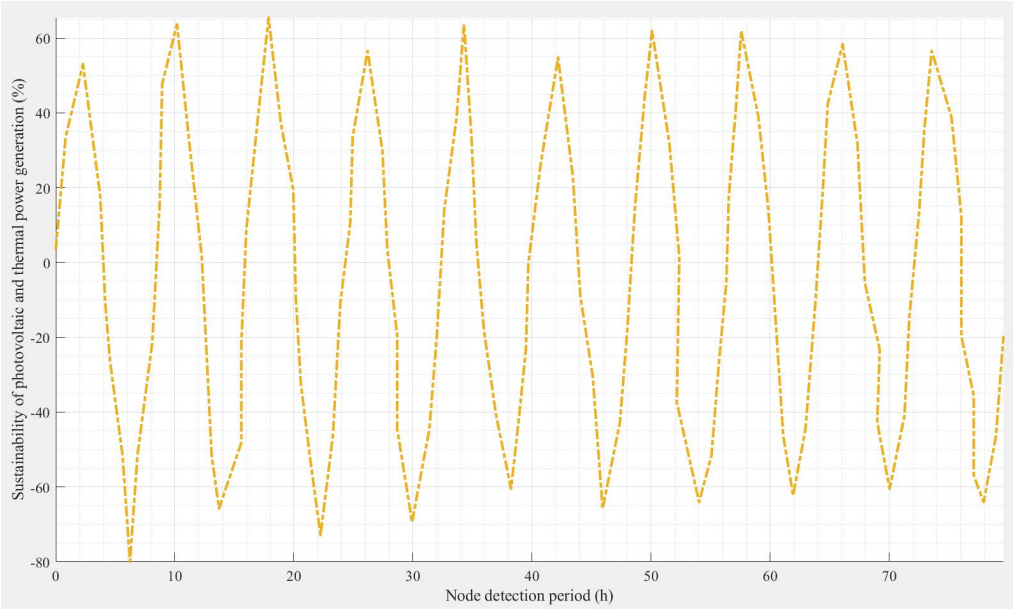


Figure 8. Sustainability of photovoltaic and wind power generation

Through the data analysis, it can be seen that the continuous power generation time of each node is relatively stable, showing fluctuation changes, mainly because the generator set shows AC changes, so its volatility is relatively strong, but the stability is good and the duration is long, so the power generation of renewable energy is ideal.

4. Conclusion

Thermal power generation is currently the main mode of power transmission, and the mediation of the grid is the way and means to maintain stability, but the energy consumption and cost of thermal power generation are high, and the environmental pollution is greater. Based on the swarm algorithm, this paper analyzes the renewable energy sources such as photovoltaic and wind power to determine the distribution scheme and mediation problem of thermal power generation after grid connection, which shows that the ant colony algorithm can adjust the relationship between thermal power generation and renewable energy, find the wind power station with the highest energy storage through node search, and carry out reasonable energy distribution, maintain the power flow and voltage stability after grid connection, and improve the accuracy of thermal power grid allocation to keep it at 90% In addition, the algorithm weakens the instability of renewable energy on the network, reduces the energy consumption of thermal power grid, and improves the deployment time to keep it between 3.45s. However, in the process of practical application, the accuracy and reliability of the ant colony algorithm need to be further improved, and the safety and stability of the power distribution system of thermal power plants need to be taken into account, so as to better meet the actual needs of the power distribution system of thermal power plants.

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