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Improved Particle Swarm Optimization Algorithm in Site Selection and Capacity of Distributed Power Supply

Iqbal Rahat*

University of New England, Australia

**corresponding author*

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Abstract: Distributed power generation has unparalleled advantages in energy substitution, environmental protection, improving system power supply reliability and reducing power supply costs. The purpose of this paper is to study the application of the improved particle swarm optimization algorithm(IPSO) in the location selection and sizing of distributed power generation. This paper first briefly introduces the characteristics of today's main distributed energy resources, and empirically analyzes the impact of distributed energy access on the distribution network. On this basis, a single-objective optimization model considering several constraints is established for the minimum investment cost and net loss of distributed generation. By examining the shortcomings of the standard particle swarm optimization algorithm, combining the optimization algorithm with various optimization techniques, a hybrid particle swarm optimization algorithm is proposed, and the effectiveness of the algorithm is studied. The optimization model is determined through the algorithm improvement, which further confirms the feasibility and effectiveness of the model and algorithm improvement. Then, in view of the environmental problems most concerned by modern society, advanced multi-objective algorithms are used to realize the overall optimization of power station location and power for distributed generation, and to provide decision makers with a variety of solutions. Experiments have shown that the overall optimization scheme in this paper can save about 20% of the cost, and through optimization, the network loss voltage can be reduced by about 30%.

1. Introduction

The promotion of distributed generation can greatly alleviate the energy crisis. Distributed power generation often uses new energy for power generation. The characteristics of new energy are that it is inexhaustible. Today, when traditional energy is increasingly depleted, with the improvement and maturity of new energy power generation technology, new energy power generation will gradually become more and more mature in the future. Instead of the status and role of traditional thermal power, it has become the main form of power generation. my country has abundant wind and solar energy resources. At present, large-scale wind and photovoltaic power sources have been built in the "Three North Regions". In the future, distributed power supply will be the main power supply in many northern regions. As a beneficial supplement to centralized power generation, distributed power generation can enhance power supply stability. Distributed power generation has unparalleled advantages in energy substitution, environmental protection, improving system power supply reliability and reducing power supply costs [1-2].

In the application research of the IPSO in the location selection and capacity determination of distributed power generation, many scholars have studied it and achieved good results. For example, Khodayari H proposed an improved swarm search algorithm, Combining the method of updating branch vector search with the group search algorithm improves the global search ability of the algorithm. Under the condition that the number, location and capacity of DG are uncertain, a mathematical model with minimum active network loss is established, and the active network loss is reduced through planning [3]. Vafaeinejad A established the objective functions of network loss, voltage offset and static voltage stability margin, and improved the basic immune algorithm by introducing three sub-populations. DG for planning. Since the number of DGs is determined in this paper, there are certain limitations in the planning process [4].

Firstly, the classification of distribution power sources and various typical distribution power sources are introduced, and the influence of grid-connected distribution power sources on the operation and safety of distribution network is analyzed. Followed by distributed energy generation site selection and sustainable energy research. In this paper, the node active network sensitivity is selected as the site selection method, and under the condition of considering the active power and reactive power of distributed generation, the theoretical analysis of the active network loss sensitivity of each node is carried out. The network is distributed. The objective function is to minimize the annual system operating cost. Finally, taking the IEEE-33 system as an example, the optimal particle swarm algorithm is used to improve the stability of distributed generation, so that the distribution network can bring significant economic benefits.

2. Application of IPSO in Site Selection and Capacity Determination of Distributed Power

2.1. The Impact of Grid-Connected Distributed Generation on Distribution Network Planning

The random entry or removal of a large number of distribution power sources in the distribution network will make the load forecast, structure and operation of the power system more unpredictable than before the DG is not connected. It is difficult for distribution system designers to accurately predict the growth trend of commodities, and it is difficult to effectively fulfill the mission of the distribution network.

The influence of DG grid connection on the design of distribution network mainly includes the following points:

(1) The occurrence of DG increases the difficulty of system load forecasting and planning. Distribution network design is not a static design problem, but a dynamic design problem, so the design is closely related to its scale. Combined with the large number of nodes in the distribution network itself, if the DG design does not control a large number of distributed generator nodes, it will bring scale damage to the DG situation and power solutions.

(2) The time period for distribution network planning is generally 5-20 years. During this period, planners must decide whether to build new plants based on the increase in load. But the introduction of DG itself is equivalent to adding a node, which can generate electricity, which is different from the general load node. Therefore, distributed generation should be considered when planning grid expansion, but this brings up issues of node location and power decisions.

(3) After the DG is connected to the grid, the previously designed and invested distribution lines can be moved, resulting in a decrease in its utilization rate, and it is difficult for the audio industry application to recover the line investment and win the sinking fund.

In conclusion, connecting the DG to the grid does not only have a significant impact on the performance of the distribution network. At the same time, it also brings significant challenges to distribution network planning. Therefore, power grid designers must consider the impact of DG grid connection on the distribution network when choosing the best solution [5-6].

2.2. Analysis of Distributed Power Location Method

Sensitivity analysis is a method that uses the differential relationship between the studied physical quantities to find the sensitivity of the dependent variable to the independent variable. In the distribution network, we can calculate the voltage and network loss sensitivity of each node according to the power flow. The set of nodes to be installed in the DG is selected according to the size of the sensitivity, and the site selection range is limited to a certain range, which is helpful for simple calculation. Generally, the node with high sensitivity is selected as the node to be installed for DG [7-8].

In this section, the sensitivity of active network loss of nodes is theoretically analyzed. First, the active network loss of each segment is obtained by using the active power and reactive power transmitted by the line, and the total network loss of the line can be obtained by superimposing the active network loss of each segment. Secondly, the partial derivative of the active power corresponding to the total network loss is obtained to obtain the active network loss sensitivity of the node.

Before the DG is not connected, the active power loss of the i-th branch line can be expressed as formula (1) [9-10]:

$$P_{loss}^{ij} = \left(U_1^2 + U_j^2 - 2U_iU_j\cos\delta_{ij}\right)g_{ij} \tag{1}$$

Then the total active power loss of all branches of the power distribution system is expressed as formula (2):

$$P_{loss} = \sum_{l=1}^{m}\left[g_{ij}\left(U_1^2 + U_j^2 - 2U_iU_j sos\delta_{ij}\right)\right] \tag{2}$$

Ploss - active power loss

l——Number of branches

m - the total number of branches

U_i, U_j - voltages at nodes i, j

g_{ij}, b_{ij} — conductance and susceptance of lines i, j

δ_{ij} ——the phase difference between the voltages of nodes i and j.

3. Application Research and Design Experiment of IPSO in Distributed Power Source Location Selection and Capacity Determination

3.1. Algorithm Process

The optimal principle of optimal particle swarm optimization can be expressed as follows: Assuming that the search space is D-dimensional, the system is randomly initialized to a population of size m. During an iterative process, the velocity and position of the population are updated to find the best solution within the search range.

Each particle tracks a single edge Pi and a global edge Pg in each iteration. Compare the person's current position to the distance between Pi and Pg to adjust their speed. Then jump at that speed, updating the particle's position. Particle swarm optimization generally chooses the maximum number of iterations or meets a predefined minimum classification condition. The specific algorithm flow is as follows [11-12]

(1) Begin. Input the initial data of the distribution network, obtain the information of each node and branch, and determine the upper and lower limits of the voltage of each node. Starting from the particle population size m, set the initial particle position Xi and initial velocity Vi within the allowable range, and take a single particle size Pi as Xi and Pg as Xi to evaluate the best global size value for all particle fitness values.

(2) Calculate the energy flow and kinetic function of each particle in the population using the forward-backward generation method, and select the minimum value as the new Pi and Pg values.

(3) Update the speed, position and weight information according to the formula, calculate the fitness value and update Pi and Pg.

(4) Check whether the maximum number of iterations or the threshold condition is reached, if so, output the DG power optimization result; otherwise, return to step (3).

(5) to get the optimal solution.

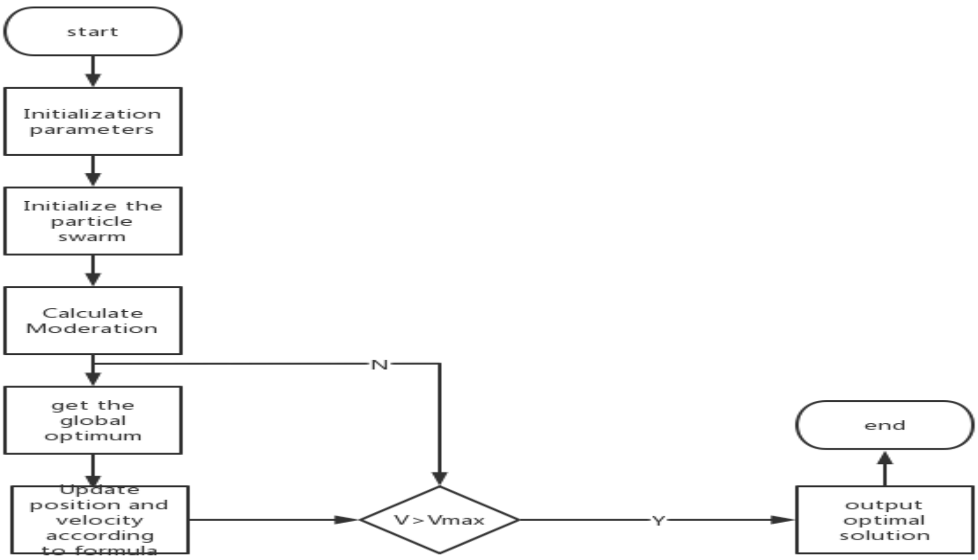

Figure 1. Related flow chart

3.2. Experimental Design

In this paper, the improved particle swarm algorithm constructed in this paper is studied in terms of the location and capacity of distributed power generation. First, the cost comparison between the planning scheme and the traditional distributed power scheme, and the second is to explore the multi-objective optimization and single-objective planning. The results of the optimization in this paper reduce the loss of a single target.

4. Experimental Analysis of the Application of the IPSO in the Site Selection and Capacity of Distributed Power Generation

4.1. Cost of Planning Scheme

This paper uses the improved particle swarm algorithm in this paper to optimize the traditional distributed power generation site selection and constant capacity scheme, and judges the superiority of the optimal solution obtained by the algorithm by comparing the costs of the two schemes. The results of DG optimization are shown in Table 1.

Table 1. Scheme optimization results

	Net loss cost	Fuel costs	DG investment cost	Environmental costs	Annual cost
Scheme 2	20.37	46.57	32.14	2.55	101.58
Scheme 1	24.37	0	59.64	0	84.01

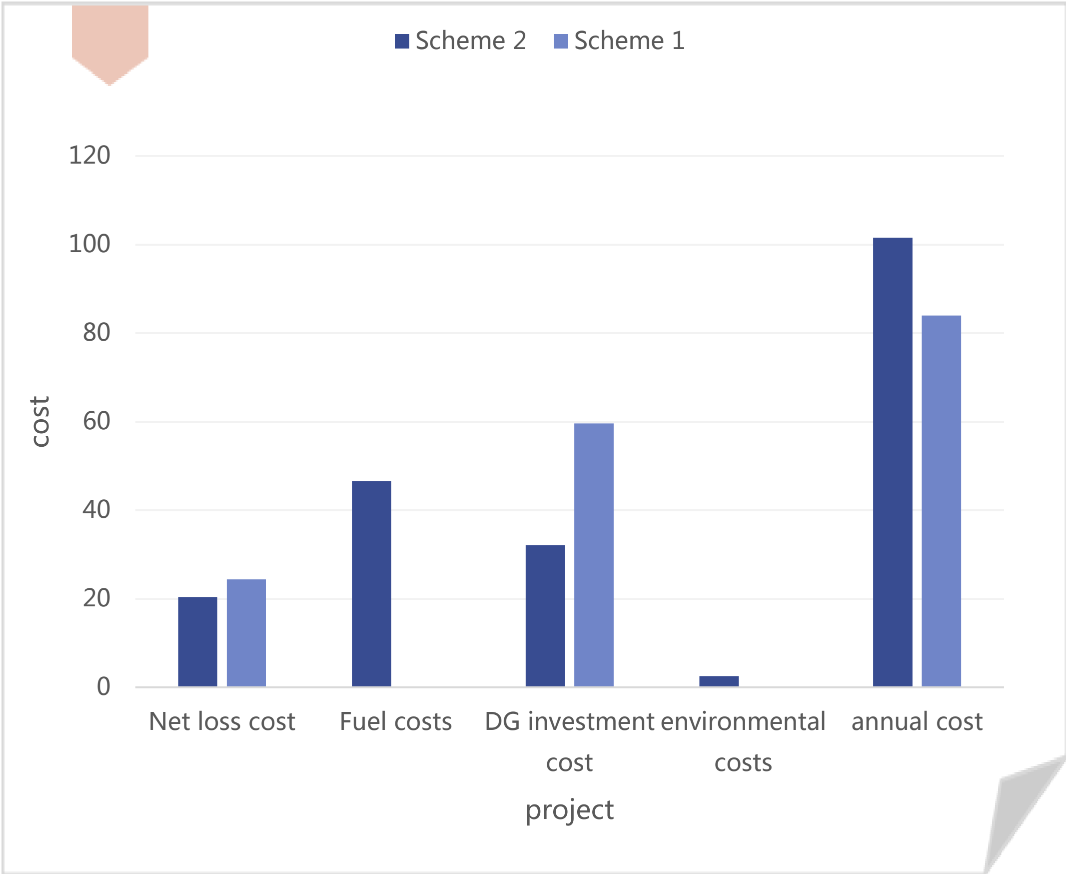

Figure 2. Comparison costs of various items in the planning scheme

As can be seen from Figure 2, from the perspective of the number of DG installations, the second solution does not consider timing, and the number of MT installations is 0. It can be seen from the analysis that when the timing is not considered, although the investment of MT is low, when the output is full, the fuel cost and environmental cost are high, while PV and WG do not require fuel and environmental cost except for the high installation cost. Therefore, the comprehensive cost of MT is much higher than that of PV and WG. Therefore, it is better to use restless MT when optimizing. From the economic point of view, the economy of option 2 is better than that of option 1, but the planning of option 2 is not in line with reality. It can be seen from the time series characteristic curves of load and DG that it is impossible for PV and WG to have continuous and constant output. They are both affected by geographical environment and other factors, and have great uncertainty, and their output is relatively small. The demand state of the system load may not be met for a certain period of time. Secondly, if the timing is not considered, there is no essential difference between PV and WG distributed power sources. Therefore, it is meaningless to study PV and WG distributed power sources.

4.2. Distributed Power Optimization

Based on the IPSO constructed in this paper, an experiment is carried out to optimize the customized capacity of distributed power sources. A set of distributed power sources is selected for multi-objective and single-objective planning. The experimental data are shown in Table 2.

Table 2. Voltage comparison before and after optimization

	Minimum voltage	Peak voltage	Net loss
Before optimization	92.31	99.6	202.685
Postoptimality	92.98	99.73	136.249

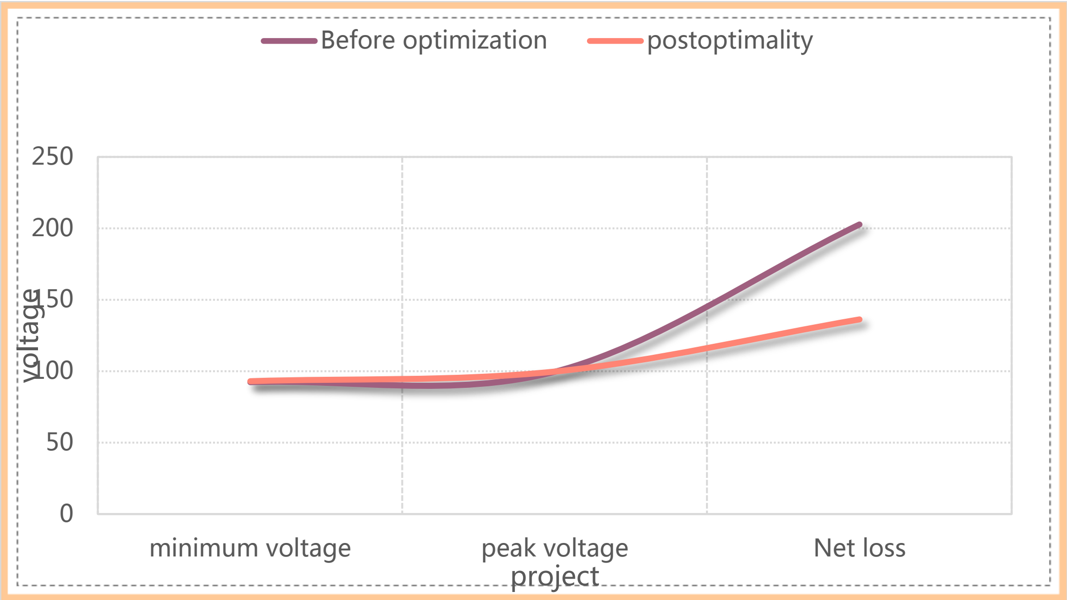

Figure 3. Distributed power supply single-target planning results

It can be seen from Figure 3 that the optimized minimum and maximum voltages have a small increase compared with those before optimization. The largest optimization is greater than the network loss voltage reduced by about 30% in terms of network loss.

5. Conclusion

The optimal configuration of distributed power is the basis for the healthy operation of the entire microgrid. Therefore, it is particularly important to reasonably plan the capacity and location of distributed power in the existing distribution network. In this paper, the influence of the access of distributed power generation on the distribution network is firstly analyzed, and then a single-objective optimal configuration model of distributed power generation is established. The multi-objective optimization model of distributed generation proposed in this paper only considers network loss, construction cost and CO_2 emissions as optimization goals. However, in the actual operation process, the commercial use of microgrids is gradually increasing, and economical dispatch has also become the main concern. At the same time, considering the actual electricity price fluctuation, the microgrid can buy or sell electricity from the large grid, and its equivalent pollution emission model also needs to be re-established. At the same time, with the increasing demand of human beings for power, the objectives and constraints involved in the optimization of distribution network with distributed power generation have become more and more complex, and the performance of multi-objective optimization algorithms should be further improved to solve this problem. Class problems provide a good technical foundation.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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