

Dynamic Economic Optimal Dispatch of Microgrid Based on Improved Differential Evolution Algorithm

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Abstract. Aiming at the static economical dispatch for microgrid ignoring the inherent link between the lack of each time interval, considering wind turbines, photovoltaic cells and sodium sulfur battery uncertainty factors on economic dispatch, taking the minimum micro power output and micro grid operation cost as objective function, the establishment of a micro grid dynamic economic dispatch model. Using VC++, the dynamic economic dispatch program of microgrid is developed by using improved differential evolution algorithm. By changing the dynamic crossover factor, the convergence speed of the algorithm and the ability to avoid falling into local optimum are improved. According to the characteristics of microgrid example structure, the output principle and operation control strategy of microgrid are formulated according to the operation of microgrid isolated grid / grid connected operation. The results show that the economic dispatch of microgrid using dynamic optimization theory is more advantageous than static scheduling in cost saving, and it makes the charge and discharge of sodium sulfur battery more global and practical.

1. Introduction

The micro grid integrates various distributed power, load, energy storage units and control devices to form a single controlled unit, which provides both electrical and thermal energy to the user. The emergence of micro grid provides an effective technical means for the comprehensive utilization of distributed energy [1-2]. The economy of microgrid is an important factor to promote the large-scale promotion of microgrid. Micro grid economic dispatch can be divided into static scheduling and dynamic scheduling. The dynamic economic dispatch takes into account the interaction between the time periods, and reflects the operation requirements of the system more effectively. Until now, the research on micro grid economic dispatch for the vast majority of static scheduling [3 – 5], for each time the power system is used to obtain the optimal cross section, and through simple and get the global optimum, but did not consider the connection between different time section.

This paper focuses on the characteristics of the micro grid, considering wind turbine (WT) and photovoltaic (PV) output affected by natural environment, as well as the existence of sodium sulfur batteries will increase the correlation between different period, established the micro grid dynamic economic dispatch model, and designed to improve the solution of dynamic differential evolution programming [6](IDE) algorithm. According to the model proposed by this theory, combined with the



corresponding control strategy, this paper compiled an improved differential evolution algorithm of VC++ optimization program, and verified by examples that the dynamic economic dispatch of microgrid has a great advantage in cost optimization [7].

2. differential evolution algorithm

The characteristics of differential evolution algorithm include the memory of optimal solution and the sharing of information within the population [8-9]. Its essence is a greedy selection algorithm based on real coding and the idea of survival of the fittest.

2.1. Improved differential evolution algorithm

The improvement of differential evolution algorithm is mainly aimed at algorithm expansion model and dynamic change of parameters.

2.1.1. Extended model of algorithm. In this paper, we use the DE/Current-to-best/2/bin strategy to generate differential vectors. The strategy is characterized by maintaining the diversity of the population while emphasizing the convergence speed of the algorithm, such as the formula (1):

$$v_{i,j}^{t+1} = x_{i,j}^t + F(x_{best,j}^t - x_{i,j}^t) + F(x_{r_1,j}^t - x_{r_2,j}^t) \quad (1)$$

Formula is the optimal individual in the population.

2.1.2. dynamic parameters

1) Scaling factor F. The scaling factor F is more conducive to efficient and rapid optimization and global search, which is suitable for the initial stage of optimization; and in the later stage of the optimization, the larger scaling factor is not conducive to the local search of the algorithm. The scaling factor decreases linearly from 0.8 to 0.5, as shown in equation (2):

$$F^t = F^1 - (F^1 - 0.5) \frac{t}{n_p} \quad (2)$$

Formula: scaling factor for t generation; = 0.8.

2) cross factor c_R In the optimization stage, smaller cross factor can improve the local search ability of the algorithm; in later optimization, cross factor can prevent the algorithm into a local optimum, so this paper uses dynamic cross factor, increasing from 0.3 to 0.6 linear type (2), as shown in the $c_R^1 = 0.3$

3. implementation process

The algorithm of dynamic economic dispatch of microgrid based on improved differential evolution algorithm is as follows. Step 1: micro grid raw data is set up, including heat load, environmental information (solar panel temperature, solar radiation value and wind speed), micro power information (initial value of sodium sulphur battery, upper and lower limit of each micro power source) and so on. Step 2: initialize the seed, randomly generate the initial population, and calculate the optimal individual $x_{best,j}^t$ in the population.

Step 3: mutation, select two individuals different from $x_{i,j}^t$ in the initial population to perform mutation operation. Step 4: cross the individual of the mutation and the original individual.

Step 5: micro power output cross boundary processing.

Step 6: handling the dynamic confinement of the sodium sulphur battery.

Step 7: calculate the fitness function value of the individual.

Step 8: select and compare the target individuals and the newly generated individuals, and retain the optimal individuals into the next generation population to prevent the loss of optimal individuals in evolutionary processes in subsequent evolution.

Step 9: population evaluation.

Step 10: determine whether the end condition is satisfied. If it reaches the maximum

The number of iterations, stopping iteration. Otherwise, proceed to step 3 and continue iterating.

Step 11: output the optimal solution. When the output of each micro power source is initialized in step 1, among them, the improved differential evolution algorithm main program flow chart, t_{\max} is maximal evolution algebra.

4. example analysis

In this paper, a case of 10kV microgrid is analysed, and the structure diagram is shown in figure 1.

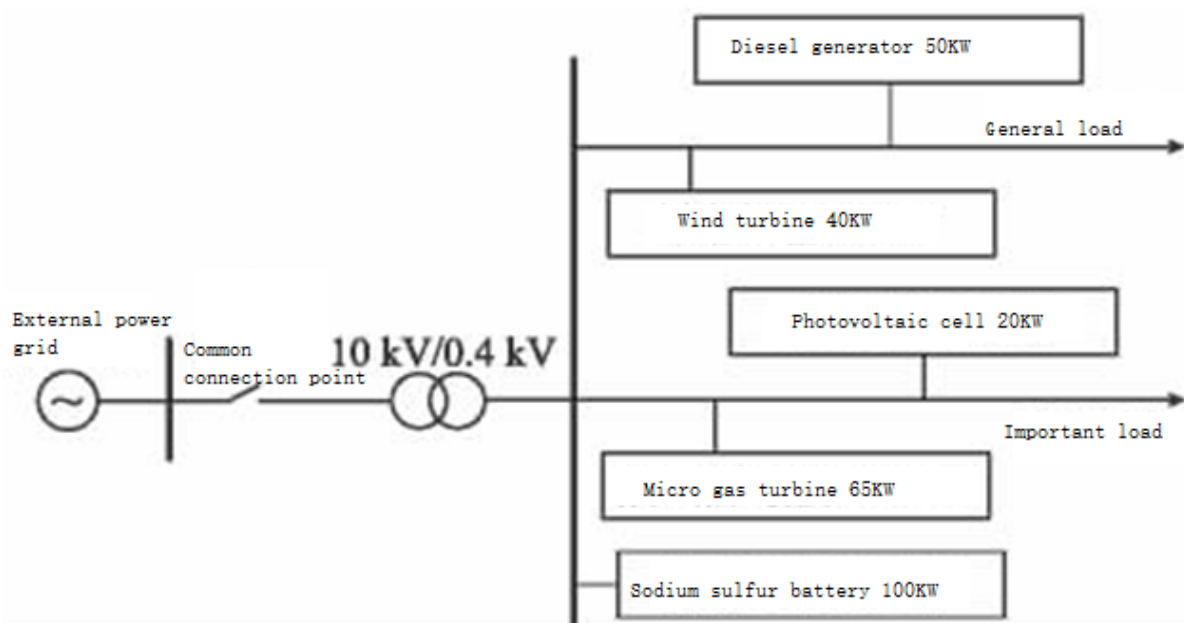


Figure 1. microgrid structure model

4.1. microgrid basic data

The basic data include four typical daily load data, local energy data and micro power technology performance parameters. The natural gas price from 2.28 yuan / m³; the price of diesel 8.13 yuan / kg; the efficiency of diesel engine 0.209; micro gas turbine sewage treatment fee of 0.1647 yuan / (kW · H), diesel generator, sewage treatment fee of 0.7621 yuan / (kW · H), the main sewage treatment fee of 0.3141 yuan / (kW · H); a an optimization cycle for the day, including 24 periods; the local price factors are shown in Table 1; micro power technology performance parameters are shown in table 2.

Table 1. Time sharing electrovalence

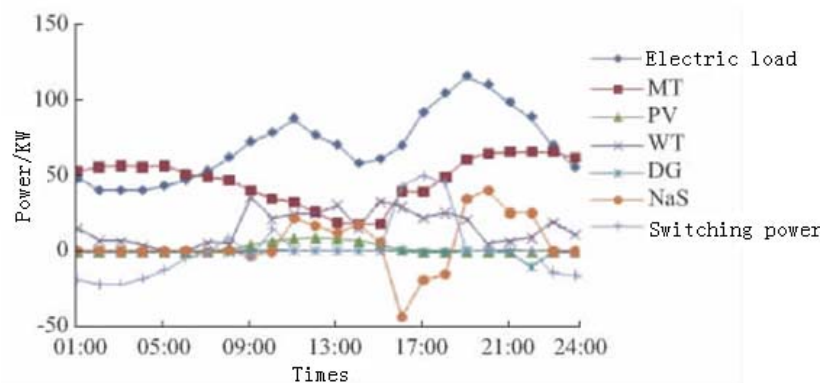
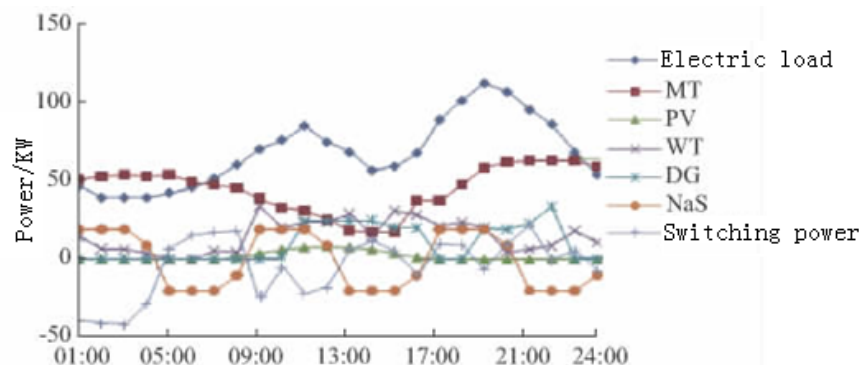
Time interval	Specific time	Price/(Yuan*(Kw. h) ⁻¹)	
		Purchasing electrovalence	selling
Peak period	11:00-15:00, 19:00-21:00,	0.83	0.65
Peacetime period	8:00-10:00,16:00-18:00, 22:00-23:00	0.49	0.38
Valley period	00:00-07:00	0.17	0.13

Table 2. Essential data of micro-source

Micro power type	Power/kw		Durable	Installation cost	Operation and maintenances coefficient
	Lower limit	Upper limit	Years/s	RMB.(kw) ⁻¹	Year.(kw. h) ⁻¹
WT	0	40	10	2.375	0.0296
PV	0	20	20	6.65	0.0096
MT	0	65	15	1.667	0.03
DG	0	50	10	1.6	0.088
NaS	0	100	15	2.7	0.0013

4.2. Operation cost analysis of dynamic and static economic dispatch for sodium sulphur battery

The economic optimization cost analysis is to optimize the typical daily data of microgrid, and obtain the total cost of microgrid under the condition of determining the output distribution. This section takes the winter thermal load grid connection operation as an example. Figure 2 is the output power curve of micro power sources in microgrid when dynamic economic optimal dispatch is adopted. Fig. 3 is a micro power output curve obtained from the micro grid static economic dispatch method proposed by document [4] when the operating conditions are exactly the same as that of Fig. 2.

**Figure 2.** Output curve of micro power source for dynamic optimal scheduling**Figure 3.** Output curve of micro power supply for static optimal scheduling

From Figure 4 shows that in 01:00 - 07:00 and 23:00 - 24:00, due to the thermal load demand, electric power load more than a micro gas turbine, can be sold to the main power grid; in 15:00 18:00, which belongs to the usual period, from the main electric power to online shopping of sodium sulphur battery charging, and used in the peak period discharge.

4.3. Influence of micro gas turbine / photovoltaic cell on operation cost of microgrid

This festival in spring and autumn only load grid as an example, Figure 4 shows the exchange of power output power of the micro power and micro grid and grid based dynamic economic dispatch. Figure 5 shows the operation of the microgrid system by increasing the capacity of wind turbines and solar photovoltaic cells to 2 x 40kW and 4 x 20kW. After the increase of wind and solar capacity, the amount of clean energy power generation has increased substantially.

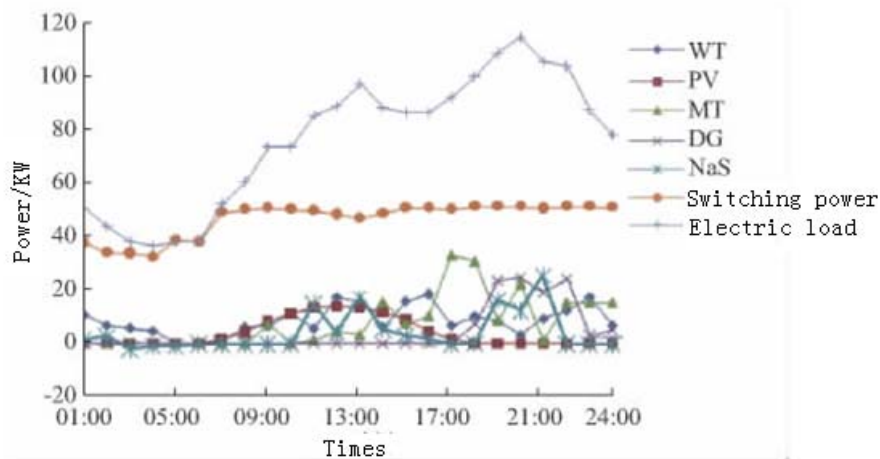


Figure 4. Output curve of micro power supply in grid operation in spring and autumn

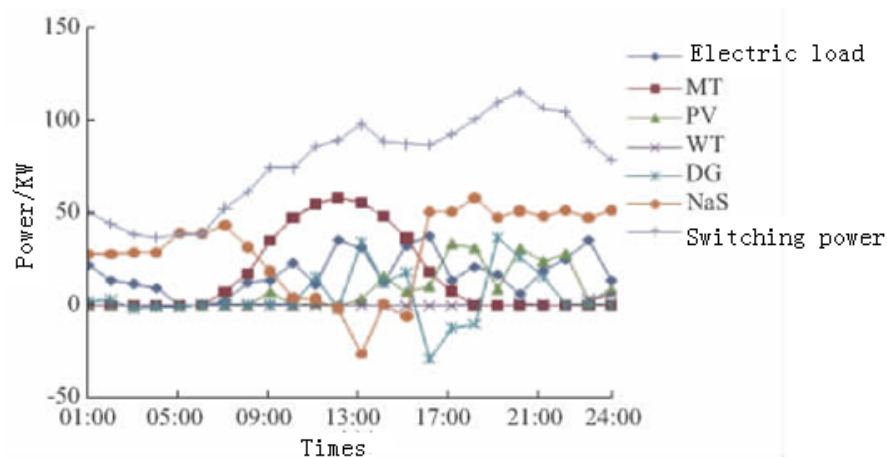


Figure 5. The output curve of micro power supply in improving the capacity of wind and solar power generation

4.4. Comparison of improved differential evolution algorithm and differential evolution algorithm

The differential evolution algorithm proposed in this paper is programmed, and the operation cost of microgrid in winter is simulated in the section. The results are compared with those obtained by improved differential evolution algorithm. The computation time of differential evolution algorithm is 68.8s, and the total cost in one cycle 24h is 1254.55 yuan; the improved differential evolution algorithm has a computing time of 62.1s, and the total cost in a cycle of 24h is 1208.95 yuan. The cost of each specific period is shown in table A of appendix A1. Comparing the operation cost of micro power supply in different periods, it can be concluded that the improved differential evolution algorithm has more advantages than the differential evolution algorithm in finding the optimal solution.

5. Conclusion

In this paper, the dynamic economic dispatch model of microgrid is established, and the output and operation cost of each micro power source in microgrid are calculated. The results show that the economic dispatch of microgrid with dynamic optimization theory is more comprehensive and practical, and has more advantages than static scheduling in cost saving. The constraint conditions of micro dynamic economic dispatch model in power grid includes only the power balance and the unit output constraints, the future could be further studied in the model increases the probability constraints of reliability of micro grid system, the micro grid dynamic economic dispatch model is more comprehensive and practical.

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