Universe Scientific Publishing Volume 8 Issue 03

Research on optimal allocation of mobile energy storage for new energy access distribution network based on Salp group algorithm

Jianghai He
China Xiongan Group Urban Development Investment Co., Ltd, Xiongan 071700,China

Abstract: In this paper, based on the characteristics of new energy, distribution network and mobile energy storage, variation, crossover and selection operations are used to increase the diversity of search groups and improve the global search ability. Then, a salpa group algorithm based on differential evolution is proposed to obtain the optimal configuration state of mobile energy storage in each period of distribution network lines. Experimental results show that the algorithm converges faster. The algorithm has higher positioning accuracy. Finally, combined with the demonstration of X distribution network line, the applicability of the optimization model and solving algorithm proposed in this paper is verified.

Key words: Salpa salpa group algorithm; New energy; Distribution network; Mobile energy storage; Optimized configuration

With the gradual advancement of the "dual carbon" goal, wind power, photovoltaic and other new energy power generation has been rapidly developed. According to the National Energy Administration, in 2022, China's new installed capacity of wind power and photovoltaic will reach 125 million kilowatts, and the cumulative installed capacity will reach 758 million kilowatts. However, wind power and photovoltaic have the characteristics of volatility, intermittence and randomness, and their large-scale installation makes the net load of the distribution network fluctuate in the short and long term, which requires frequency adjustment and peak regulation. Therefore, the mobile energy storage system in distributed energy storage is helpful to achieve the load balance of the distribution network with new energy as the main body, stabilize the output power, promote the absorption of new energy, improve the utilization rate, and ensure the safe and stable operation of the distribution network.

At present, many scholars at home and abroad have carried out research on the optimal configuration of distributed energy storage in the distribution network. Considering system balance constraints and equipment operation constraints, Geng Jian et al. built a comprehensive model to meet the economic and environmental optimization requirements of distributed distribution networks. Yan Qunmin et al. summarized in detail the optimal configuration requirements and appropriate solving algorithms of distributed energy storage technology under different application modes on the power supply side, the power grid side, the user side and the microgrid side. Although the above researches can solve multi-objective optimization problems, the search time is long, the convergence speed is slow, the convergence accuracy is low in the process of solving multi-objective optimization problems, and it is difficult to solve the multi-objective optimization problems with complex objective functions or constraints. Therefore, it is a very important and practical topic to propose an optimization configuration solution method with faster convergence speed and higher positioning accuracy.

I. Problem Description

It is known that the position state of mobile energy storage in the new energy distribution network with a dispatch period of one day, the distribution network line has a total of line nodes, including a photovoltaic node, a fan node and a mobile energy storage node, which are balance nodes. Moreover, the line node is the set of all the last nodes started by the node, and the set of all the first nodes ended by the node. $T = 24$咻 n n_s n_w n_m o $t \in [1,T]$ $o,i,j,k \in [1,n]$ v_j j u_j j Ω Is the set of all operating paths of mobile energy storage within the time span, is the set of all operating paths of the node within the time span, and is the set of all operating paths of the node within the time span. Δt Ω_i^+ Δt i Ω_i^- Δt i

II. Solving the optimal configuration model of Salpa salpa group algorithm based on differential evolution

The Salpa Salpa Group algorithm (SSA) is a new optimization algorithm inspired by the population behavior of Salpa Salpa in the ocean. The specific solution process of the DE-SSA based on differential evolution is as follows:

1. Assuming that Salps exist in a dimensional predation space, it represents the number of salps and the number of optimization parameters. $N \times D$ N D Food exists in the upper and lower bounds of the predation space, and the initial positions of salps are randomly generated, namely:. $ub = [ub_1, ub_2, \cdots, ub_D]$ $lb = [lb_1, lb_2, \cdots, lb_D]$ $F = [F_1, \ F_2 \ \cdots \ F_D]^T$ N $X_{N \times D} = rand(N,D) \times (ub - lb) + lb$

Where, the position of salp leader is, and the position of follower is. $X_d^1(1), (d = 1,2,\cdots,D)$ $X_d^m(1), (d = 1,2,\cdots,D; m = 2,3,\cdots,N)$

2. Taking the objective function of the mobile energy storage optimization configuration model as the fitness function, the fitness value of each salp's initial search food location was calculated. $f(X)$ N

3. Sorted the fitness values of each salps' initial food search location, and selected the location with the best fitness value as the initial food search location. N

4. In order to balance the randomness and stability of the algorithm when searching for food location, the number of salps leaders is

selected as half of the group number, that is, the first half of the fitness value from best to worst is the leader, and the last half is the follower.

5. Salps leaders are responsible for searching for food in the predator space of dimension and updating the location according to formula (13). $N \times D$

$$X_d^1(l+1)=\begin{cases} F_d + c_1 \cdot \left(\left(ub_d - lb_d\right) \cdot c_2 + lb_d\right) & c_3 \geq 0.5 \\ F_d - c_1 \cdot \left(\left(ub_d - lb_d\right) \cdot c_2 + lb_d\right) & c_3 < 0.5 \end{cases} \quad (13)$$

Where, is the number of current iterations; l $l_{\max}$ Is the maximum number of iterations; $X_d^1(l+1)$ For the position of the leader of the first generation of salps; $l+1$ d c_1 Is the convergence factor, which is used to balance the global search and local search of the algorithm, usually take; $c_1 = 2e^{-(4l/l_{\max})^2}$ c_2 And to increase the randomness of salp search, in the generated random number. c_3 $[0,1]$

The position of salps followers is only affected by the salps earlier in the "chain", and the position is updated according to formula (14).

$$\begin{aligned} X_d^m(l+1) &= X_d^m(l) + R_d^m(l) \\ &= X_d^m(l) + \frac{1}{2}\left[X_d^{m-1}(l) - X_d^m(l)\right] = \frac{1}{2}\left[X_d^m(l) + X_d^{m-1}(l)\right] \end{aligned} \quad (14)$$

6. Calculate the updated fitness value of each salp's search food location. N

7. Two different salps leaders were randomly selected, and the mutation operation was performed on the leader positions of the variated salps according to formula (15). r_1

$$V_d^{r_1}(l+1) = X_d^{r_1}(l) + F \times \left(X_d^{r_2}(l) - X_d^{r_3}(l)\right) \quad (15)$$

Cross the salp leader position according to formula (16). r_1

$$U_d^{r_1}(l+1)=\begin{cases} V_d^{r_1}(l+1), rand(0,1) \leq CR \;\; or \;\; d = rand(1,D) \\ X_d^{r_1}(l), \quad rand(0,1) > CR \;\; or \;\; d \neq rand(1,D) \end{cases} \quad (16)$$

Finally, update the search food location of generation 1 according to formula (17). $l+1$

$$X_d^{r_1}(l+1)=\begin{cases} U_d^{r_1}(l+1), f\left(U_d^{r_1}(l+1)\right) \leq f\left(X_d^{r_1}(l)\right) \\ X_d^{r_1}(l), \quad f\left(U_d^{r_1}(l+1)\right) > f\left(X_d^{r_1}(l)\right) \end{cases} \quad (17)$$

8. After the above process is repeated until the maximum number of iterations is completed or the fitness value is optimized, the dimension vector corresponding to the current search position of Salps group is the optimal solution of the optimal configuration model. D

III. Analysis of numerical examples

In order to verify the feasibility and effectiveness of the proposed optimal configuration model and solving algorithm, this paper carries out an empirical analysis of X distribution network lines. The X distribution network has a total of 33 line nodes, including 2 photovoltaic nodes, 3 fan nodes and 2 mobile energy storage. Among them, the PV node has a power factor of 0.95, the apparent power upper limit is 0.6MVA, and the fan node has a power factor of 0.97. The rated power of mobile energy storage is 0.3MW, the rated power is 1MWh, the initial power is 0.5MWh, the upper and lower limit of the state of charge are 0.9 and 0.1 respectively, the maximum number of movement per day is 4, and the time span is 2h. The maximum transmission power of the X distribution network line is 3MW, the balance node is node 1, the reference voltage is 12.66kV, the balance node voltage is 1.03 reference voltages, and the safe upper and lower limits of the node voltage are 1.1 and 0.9 reference voltages respectively.

Firstly, the single-objective optimal configuration of X distribution network lines is carried out with the objectives of minimum wind and light abandonment, minimum loss of distribution network and minimum operating cost of distribution network respectively. The optimization results are shown in Table 1.

Table 1 Compares the results of 13 kinds of single objective optimal configurations

Optimization objective	Wind and light jettison (MW)	Loss of distribution network (MW)	Distribution network operating cost (Yuan)
Minimum discard of wind and light	0.00	1.95	64267.26
The distribution network has minimal network loss	0.51	1.74	63638.57
Distribution network operating costs are minimal	15.41	2.43	55593.85

As can be seen from Table 3, the results of single objective optimization cannot make the abandonment of wind and light of X distribution network line, the loss of distribution network and the operation cost of distribution network reach the optimum at the same time. Finally, after calculation, two mobile energy storage moving routes and power curves can be obtained respectively, as shown in Table 4 and

Table 5, to achieve the optimal wind and light abandonment amount, distribution network loss and distribution network operating cost of X distribution network line.

Table 2 Mobile energy storage 1 mobile route that meets the multi-objective optimal at the same time

t	1 to 2	2-3	5-6	7-8 -	9-10	11-12
Position	17-17	17-32	32 -	32 -	32 -	32 -
Status	C-D	A-A	D-D	D-D	D-D	C-C
t	13 and 14	15 to 16	17-18	19 and 20	21-22	23 to 24
Location	32 -	32-15	15-15	15-15	15-15	15 to 17
Status	C-D	A-A	D-C	C-C	D-D	A-A

Table 3 Mobile energy storage that meets multiple objectives optimally at the same time 2 Mobile routes

t	1 to 2	2-3	5-6	7-8 -	9-10	11-12
Position	24-24	24-24	24-24	24-24	24 to 32	32 -
Status	D-D	D-D	D-D	D-D	A-D	C-C
t	13 and 14	15 to 16	17-18	19 and 20	21-22	23 to 24
Location	32 -	32-14	14-14	14-14	14-14	14 to 24
Status	C-D	A-A	D-C	C-C	D-D	A-A

Finally, under the mobile energy storage moving route and power curve, the optimal wind and light abandonment amount, distribution network loss and distribution network operating cost of X distribution network can be obtained, as shown in Table 6.

Table 4 Results of optimal configuration that simultaneously meets multi-objective optimality

Optimization objectives	Wind and light jettison (MW)	Loss of distribution network (MW)	Distribution network operating cost (Yuan)
Meet the multi-objective optimal at the same time	5.35	1.90	59378.93

As can be seen from Table 6, the objective function value of the optimal configuration results that simultaneously meet the multi-objective optimization is close to that of the optimal configuration results that respectively take the minimum abandonment of wind and light, the minimum loss of the distribution network and the minimum operating cost of the distribution network as single objectives, which satisfies the coordinated optimization of multi-objectives and is better applied to the multi-objective optimal configuration problems in practical projects.

IV. Conclusions

This paper designs a new energy access distribution network mobile energy storage optimization configuration method. A salp group algorithm based on differential evolution is proposed with faster convergence speed and higher positioning accuracy. The optimal configuration state of mobile energy storage in each period of distribution network is obtained by searching the hunting location of salp salp. Finally, the empirical results of X distribution network line show that the method proposed in this paper can effectively promote the absorption of new energy, reduce the network loss and operation cost of distribution network, and provide certain decision-making reference for distribution network planning and operation personnel.

References:

[1]DuDongmei,CaoDonghui,HeQing.Discussiononlow-carbontransformationofChina'spowerindustryunderthe"double-carbon"goal[J]. Ploidy Thermalpowergeneration, 2022 (10) : 1-9.

[2]GengJian,YangDongmei,GaoZhengping.OptimaloperationofdistributedintegratedenergymicrogridwithCCHPconsideringenergystor The age [J] Jiangsuelectricalengineering, 2021, 40 (1) : 25-32.

[3]ZhouquanWu,PradeepKrishnaBhat,BoChen.Optimalconfigurationofextremefastchargingstationsintegratedwithenergystoragesyst Emandphotovoltaicpanelsi ndistributionnetworks [J]. Journal of Energies, 2023 (5) : 2385.

[4]CaiHao,ShiKai,TangJing.Optimalconfigurationofrenewableenergydistributedpowergenerationbasedonimprovedant-lionoptimiza Tionalgorithm [J] Electrica lmeasurementandinstrumentation, 2022,59 (11) : 88-95.

[5]SuoZhiwen,LiHui,ZhangFeng.OptimalconfigurationofadistributedsynchronouscondenserforanHVDCsending-endsystemwithahigh-p Roportionofrenewableenergy [J] Powersystemprotectionandcontrol, 2022, 50 (23) : 133-141.

[6]YanQunmin,MuJiahao,MaYongxiang.Reviewofdistributedenergystorageapplicationmodeandoptimalconfiguration[J].Jiangsuelect Ricalengineering, 2022, 9 (2) : 67-74.