International Journal of Engineering Science and Applied Mathematics
Volume.14, Number 9 ; September-2023;
ISSN: 2836-9521|Impact Factor: 6.64
https://zapjournals.com/Journals/index.php/ijesam/index
Published By: Zendo Academic Publishing

OPTIMAL PLACEMENT OF DISTRIBUTED GENERATION (DG) UNITS IN POWER SYSTEM USING REPEATED LOAD FLOW ANALYSIS METHOD

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Keywords:

Distributed Generation, Distribution System. Newton Raphson (N-R) Load Flow Method

DOI

10.5281/zenodo.8367108

Abstract

In this paper, Repeated Load Flow Analysis method has been used to determine the optimal placement of Distributed Generation (DG) units in power system. A test network - 73-bus Port Harcourt 33 kV Power distribution system has been simulated in Electrical Transient Analyzer program (ETAP 12.6) software using Newton Raphson (N-R) load flow method. The optimal placement of the DGs is selected at the candidate load buses where voltage profile rises to acceptable limit through load flow repeated simulation. The result obtained identified the following buses: 16, 31, 37, 53, 57, 58, 59, 67, and 69 and as optimal DG placement. The result obtained after DG placement reveals acceptable voltage levels at the problem buses and the entire network.

INTRODUCTION

The load growth which emanate from rapid industrialization and population growth has resulted in an escalation in the electrical power demand. This problem has led to overloading of power lines, poor voltage profile, high line losses, incessant load shedding and power outages. The placement of DG units in the distribution network will constitute a reliable option and the most economical solution to meet the increased electricity demand due to load growth. Different methods have been proposed for optimal placement of distributed generation in power distribution system while considering different objectives such as reduction of system losses, improvement in system voltage profile, system reliability and voltage stability etc.

Load flow algorithm computes the voltage magnitudes and phase angles at each bus of the network under steady state operating conditions. These programs also compute real and reactive power in each of the line

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and power losses for all equipment, including transformers and distribution lines; thus, overloaded transformers and distribution lines are identified and remedial measures can be implemented.

LITERATURE REVIEW

Distributed Generation was favoured in the last few years due to the liberalization process of the electricity infrastructure as well as the impulse to produce electricity independent of fossil fuels. The first installation of small power plants therefore started to take place during the 80s and 90s, mostly close to the customers, connected to the distribution side of the network because of their small rating. These installations therefore were denoted as embedded or distributed generation. Many studies have been performed to identify the optimal placement of distributed generation in power distribution system.

Greatbanks (2003) has formulated a methodology for locating the most appropriate site and deciding the size of DG. Optimum sitting is done by sensitivity analysis of power flow equations. Optimum sizing is formed as a security constrained optimization problem and solved by genetic algorithm. The soft computing techniques for optimization are mainly based on GA. This GA method has been employed successfully to solve complex optimization problems.

Caisheng et al. (2004) presented a paper on analytical method to determine the optimal location to place distributed generation in radial as well as networked systems to minimize the power loss of the system.

Kashem et al. (2007) addressed the issue of optimizing DG planning in terms of DG size and location to reduce the amount of line losses in distribution networks. Their optimization methodology, which was based on the Sequential Quadratic Programming (SQP) algorithm, assessed the compatibility of different generation schemes upon the level of power loss reduction and DG cost.

Amanifar and Hamedani in 2011 applied PSO technique with sensitivity analysis for solving the optimal DG placement sizing problem by minimizing the total system cost, reducing losses and THD, and improving the voltage profile. The advantage of this combined method is that the search space is reduced, which eventually increases the speed of the optimization process.

According to Pathak et al. (2012), the classical method has the following disadvantages: weak in handling qualitative constraints, poor convergence, too slow if the number of variables are large and computationally expensive for the solution of a large system. In most cases, mathematical formulations have to be simplified to get the solutions because of the extremely limited capability to solve real-world large-scale power system problems.

Vivek et al. (2012) presented an efficient and reliable Particle Swarm Optimization (PSO) algorithm for solving Reactive power optimization including voltage deviation in Power System. Voltage deviation is the capability of a power system to maintain up to standard voltages at all buses in the system under standard conditions and under being subjected to a disturbance. Reactive power optimization is a complex combinatorial programming problem that reduces power loses and improves voltage profiles in a power system. To overcome this shortcoming, a multi-objective particle swarm optimization is proposed and applied in reactive power optimization on IEEE-30 bus, Here the RPO problem has been formulated as a constrained multi-objective optimization problem by combining of two objective functions

(real power loss and voltage profile improvement) linearly shows that the particle swarm optimization more effectively solves the reactive power optimization problem in power system.

Funso et al. (2013) implemented load flow, short circuit, transient stability, modal/ eigenvalues calculation and harmonics analysis on Nigerian 330KV electrical network with distributed generation penetration. The conventional sources and DG were modelled using a calculated programme called Power Factory written DigSILENT. This method is time consuming and rigorous.

Julius et al. (2013) presents a GA- IPSO based approach which utilizes combined sensitivity factor analogy to optimally locate and size a multi-type DG in IEEE 57-bus test system with the aim of reducing power losses and improving the voltage profile. The multi- objective function can be improved by taking into consideration other power system parameters like stability issue.

Basudev et al. (2013) presented a paper on the impact of distributed generation on reliability of distribution system. After penetration of DG, the passive distribution system becomes an active system. The reliability improvement is maximum if the DG is connected at a location from where it can meet the highest load demand.

Ayodele et al. (2015) presented optimal location sizing and appropriate technology selection of distributed generators for minimizing power loss using Genetic algorithm. This work was demonstrated using IEEE 14-bus network to test the applicability of the algorithm. The result reveals that the developed algorithm is able to successfully select the most suitable DG technology and optimally size and place the DGs to minimize power loss in the network. The result reveals that multiple placements can further reduce the power loss in the network.

Nweke et al. (2016) applied an analytical method to determine optimal location and sizing of DGs in the Nigerian power network for active power loss minimization. The proposed method emphasized on real power loss only in their formulation. The authors have ignored the reactive power losses which is key in the operation of power systems. In modern practical power systems reactive power injection plays a critical role in voltage stability control, thus the reactive power losses need to be incorporated in optimizing DG allocation for voltage profile improvement. For further research, the authors suggested genetic algorithm (GA)to reduce computation requirements of the techniques.

Poulami et al. (2016) presented the particle swarm optimization (PSO) algorithm for solving Load-Flow Computation problem for power loss minimization. The PSO is a relatively new and powerful intelligent evolution algorithm for solving optimization problems. It is a population- based approach. The proposed approach employs the PSO algorithm for the optimal setting of optimal power flow (OPF) based on loss minimization function. This paper also compares the loss for conventional Newton-Raphson method and PSO method on power flow. The approach of PSO has been examined and tested on standard IEEE 14, IEEE 30 bus test systems. The obtained results are compared with conventional using Newton-Raphson method to evaluate the performance.

Mournika et al. (2017) highlighted that distributed generators (DGs) play a vital role in present power distribution networks. The integration of distributed generators in distribution systems require optimal placement and sizing of distributed generators to yield minimum power losses and improved voltage profile. Often single DG placement may not be sufficient for power distribution system and multiple DGs may be required to be integrated to power distribution network. Concerning this, optimal location of multiple DGs in power distribution systems is very important. This paper presents a Particle Swarm Optimization (PSO) based algorithm for optimal location of multiple DGs into the power distribution network for power loss minimization. The proposed algorithm has two major steps; first step is the finding of optimal location and active power injections of multiple DGs and later is the computation of optimal reactive power injection of DGs. A bio-inspired particle swarm optimization algorithm is used in the first step to locate multiple DGs optimally and to obtain optimal active power injections of DGs.In the second step, reactive power injections of DGs are selected based on the reactive power requirement of the area fed by the DG. The proposed method is successfully tested on IEEE 13 bus system and its performance has been benchmarked with the Improved Analytical method.

Zuhaila et al. (2017) identified the optimal location of DG heuristically using power system simulation program for design and analysis of distribution system (PSS/Adept). The simulation was conducted by observing the power losses of the test system by installing DG at each load buses. Bus with minimum power loss was chosen as the optimal location of DG. In order to study the impact of DG to the fault current, various locations and sizes of DG were also selected. The simulations were conducted on IEEE 33-bus distribution test system and IEEE 69-bus distribution test system. The results showed that the impact of DG to the fault current is significant especially when fault occurs at busses near to DG location.

Hasibuan et al. (2018) presented a paper on the impact of distributed generation on distribution system losses using genetic algorithm. The implementation of this method was made on IEEE 30 standard bus test system. Results shows decrease in power losses in the distribution system when DG optimal located.

Mario et al. (2018) carried out a review of the application of methods in determining the optimal location of DG on the distribution system.A genetic algorithm is the most used nontraditional method for determination of the optimal location and size of DGs in distribution network. The optimal allocation can be determined by using the optimization method.

Distributed Generation Placement Methods in Power System

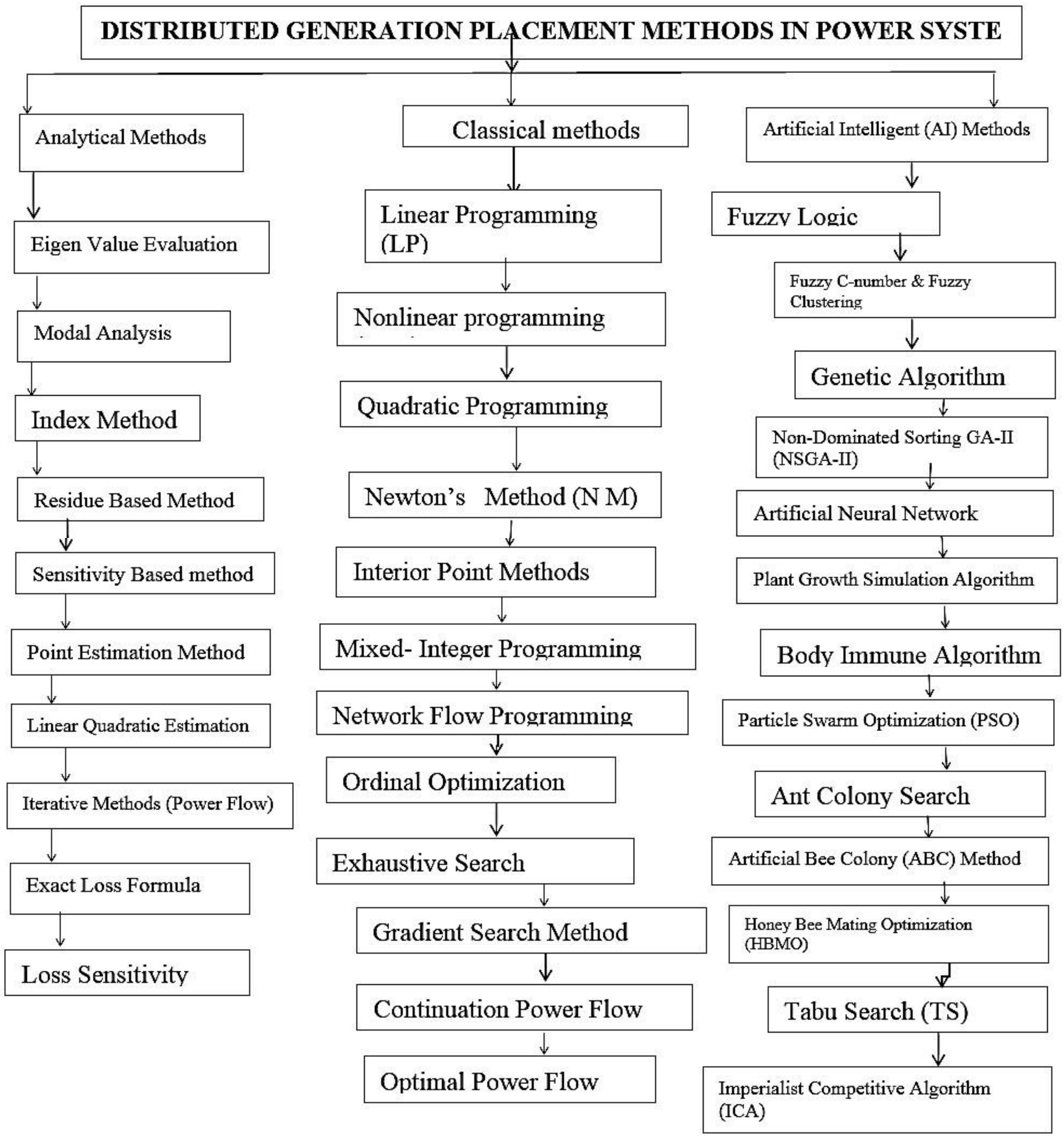

Fig.2.1 Flow chart of Distributed Generation Placement Methods in Power System

Three broad categories of methods are usually adopted and have been identified to be analytical methods (Wang, 2004), classical methods (Georgilakis, 2013) and artificial intelligence (Meta- heuristic) methods

Analytical methods.

Analytical methods represent the system by a mathematical model and compute its direct numerical solution. Such techniques are suitable for small and simplistic system where the numbers of state variable involved are small in number. However, for large and complex systems, analytical methods perform adversely in respect to computational efficiency (Prem et al., 2016 and Sambaiah, 2018 **Classical**

methods.

Another class of techniques used for optimizing the placement of DGs in power system is the classical methods. The classical methods are performing better than analytical methods for finding a near-optimal solution with better accuracy but present some inconveniences due to the danger of convergence, the long execution time, algorithmic complexity, and the generation of a weak number of non-dominated solutions. This includes:

Artificial Intelligence Methods (meta-heuristic) methods

Artificial intelligence (AI) methods or meta-heuristic techniques are performing better in terms of accuracy and convergence for extensively large and complex networks. Growing interest in the application of artificial intelligence (AI) techniques to power system engineering has introduced the potential of using this state-of-the-art technology. AI techniques, unlike strict mathematical methods, have the apparent ability to adapt to nonlinearities and discontinuities commonly found in power systems. The major advantage of the AI methods is that they are relatively versatile for handling various qualitative constraints. AI methods can find multiple optimal solutions in a single simulation run. So, they are quite suitable in solving multi-objective optimization problems. In most cases, they can find the global optimum solution.

METHODOLOGY

The Port Harcourt 33kV distribution network diagram, line data and bus data for the impact analysis is drawn from (Esobinenwu et al., 2019). This is Modelled and simulated in Electrical Transient Analyzer Program (ETAP) 12.6 software using Newton Raphson load flow method.

Mathematical Formulation of Newton–Raphson Load Flow Equations for Power System Network (Polar Co-Ordinate Approach)

The Newton-Raphson method for load flow solution solves iteratively using the load flow equations (Gupta, 2017)

For any ith bus,

$$V_i = V_i e^{j\delta} \text{ then } V^*_i = V_i e^{-j\delta} \quad (1)$$

Where $\delta$the phase is angle of the bus voltages and θ_{ik} is an admittance angle.

For kth bus, $V_k = V_k e^{j\delta_k}$ and $Y_{ik} = Y_{ik} e^{-j\theta_{ik}}$

Where $\delta$the phase is angle of the bus voltages and θ_{ik} is an admittance angle.

The complex power injected into the ith bus of an n-bus system is given by

$$S_i = P_i + jQ_i = V_i I_i^* \tag{3}$$

or

$$S_i^* = P_i - jQ_i = V_i^* I_i \tag{4}$$

$$I_i = \sum_{k=1}^{n} Y_{ik} V_K \tag{5}$$

Substituting the values of V_i^*, V_k, $Y_{ik}$from equations (1) and (2) in equation (6),

We have:

$$P_i - jQ_i = \sum_{k=1}^{n} V_i V_k Y_{ik} e^{-j(\theta_{ik} + \delta_i - \delta_k)} \tag{7}$$

Separating the real and imaginary Parts, we get,

Real power, $P_i = V_i^* \sum_{k=1}^{n} Y_{ik} V_k = \sum_{k=1}^{n} V_i V_k Y_{ik} Cos\left(\theta_{ik} + \delta_i - \delta_k\right)$

$$= V_i V_k Y_{ik} Cos\,\theta_{ii} + \sum_{\substack{k=1 \\ k \neq i}}^{n} V_i V_k Y_{ik} Cos\left(\theta_{ik} + \delta_i - \delta_k\right) \tag{8}$$

Reactive power, $Q_i = V_i^* \sum_{k=1}^{n} Y_{ik} V_k = \sum_{k=1}^{n} V_i V_k Y_{ik} Sin\left(\theta_{ik} + \delta_i - \delta_k\right)$

$$= V_i V_k Y_{ik} Sin\,\theta_{ii} + \sum_{\substack{k=1 \\ k \neq i}}^{n} V_i V_k Y_{ik} Sin\left(\theta_{ik} + \delta_i - \delta_k\right) \tag{9}$$

for i= 2, 3, 4, …, n because bus 1 is slack bus. Now, the linear equation in polar form becomes

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J1 & J2 \\ J3 & J4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta V \end{bmatrix} \qquad (10)$$

Where J_1, J_2, J_3 and J_4 are the elements of Jacobian matrix and can be determined from power equations (8) and (9) as follows:

The off–diagonal and diagonal elements of J_1 respectively, are

$$\frac{\partial P_i}{\partial \delta_k} = V_i V_k Y_{ik} Sin\left(\theta_{ik} + \delta_i - \delta_k\right) \quad ; \text{fork} \neq \text{i} \qquad (11)$$

$$\frac{\partial P_i}{\partial \delta_i} = -\sum_{\substack{k=1 \\ k \neq i}}^{n} V_i V_k Y_{ik} Sin\left(\theta_{ik} + \delta_i - \delta_k\right) \qquad (12)$$

The off – diagonal and diagonal elements of J_2, are

$$\frac{\partial P_i}{\partial V_i} = V_i Y_{ik} Cos\left(\theta_{ik} + \delta_i - \delta_k\right) \; ; \text{fork} \neq \text{I} \qquad (13)$$

$$\frac{\partial P_i}{\partial V_i} = 2 V_i Y_{ii} Cos \; \theta_{ii} + \sum_{\substack{k=1 \\ k \neq i}}^{n} V_k Y_{ik} Cos\left(\theta_{ik} + \delta_i - \delta_k\right) \qquad (14)$$

The off – diagonal and diagonal elements of J_3 are

The off – diagonal and diagonal elements of J_3 are

$$\frac{\partial Q_i}{\partial \delta_k} = -V_i V_k Y_{ik} Cos\left(\theta_{ik} + \delta_i - \delta_k\right) \; ; \text{for k} \neq \text{I} \qquad (15)$$

And $$\frac{\partial Q_i}{\partial \delta_i} = \sum_{\substack{k=1 \\ k \neq i}}^{n} V_i V_k Y_{ik} Cos\left(\theta_{ik} + \delta_i - \delta_k\right) \; ; \text{for k} \neq \text{i} \qquad (16)$$

The off – diagonal and diagonal elements of J_4 are

$$\frac{\partial Q_i}{\partial V_k} = V_i \ Y_{ik} \ Sin \left(\theta_{ik} + \delta_i - \delta_k\right) \ ; \text{for } k \neq i \qquad (17)$$

$$\frac{\partial Q_i}{\partial V_i} = 2 V_i \ Y_{ii} Sin \ \theta_{ii} \ + \sum_{\substack{k=1 \\ k \neq i}}^{n} V_k \ \ Y_{ik} Sin \left(\theta_{ik} + \delta_i - \delta_k\right) \text{for } k \neq i \qquad (18)$$

The elements of Jacobian matrix are computed with the latest voltage estimate and computed power. The formulation in polar co-ordinates takes less computational efforts and also needs less memory space.

NEWTON RAPHSON LOAD FLOW SIMULATION DIAGRAM IN ETAP ENVIRONMENT

Figure 1 to 4 shows the simulated composite diagram of the 73 bus of the Port

Harcourt 33kV power distribution system with the inclusion of distributed generation.

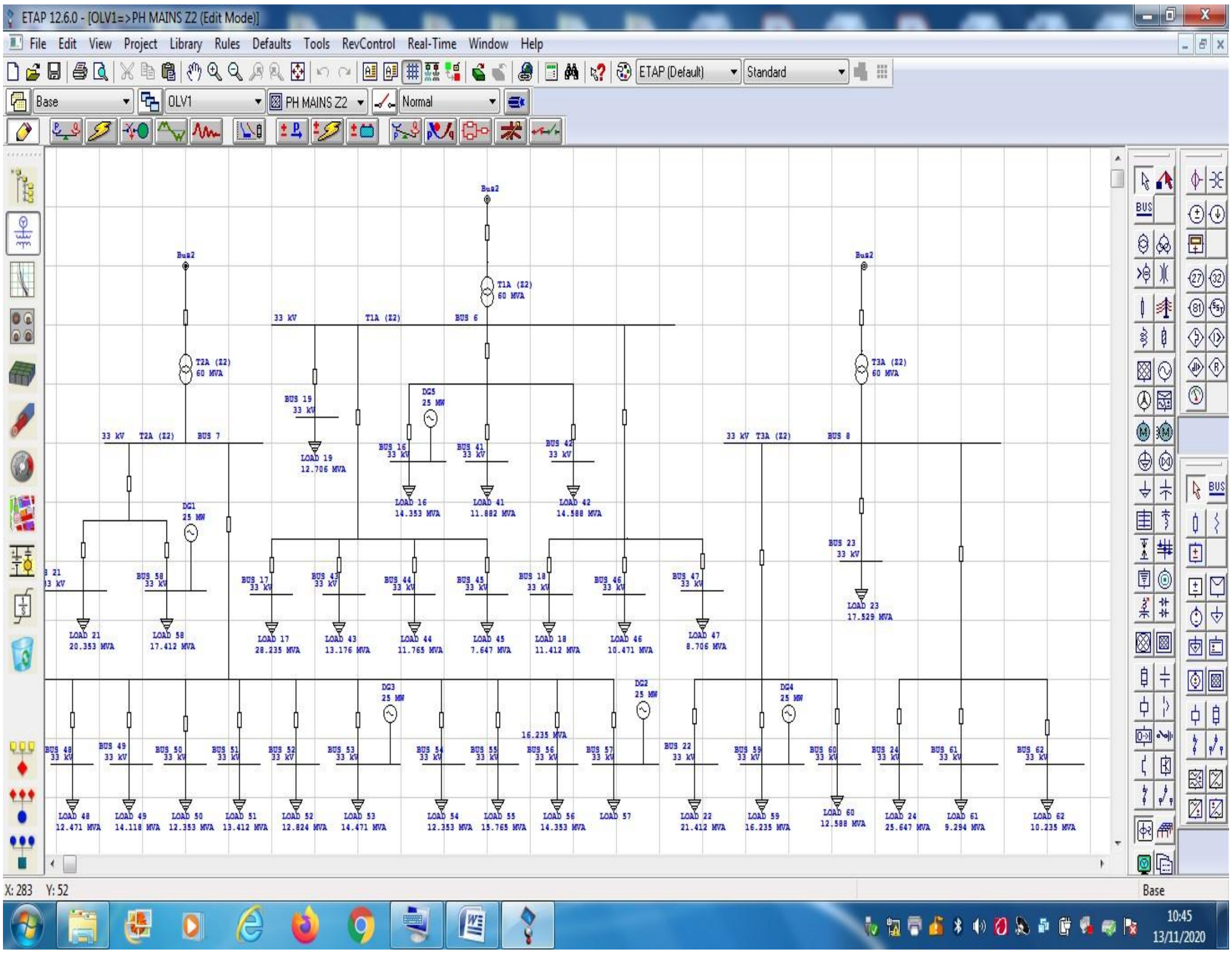

Figure 1: Port Harcourt Zone 2 (PHZ2)

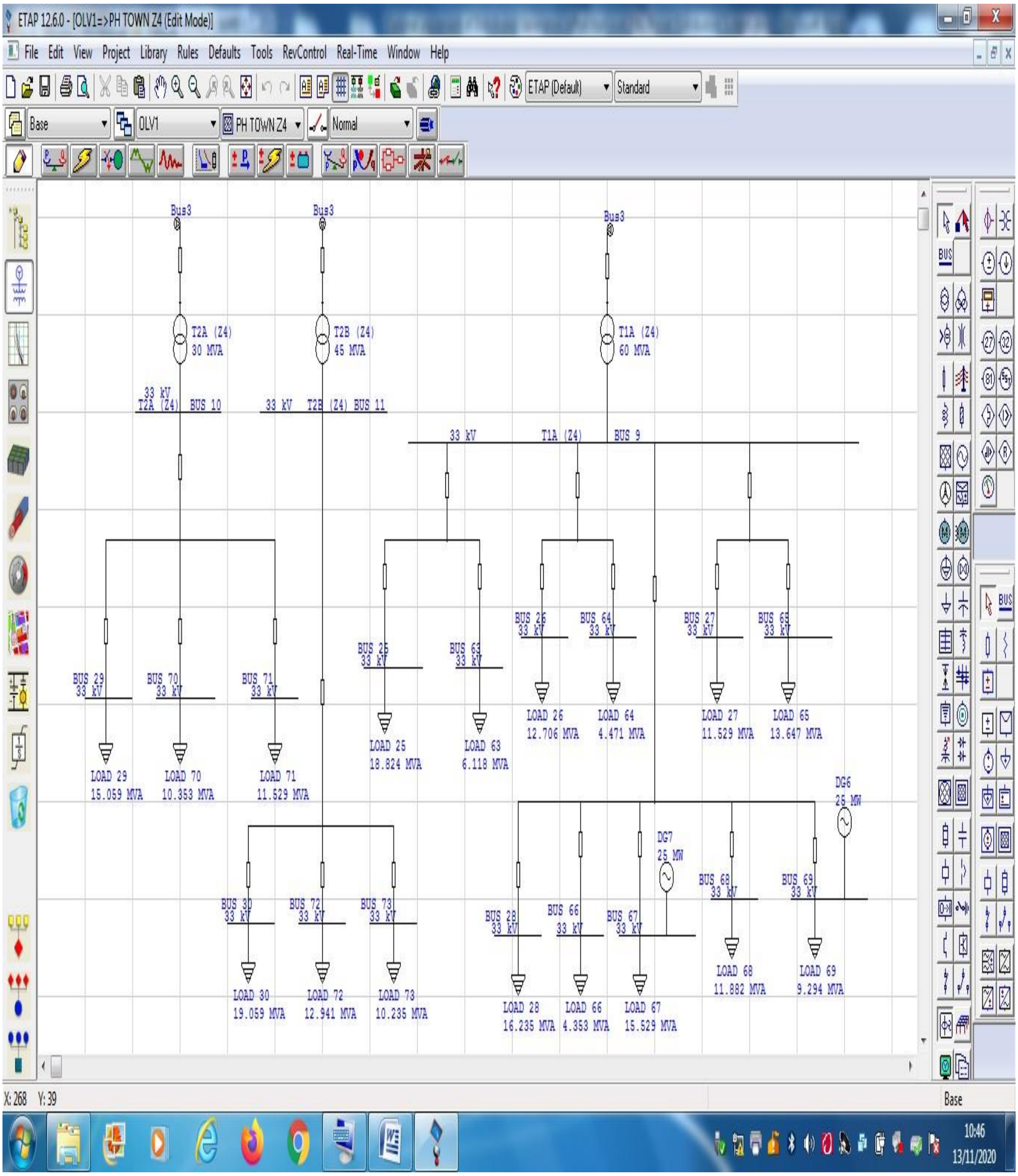

Figure 2: Port Harcourt Zone 4 (PHZ4)

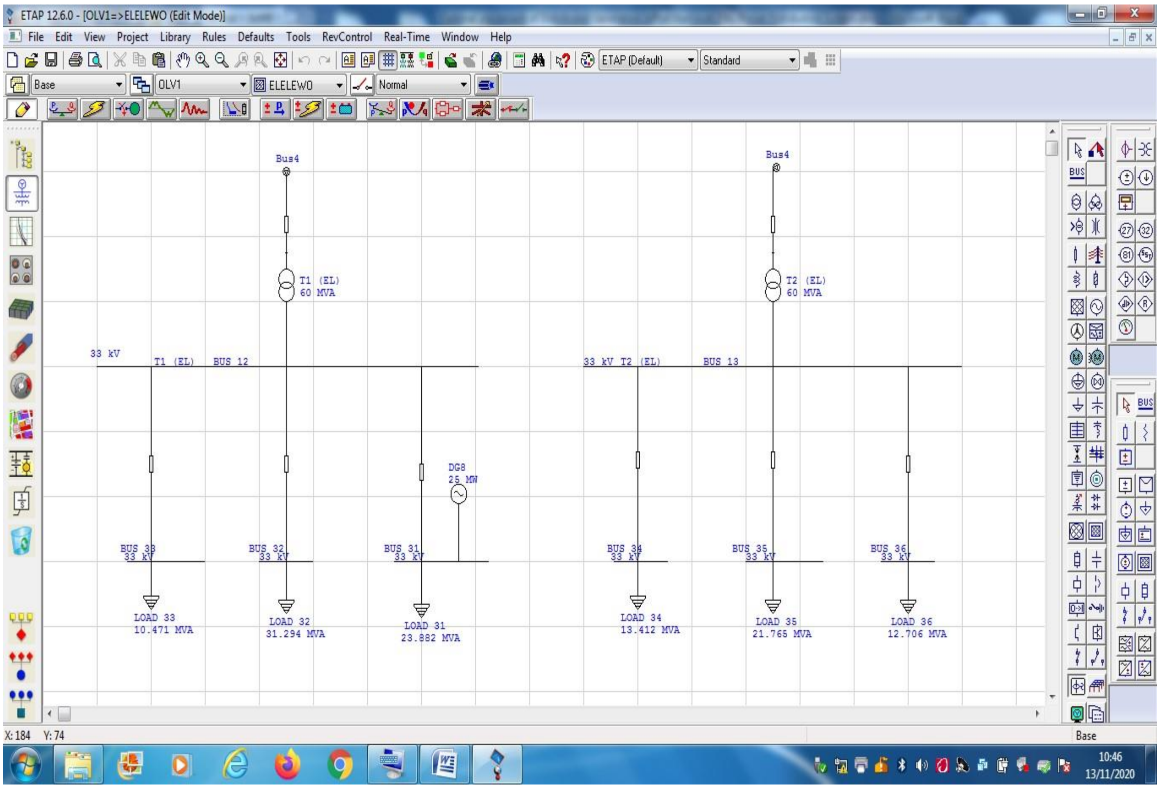

Figure 3: ELELEWO

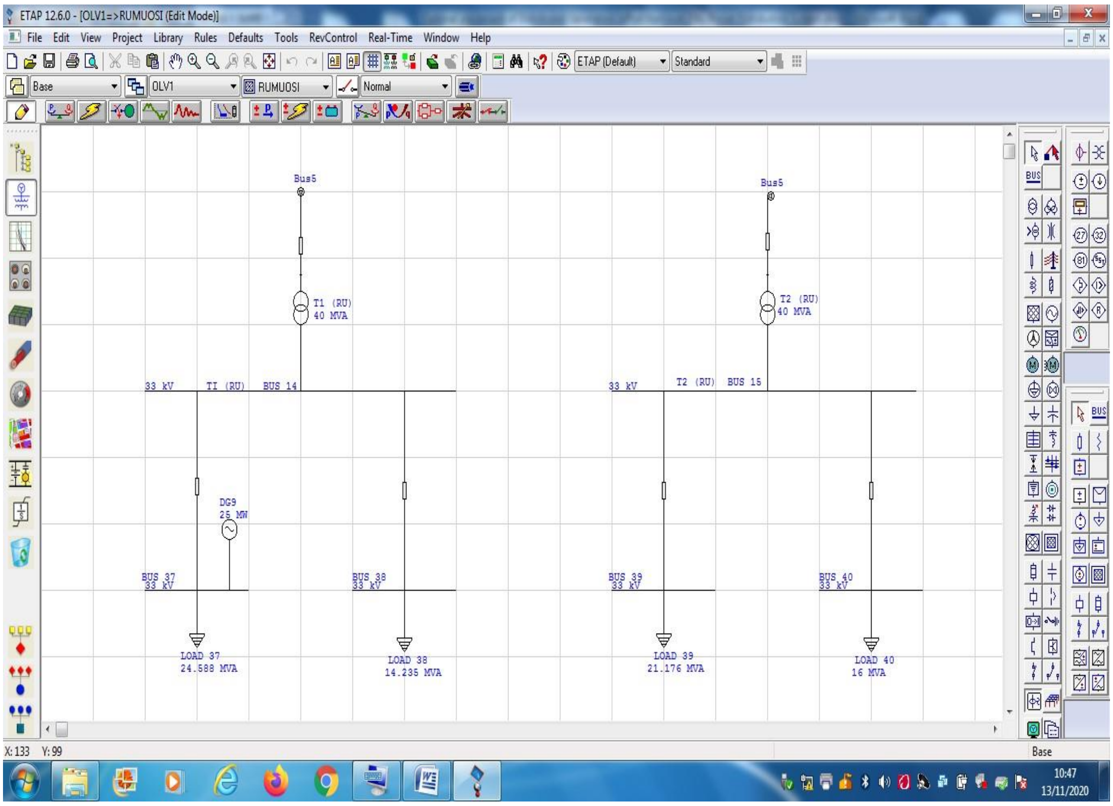

Figure 4: RUMUOSI

RESULT Table 1. Bus voltage per unit value

Bus ID	Nominal kV	Calculated Voltage (KV)	P.U Value	Condition
BUS 1	132	135.96	1.03	Improved
BUS 2	132	132.131	1.00	Improved
BUS 3	132	133.952	1.01	Improved
BUS 4	132	134.538	1.02	Improved
BUS 5	132	131.667	1.00	Improved
BUS 6	33	33.83	1.03	Improved
BUS 7	33	33.856	1.03	Improved
BUS 8	33	34.34	1.04	Improved
BUS 9	33	32.829	0.99	Improved
BUS 10	33	32.327	0.98	Improved
BUS 11	33	33.016	1.00	Improved
BUS 12	33	33.014	1.00	Improved
BUS 13	33	32.633	0.99	Improved
BUS 14	33	33.292	1.01	Improved
BUS 15	33	32.469	0.98	Improved
BUS 16	33	33	1.00	Improved
BUS 17	33	32.93	1.00	Improved
BUS 18	33	33.214	1.01	Improved
BUS 19	33	33.171	1.01	Improved
BUS 20	33	32.389	0.98	Improved
BUS 21	33	32.784	0.99	Improved
BUS 22	33	33.011	1.00	Improved
BUS 23	33	33.723	1.02	Improved
BUS 24	33	32.907	1.00	Improved
BUS 25	33	31.911	0.97	Improved

BUS 26	33	32.506	0.99	Improved
BUS 27	33	32.465	0.98	Improved
BUS 28	33	32.691	0.99	Improved
BUS 29	33	31.806	0.96	Improved
BUS 30	33	32.358	0.98	Improved
BUS 31	33	33	1.00	Improved
BUS 32	33	32.333	0.98	Improved
BUS 33	33	32.76	0.99	Improved
BUS 34	33	32.198	0.98	Improved
BUS 35	33	31.592	0.96	Improved
BUS 36	33	32.085	0.97	Improved
BUS 37	33	33	1.00	Improved
BUS 38	33	32.976	1.00	Improved
BUS 39	33	31.525	0.96	Improved
BUS 40	33	32.243	0.98	Improved
BUS 41	33	32.544	0.99	Improved
BUS 42	33	32.404	0.98	Improved
BUS 43	33	32.791	0.99	Improved
BUS 44	33	32.611	0.99	Improved
BUS 45	33	32.805	0.99	Improved
BUS 46	33	32.87	1.00	Improved
BUS 47	33	33.059	1.00	Improved
BUS 48	33	32.178	0.98	Improved
BUS 49	33	32.333	0.98	Improved
BUS 50	33	32.314	0.98	Improved
BUS 51	33	32.327	0.98	Improved
BUS 52	33	32.335	0.98	Improved

BUS 53	33	33	1.00	Improved
BUS 54	33	32.208	0.98	Improved
BUS 55	33	32.314	0.98	Improved
BUS 56	33	32.192	0.98	Improved
BUS 57	33	33	1.00	Improved
BUS 58	33	33	1.00	Improved
BUS 59	33	33	1.00	Improved
BUS 60	33	32.79	0.99	Improved
BUS 61	33	32.686	0.99	Improved
BUS 62	33	32.599	0.99	Improved
BUS 63	33	31.952	0.97	Improved
BUS 64	33	32.445	0.98	Improved
BUS 65	33	31.916	0.97	Improved
BUS 66	33	32.673	0.99	Improved
BUS 67	33	33	1.00	Improved
BUS 68	33	32.563	0.99	Improved
BUS 69	33	33	1.00	Improved
BUS 70	33	31.602	0.96	Improved
BUS 71	33	31.464	0.95	Improved
BUS 72	33	32.141	0.97	Improved
BUS 73	33	32.078	0.97	Improved

Table 2. Line losses

ID	MW Flow	Mvar Flow	kW Losses	kvar Losses

Line1	352.417	317.323	5367	13916
Line2	129.409	92.627	1008	2374
Line3	74.411	55.2	410	751
Line4	43.182	36.535	80.963	57.604
Line5	105.331	92.383	69.425	160
Line6	119.318	94.309	81.81	193
Line7	79.219	80.179	44.935	96.143
Line8	63.901	39.892	13.949	20.634
Line9	29.484	23.673	3.515	-6.739
Line10	35.012	26.695	4.766	-3.458
Line11	35.175	25.652	4.619	-3.982
Line12	38.825	28.796	5.694	-1.161
Line13	13.131	13.729	0.918	-13.012
Line14	29.965	22.768	3.604	-5.966
Line15	7.8	8.17	8.752	9.019
Line16	23.952	14.874	54.452	62.845
Line17	9.835	6.099	9.049	9.349
Line18	11.086	6.946	173	183
Line19	28.497	17.704	79.59	92.494
Line20	17.102	10.613	28.043	31.753
Line21	18.243	11.323	31.468	35.769
Line22	15.787	9.897	227	254
Line23	21.722	13.486	44.865	51.555
Line24	14.985	9.298	22.728	25.56
Line25	10.49	6.506	10.745	11.401
Line26	9.493	5.887	8.823	9.142

Line27	13.56	8.413	17.742	19.629
Line28	11.905	7.385	14.45	15.818
Line29	15.6	9.68	23.956	26.972
Line30	0.3	0.278	0.112	-12.78
Line31	25.965	16.323	430	498
Line32	8.826	5.491	54.329	54.588
Line33	10.97	6.852	117	126
Line34	17.401	11.015	446	508
Line35	10.349	6.475	139	148
Line36	0.934	5.117	34.202	15.976
Line37	12.175	7.588	92.501	100
Line38	16.819	10.626	393	446
Line39	13.056	8.127	72.632	80.169
Line40	9.923	6.192	100	105
Line41	12.12	7.588	164	179
Line42	11.121	6.92	62.694	66.997
Line43	9.865	6.155	98.841	103
Line44	6.458	4.01	34.327	29.302
Line45	8.912	5.555	82.021	82.355
Line46	7.461	4.635	34.766	32.261
Line47	10.16	6.332	81.114	85.62
Line48	11.569	7.192	48.118	52.107
Line49	10.115	6.289	46.827	49.344
Line50	10.988	6.831	47.355	50.794
Line51	10.509	6.532	43.314	46.033
Line52	7.7	11.522	136	147
Line53	10.075	6.276	73.091	76.988

Line54	12.909	8.029	59.929	66.02
Line55	11.699	7.292	89.62	97.288
Line56	6.2	12.803	144	156
Line57	5.2	3.968	19.58	14.496
Line58	6.097	-7.046	103	98.771
Line59	10.639	6.627	75.094	79.447
Line60	7.808	4.859	58.086	55.632
Line61	8.572	5.343	81.747	81.409
Line62	4.878	3.023	2.407	1.624
Line63	3.683	2.279	9.269	2.155
Line64	11.01	6.896	159	171
Line65	3.633	2.249	6.366	1.158
Line66	6.8	8.581	54.854	56.069
Line67	9.878	6.14	43.992	45.917
Line68	12.1	13.656	91.358	102
Line69	8.122	5.053	51.666	51.705
Line70	8.997	5.613	88.357	91.395
Line71	10.507	6.544	72.621	77.3
Line72	8.291	5.164	70.113	69.842
Line73	14.548	5.944	296	324
Line74	106.255	52.401	3354	3946
Line75	23.618	25.961	833	966
Line77	29.368	18.451	344	400
Line78	34.903	21.978	505	590
Line79	52.399	33.136	1004	1177
Line80	26.573	16.711	365	422
Line81	12.21	6.97	288	310

Line82	39.345	25.14	1243	1452
Line83	20.288	12.809	426	488
Line84	14.271	8.894	98.012	109
Line85	20.668	12.972	165	189
Line86	8.43	-5.164	113	112

Table 3: Overall Summary of RLF

Study ID	WITH DG
Study Case ID	RLF
Data Revision	Base
Configuration	Normal
Loading Cat	Design
Generation Cat	Design
Diversity Factor	Normal Loading
Buses	96
Branches	95
Generators	9
Power Grids	1
Loads	58
Load-MW	736.237
Load-Mvar	591.593
Generation-MW	736.237
Generation-Mvar	591.593
Loss-MW	23.594
Loss-Mvar	149.937

Discussion

Repeated load flow method identified: BUS 16(Oyigbo), BUS31(Eleme), BUS37(New Airport), BUS53(Rivoc), BUS57(Onward Fishery), BUS58(Elekahia), BUS59(Shell Industrial), BUS67(U.O.E), and BUS69(Master Energy) for optimal DG placement. The result of simulation shows overall power loss as 23.594MW and 149.937MVar. These represent (37.6% MW and 37.5MVar) reduction and an improvement in the system

Conclusion

This method (RLF) will be beneficial to power system planners and distribution companies to enhance the quality of power supply and for sustainable electric power system in the country. Distributed generation should be encouraged for off- grid rural electrification to meet the power need of the state and which may result to the nations improvement in rural electrification. Load flow analysis should be a regular routine operation of the utility company to access the steady state performance of the distribution system. The information from load flow analysis will enable the DISCOs to improve the distribution network.

References

Amanifar, O., & Hamedani, M.E. (2011). Optimal distributed generation placement and sizing for loss and THD reduction and voltage profile improvement in distribution systems using particle swarm optimization and sensitivity analysis. International Journal on Technical and Physical Problems of Engineering, 3(7), 47-53.

Ayodele, T.R., Ogunjuyibe, A.S.O., & Akinola, O.O. (2015). Optimal location, sizing, and appropriate technology selection of distributed generators for minimizing power loss using Genetic Algorithm. Journal of Renewable Energy. http://dx.doi.org/10.1155/2015/832917

Basudev, D., & Bimal, C.D. (2013). Impact of distributed generation on reliability of the distribution System. Journal of Electrical and Electronics Engineering, 8(1), 42-50.

Borges, C.L.T., & Falcao, D.M. (2006). Optimal distributed generation allocation for reliability, losses, and voltage improvement. International Journal of Electrical Power Energy System, 28(6), 413-420.

Caisheng, W., & Hashem, N. (2004). Analytical approaches for optimal placement of distributed generator sources in power systems. IEEE Transactions on Power Systems, 19(4), 2068-2076.

Chizindu Stanley Esobinenwu (2021). Impact of Distributed Generation in Power System using Particle Swarm Optimization. International Journal of Innovative Scientific & Engineering Technologies Research, 9(1), 20-25.

Chizindu Stanley Esobinenwu and J.P. Iloh (2019). Optimal Placement of Distributed Generation in Power System using Particle Swarm Optimization. Global Scientific Journals, 7(11), 1513–1522.

Chizindu Stanley Esobinenwu, A.J. Atuchukwu, and J.P. Iloh (2019). Sensitivity Analysis for Optimal Distributed Generation Placement in Port Harcourt 33kV Power Distribution System. International Research Journal of Engineering and Technology (IRJET), 6(11), 1710-1721.

Chizindu Stanley Esobinenwu, S.O.E. Ogbogu, and J.P. Iloh (2019). Evaluation of the Voltage Profile of Port Harcourt 33kV Power Distribution System. American Journal of Engineering Research (AJER), 8(11), 20-33.

Funso, K.A., & Michael, O.O. (2013). Investigation of Nigerian 330KV Electrical Network with Distributed Generation- Part 1: Basic Analysis. Electrical and Electronic Engineering, 3(2), 49-71.

Georgilakis, P.S., & Hatziargyriou, N.D. (2013). Optimal distributed generation placement in power distribution networks: models, methods, and future research. IEEE Transactions on Power Systems, 28(3), 3420–3428.

Greatbank, J.A., Popovic, D.H., Begovic, M., Pregelji, A., & Green, T.C. (2003). Optimization for security and reliability of power systems with distributed generation.

Hasibuan, A., Masri, S., & Othman, W. (2018). Effect of distributed generation installation on power loss using genetic algorithm method. IOP Conference Series: Materials Science and Engineering. https://doi.org/10.1088/1757-899x/308/1/012034

Julius, K.C., & Nicodemus, A.O. (2013). A GA/IPSO based approach for system loss reduction and voltage profile improvement employing arithmetic crossover and mutation. International Journal of Engineering Science and Technology, 5(7), 1501-1510.

Kashem, M.A., Negnevitsk, M., & Ledwich, G. (2007). Optimal distributed generation parameters for reducing losses with economic consideration, 2007 IEEE Power Engineering Society General Meeting. https://doi.org/10.1109/pes.2007.386058

Mario, S., Zvonimir, K.F., & Marinko, S. (2018). Review of non-traditional optimization methods for allocation of distributed generation and energy storage in distribution system, Technical Gazette, 25(1), 294-301.

Mournika, L.P., Amit, J., & James, R.K. (2017). Particle swarm optimization application for optimal location of multiple distributed generators in power distribution network. Journal of Electrical and Electronic Systems, 6(4), 244- 248.

Nweke, J.N., Ekwue, A.O., & Ejiogu, E.C. (2016). Optimal location of distributed generation on the Nigerian power system. Nigerian Journal of Technology, 35(2), 398-403.

Pathak, S., & Vaidya, B.N. (2012). Optimal power flow by particle swarm optimization for reactive loss minimization. International Journal of Scientific and Technology Research, 1(1), 1-6.

Poulami, D., Sudip, K.N., Sourav, S, & Sankar, N.P. (2016). An approach to optimize FIR filter coefficients using the GA, PSO, and BAT algorithm and their comparative analysis. https://doi.org/10.1109/iccece.2016.8009579