Acta Technica 62 (2017), No. 5A, 323–332

Research on the influence of distribution network reconstruction, distributed power supply location and capacity on distribution network loss

Guanjun Li[1], Chen Zhou[1], Feng Wen[2], Zongyao Tang[2], Anping Hu[1], Yongliang Jiang[3]

Abstract. Distribution network reconfiguration is an effective method to optimize the distribution network. The access of distributed power supply affects the operation of the distribution network. In this paper, the IEEE33 node distribution network has proposed as an example based on the genetic algorithm, we have studied the distribution network reconfiguration before and after the change of network loss and node voltage, and analyzed the network loss of power supply when the access point is not at the same time. The results show that when the topology of distribution network is constant, the power loss at the end of the distributed power access point is smaller; the amount of loss reduction is proportional to the distributed power capacity.

Key words. Distribution network reconstruction, distributed power supply, position, capacity
.

1. Introduction

Distribution network reconfiguration is an effective operation means of distribution network optimization, by controlling the state of the line switch to change the distribution network topology, and it helps to achieve the purpose of increasing voltage, balancing load, reducing network loss [1-3]. With the deteriorating global environment and the ever-scarce primary energy supply, the utilization of renewable energy is receiving more and more attention. Distributed power access in the power grid is also becoming more and more widespread. Distributed power supply will

[1]Workshop 1 - China Electric Power Research Institute, Nanjing 210061, Jiangsu, China
[2]Workshop 2 - School of Electrical Engineering, Southeast University, Nanjing 210096, Jiangsu, China
[3]Workshop 3 - Suzhou yuanhui electric co. LTD, Suzhou 215000, Jiangsu, China
[4]Corresponding author: Zongyao Tang ;email:1425824826@qq.com

become an important factor Production of electricity, but also it will bring some impact on the grid [4-7].

Distribution Network Reconfiguration and Distributed Power Distribution Network, these two issues are closely linked inseparable, when the minimum loss for the reconstruction of the target, the location of the distributed power supply, the choice of capacity is also particularly important. In this paper, we take the least loss as the goal by using genetic algorithm; this algorithm has applied to the reconfiguration of the IEEE33 model of node distribution network. First, the changes of the network loss and voltage are analyzed before and after the reconfiguration. At the same time, the change of network loss is analyzed. Finally, the influence of different distributed power access locations and different distributed power capacity on the loss of distribution network is analyzed after access to distributed generation.

2. The distribution network reconfiguration

2.1. Mathematical model of distribution network reconfiguration

In this paper, the minimum loss as the objective function of distribution network reconfiguration, the constraints are as follows, distribution network structure is radial, and the line current is not more than limit node voltage to meet the requirements. The mathematical expression is as follows [8-11].

The objective function:

$$\min f = \sum_{k=1}^{n_L} R_k \frac{P_k^2 + Q_k^2}{U_k^2} \tag{1}$$

Where nL is the total number of branches, Rk, Pk, Qk, Uk are respectively the resistance, active power, reactive power, and the bus voltage of the branch k at the head of the branch at a certain moment.

Restrictions:

1) network topology constraints, was radial.

2) System power flow constraint: g(x)=0.

3) Transmission line capacity constraints:

$$Si < Simax \tag{2}$$

4) node voltage constraints:

$$U_{\min} \le U_i \le U_{\max} \tag{3}$$

Umin is the minimum node voltage, Umax is the maximum node voltage.

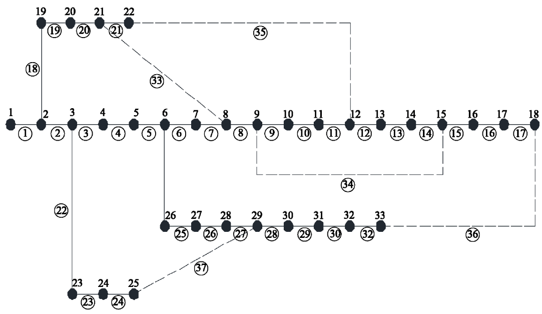

Fig. 1. IEEE33 node structure diagram

2.2. Distribution network reconfiguration based on genetic algorithm

This paper uses the IEEE 33 node distribution system shown in Figure 1. The rated voltage of the system of Fig. 1 is 12.66kV, the total network load is 3715kW + j2300kvar, the per unit value of the balanced node voltage is 1.0pu, and the maximum iteration number M is 100.

For the above distribution network system, we can use genetic algorithm for distribution network reconfiguration, the network loss and voltage before and after reconstruction are shown in Table 1 and Figure 2.

Table 1.Comparison of switch status, network loss and voltage before and after the reconfiguration

Parameters	Before refactoring	After refactoring
Contact Switch Set	8-21 9-15 12-22 18-33 25-29	7-8 14-15 9-10 32-33 25-29
Network loss/kW	202.68	139.55
Lowest node voltage polyol /pu	0.9131	0.9378

It can be seen from the above analysis that the network loss after reconstruction is reduced by 31.15% and the voltage at each node is also improved.

2.3. power supply position on the impact of loss

We must cut off the power node 1 and maintain the topology of the power distribution network after the reconstruction of the IEEE 33 node, and the power sources are respectively selected to connect at the nodes 3 to 33 to calculate the network loss when the power supply locations are different.

Table 2. Network loss of different power locations

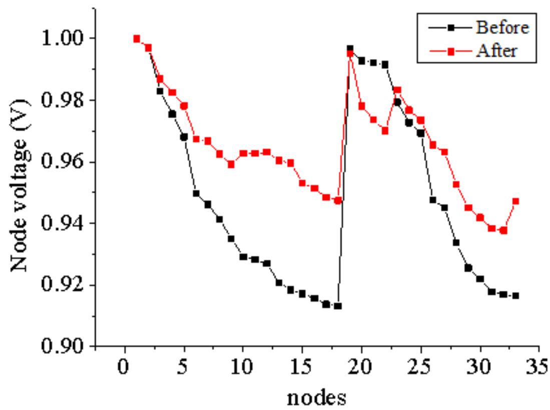

Fig. 2. Comparison of node voltage before and after the reconfiguration

Power Access Node Location	Network loss /kw	Power Access Node Location	Network loss/ kw
2	139.55	18	331.19
3	119.74	19	147.77
4	130.42	20	244.02
5	145.69	21	278.22
6	185.81	22	384.27
7	214.77	23	154.47
8	589.99	24	236.96
9	836.89	25	360.31
10	997.55	26	200.05
11	931.74	27	221.65
12	818.23	28	317.83
13	1462.9	29	407.35
14	2236.6	30	473.90
15	2222.9	31	676.53
16	3631.2	32	761.75
17	1760.3	33	2373.6

As it can be seen from the above table, in the case of this kind of network structure, the access locations of the power sources are arranged in ascending order according to the network loss (selecting the ones with smaller network loss): 3,4,5,19,23,6 , 26,7,27,24,20,21,28,18,25,22.

It can be seen from the above results that in the fixed distribution network structure, under the fixed distribution network structure, the location of the power supply access is re-selected. In general, the electrical distance from the original access location is greater Nearly, the smaller the network loss. However, it can be seen from the above data that when the power is connected to node 3, the network loss is smaller than that when node 2 is connected. Therefore, properly adjusting the position of the power access node can effectively reduce the network loss of the power distribution network.

3. Distributed power supply location, capacity impact on distribution network loss

Set a distributed power point with a capacity of 200 and a power factor of 0.8, and respectively access the nodes 2 ˜ 33 in the distribution network to obtain the network loss in each case.

Table 3. Network loss of different power locations

Distributed power Access Node Location	Network loss /kw	Distributed power Access Node Location	Network loss /kw
2	138.49	18	125.2
3	134.79	19	137.91
4	133.1	20	132.85
5	131.48	21	131.56
6	128.06	22	130.77
7	127.99	23	133.68
8	128.55	24	131.69
9	127.65	25	130.81
10	129.11	26	127.37
11	129.09	27	126.47
12	129.1	28	123.2
13	128.64	29	120.85
14	128.57	30	119.59
15	126.23	31	118.7
16	125.83	32	118.58
17	125.34	33	125.24

As can be seen from the table above, compared with the network loss of 139.55kW when the distributed power is not connected, the network loss decreases after the distributed power supply is accessed. In general, the closer the access point is to the end of the branch, the network loss is smaller. Several access points with the smallest network loss are 31, 32, 30, 29 and so on, that is, nodes far away from the electrical source of the power supply. Therefore, the further the distributed power access point is from the electrical source, the network loss is smaller.

Increase the distributed power capacity to 400,600, the power factor is still 0.8, we can get the distributed power location at different time loss as shown in Table 4, Table 5.

Table 4. Network loss of different power locations

Distributed power Access Node Location	Network loss /kw	Distributed power Access Node Location	Network loss /kw
2	137.48	**18**	116.79
3	130.34	**19**	136.39
4	127.17	**20**	127.15
5	124.15	**21**	124.82
6	117.84	**22**	123.66
7	117.82	**23**	128.36
8	120.02	**24**	124.91
9	118.84	**25**	123.67
10	121.81	**26**	116.61
11	121.67	**27**	114.99
12	121.49	**28**	109.21
13	121.38	**29**	105.11
14	121.55	**30**	102.98
15	117.23	**31**	101.86
16	116.87	**32**	101.81
17	116.66	**33**	117.13

Table 5. Network loss of different power locations

Distributed power Access Node Location	Network loss /kw	Distributed power Access Node Location	Network loss /kw
2	136.51	18	113.7
3	126.21	19	135.01
4	121.76	20	122.4
5	117.57	21	119.29
6	108.88	22	118.15
7	109.02	23	123.61
8	113.86	24	119.18
9	112.96	25	118.06
10	117.48	26	107.23
11	117.11	27	105.07
12	116.57	28	97.485
13	117.55	29	92.203
14	118.2	30	89.542
15	112.22	31	88.768
16	112.28	32	88.961
17	112.97	33	114.55

Table 3, Table 4 and Table 5 shows that when distributed power access points are the same, the capacity is larger, and the network loss is smaller. However, when the access points are not the same, the effect of reducing the network loss is different, we do the comparison of network losses for Table 3, Table 4 and Table 5, which is shown in Figure 3.

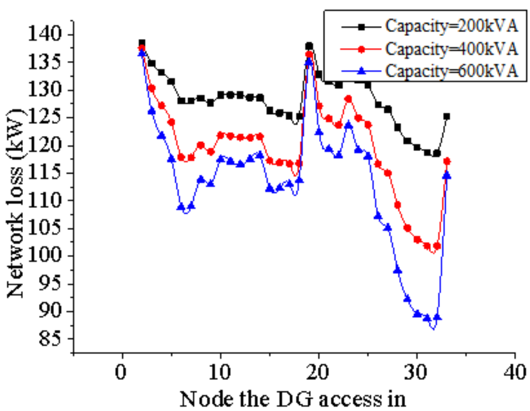

Fig. 3. Influence of capacity to network loss

As can be seen from Figure 3, at points 2, 19, 3 and so on, different capacities have little effect on the network loss. This is in contrast with the aforementioned analysis that "the effect of loss of access to distributed power at these points on network loss is insignificant" Match.

Network access is not access to distributed power loss, which is marked P1, accessed to 200kVA distributed power loss is recorded as P2, accessed to 400kVA distributed power loss is recorded as P3, after accessing to 600kVA distributed power network is recorded as P4. The difference between P1 and P2 is ΔP(1-2), the difference between P1 and P3 isΔP(1-3), and the difference between P1 and P4 isΔP(1-4). Specific values are as follows Table shows.

Table 6. Network loss Difference table for different distributed power capacity

Network Loss /kW Access node	$\Delta P_{(1-2)}$	$\Delta P_{(1-3)}$	$\Delta P_{(1-4)}$
2	1.06	2.07	3.04
3	4.76	9.21	13.34
4	6.45	12.38	17.79
5	8.07	15.4	21.98
6	11.49	21.71	30.67
7	11.56	21.73	30.53
8	11	19.53	25.69
9	11.9	20.71	26.59
10	10.44	17.74	22.07
11	10.46	17.88	22.44
12	10.45	18.06	22.98
13	10.91	18.17	22
14	10.98	18	21.35
15	13.32	22.32	27.33
16	13.72	22.68	27.27
17	14.21	22.89	26.58
18	14.35	22.76	25.85
19	1.64	3.16	4.54
20	6.7	12.4	17.15

The relationship between ΔP(1-2), ΔP(1-3), ΔP(1-4)and distributed power capacity is analyzed. ΔP(1-3)/ΔP(1-2), ΔP(1-4)/ΔP(1-2)are shown in Figure 4.

As can be seen from the figure above, when access to distributed power supply, the reduction of network loss is generally proportional to the capacity of distributed power supply, but at some nodes, such as nodes 18,19, the proportion will be smaller than normal, which Because distributed power access to these points when the loss

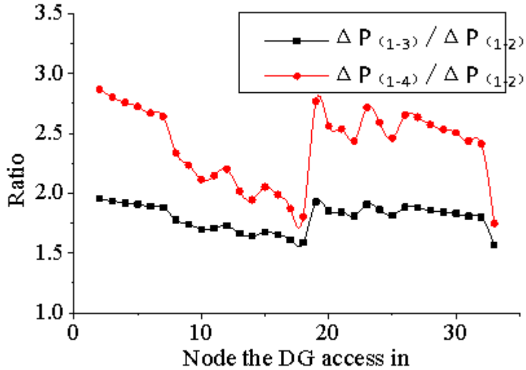

Fig. 4. Comparison of network loss of different capacity

reduction of the network itself is very small, coupled with large calculation error, so the final proportion of the size there is a certain error.

4. Conclusions

(1)In the fixed distribution network structure, the power distribution structure with the lowest loss is obtained when a node is connected to the power supply, and then the power supply access position is reselected. In general, the closer to the electrical distance from the original access location, the network loss is smaller, but proper adjustment of the location of the power access node can still effectively reduce the distribution network loss.

(2)When the distribution network topology is the same, in general, the distributed power access point is closer to the end of the branch, the network loss is smaller, that is, the further the distributed power access point is away from the power supply, the network loss small is more.

(3)When the distribution network topology is the same, when access to distributed power supply, under normal circumstances, the reduction of network loss is proportional to the distributed power capacity.

References

[1] A. Asrari, T. Wu, S. Lotfifard: *The Impacts of Distributed Energy Sources on Distribution Network*. Reconfiguration IEEE Transactions on Energy Conversion *31* (2016), No. 2, 606–613.

[2] S. R. Tuladhar, J. G. Singh, W. Ongsakul: *Multi-objective approach for distribution network reconfiguration with optimal DG power factor using NSPSO Iet Generation*. Transmission & Distribution *10* (2016), No. 12, 2842–2851.

[3] A. Lotnyk, U. Ross, T. Dankwort, I. Hilmi, L. Kienle: *Atomic structure and dynamic reconfiguration of layered defects in van der Waals layered Ge-Sb-Te based materials*. Acta Materialia *141* (2017), 92–96.

[4] E. R. Sanseverino, T. N. Ngoc, M. Cardinale, V. L. Vigni, D. Musso: *Dynamic programming and Munkres algorithm for optimal photovoltaic arrays reconfiguration.* Solar Energy (2015), No. 122, 347–358.

[5] Z. K. Li, X. Y. Chen, K. Yu, H. M. Liu, B. Zhao: *Hybrid particle swarm optimization for distribution network reconfiguration.* Proceedings of the Csee *36* (2008), No. 88, 1–7.

[6] W. Wang, X. S. Han: *Overview of distribution network reconfiguration.* Journal of Shandong University of Technology (2008).

[7] C. Wang, B. Dou, B. Jiang, Y. Song, B. Du: *Sorption-enhanced steam reforming of glycerol on Ni-based multifunctional catalysts International.* Journal of Hydrogen Energy *40* (2015), No. 22, 7037–7044.

[8] C. Chen, F. Wang, B. Liu, Y. Cao, C. Huang, X. Dong: *Distribution network reconfiguration based on basic ring matrix and improved harmony search algorithm.* Automation of Electric Power Systems (2014), No. 6, 55–60.

[9] C. Wang, H. Z. Cheng: *Reconfiguration of distribution network based on plant growth simulation algorithm.* Proceedings of the Csee *111* (2007), No. 4, 13–16.

[10] H. Arasteh, M. S. Sepasian, V. Vahidinasab: *An aggregated model for coordinated planning and reconfiguration of electric distribution networks* . Energy *94*, (2016), 786–798.

[11] M. R. Dorostkar-Ghamsari, M. Fotuhi-Firuzabad, M. Lehtonen, A. Safdarian: *Value of Distribution Network Reconfiguration in Presence of Renewable Energy Resources.* IEEE Transactions on Power Systems *31* (2016), No. 3, 1879–1888.

Received November 16, 2017