International Journal of Current Trends in Engineering & Technology
ISSN: 2395-3152
Volume: 02, Issue: 05 (SEPTEMBER-OCTOBER, 2016)

Transforming an Existing Distribution Network into Autonomous Micro-Grid Using PSO to Reduce Losses & Improve Voltage Profile

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Abstract—a distribution network with renewable and fossil-based resources can be operated as a micro-grid, in autonomous or non-autonomous modes. Autonomous operation of a distribution network requires cautious planning. In this context, a detailed methodology to develop a sustainable autonomous micro-grid is presented. The proposed methodology suggests novel sizing and siting strategies for distributed generators and structural modifications for autonomous micro-grids. The Micro grids are modern, small scale, decentralized electrical energy system. These are solution for energy crisis, along with improving the power supply reliability, quality and efficiency. Any time a micro grid is implemented in an electrical distribution system and it have optimal size and need optimal location .The correct size and location of distributed generation (DG) play a significant role in reduce power losses in distribution systems. It represents techniques to reduce power losses in a distribution feeder by optimizing DG model in terms of size, location and operating point of DG. The Particle Swarm Optimization (PSO) algorithm solves the optimal network reconfiguration problem for power loss reduction. Structural modifications based on ranking of buses have been attempted for improving the voltage profile of the system, resulting in reduction of real power distribution losses. The proposed methodology is adopted for a standard 33-bus distribution system to operate as an autonomous micro-grid. Results confirm the usefulness of the proposed approach in transforming an existing radial distribution network into an autonomous micro-grid.

Keywords – Power Loss Minimization, voltage Profile Improvement, micro grid, Distributed power generation, load flow, siting and sizing, particle swarm optimization.

I. INTRODUCTION

Recent development in small generation technologies has drawn an attention, to change in the electric infrastructure for adapting distributed generation (DG). Employment of DG technologies makes it more likely that electricity supply system will depend on DG systems and will be operated in deregulated environment to achieve a variety of benefits. As DG systems generate power locally to fulfil customer demands, appropriate size and placement of DG can drastically reduce power losses in the system [1]. To reducing losses there are many alternatives available at distribution level, reconfiguration, capacitor installation load balancing and introduction of high voltage level. There are two type of switches are used in primary distribution system which is normally closed switch (Sectionalizing switch) and normally open switch (tie switch).Those type of two switches are designed for both protection and configuration management resulting in cost reducing [2]. Depending upon the rating and location of DG units there is also possibility for voltage swell and losses are increase. The scenario to exploit complete potential of distributed generation, proper siting and sizing of DG become important. To develop sizing algorithm that transform an existing distribution network to sustainable autonomous system. This operation the generation and corresponding load of distribution network can separate from feeder network.The proposed programmed switching of already existing switches to reconfigure the distribution network for stable operation as micro-grid. Two types of switches are used in primary distribution systems viz., sectionalizing switches (normally closed) and TIE switches (normally open) [3], [4].In this context, reconfiguration of an existing distribution system has also been attempted for performance improvement of an autonomous micro-grid. Ranking of the buses based on maximum loadable limits has been employed to identify the nodes. Based on this ranking, additional TIE branches are to be connected. The standard 33-bus distribution system is used for validation of the algorithms proposed and MATLAB coding has been developed for implementation of the proposed algorithm.

II. PARTICLE SWARM OPTIMIZATION

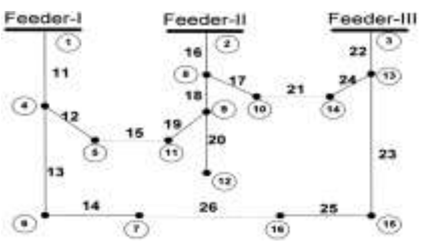
It is technique used to explore search space of given to find setting required to maximize particular objective. The particle swarm optimization algorithm is new swarm intelligence technique, inspired by social behaviour of bird flocking. This technique first described by James Kennedy and Russell c. Eberhart in 1995, [5]. It was found that with some modification. Social behaviour model can serve as powerful optimize. If binary PSO algorithm is adopted, the quantity of switches to be optimized will be very large to overcome this problem using proposed an algorithm to simplify this network. The algorithm not only minimizes the dimensionally problem but also avoids generation of many invalid particles. The distribution network is simplified through grouping branches are represented by one dimensional coding. PSO is a population-based evolutionary technique that has many key advantages over other optimization techniques like [6], [7].

- It is a derivative-free algorithm unlike many conventional techniques.
- It has the flexibility to be integrated with other optimization techniques to form a hybrid tool.
- It is less sensitive to the nature of the objective function.
- It has less parameter to adjust unlike many other competing evolutionary techniques.
- It has the ability to escape from local minima.

- It is easy to implement and program with basic mathematical and logic operations.
- It can handle objective functions with stochastic nature.

III. PROBLEM FORMULATION

The planning of micro-grid to optimally site and size DG is achieved by formulation model as an optimization problem. The optimal sizing and sifting for DG installation lead to highest value of overall benefit one of explanation for introducing DG is improve voltage profile of system and sustain voltage at customer terminal within an acceptable range [8]. In distribution system tie switches and sectionalizing switch are the two types of switches. The tie switches are (10-14) (5-11) and (7-16) in dotted branches conning nodes and switches in other continuous branches are sectionalizing switches. Normally open the tie switches and normally closed the sectionalizing switches. When operating condition has been changed Feeder reconfiguration is performed by closing /opening of these two types of switches to minimize line resistive line losses. When tie switch may be closed for the purpose of transferring loads to different feeders, and, at the same time, a sectionalizing switch should be opened to maintain the radial structure of the distribution network.



When the loads of feeder 2 become heavy under normal operating conditions, the tie switch connecting nodes (5-11) may be closed to transfer the load at bus 11 from feeder 2 to feeder 1 and at the same time the sectionalizing switch connecting nodes (9-10) must be opened to maintain the radial structure of the network.

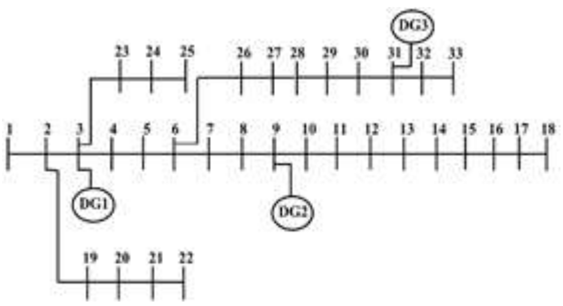


Figure 1 One line diagram of the autonomous micro-grid with optimally placed DG units

IV. CASE STUDY

The standard 33 bus distribution system with a demand, as shown in Table 4.1 .It has been adopted for the validation of the proposed methodology. The base voltage and base MVA chosen for the entire analysis are 11 kV and 100 MVA, respectively.

4.1 Optimal Number and Location of DG Units for Autonomous Micro-Grids

A detailed analysis has been carried out iteratively by varying the number of DG sites (i.e., number of DG units varying from r=1 to r=6 taking one unit/site) in the given system. The net real power loss for each of the conditions (i.e., r=1 to 6) is tabulated in Table 4.1.1

Table 4.1 Ranking of buses based on maximum Load of Real Power Demand

Bus No	Load		Bus No	Load	
	Mw	Mvar		Mw	Mvar
1	0.4	0.25	17	0.36	0.22
2	0.36	0.22	18	0.36	0.22
3	0.48	0.30	19	0.36	0.22
4	0.24	0.15	20	0.36	0.22
5	0.24	0.15	21	0.36	0.22
6	0.8	0.49	22	0.36	0.22
7	0.8	0.49	23	1.68	1.04
8	0.24	0.15	24	1.68	1.04
9	0.24	0.15	25	0.24	0.15
10	0.18	0.11	26	0.24	0.15
11	0.32	0.20	27	0.24	0.15
12	0.32	0.20	28	0.48	0.30
13	0.48	0.30	29	0.8	0.49
14	0.24	0.15	30	0.6	0.37
15	0.24	0.15	31	0.84	0.52
16	0.24	0.15	32	0.24	0.15
			33	0.48	0.30

The real power losses in MVA and the cost of generation of the DGs in 0.1 million rupees have been normalized on a ten point scale using (1) and the variation of the losses and cost of power generation has been plotted against the number of DG units In this work, different types of DGs are assumed to be employed and hence different cost coefficients. All the DG units are expected to provide reactive power support to maintain a constant power factor of 0.85 lagging at each of their respective locations. Consequent to deciding the number of DGs sites (units) required, the optimal placement for the three DG units is taken up. For all possible combinations of three locations, the optimal sizing algorithm is run and the corresponding losses have been recorded. It has been seen from Table 4.1.1 that for three DGs the optimal location pertaining to minimum distribution losses with moderate generation cost.

4.2 Optimal Reconfiguration of Autonomous Micro-Grids with TIE switches

The TIE-switches employed in the system based on ranking of buses are used in reconfiguring the radial distribution network into an autonomous micro-grid. It is evident that such reconfiguration transforms a radial network in to a weakly meshed network, thereby improving the reliability of service to customers in to an autonomous micro-grid. It is evident that such a

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reconfiguration transforms a radial network into a weakly meshed network, thereby improving the reliability of service to customers. A radial network operated as an autonomous micro-grid has the possibility of formation of accidental islands due to the occurrence of any electrical disturbances viz., line contingency or line outage The list of all possible combinations of TIE connections & power loss with min & max bus voltage in p. u. have been tabulated in Table 4.2.1.

Table 1 Optimal Number & Location of DG unit.

No of DG locations (r)	Optimal locations of DG units	Size of the DG units/ Real power rating in MW	Distribution real power losses in MW	Generation Unit Wise cost
1	6	15.8748	0.3748	3.9510 Rs/unit
	3	6.8987	0.3987	4.4937 Rs/unit
2	29	9		
	3	6	0.1159	4.8666 Rs/unit
3	9	3.6159		
	31	6		
	1	3.5685	0.0685	5.2042 Rs/unit
	3	4		
4	15	4		
	29	4		
	1	1.5469	0.0469	5.8480 Rs/unit
	2	3		
5	5	3		
	14	4		
	30	4		
	1	1.5409	0.0409	6.4850 Rs/unit
	2	2		
	3	3		
6	6	3		
	12	3		
	30	3		

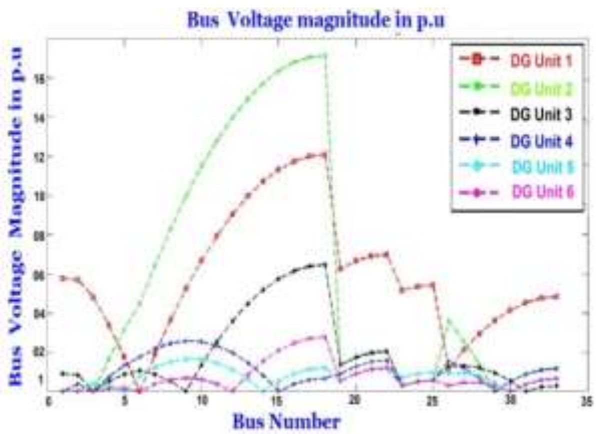

Figure 2 Voltage profile of the autonomous micro-grid before reconfiguration for PSO-based optimally sized DG units

A total combination has been identified as geographically feasible for placing additional TIE branches. Reconfiguration based on appropriate switching of TIE switches is effected and the total real power distribution losses have been evaluated for each of the possible combinations. Ranking of the configurations based on the real power losses is tabulated in Table 4.2.2 depict the top five combinations that satisfy the voltage constraints. Further analysis is performed on these shortlisted structures to choose the final optimal structure for the autonomous micro-grid.

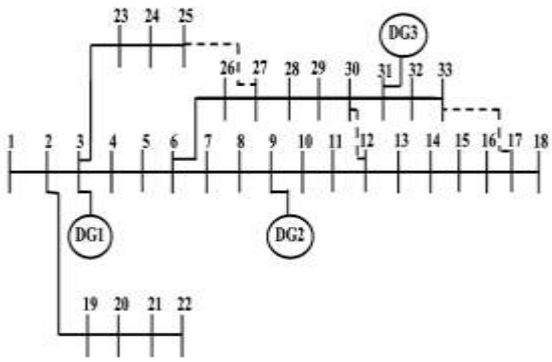

Figure 3 One line diagram of the autonomous micro-grid with locations for placing TIE switches for reconfiguration.

Table 2 Ranking of Possible Combination of Reconfiguration for PSO Based optimal sized Generation

Rank	Tie switch position	Real power loss in MW	Max. bus voltage/pu	Min. bus voltage/pu
1	33-17,33-25,33-12	0.0868	1.0258	1.000
2	33-17,33-25,27-12	0.0864	1.0243	1.000
3	27-17,33-25,33-12	0.0929	1.0276	1.000
4	33-17,33-25,30-12	0.0785	1.0211	1.000
5	33-17,27-25,33-12	0.0883	1.0276	1.000

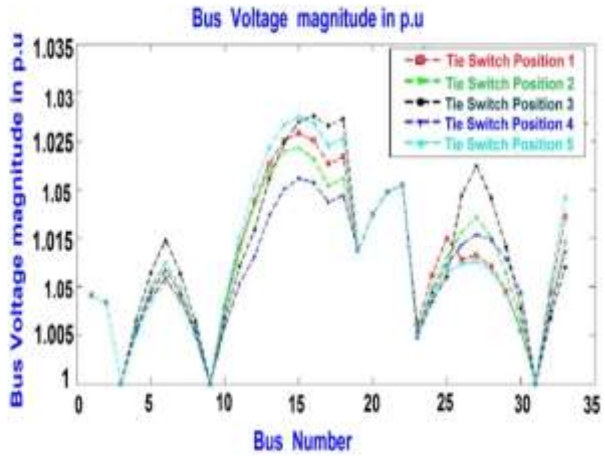

Figure 4 Voltage profile of the autonomous micro-grid after reconfiguration for PSO-based optimally sized DG units.

V. CONCLUSION

This paper has proposed a comprehensive methodology for transforming an existing radial distribution system fed from a substation feeder to an autonomous micro-grid. A detailed objective function for converting an existing radial distribution network into an autonomous sustainable micro-grid has been formulated. New techniques for determining the number of units required, siting and sizing of the units, and structure of the micro-grid have been developed.

Two non-traditional optimization techniques have been employed separately for solving the sizing problem. For the 33 bus distribution system taken for study, the proposed method gives three DG units as the optimal number of units. The optimal locations for these units are found to be buses 3, 9, and 31.

Table 3 Comparison of bus voltages in per unit before and after Reconfiguration for PSO-based optimal sizing of DG units

BUS NO	V in P.U Before Reconfiguration	V in P.U After Reconfiguration Tie Switch Position 1	V in P.U After Reconfiguration Tie Switch Position 2	V in P.U After Reconfiguration Tie Switch Position 3	V in P.U After Reconfiguration Tie Switch Position 4	V in P.U After Reconfiguration Tie Switch Position 5
1	1.0090	1.0090	1.0090	1.0090	1.0090	1.0090
2	1.0083	1.0083	1.0083	1.0083	1.0083	1.0083
3	1	1	1	1	1	1
4	1.0051	1.0051	1.0057	1.0065	1.0055	1.0051
5	1.0087	1.0088	1.0099	1.0114	1.0094	1.0086
6	1.0108	1.0108	1.0125	1.0148	1.0117	1.0106
7	1.0087	1.0087	1.0098	1.0113	1.0093	1.0085
8	1.0051	1.0051	1.0057	1.0064	1.0054	1.0050
9	1	1	1	1	1	1
10	1.0135	1.0078	1.0077	1.0068	1.0059	1.0083
11	1.0254	1.0141	1.0138	1.021	1.0103	1.0151
12	1.0358	1.0188	1.0184	1.0158	1.0131	1.0203
13	1.0446	1.0226	1.0219	1.0211	1.0173	1.0242
14	1.0519	1.0250	1.0239	1.0248	1.0200	1.0267
15	1.0519	1.0258	1.0243	1.0270	1.0211	1.0276
16	1.0616	1.0250	1.0231	1.0276	1.0207	1.0269
17	1.0639	1.0227	1.0204	1.0266	1.0187	1.0246
18	1.0647	1.0234	1.0211	1.0273	1.0194	1.0253
19	1.0137	1.0137	1.0137	1.0137	1.0137	1.0137
20	1.0175	1.0175	1.0175	1.0175	1.0175	1.0175
21	1.0197	1.0197	1.0197	1.0197	1.0197	1.0197
22	1.0204	1.0204	1.0204	1.0204	1.0204	1.0204
23	1.0031	1.0062	1.0055	1.0048	1.0052	1.0050
24	1.0050	1.0112	1.0098	1.0085	1.0093	1.0088
25	1.0057	1.0150	1.0130	1.0110	1.0122	1.0115
26	1.0128	1.0128	1.0156	1.0194	1.0143	1.0124
27	1.0132	1.0132	1.0171	1.0225	1.0154	1.0126
28	1.0121	1.0121	1.0150	1.0191	1.0148	1.0117
29	1.0095	1.0095	1.0115	1.0141	1.0128	1.0092
30	1.0055	1.0055	1.0065	1.0078	1.0094	1.0053
31	1	1	1	1	1	1
32	1.0022	1.0094	1.0081	1.0068	1.0076	1.0104
33	1.0029	1.0172	1.0146	1.0120	1.0136	1.0192

The case study presents five best reconfiguration options, obtained using the proposed methodology. Significant improvement in the voltage profile and reduction in losses were observed in the autonomous operation as compared to non-autonomous operation DGs.

REFERENCE

[1]. P.M. Costa, and M.A. Matos, "Loss Allocation in Distribution Networks with Embedded Generation", IEEE Transactions on Power Systems, Vol.19, Issue 1, pp. 384 –389, 2004.

[2]. S. Civanlar, J. J. Grainger and S. H. Lee, "Distribution Feeder Reconfiguration for Loss Reduction," IEEE Transactions on Power Delivery, Vol. 3, No. 3, pp. 1217-1223, July 1988.

[3]. Z. Li, X. Chen, Y. Sun, and H. Liu, "A hybrid particle swarm optimization approach for distribution network reconfiguration problem," in Power and Energy Society General Meeting–Conversion of Electrical Energy in 21st Century, pp. 1–7, 2008.

[4]. S. C. Mohan, R. P. K. Devi, and B. Venkatesh, "Radial system reconfiguration to minimize operating costs in markets," Int. J. Emerging Elect. Power Syst., vol. 8, no. 1, 2007.

[5]. Maurice Clerc, "Standard Particle Swarm Optimization".

[6]. M. R. Alrashidi and M. El-Hawary, "A Survey of Particle Swarm Optimization Applications in Power System Operations," Electric Power Components and Systems, Vol. 34, No. 12, pp. 1349-1357, December 2006.

[7]. Y. del Valle, G. K. Venayagamoorthy, S. Mohagheghi, J. C. Hernandez and R. G. Harley, "Particle Swarm Optimization: Basic Concepts, Variants and Applications in Power Systems", IEEE Transactions on Evolutionary Computation, Vol. 12, No. 2, pp. 171-195, April 2008.

[8]. M. R. Aghaebrahimi, M. Amiri "An Immune-Based Optimization Method for Distributed Generation Placement in Order to Optimize Voltage Profile", IEEE International Conference on Sustainable Power Generation and Supply, Nanjing, 978-1-4244-4934-7, 2009.