Economic Optimal Dispatch of Grid-connected Microgrid Based on Improved Genetic Algorithm

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Abstract. Nowadays, the demand for energy is expanding, the fossil resources are on the verge of exhaustion, and the ecological environment is getting worse and worse. In this form, this paper studies the economic optimal dispatch of microgrid under the background of energy saving and emission reduction. Firstly, the mathematical model of microgrid composed of distributed power, energy storage devices and loads is established. Secondly, under the background of energy saving and emission reduction, the objective function of multi-objective optimal operation of microgrid is established considering both economic and environmental aspects. Finally, the improved Genetic Algorithm is used to solve the objective function. The results of optimization can reduce microgrid system generation cost.

1. Introduction
Microgrid has become an important means of distributed generation access because of its flexibility, complementarity between distributed generations and improvement of system reliability. The emergence of microgrid responds to load growth in a new way, and has broad prospects in sustainable development, improving stability and flexibility of power system [1-6].

The economic optimal dispatching model of microgrid not only considers the different characteristics and constraints of the distributed units, but also considers the economy and environmental protection of the whole system. On the premise of meeting the load demand, the optimal output combination scheme is obtained by optimizing the coordination among the units, which requires higher convergence speed and accuracy of the algorithm. The non-intelligent optimization algorithm represented by linear programming and non-linear programming does not have high convergence speed and accuracy, but the intelligent optimization algorithm represented by genetic algorithm and simulated annealing algorithm can better solve such problems. Therefore, the intelligent optimization algorithm is generally used to solve [7-11].

Genetic algorithm is a typical intelligent optimization algorithm, which has the advantages of simple search, strong expansibility and easy realization. However, when the traditional genetic algorithm is used to solve the economic optimal dispatching model of microgrid, due to its premature and easy
convergence characteristics, it may fall into local optimum, which will affect the value of the objective function not to reach the optimal value. Simulated annealing arithmetic originates from metal annealing process in physics, because of its unique probability jump characteristics, it can jump out of local optimum. In this paper, genetic algorithm and simulated annealing algorithm are combined into genetic simulated annealing algorithm to solve the optimal dispatching problem of microgrid and improved, the problem of falling into local optimum can be avoided as far as possible and the quality of the optimal solution can be improved.

2. Economic Optimization Dispatching Model of Microgrid

2.1. Structure of Grid-connected Microgrid

In this paper, grid-connected Microgrid is taken as the research object. Its structure is shown in figure 1, including distributed generation, energy storagr, power grid and load. The distributed generation includes wind turbine (WT), photovoltaic (PV), microturbine (MT), fuel cell (FC) and energy storage (ES).

![Figure 1. The structure of grid-connected microgrid.](image)

2.2. Objective Function

The objective of microgrid economic optimization dispatching is to minimize the cost of generating electricity and the emission of polluted gases. Converting the minimum emission of polluted gases into the minimum emission cost of polluted gases can transform the multi-objective into a single objective, that is, the minimum comprehensive cost of microgrid system. According to this, the integrated cost of microgrid system operation consists of the cost of generating electricity and the cost of polluting gas emission. The objective function can be expressed as follows:

$$\text{min } C = C_G + C_E$$  \hspace{1cm} (1)

where, $C$ is the total cost of microgrid system (yuan), $C_G$ is the generation cost (yuan) and $C_E$ is the cost of pollutant gas emission (yuan). In grid-connected microgrid, $C_G$ is mainly composed of fuel supply cost, maintenance cost of distributed units and the cost of power interaction between microgrid and power grid.

$$C_G = C_F + C_M + C_{\text{Grid}}$$ \hspace{1cm} (2)

where, $C_F$ is the fuel supply cost (yuan), $C_M$ is the maintenance cost (yuan) and $C_{\text{Grid}}$ is the cost of power interaction between microgrid and power grid (yuan). In grid-connected microgrid.

$$C_F = \sum_{i=1}^{N} \left( \sum_{t=1}^{T} C_{\beta} \times \frac{P_i(t)}{\eta_i(t)} \right)$$ \hspace{1cm} (3)
where, $T$ is total dispatch period (h), $N$ is the number of micropower supply, $P_i(t)$ is the output power of distributed unit $i$ at time $t$ (kW), $\eta_i(t)$ is the generation efficiency of distributed unit $i$ at time $t$ (%), $C_{f}(t)$ is the fuel of distributed unit $i$ at time $t$ (yuan/kWh), $\xi_{mi}$ is the maintenance cost coefficient of distributed unit $i$, $C_{es}(t)$ is the price variable (yuan/kWh), $C_{BUY}(t)$ is the price of purchasing power (yuan/kWh) and $C_{SELL}(t)$ is the price of selling power (yuan/kWh) and $P_{Grid}(t)$ is transmission power between the microgrid and power grid (kW).

$$C_{e} = \sum_{i=1}^{N} \sum_{j=1}^{I} (C_{ej} \times \sum_{i=1}^{N} (\xi_{ej} \times P_i(t)))$$

where, $C_{ej}$ is the penalty fee of type $j$ polluted gas (yuan/kg), $\xi_{ej}$ is the emission coefficient of distributed unit $i$ and type $j$ polluted gas (kg/kWh).

### 2.3. Constraint Condition

According to the requirement of safe and stable operation of microgrid, several constraints for optimal dispatch of microgrid energy are given.

In any dispatching period, the microgrid must meet the heat and electric power requirements.

$$P_{h-load}(t) = Q_{heat}(t)$$

$$P_{load}(t) = \sum_{i=1}^{N} (P_i(t) + P_{Grid}(t))$$

where, $P_{c-load}$, $P_{h-load}$ and $P_{load}$ are the cool, heat and electric load demand of microgrid at time $t$ (kW), respectively.

In any dispatching period, the output of each distributed generation unit in microgrid is strictly restricted by its capacity, that is, the output of each generation unit has upper and lower limits.

$$P_i^{min} \leq P_i(t) \leq P_i^{max}$$

where, $P_i^{min}$ and $P_i^{max}$ are the lower and upper limit of the output power of distributed unit $i$ (kW).

### 3. Solving Method

The premature convergence of genetic algorithm makes it easy to fall into local optimum when solving the economic optimal dispatching problem of microgrid. And the simulated annealing algorithm has strong ability in local search and is not easy to fall into local optimum because of its unique probability jump characteristics, but the probability jump characteristics also make it greatly affected by parameters, slow convergence speed and solving time. Long and other shortcomings. This paper combines genetic algorithm with simulated annealing algorithm to form genetic simulated annealing algorithm, which can avoid falling into the local optimum and solve the problem for a long time, and improve the quality of the optimal solution.

The genetic algorithm optimizes the population unit, and the simulated annealing algorithm optimizes the individual. So in the genetic simulated annealing algorithm, the simulated annealing algorithm should optimize the new individuals in the new generation of population, and apply its unique
probability jump characteristics to the individual unit, so as to enhance the search ability of the algorithm and avoid falling into local optimum. As figure 2 shows, simulated annealing operation means replacing old individuals and generating new individuals.

![Figure 2. The flow chart of improved genetic algorithm.](image)

4. Case Study

4.1. Parameter Settings

For the optimal dispatching problem of microgrid studied in this paper, local environmental data such as temperature, wind speed and illumination are needed. Figures 3 show the data curves of local temperature, wind speed and illumination.

![Figure 3. The data curves of temperature, wind speed and illumination.](image)

In the simulation analysis of typical winter day, only the electric and heat load are considered. Figure 4 shows the forecast curves of typical winter daily electric and heat load of the microgrid.

![Figure 4. The forecast curves of the electric load and heat load.](image)
The remaining operating parameters of microgrid system are given in [5].

4.2. Simulation Result
According to the heat load and electric load demand of typical winter day, the economic optimal dispatching model of grid-connected microgrid is simulated and solved, and the power generation curves of each unit under optimized typical winter day are obtained as shown in Figure 5.

![Figure 5](image)

**Figure 5.** The power generation curves of each unit.

Because only MT generates heat energy in the system, the MT output is first determined according to the priority of "fixing electricity by heat". WT and PV operate at maximum output power. FC, ES and Grid adjust discharge sequence according to the change of electricity price.

5. Conclusion
In this paper, the environmental parameters of a typical winter day in a certain area are given. The simulation model of energy optimal dispatching of microgrid is built in MATLAB. The improved genetic algorithm is used to solve the problem. The dispatching schemes at different times are given. The validity of the multi-objective optimal dispatching model of microgrid established in this paper is verified, and the convergence speed and searching ability of the improved genetic algorithm proposed in this paper are verified.

6. Appendices
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