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Optimal Dispatch of Microgrid based on Multi-object Group Search Algorithm

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Abstract

Based on the premise that the output and load balance of each power generation unit, this paper builds a microgrid system composed of photovoltaic, wind energy, energy storage devices, diesel generators, and large power grid. The optimal dispatch model of the microgrid is established with the objective of the lowest economic cost and the smallest pollution of the microgrid, and the multi-objective group search algorithm is used to solve the model to obtain the optimal dispatching scheme of the microgrid. Finally, simulation examples verify the effectiveness of the system's optimal scheduling.

Keywords

Microgrid; Multi-objective Group Search Algorithm; Optimal Dispatch.

1. Introduction

At present, the world's energy supply continues to be tight, the pressure on the traditional power grid is gradually increasing, and more and more distributed power sources using solar, wind, and biomass energy are used in the existing power grid[1]. This paper takes economy and environmental protection as the goals, and establishes a multi-objective optimization model of grid-connected microgrid. At the same time, the multi-objective group search algorithm based on pareto non-dominant relationship is used to solve the model.

2. Modeling of each distributed power generation units

2.1 Photovoltaic power generation

$$P_{PV}=P_{STC}\frac{G_T}{G_{STC}}(1+k(T_c-T_r)) \tag{1}$$

Where: P_{PV} is the actual output power of the photovoltaic unit; P_{STC} is the maximum output power of the photovoltaic unit under standard test conditions; G_T is the actual solar intensity; G_{STC} is the solar intensity under standard test conditions; k is the power temperature coefficient; T_r is the rated temperature of the photovoltaic cell; T_c Is the actual temperature of the photovoltaic cell.

2.2 Wind power

$$P_{WT}=\begin{cases}0, v\leqslant v_{in}\ or\ v\geqslant v_{out}\\ P_r\dfrac{v-v_{in}}{v_r-v_{in}}, v_{in}\leqslant v\leqslant v_r\\ P_r, v_r\leqslant v\leqslant v_{out}\end{cases} \tag{2}$$

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Where: P_r is the rated power of the fan; v is the actual wind speed; v_{in} is the cut-in wind speed; v_{out} is the cut-out wind speed; is the rated wind speed.

2.3 Diesel generators

$$C_{DE}=\sum_{t=1}^{T}U_{DE,t}[a(P_{DE,t})^2+bP_{DE,t}+c] \tag{3}$$

Where: $U_{DE,t}$ is the working state of the diesel generator at time t, $U_{DE,t}=1$ is the working state, and $U_{DE,t}=0$ is the non-working state; $P_{DE,t}$ is the output power of the diesel generator at time t; a,b,c is the fuel consumption coefficient.

2.4 Energy storage device

$$SOC_t=(1-\sigma)SOC_{t-1}-\frac{P_{BSS,t}\Delta t\eta_c}{E_{BSS}} \tag{4}$$

$$SOC_t=(1-\sigma)SOC_{t-1}-\frac{P_{BSS,t}\Delta t}{E_{BSS}\eta_f} \tag{5}$$

Where: σ is the self-discharge efficiency of the battery per unit time; $P_{BSS,t}$ is the charge and discharge power of the battery at time t; η_c,η_f is the charge and discharge efficiency of the battery respectively; Δt is the battery working time, with one hour as the basic unit; E_{BSS} is the rated capacity of the battery.

3. Optimize the scheduling model

3.1 Objective functions

(1) Economic goal: the lowest operating cost of microgrid

$$f_1=\min(C_{fuel}+C_m+C_s+C_{buy}-C_{sell}) \tag{6}$$

Where: C_{fuel} I s the fuel cost of diesel generators; C_m is the maintenance cost of each power generation unit; C_s is the start-up and shutdown costs of diesel generators; C_{buy} is the cost of purchasing electricity from the microgrid to the large power grid, and C_{sell} is the cost of microgrid to the large power grid The cost of selling electricity.

(2) Environmental protection goals:

$$f_2=\min\left[\sum_{t=0}^{T}\sum_{k=1}^{m}\sum_{i=1}^{n}G_{i,k}P_{i,t}+\sum_{t=0}^{T}\sum_{k=1}^{m}G_{buy,k}P_{buy,t}\right] \tag{7}$$

Where: $G_{i,k}$ is the emission coefficient of the k-th pollutant gas emitted by the i-th power generation unit; $G_{buy,k}$ is the k-th pollutant gas emission coefficient when the microgrid purchases electricity from the large power grid.

3.2 Restrictions

(1) Power balance constraint

$$\sum_{i=1}^{n}P_{i,t}+P_{buy,t}-P_{sell,t}=P_{load,t} \tag{8}$$

(2) Power generation capacity constraints

$$P_{i-\min}\leqslant P_{i,t}\leqslant P_{i-\max} \tag{9}$$

(3) Grid transmission capacity constraints

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$$P_{buy\min} \leqslant P_{buy,t} \leqslant P_{buy\max} \quad (10)$$

$$P_{sell\min} \leqslant P_{sell,t} \leqslant P_{sell\max} \quad (11)$$

(4) Battery capacity constraints

$$SOC_{\min} \leqslant SOC_t \leqslant SOC_{\max} \quad (12)$$

3.3 Algorithm implementation process

Multi-objective group search algorithm is an algorithm that combines group search algorithm with non-dominated sorting in multi-objective optimization and crowding distance into an algorithm that handles multi-objective optimization problems. The steps are as follows:

Step 1: Population initialization, including individual location and search angle

Step 2: Calculate the initial population fitness function value

Step 3: Set up an external elite set, and stipulate that the maximum capacity of the external elite set is M.

Step 4: 1) Discoverer search: first search at a 0 degree angle, and then search for new positions in the front, left and right respectively. Compare the relationship between the new position and the original position. If a better position is still not searched after a iteration, the finder resets the angle. 2) Searcher search: randomly select 80% of individuals as searchers to follow the finder to search. 3) Wanderer search: The remaining individuals search independently as wanderers: the search angle and search distance movement are randomly generated.

Step 5: Update the external elite set according to the non-dominated ranking, as well as the discoverer and search angle.

Step 6: Increase the number of iterations by one, and return to step 4 to search again until the maximum number of iterations is reached.

The initial angle of the set GSO is $\varphi^0 = \pi/4$; constant $a = round\left(\sqrt{n+1}\right)$; Dim is the space dimension; $\theta_{\max} = \pi/a^2$; $\alpha_{\max} = \pi/2a^2$; The group size is 48.

4. Numerical example simulation

The microgrid consists of diesel generators (rated power 60 kW), photovoltaic panels (rated power 0.2 kW), wind generators (rated power 100 kW), storage batteries (rated power 30 kW) and a large power grid.

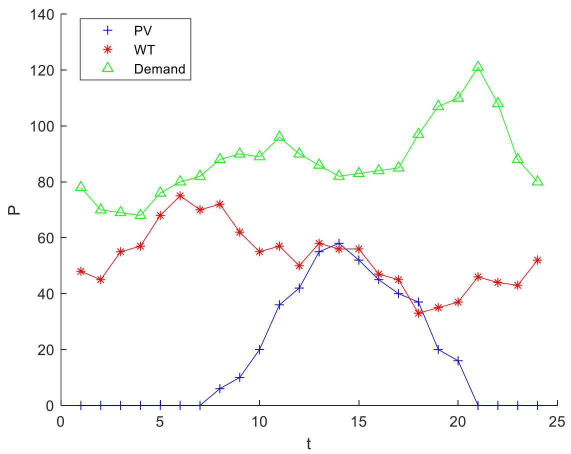

Fig. 1 Load, wind turbine and photovoltaic output

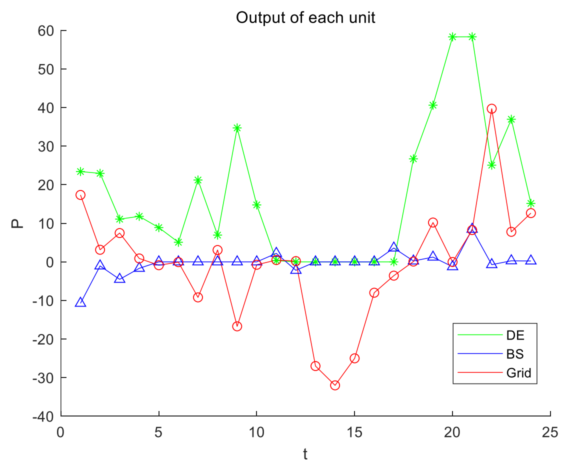

Fig. 2 Grid-connected dispatching plan

Figure 2 shows a compromised dispatching scheme when microgrid is connected to the grid. The operating cost of the microgrid is 596.75 yuan, and the pollutant gas emission is 235.45kg. During

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the low power consumption period, the main power grid and diesel generators are used to generate electricity, and the energy storage device is charged as much as possible; in the first peak power consumption period, the net load is less than 0, and the energy storage device is discharged and sold to the large power grid Electricity; during the second peak time period, diesel generators and energy storage devices are mainly used to generate electricity, and the excess electricity is sold to the large power grid.

5. Conclusion

This paper studies the multi-objective optimal dispatching of grid-connected microgrids. Establish a multi-objective optimization model of the microgrid and the model is solved by the multi-objective group search algorithm, which realizes the economic and environmental optimization of the grid-connected microgrid Scheduling. It is proved that the multi-objective group search algorithm can well realize the multi-objective optimization of the microgrid.

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