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OPTIMAL DISTRIBUTED GENERATION PLACEMENT CONSIDERING VOLTAGE PROFILE IMPROVEMENT AND LOSS REDUCTION: CASE STUDY ON 11KV MINNA DISTRIBUTION NETWORK

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Abstract

Distributed generation (DG) devices can be strategically placed in power systems for grid reinforcement so as to minimize real power losses, improve bus voltages and increase the efficiency of the distribution system. The optimal DG placement (OPDG) method is used to provide the best locations and sizes of DGs to optimize electrical distribution network operation taking into account DG capacity and voltage constraints. This paper proposes a Particle Swarm Optimization (PSO) based technique for the optimal allocation of Distributed Generation (DG) units in the network. Three types of DGs are considered and the distribution load flow is used to calculate exact loss. Load flow algorithm is combined appropriately with PSO to access acceptable results of this operation. Objective function is formulated for determining the optimal location and sizing of distributed generation (DG) units in the distribution network for active power loss reduction and voltage profile enhancement. The suggested method is programmed under ETAP Version 12.6.0 (2012) software.

Keywords—*Distributed Generation (DG), Optimal Placement of DG, Distribution Network, Particle Swarm Optimization (PSO), Power Loss Minimization, Voltage Profile Improvement.*

Introduction.

Electricity power generation started with local generators normally connected to steam engines. At that time electricity, distribution networks were mainly covering small areas equipped with their own generators. Since then electricity networks have become more and more interconnected and today electricity networks form wide area transmission networks over hundreds of kilometers. While the networks became larger and widespread, the electricity power consumption was increasing and large power plants were built to supply the residential, industrial and other loads with electrical power. The large power plants are in most cases coal or gas fired thermal power plants or nuclear power plants. In areas with convenient conditions large hydro power plants were quite usual. Common for all the large scale power plants is the fact that they are connected to high voltage (HV) transmission networks and the power is then transferred through the transmission network to the distribution network and finally to the consumers (Jenkins *et al.,* 2000).Nowadays, non-convectional generation is growing more rapidly around the world due to its small size, low cost and less environmental impact with high potentiality. Investment in distributed generation (DG) enhances economical, technical and environmental benefits.

Distributed generation is small scale electrical power generation which is normally connected to distribution system. DG may come from a variety of source and technologies. DGs from renewable sources, like wind, solar and biomass are often called as “Green energy”. In addition to this, DG includes micro turbines, gas turbines, diesel engines, fuel cells and internal combustion reciprocating engines. So, optimal placement and proper size of DG attract lucrative research interest. A number of works have been reported in this area of optimal location and sizing in power system using different optimization techniques. A good number of publications have looked at optimizing the location and sizing of DG based on different criteria.

Moradi et al.,(2014) presented an efficient hybrid method based on imperialist competitive algorithm (ICA) and genetic algorithm (GA) for optimal placement and sizing of DG sources and capacitor banks simultaneously. Mohanty and Tripathy (2016) developed teaching learning based optimization (TLBO) techniques for optimal location and sizing of DG units in a radial distribution system. In their paper Voltage stability index was formulated as the objective function. Nweke, Ekwueand and Ejiogu (2016) presented an analytical method for the optimal sizing and placement of DG on the Nigerian power net work for active power loss minimization. Singh et al., (2017) proposed a new technique to determine optimal location and size of DGs for power loss reduction and improvement in voltage profile. Distribution System Voltage Stability Index (DSVSI) based approach was carried out to identify critical buses and allocation of different types of DGs supplying real and reactive power. Amini and Kazemzadeh (2017) proposed determination of the appropriate sizing and placement of DGs on unbalanced distribution network. The appropriate sizes of DGs were obtained using probabilistic methods while the convenient location was selected using weighted multi-objective IPSO. Ariyo and Omoigui (2012) carried out investigation of Nigerian 330 kV electrical network with distributed generation penetration. In the work, the Nigerian 330 kV electrical network was expended by incorporating wind, solar and small-hydro source.

Algorithm. Kumar, Nallagownden and Elamvazuthi (2017) discusssed optimal placement of probabilistic based solar power DG on the distribution system. A multi-objective function of power loss reduction and voltage stability index improvement were optimized.

Methodology

Minna subtransmission power station

Optimal Distributed Generation Placement Considering Voltage Profile Improvement and Loss Reduction of Minna GRA 11kV distribution network under the influence of distributed generators will be implemented using power flow analysis. The analysis will be done in the environment of ETAP version 12.6.0 software. Minna High voltage Distribution network consists of two number injection substations i.e. 2 x 0.5 MVA 33/11Kv injection substation located opposite Shiroro hotel and 2 x 7.5MVA at Zarumai injection substation. These four number power transformers feed the entire town through a number of 11Kv feeders in various locations, these feeders are namely Piggery, Chanchaga, shiroro, Tunga, Maitumbi, Bosso and GRA feeder.

Data collection

Load details were not available at the Abuja Electricity Distribution Company office in Minna, however with help of the maintenance staff load current were measured from the secondary side of each of the 11/0.415kV distribution transformer using clamp-on ammeter. Other information collected were substations name, transformer rating, transformer peak, impedance value, number of outgoing units and distance between substations.

To optimally determine location of single and multiple DGs on the GRA Feeder Network, particle swam optimization technique was adopted.

Particle Swarm Optimization Algorithm

The PSO-based approach for solving Optimal Placement of DG to minimize the loss will take the following steps:

- Step 1: Input line and bus data, and bus voltage limits.
- Step 2: Calculate the loss using distribution load flow based on backward-forward sweep.
- Step 3: Randomly generates an initial population (array) of particles with random positions and velocities on dimensions in the solution space. Set the iteration counter k= 0.
- Step 4: For each particle if the bus voltage is within the limits, calculate the total loss. Otherwise, that particle is infeasible.
- Step 5: For each particle, compare its objective value with the individual best. If the objective value is lower than Pbest, set this value as the current Pbest, and record the corresponding particle position.
- Step 6: Choose the particle associated with the minimum individual best Pbest of all particles, and set the value of this Pbest as the current overall best Gbest.
- Step 7: Update the velocity and position of particle.
- Step 8: If the iteration number reaches the maximum limit, go to Step 9. Otherwise, set iteration index k=k+1, and go back to Step 4.
- Step 9: Print out the optimal solution to the target problem. The best position includes the optimal locations and size of, DG, and the corresponding
- Figure1 shows the flow chart of the particle swam optimization procedure implemented to obtain the optimal locations and sizes of DG:

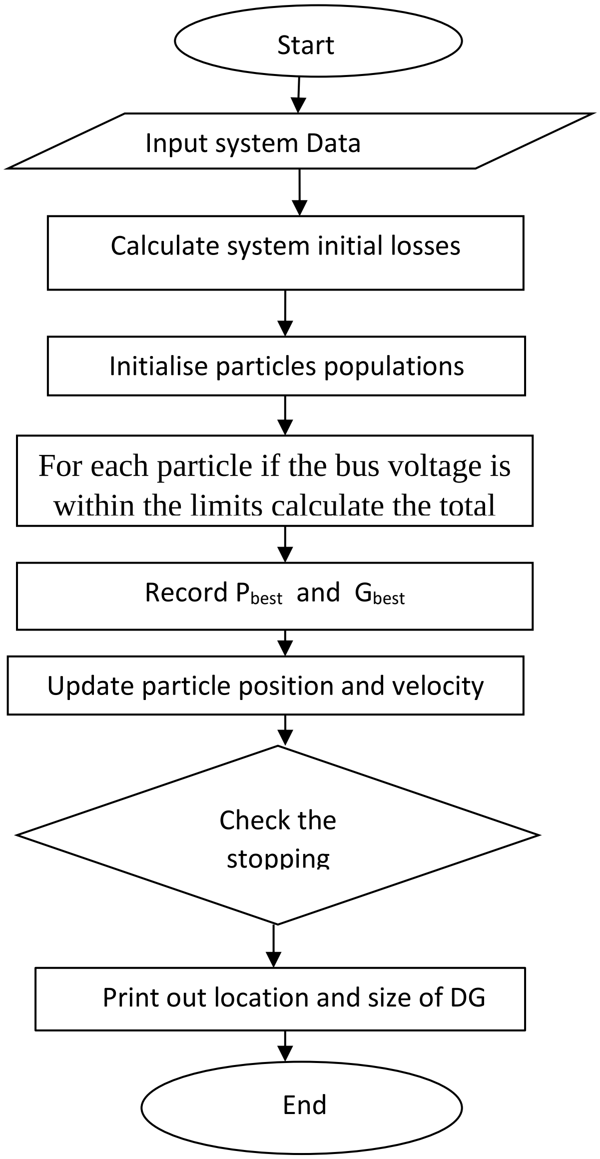

Figure1 Flow chart of PSO Procedure

Network Modeling

Electrical and Transient Analysis Program ETAP Version 12.6.0 (2012) software was used for modeling and analysis of the network under study. ETAP has been designed and developed for engineers to handle the diverse discipline of power system engineering for a broad spectrum of industries in one integrated package with multiple interface view such as; AC and DC networks, cable raceways, ground grid, GIS, panels, arc-flash, protective device coordination/selectivity and AC and DC control system diagram. The network model of GRA feeder is used as test network.

Problem Formulation

The problem formulation contains the objective functions and constrains the PSO algorithm is used in order to solve the optimization problem. The test system used to verify the effectiveness of the technique is described below.
To minimize a function consisting of some parameters, the general function is written as a summation of those parameters:

$$f_1 = \Sigma_i^N = P_{DG_i}$$

(1)

Where, DG_i is the DG capacity of the ith bus, N is the set of possible locations.

Parameter of the total power loss of the network.

The power loss of the network is calculated in equation 2

$$f_2 = f(p_{loss}) = p_{loss} \tag{2}$$

Here, P_{loss} is the total power loss of the network. A real power loss analysis was evaluated for the system with and without DG. The loss in the system can be calculated using equation (3) Witchit *et al* (2007) also called the exact loss formula Elgerd*et al*.(1971).

$$f_2 = \sum_{i=1}^{N} \sum_{j=1}^{N} \left[\alpha_{ij} \left(P_i P_j + Q_i Q_j \right) + \beta_{ij} \left(Q_i P_j + P_i Q_j \right) \right] \tag{3}$$

$$\text{where, } \alpha_{ij} = \frac{R_{ij} cos(\partial_i - \partial_j)}{V_i V_j}$$

(4)

$$\beta_{ij} = \frac{R_{ij} \sin(\partial_i - \partial_j)}{V_i V_j}$$

(5)

P_i and Q_i are net real and reactive power injection in bus i, respectively.
R_{ij} is the resistance between buses i and j
V_i and δ_i are the voltage and angle at bus i respectively subject to some constraints.

According to the preceding equations, the final objective function to be minimized is acquired as follows:

$$f = \sum_{i=1}^{N} P_{DG_i} + \sum_{i=1}^{N} \sum_{j=1}^{N} \left[\alpha_{ij} \left(P_i P_j + Q_i Q_j \right) + \beta_{ij} \left(Q_i P_j + P_i Q_j \right) \right] \tag{6}$$

Constraints

Constraints are issue of great importance in optimization procedures. An optimal answer is the answer that satisfies all of the constraints of the optimization problem.The following constraints are considered while siting and sizing DG.

The Power constraints

This is given by

$$\sum_{i=1}^{N} P_{DG_i} = \sum_{i=1}^{N} P_{D_i} + P_L \tag{7}$$

Where, P_L is the real power loss in the system.

P_{DG_i} is the real power generation of DG at bus i.

P_{D_i} is the power demand at bus.

The voltage constraints

The variation range of all of the distribution buses should be within a specified limit. The voltage constraint is given below

$$|V_i|^{min} \leq V_i \leq |V_i|^{max} \tag{8}$$

$$|V_i|^{min}=0.95(\text{pu})|V_i|^{max}=1.05(\text{pu}) \tag{9}$$

Where

V_{min} is the minimum bus voltage and V_{max} is the maximum bus voltage

Test system and simulation Results

The effectiveness of the proposed idea is tested on 11Kv/0.415 GRA Feeder consisting of 44-nodes. The node where load is connected is considered to be the location of DG. DG is placed at each node and optimal size of DG is calculated The real power loss of the test system before the introduction of DG into the system is 282.3kW while the reactive power loss is 514.8 Kvar. A program was written in MATLAB 2009 to calculate the DG location and its corresponding size in MW which will be use to improve the system losses and voltage profile. The required bus data of the GRA 11kV network for the optimization is given in appendix (Table 1)

Simulation Results

Results obtained from the load flow analysis without DG and with incremental placements of DG on the 11kV GRA feeder are shown in tables 2 to 5. The performance of the network with and without DG are also presented. The results obtained are discussed.

Table 2: Results obtained after the simulation without DG

ID	MW	Mvar	MW	Mvar	KW	Kvar	FROM	TO	%VD
Line1	4.558	2.946	-4.548	-2.939	9.2	6.4	97.6	97.4	0.2
Line2	0.162	0.104	-0.162	-0.104	0	-0.1	97.4	97.3	0.01
Line3	4.387	2.836	-4.357	-2.815	30.1	20.7	97.4	96.7	0.68
Line4	4.318	2.789	-4.284	-2.765	33.7	23.3	96.7	95.9	0.77
Line5	4.099	2.646	-4.057	-2.617	42.5	29.3	95.9	94.9	1.02
Line6	3.891	2.504	-3.877	-2.494	14.2	9.8	94.9	94.5	0.35
Line7	0.769	0.488	-0.768	-0.487	0.8	0.4	94.5	94.4	0.1
Line8	0.005	0.003	-0.005	-0.003	0	-0.1	94.4	94.4	0
Line9	0.763	0.484	-0.762	-0.484	0.4	0.2	94.4	94.4	0.05
Line10	2.951	1.901	-2.947	-1.898	4.2	2.8	94	93.8	0.14
Line11	2.907	1.873	-2.897	-1.866	10.1	6.9	93.8	93.5	0.33

Table 3: Results obtained after the simulation with one DG connected.

ID	MW	Mvar	MW	Mvar	KW	Kvar	FROM	TO	%VD
Line1	1.325	1.397	-1.324	-1.396	1.1	0.7	98.9	98.8	0.07
Line2	0.167	0.107	-0.167	-0.107	0	-0.1	98.8	98.8	0.01
Line3	1.157	1.289	-1.154	-1.287	3.2	2	98.8	98.6	0.22
Line4	1.113	1.26	-1.11	-1.258	3.5	2.2	98.6	98.4	0.24
Line5	0.915	1.132	-0.912	-1.13	3.6	2.2	98.4	98.1	0.28
Line6	0.734	1.009	-0.733	-1.009	1	0.6	98.1	98	0.09
Line7	0.826	0.524	-0.826	-0.524	0.9	0.4	98	97.9	0.11

Line8	0.006	0.003	-0.006	-0.003	0	-0.1	97.9	97.9	0
Line 9	0.82	0.52	-0.819	-0.52	0.4	0.2	97.9	97.9	0.05
Line10	-0.244	0.384	0.244	-0.384	0.1	0	98	98	0
Line11	-0.287	0.357	0.288	-0.357	0.2	0	98	98	0

Table 4: Results obtained after the simulation with two DGs connected.

ID	MW	Mvar	MW	Mvar	KW	Kvar	FROM	TO	%VD
Line1	0.874	1.049	-0.873	-1.048	0.6	0.3	99.2	99.1	0.05
Line2	0.168	0.107	-0.168	-0.108	0	-0.1	99.1	99.1	0.01
Line3	0.706	0.941	-0.704	-0.94	1.5	0.8	99.1	99	0.14
Line4	0.663	0.913	-0.662	-0.912	1.5	0.8	99	98.8	0.16
Line5	0.466	0.785	-0.464	-0.785	1.4	0.7	98.8	98.7	0.17
Line6	0.285	0.662	-0.284	-0.662	0.3	0.1	98.7	98.6	0.05
Line7	0.837	0.531	-0.836	-0.53	0.9	0.5	98.6	98.5	0.11
Line8	0.006	0.003	-0.006	-0.003	0	-0.1	98.5	98.5	0
Line9	0.83	0.527	-0.83	-0.527	0.4	0.2	98.5	98.5	0.05
Line10	-0.706	0.029	0.706	-0.029	0.2	0	98.7	98.7	0.02
Line11	-0.75	0.001	0.75	-0.001	0.4	0.2	98.7	98.8	0.06

Table 5: Results obtained after the simulation with three DGs connected.

ID	MW	Mvar	MW	Mvar	KW	Kvar	FROM	TO	%VD
Line1	0.211	0.374	-0.211	-0.374	0.1	0	99.7	99.7	0.01
Line2	0.17	0.109	-0.17	-0.109	0	-0.1	99.7	99.7	0.01
Line3	0.041	0.265	-0.041	-0.265	0.1	-0.2	99.7	99.7	0.02
Line4	0	0.237	0.001	-0.238	0.1	-0.2	99.7	99.7	0.02
Line5	-0.2	0.109	0.2	-0.109	0.1	-0.3	99.7	99.7	0.02
Line6	-0.383	-0.016	0.383	0.016	0.1	-0.1	99.7	99.7	0.02
Line7	-0.845	-0.346	0.846	0.346	0.8	0.3	99.7	99.8	0.1
Line8	0.006	0.003	-0.006	-0.003	0	-0.1	99.8	99.8	0
Line9	-0.852	-0.35	0.852	0.35	0.4	0.2	99.8	99.9	0.05

Line10	0.306	0.226	-0.306	-0.226	0	0	99.6	99.6	0.01
Line11	0.261	0.198	-0.261	-0.198	0.1	-0.1	99.6	99.6	0.03

Table 6: Effect of DG placement on network losses reduction

Number of DGs	Bus Location	DG size	Total Installed Capacity	Loss without DG (kW)	Loss With DG (Kw)	% Loss Reduction
1	7	0.5	0.5	282.3	109.4	61.27
2	7 19	0.5 0.25	0.75		75.6	73.24
3	7 19 37	0.5 0.25 0.15	0.9		57.1	79.79

Table 7: The voltage profile improvement as DGs are injected into the network

T1 ZARUMAI	97.6	98.9	99.2	99.7
T2 GRA POLICE	96.3	97.8	98.1	98.6
T3 S/S	93.9	95.8	96.1	96.8
T4	94.7	97.1	97.6	98.4
T5 ALH. A. KURE	92.1	95.2	95.7	96.7
T6 MTN1	94.1	97.5	98.1	99.4
T7	91.6	95.5	96.2	97.1
T9	93.1	97.2	97.9	98.8
T15	89.4	96.6	97.8	97.8
T17	89.2	97.1	97.9	97.9
T19	89.8	98.2	98.6	98.6
T21	86.2	94.6	94.8	94.8
T23	92.5	95.9	96.5	97.8
T24 STREET LIGHT	93.7	97.2	97.8	99.3
T25	91.9	95.3	95.9	97.4

T26 SCH. OF HEALTH	90.5	93.8	94.4	95.9
T29 S/S	92.5	95.9	96.5	98.0
T30	87.7	94.9	95.5	96.9
T31	89.5	96.2	97.3	97.5
T32	91.0	96.8	97.8	98.3
T33	91.0	96.8	97.8	98.2
T34	91.7	97.5	98.5	99.0
T35	89.6	96.3	97.4	97.6
T36	88.2	94.8	95.9	96.1
T37	90.2	96.9	98.0	98.2
T38	87.8	94.4	95.4	95.6
T39	89.8	96.5	97.7	97.8
T43	89.5	96.9	98.1	98.1
T44	89.8	97.9	98.6	98.6

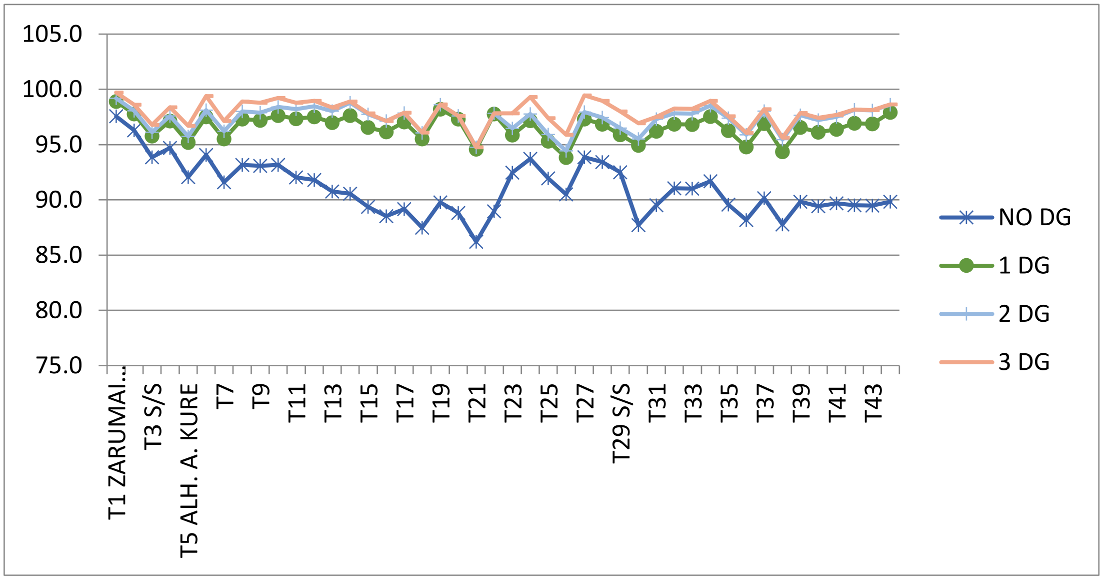

Figure 2: Voltage Profile Improvement, before and after installing 3 DG unit

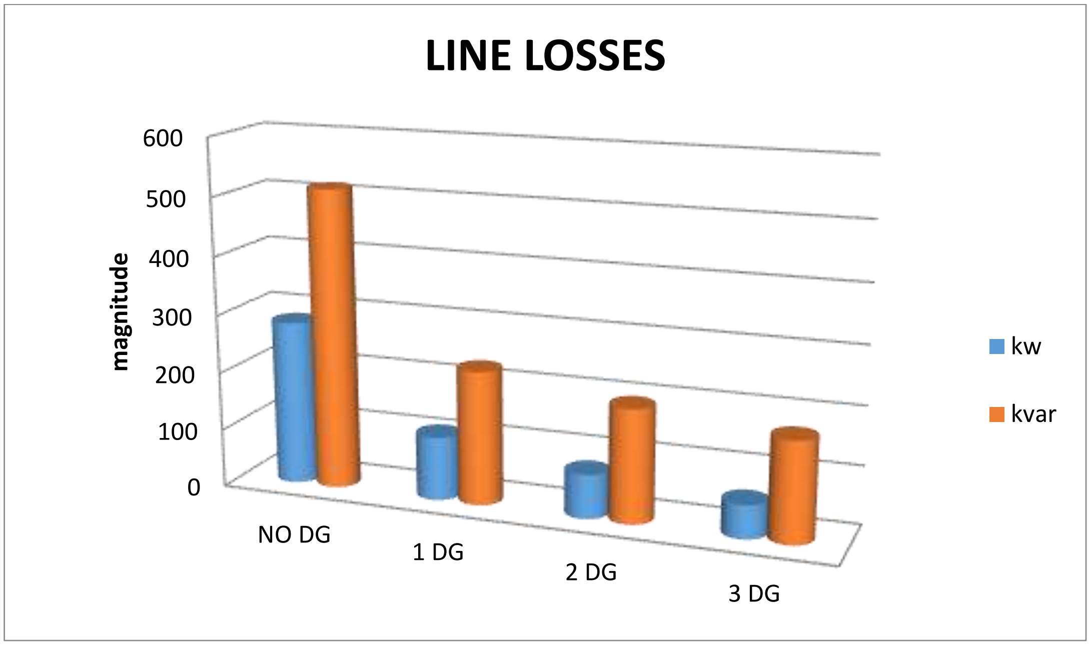

Figure 3: Losses Profile Improvement with varying numbers of DG.

Discussion of Results

Results obviously show that the more the number of DG units the less the system power loss and the better the system voltage profile. These results can be clearly obtained from tables 2 to 7 and Figure 2 and 3.

The result obtained from load flow analysis without DG, table 2 and 6 shows the total network active power loss of 282.3kW and reactive power of 514.6 kvar and voltage profile ranging from 86 percent to 97 percent.

Results from table 3 and 6 with one DG power of 0.5 MW injected a power loss reduction from 282.3 to 109.4 KW representing 61.27 percent and voltage profile improvement from 94 percent to 97 percent.

With the injection of two DG of 0.75MW rating capacity, table 4 and table 6, present a power loss reduction from 109.4 kW to 75.6kW representing total percentage loss reduction of 73.24 percent and a voltage profile improvement from 95 percent to 98 percent.

Results from table 5 to 7 with three DGs power of 0.9 MW injected a power loss reduction from 109.4 to 57.1kW representing 79.79 percent loss reduction and voltage profile improvement from 95 percent to 99 percent.

Figure 2 shows voltage magnitude versus node number for 44 node network when DG is placed at node 7,19 and 37. From Figure 2, it is seen that the voltage profile has improved after inserting DGs at node 7,19 and 37. Figure 3 shows active power losses of the network system after inserting DG at each node individually. From Figure 6, we noticed that active power losses are minimum if we place 282.3 kW DG at node 7,19 and 37.

Conclusion

The paper has presented the size and location of DG which are the crucial factors in the application of DG for loss minimization and voltage profile improvement. This paper also presents an algorithm for the identification of bus location using PSO. This methodology is tested on the 11kV GRA distribution network in Minna. By installing DGs at all the potential locations, the total power loss of the system has been reduced drastically and the voltage profile of the system is also grossly improved.

Simulation of the distribution network shows both active and reactive power losses of the entire feeder and the various voltages drops across the buses. With the gradual injection of DG whose location were determine by the PSO algorithm improve all in line with the design objective function and constrains.

Recommendations

The completion of this research work gives rise to work in many other related areas. The following areas are identified area for future work:

- The allocation of DG by cost implication and other economic consideration.
- Exploring other optimization techniques to further establish the viability of the optimal placement of DG.
- Use of a different objective function.

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Appendix

Table 1: Bus Data of the GRA 11kV Feeder

Busi	Busj	Pi	Pj	Qi	Qj	Vi	Vj	Vi-Vj	di	dj	di-dj	Rij
1	2	1.253	1.251	1.34	1.315	10	9.736	0.264	0	-0.5	0.5	0.884149
2	3	1.251	1.251	1.315	1.217	9.736	9.63	0.106	-0.5	-0.5	0	0.884149
3	4	1.251	1.051	1.217	1.188	9.63	9.39	0.24	-0.5	-0.5	0	0.884149
4	5	1.051	0.914	1.188	1.098	9.39	9.47	-0.08	-0.5	-0.4	-0.1	0.884149
5	6	0.914	0.732	1.098	0.975	9.47	9.215	0.255	-0.4	-0.4	0	0.884149
6	7	0.732	0.828	0.975	0.525	9.215	9.41	-0.195	-0.4	-0.4	0	0.884149
7	8	0.828	0.006	0.525	0.003	9.41	9.164	0.246	-0.4	-0.4	0	0.884149
8	9	0.006	-0.097	0.003	0.449	9.164	9.324	-0.16	-0.4	-0.4	0	0.884149
9	10	0.097	0.248	0.449	0.348	9.324	9.314	0.01	-0.4	-0.3	-0.1	0.884149
10	11	0.248	0.292	0.348	0.321	9.314	9.3	0.014	-0.3	-0.3	0	0.884149
11	12	0.292	0.302	0.321	0.315	9.3	9.2	0.1	-0.3	-0.3	0	0.884149
12	13	0.302	0.37	0.315	0.272	9.2	9.18	0.02	-0.3	-0.3	0	0.884149

13	14	0.37	0.403	0.272	0.252	9.18	9.08	0.1	-0.3	-0.2	-0.1	0.884149
14	15	0.403	0.663	0.252	0.087	9.08	9.06	0.02	-0.2	-0.2	0	0.884149
15	16	0.663	0.735	0.087	0.041	9.06	8.94	0.12	-0.2	-0.2	0	0.884149
16	17	0.735	1.429	0.041	0.916	8.94	8.85	0.09	-0.2	-0.2	0	0.884149
17	18	1.429	1.324	0.916	0.868	8.85	8.92	-0.07	-0.2	-0.2	0	0.884149
18	19	1.324	1.325	0.868	0.848	8.92	8.75	0.17	-0.2	-0.2	0	0.884149
19	20	1.325	0.907	0.848	0.575	8.75	8.98	-0.23	-0.2	-0.2	0	0.884149
20	21	0.907	0.749	0.575	0.475	8.98	8.88	0.1	-0.2	-0.2	0	0.884149
21	22	0.749	0.559	0.475	0.355	8.88	8.62	0.26	-0.2	-0.2	0	0.884149
22	23	0.559	0.341	0.355	0.214	8.62	8.9	-0.28	-0.2	-0.2	0	0.884149
23	24	0.341	0.307	0.214	0.193	8.9	9.25	-0.35	-0.2	-0.2	0	0.884149
24	25	0.307	0.258	0.196	0.162	9.25	9.37	-0.12	-0.2	-0.2	0	0.884149
25	26	0.258	0.237	0.162	0.335	9.37	9.19	0.18	-0.2	-0.2	0	0.884149
26	27	0.237	0.201	0.335	0.375	9.19	9.05	0.14	-0.2	-0.2	0	0.884149
27	28	0.201	0.224	0.375	0.485	9.05	9.39	-0.34	-0.2	-0.2	0	0.884149
28	29	0.224	0.235	0.485	0.753	9.39	9.34	0.05	-0.2	-0.2	0	0.884149
29	30	0.235	0.237	0.753	0.354	9.34	9.25	0.09	-0.2	-0.4	0.2	0.884149
30	31	0.237	0.335	0.354	1.305	9.25	8.77	0.48	-0.4	-0.4	0	0.884149
31	32	0.335	0.375	1.305	1.245	8.77	8.95	-0.18	-0.4	-0.4	0	0.884149
32	33	0.375	0.485	1.245	1.51	8.95	9.1	-0.15	-0.4	-0.4	0	0.884149
33	34	0.485	0.753	1.51	0.265	9.1	9.1	0	-0.4	-0.4	0	0.884149
34	35	0.753	0.354	0.258	0.237	9.1	9.17	-0.07	-0.4	-0.4	0	0.884149
35	36	0.354	1.305	0.237	0.201	9.19	8.96	0.23	-0.4	-0.4	0	0.884149
36	37	1.305	1.245	0.208	0.321	8.96	8.82	0.14	-0.4	-0.4	0	0.884149
37	38	1.245	1.51	0.321	0.315	8.82	9.777	-0.957	-0.4	-0.4	0	0.884149
38	39	1.51	0.265	0.315	0.272	9.777	9.02	0.757	-0.4	-0.3	-0.1	0.884149
39	40	0.265	0.458	0.272	0.252	9.02	8.87	0.15	-0.3	-0.3	0	0.884149
40	41	0.485	0.758	0.252	0.087	8.87	8.94	-0.07	-0.3	-0.2	-0.1	0.884149
41	42	0.785	0.105	0.087	0.041	8.94	8.97	-0.03	-0.2	-0.2	0	0.884149
42	43	0.105	0.007	0.041	0.105	8.97	8.95	0.02	-0.2	-0.2	0	0.884149
43	44	0.101	0.067	0.021	0.116	8.91	8.92	0.02	-0.3	-0.2	0	0.884149