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Distributed Generation Effect on Distribution System

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ABSTRACT

The idea about this proposed work, to know the Distributed Generation (DG) impact on distribution scheme. This is to improve the performance of the system using power loss reduction and voltage development. In this proposed work Wind Turbine (WT) and Photo-Voltaic (PV) units were taken for DGs and various algorithms are tested to get the effect of DG on network. In this paper one new hybrid algorithm is proposed to have optimal size and location of various types of DGs. Initially, active and reactive power losses of the test system and voltage at every bus of the test system were examined using Back and Forward (B/FW) Sweep technique. Similarly, Gravitational Search Analysis (GSA), BAT Analysis (BA) and Ant Lion Optimization (ALO) techniques were utilized to examine the parameters of the same test system. Finally, all the constraints were compared with projected hybrid approach. All the algorithms have tested on IEEE-33 and IEEE-69 standard test systems. Furthermore, the MATLAB simulation is used to get the optimal allocation of DGs.

1. INTRODUCTION

The world wide apprehensions about the atmosphere, associated along with development of techniques to link non-conventional energy resources to grid and electric power market deregulation of has abstracted the distribution planners concentration towards distributed generation (DG) connection to grid-connected [1, 2]. DG known as a small-scale electrical energy generation for the requirement of sustaining station load dissimilar from the conventional or Central power station [3]. Majority of DG sources are considered with the help of green energy that is assumed pollution free. Penetration of have many technical advantages.

Furthermore, DG is accessible in modular unit, considered by easy of identify location for small generators, little construction times, and minimum capital investment [4, 5]. The technical advantages of DG include improvement of voltage, reduction in loss of power, relieved from transmission and distribution congestion, enhanced network reliability and quality of power. All the above are aids to accomplished by introducing DGs at correct sites with correct capacity otherwise, it could lead to adverse effects like augmented power losses [6, 7]. The wrong placement will leads to raise in scheme losses and sometimes it may even collapse the entire scheme [8]. Though, the tasks of detecting the optimal sizes and sites of DG units in distribution scheme are not easy [9].

Now the DG installation is placing a big vital role in distribution schemes due to its advantages over the methods in reduction in network total power loss, reduction in total operating power of the network, user friendly and environmental friendly, increase in system voltage, and reliability [10, 11]. The placement of DG is purely the choice of its owners and also investors. It also depends on location and the availability of the fuel and condition of climate [12, 13]. Though the introduction and the modifications depend on number of DGs installation like one or single DG installation and installation of multi-DGs. Various techniques have presented to find the optimal site and capacity of the DG [14-17]. Besides the reduction in power loss, the DG location is may be on the basis of reduction in cost. The mixed integer linear program, Tabu Search (TS), Genetic Approach (GA), Particle Swarm Optimization (PSO) approach, Ant Colony Optimization (ACO) and direct search approach are utilized to calculate the best DG location and siting. In those papers when introducing DGs emphasis is provided on the reduction in line loss [18-20]. Consequently, the optimization approaches would be engaged for deregulation of power industry, permitting for the optimal allocation of the DG. In the work, an efficient approach is projected to validate the load flow issue and the placement issue of DG.

2. OBJECTIVE FUNCTIONS

Figure 1 represents a simple two bus system. This work is to examine the suitable size and site of DG. The main objective in this research is enhancement of voltage and minimization of power losses.

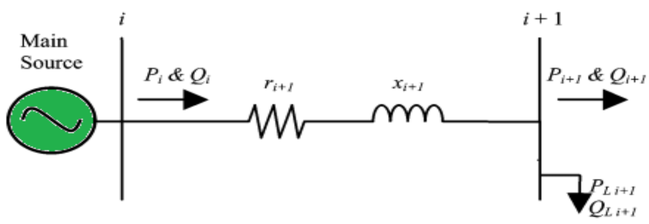

Figure 1. Single line layout of two bus scheme

$$VoltageDeviationIndex = \sum_{i}^{N} \frac{|V_{rated} - V_i|}{V_{rated}} \quad (1)$$

where, V_{rated} be the network rated value of voltage and it is 1.0 p.u. V_i be the i^{th} bus voltage in p.u. N be the network total buses number.

$$Minimization\ of\ real\ power\ loss = \left(\sum_{i=2}^{N_{bus}} \left(P_{gni} - P_{dni} - V_{mi} V_{ni} Y_{mni} \cos(\delta_{mi} - \delta_{ni} + \theta_{ni}) \right) \right) \quad (2)$$

where, P_{gni} is generator output active power at bus ni, P_{dni} is the active power demand at bus ni, V_{mi} be the voltage of bus mi, V_{ni} be the voltage of bus ni, Y_{mni} be the admittance magnitude among mi bus and bus ni, δ_{mi} be the voltage phase angle at bus mi, δ_{ni} be the voltage phase angle at bus ni, θ_{ni} be the angle of admittance of $Y_i = Y_{ni} \angle \theta_{ni}$. N_{bus} represents number of buses in given test scheme, N_i is receiving bus number (N_i = 2, 3, N_n) and mi is the bus number that sending power to bus ni ($m2 = n1 = 1$) and i is the branch number that fed bus ni.

2.1 Constraints

$$P_{Gi} - P_{Di} - V_i \left(\sum_{j=1}^{N_{bus}} \left(V_j Y_{ij} \cos(\delta_j - \delta_i + \theta_{ij}) \right) \right) = 0$$
$$Q_{Gi} - Q_{Di} - V_i \left(\sum_{j=1}^{N_{bus}} \left(V_j Y_{ij} \sin(\delta_j - \delta_i + \theta_{ij}) \right) \right) = 0 \quad (3)$$
$$i = 1, 2, ..., Nbus$$

Here P_{Gi} and Q_{Gi} states active and reactive power generated at i bus respectively; P_{Di} and Q_{Di} states active and reactive load at i bus respectively, P_i and Q_i states active and reactive injected power at i bus, Y_{ij} and θ_{ij} states the amplitude of admittance and branch voltage angle connecting i and j buses.

2.1.1 Voltage limits

For this paper work, the deviation of voltage is definite from 1.05 pu and 0.90 pu.

$$V_{\max} \geq V \geq V_{\min} \quad (4)$$

Here: V_{max} be the peak voltage of bus and V_{min} be the lowest voltage of bus.

2.1.2 Real power loss constraint

$$PL_{withoutDG} \geq PL_{withDG} \quad (5)$$

2.1.3 DG constraint

$$\sum_{i=1}^{Nbus} P_{Di} \geq P_{DG} \geq 0 \quad (6)$$

$$\sum_{i=1}^{Nbus} Q_{Di} \geq Q_{DG} \geq 0 \quad (7)$$

where, P_{Di} and Q_{Di} are the active and reactive load demand at the same bus.

3. B/W AND F/W SWEEP APPROACH FORMULATION

Algorithm:

1. Get line information that consists of line resistance and line reactance and Bus information including real and reactive powers at each bus.
2. Read base values such as base KV and base MVA.
3. Convert the load impedance into per unit values.
4. Start Backward sweep analysis i.e. the analysis starts from the destination node to source node. This backward sweep analysis is used to determine real and reactive powers and the voltages of all the buses. The equations are as follows:

$$V_i = V_{i+1} + conj((P_{i+1} + jQ_{i+1}) / V_{i+1}) \quad (8)$$

$$P_i = P_{i\_Load} + P_{i\_Loss} \quad (9)$$

$$Q_i = Q_{i\_Load} + Q_{i\_Loss} \quad (10)$$

$$P_{i\_Loss} = ((P_{i+1}^2 + Q_{i+1}^2) / V_{i+1}^2) * R_i \quad (11)$$

$$Q_{i\_Loss} = ((P_{i+1}^2 + Q_{i+1}^2) / V_{i+1}^2) * X_i \quad (12)$$

where, V_i is the node current voltage, V_{i+1} is voltage at next node, P_{i+1} is next node active power, Q_{i+1} is next node reactive power, R_i is the line resistance among i and $i+1$ node and X_i is the line reactance line among i and $i+1$ node.

5. Now check for criterion of Convergence as follows:

$$\varepsilon \geq V_{calculated} - V_{described} \quad (13)$$

Here ε specified the tolerance.

6. If the system is under the tolerance limits i.e. the system converged, then goes to step 11. Otherwise then start Forward sweep analysis as step 7.
7. The Forward sweep analysis starts at source node and by finding active and reactive power loss and the voltages at all the busses reach the destination node. The equations for Forward sweep analysis as follows:

$$V_{i+1} = V_i + conj((P_i + jQ_i) / V_i) \quad (14)$$

$$P_i = P_{i\_Load} + P_{i\_Loss} \quad (15)$$

$$Q_i = Q_{i\_Load} + Q_{i\_Loss} \quad (16)$$

$$P_{i\_Loss} = ((P_i^2 + Q_i^2) / V_i^2) * R_i \quad (17)$$

$$Q_{i\_Loss} = ((P_i^2 + Q_i^2) / V_i^2) * X_i \quad (18)$$

8. Now again check the criterion of Convergence as mentioned above.
9. If the system is under the tolerance limits i.e. the system is converged then go to step 11. Otherwise go to step 4.
10. Print total power losses and voltages of all the busses in the system.
11. Stop.

4. POWER FLOW MODELLING OF DGS

DGs were considering as generator buses and load buses in the case of power flow studies. The DG should reach their reacive power constraint when DG is considered as generator bus and finally this generator bus converts into load bus.

In this case, DG generates fixed real power and reactive power [21]. Hence, real power load and reactive power load at the interconnected bus (P_L and Q_L) are changed as given in Eqns. (19) and (20),

$$P_L(t) = P_L(t) - P_{DG}(t) \tag{19}$$

$$Q_L(t) = Q_L(t) - Q_{DG}(t) \tag{20}$$

Now, this multi-objective function is for reduction in real power losses and voltage improvement at all buses. Classification of DG sources as 4 – types [22].

Type1: Active power injecting only.
Type2: Reactive power injecting only
Type3: Injecting both powers active and reactive.
Type4: Injecting active but consuming reactive power.

5. PROPOSED APPROACH

The projected methodology is an effective method for getting the finest capacity and site the DG. This supirior methodology is a hybridization of BA and ALO to improve the outcome of the test scheme. The ALO approach is employed to estimation of loss of real power. The outcome of the ALO approach is having high iteration to achieve the better outcome and poor performance. To enhance the performance of ALO which is based on the BAT approaach. The process of the projected technique is presented in subsequent section and the flow chart for the proposed method is shown in Figure 2.

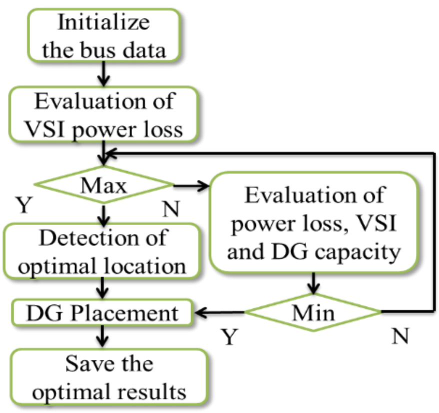

Figure 2. Proposed hybrid technique flow chart

6. RESULTS

This projected scheme is worked on MATLAB. Outcome is tested on IEEE-33 which have of 33 buses and 32 branches with 12.66 kV and 100 MVA are base values and 3.715 MW is complete real and 2.3 MVAR is complete reactive power load shown in Figure 3 and IEEE-69 which have of 69 buses and 68 branches with 12.66 kV and 100 MVA are base values and 3.80219 MW is complete real and 2.6946 MVAR is total reactive power load shown in Figure 4, Power factor of this scheme is 0.85 lagging, 0.85 leading and Unity. For the implementation purpose, projected hybridization technique and traditional scheme parameters are given in Table 1.

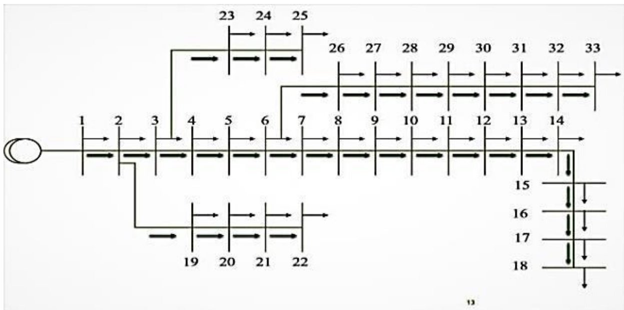

Figure 3. IEEE-33 standard test system

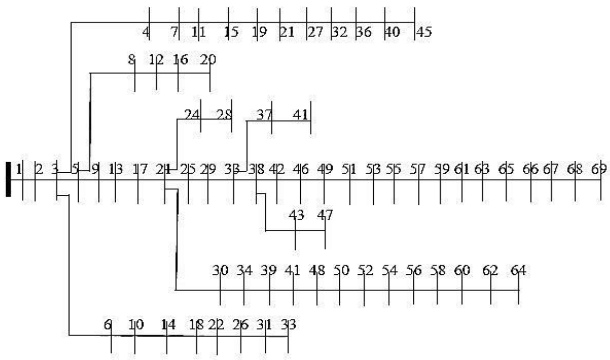

Figure 4. IEEE-69 test bus

Table 1. Implementation parameters

Description	Algorithms	Values
Population size (n)	BA	20
Number of generations (N)		10
Loudness (A)		1
Pulse rate (r)		1
Frequency (Q)		(0,2)
Dimension (d)		4
Ant lion pits	ALO	3
Number of Ant lions		10
Max iteration		100

In this paper, two DGs has considered for better site and sized. All the objecctives like DG capacity, DG site, loss of active power, cost of power loss, cost of DGs and Voltage Stability Index (VSI) when the power factor is unity, 085 lagging and 0.85 leading using various methods of algorithms are reported in Tables 2 to 5. In Table 6 comparison analysis of power loss and VSI are mentioned. In Table 7 & 8 cost of Power Loss validation per year for IEEE-33 and IEEE-69 bus scheme has done. In Tables 9 & 10 cost of DG validationn per annum for IEEE-33 bus and IEEE-69 bus scheme has done.

Table 2. Optimal location and capacity of DG using GSA method on IEEE-33 & 69 Bus

Bus No	Normal Power Loss (*kW*)	Power loss (*kW*)		% Reduction	DG capacity (*kW*)		Optimal bus connected for DG		Load connected Bus
		Load Power Loss	GSA Power Loss		*PV*	*WT*	*PV*	*WT*	
33	210.016	220.7793	207.6548	5.94	12	204	4	19	24
		225.8542	200.4888	11.23	85	190	2	27	31
		223.8893	198.9805	11.12	100	196	22	6	29
		220.0239	201.2303	8.54	60	193	3	4	7
69	237.9656	241.4972	226.566	6.18	12	205	20	20	10
		238.2408	232.6279	2.35	85	160	48	24	48
		386.3267	230.712	40.28	100	153	12	30	60
		261.2378	227.2329	13.01	60	165	12	14	63

Table 3. Optimal location and capacity of DG using BAT method on IEEE-33 & 69 Bus

Bus No	Normal Power Loss (*kW*)	Power loss (*kW*)		% Reduction	DG capacity (*kW*)		Optimal bus connected for DG		Load connected Bus
		Load Power Loss	BAT Power Loss		*PV*	*WT*	*PV*	*WT*	
33	210.016	220.7793	206.5204	6.45	12	160	20	14	24
		225.8542	172.3606	23.68	85	190	16	16	31
		223.8893	170.8101	23.70	100	179	18	31	29
		220.0239	180.0811	18.15	60	172	10	17	7
69	237.9656	241.4972	226.7515	6.10	12	209	24	26	10
		238.2408	224.9875	5.56	85	158	54	19	48
		386.3267	224.867	41.79	100	196	53	68	60
		261.2378	193.4544	25.94	60	204	61	58	63

Table 4. Optimal location and capacity of DG using ALO method on IEEE-33 & 69 Bus

Bus No	Normal Power Loss (*kW*)	Power loss (*kW*)		% Reduction	DG capacity (*kW*)		Optimal bus connected for DG		Load connected Bus
		Load Power Loss	ALO Power Loss		*PV*	*WT*	*PV*	*WT*	
33	210.016	220.7793	183.806	16.74	12	163	18	17	24
		225.8542	177.209	21.53	85	156	16	11	31
		223.8893	150.4867	32.78	100	198	12	18	29
		220.0239	183.7687	16.47	60	169	9	11	7
69	237.9656	241.4972	236.312	2.14	12	178	45	58	10
		238.2408	187.3165	21.37	85	217	62	59	48
		386.3267	212.3519	45.03	100	216	8	60	60
		261.2378	218.3531	16.41	60	196	20	60	63

Table 5. Optimal location and capacity of DG using proposed method on IEEE-33 & 69 Bus

Bus No	Normal Power Loss (*kW*)	Power loss (*kW*)		% Reduction	DG capacity (*kW*)		Optimal bus connected for DG		Load connected Bus
		Load Power Loss	Proposed Power Loss		*PV*	*WT*	*PV*	*WT*	
33	210.016	220.7793	173.856	21.25	12	153	18	7	2
		225.8542	167.009	26.05	85	150	16	15	12
		223.8893	138.2429	38.25	100	135	12	10	14
		220.0239	156.4589	28.89	60	162	19	25	25
69	237.9656	241.4972	216.256	10.45	12	158	40	55	6
		238.2408	166.8459	29.96	85	207	60	59	9
		386.3267	155.4853	59.75	100	166	18	62	52
		261.2378	202.6521	22.42	60	176	25	60	63

Table 6. Comparison analysis of power loss and VSI

Methods	Power Loss (kW)	VSI (p.u)
Proposed Method	138.25	0.64451
ALO	150.55	0.9847
BAT	180.57	0.9578
GSA[24] method	182.19	0.9364
IWD[23]	185.78	0.9155
BFOA [23]	186.48	0.9047
Multi objective particle swarm optimization (MOPSO) [23]	194.25	0.87
Particle Swarm Optimization (PSO) [23]	204.78	0.81
Genetic Algorithm (GA) [23]	208.65	0.72

Table 7. Cost of power loss comparison per year for IEEE 33 bus

Hour	Base power loss cost in Rs	Load power loss cost in Rs	GSA power loss cost in Rs	BAT power loss cost in Rs	ALO power loss cost in Rs	ALO_BAT power loss cost in Rs
1	8517998	8923905	7373983	8440513	7391728	7046572.67
2	8517998	8923905	8195503	7308062	8476607	7265525.06
3	8517998	8923905	7333742	7528798	7813107	7257944.75
4	8517998	8923905	7661734	7517226	7727067	7441914.68
5	8517998	8923905	8186519	7561682	7522080	7486709.14
6	8517998	8923905	7512772	7492773	7418815	7274989.49
7	8517998	8923905	8493392	8498914	8491055	8489011.77
8	8517998	8923905	8451636	8449676	8448817	8425020.6
9	8517998	8923905	8439029	8229026	8404840	8180354.81
10	8517998	8923905	7986251	8046167	8113817	7499009.4
11	8517998	8923905	8330884	8473763	8000282	7473762.56
12	8517998	8923905	7987481	8473763	8332954	7473762.56
13	8517998	8923905	8156772	8063823	8172119	8061563.15
14	8517998	8923905	8439029	8405220	8502651	8229026.32
15	8517998	8923905	8470716	8511538	8470489	7514878.21
16	8517998	8923905	8489433	8496191	8516868	8508245.54
17	8517998	8923905	7683846	8482849	7696048	7257115.29
18	8517998	8923905	7497171	8477682	7544748	7378233.86
19	8517998	8923905	8434907	8475967	7506600	7323525.38
20	8517998	8923905	8204306	7549351	7396649	7242864.13
21	8517998	8923905	7813055	7403818	8299594	7378969.95
22	8517998	8923905	8051446	7487396	7892847	7481511.07
23	8517998	8923905	7761192	8205383	7649459	7212076.36
24	8517998	8923905	7558257	7734516	8104634	7711234.14

Table 8. Cost of power loss comparison per year for IEEE 69 bus

Hour	Base power loss cost in Rs	Load power loss cost in Rs	GSA power loss cost in Rs	BAT power loss cost in Rs	ALO power loss cost in Rs	ALO_BAT power loss cost in Rs
1	9651600	9651600	9671586	9219854	9229448	7244573.81
2	9651600	9651600	9356107	9299953	9652663	7632597.48
3	9651600	9651600	9652362	9664497	9339775	7546746.19
4	9651600	9651600	9268497	9278224	9411663	7626895.48
5	9651600	9651600	9350876	9653844	9247944	8217111.47
6	9651600	9651600	9664783	9651392	8538077	7794949.59
7	9651600	9651600	9651579	9648141	9641183	8508245.54
8	9651600	9651600	9651586	9619344	9619679	8502077.95
9	9651600	9651600	9648673	9530788	9500202	8144125.95
10	9651600	9651600	9492634	9443047	9441862	8200184.15
11	9651600	9651600	9651486	9651749	9461584	8473762.56
12	9651600	9651600	9465580	9455369	9461584	8469388.97
13	9651600	9651600	9653613	9001161	9470669	8007547.99
14	9651600	9651600	9529950	9499182	9651601	8404839.71
15	9651600	9651600	9651533	9635178	9632185	8498646.59
16	9651600	9651600	9651539	9638333	9611790	8505460.77
17	9651600	9651600	9652089	9328034	9292236	8189127.06
18	9651600	9651600	9313432	9302098	9632466	8309651.13
19	9651600	9651600	9235937	9650583	9234193	7916035.42
20	9651600	9651600	9260795	9279799	9434449	7568355.16
21	9651600	9651600	9650720	9362206	9260210	8469507.36
22	9651600	9651600	9651427	9663745	9663513	7631668.76
23	9651600	9651600	9653771	9304664	9651274	7716827.45
24	9651600	9651600	9306660	9422985	9312535	7592195.86

Table 9. Cost of DG comparison per year for IEEE 33 bus

Hour	Cost of DG GSA	Cost of DG BAT	Cost of DG ALO	Cost of DG ALO_BAT
1	7575926	7.71E+06	7866419	33.1186
2	8517998	8506202	8510348	491.1524
3	7724767	7468376	7357465	461.6039
4	8478970	7651560	7481571	355.3109
5	7769345	8125602	7723558	577.6897
6	8242439	7794950	7373983	556.5678
7	7697305	8456816	8181609	1.4901
8	7679697	8478540	8306350	34.5988
9	8119172	8193582	8489999	199.2426

Hour	Cost of DG GSA	Cost of DG BAT	Cost of DG ALO	Cost of DG ALO_BAT
10	7640147	8060989	7631800	221.9176
11	8070763	8448372	8048931	301.9428
12	7987481	8387257	8495706	209.9608
13	8051200	7961421	8112656	200.5902
14	7761041	8370566	7464349	198.1552
15	8512047	8511112	8495152	3.454
16	7308774	7561328	7284663	14.6157
17	8517998	8497279	8388254	24.4005
18	7294707	8155235	7835034	533.5672
19	8161740	7642903	8229158	438.9456
20	7528630	7546746	8441886	496.2231
21	7244574	7627491	7823310	469.245
22	7724767	8303362	7481328	378.4716
23	7715357	8215940	8279658	158.3316
24	8003379	7439767	8238586	441.3625

Table 10. Cost of DG comparison per year for IEEE 69 bus

Hour	GSA DG cost	BAT DG cost	ALO DG cost	ALO_BAT DG cost
1	9.7747	84.8218	260.787	6.1849
2	57.4047	65.4217	96.8956	258.8895
3	111.2024	88.9083	101.0712	107.1286
4	81.1755	20.6007	94.1843	2.7076
5	87.9584	74.3554	86.7322	75.2184
6	91.5814	2.4872	1.3107	81.4918
7	0.25629	2.799	0.29865	0.26301
8	7.6965	5.0608	6.6971	0.28104
9	3.8551	9.1351	29.0238	0.41392
10	40.6819	41.885	133.5955	33.7049
11	49.2409	2.1102	47.526	54.0138
12	49.2409	57.8351	1.2625	1.9995
13	49.5119	0.95907	40.6819	12.4266
14	0.32479	36.0366	24.0083	0.39216
15	6.6971	19.8897	0.26118	19.8897
16	2.7966	2.799	1.0334	0.30088
17	64.5767	102.6642	1.1716	107.5617
18	82.561	310.2486	72.0044	1.6327
19	107.8643	4.7584	1.2331	112.154
20	87.486	87.5545	9.976	86.3331
21	1.5051	301.2334	1.5834	7.8534
22	74.8819	0.70593	86.6014	101.4023
23	5.3722	9.9285	109.9	23.9401
24	78.3951	74.7885	90.0874	2.9012

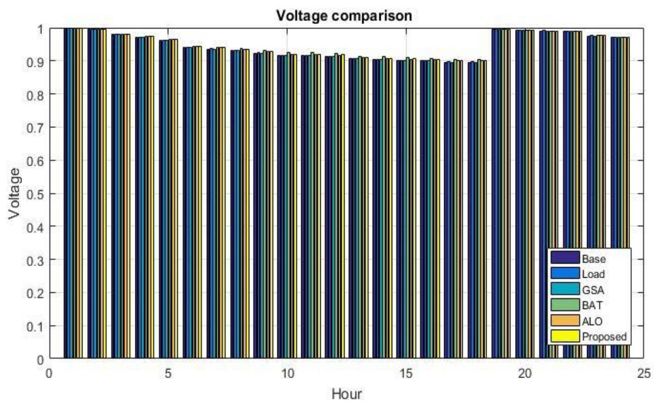

Figure 5. Comparison analysis of voltages using various methods for 24 hours on IEEE-33 bus system

The Comparison Analysis of load line power loss using various methods connected in different DGs from different time period is illustrated in Figures 5 to 12. From the simulation outcomes it may be observed that low active power losses and improved voltage at each bus was achieved by the connection of DGs at the optimal place obtained by VSI using various approaches. Overall loss reduction is accomplished with the integration of DGs utilizing the projected technique which is much superior than the power loss of different techniques. Hence, this can be concluded that improved ALO technology is much effective than other technologies in reduction of power loss of IEEE-33 and IEEE-69 standard radial distribution system.

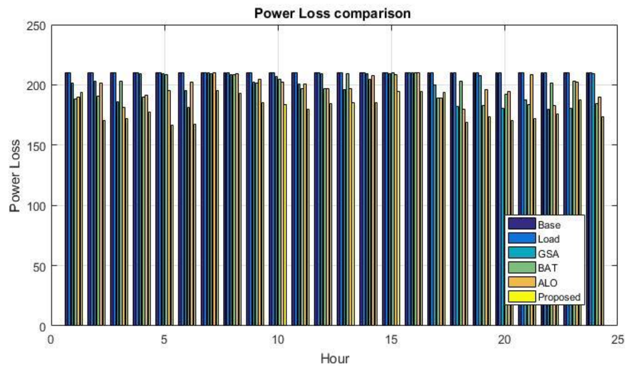

Figure 6. Comparison analysis of loss of power using various methods for 24 hours on IEEE-33 bus system

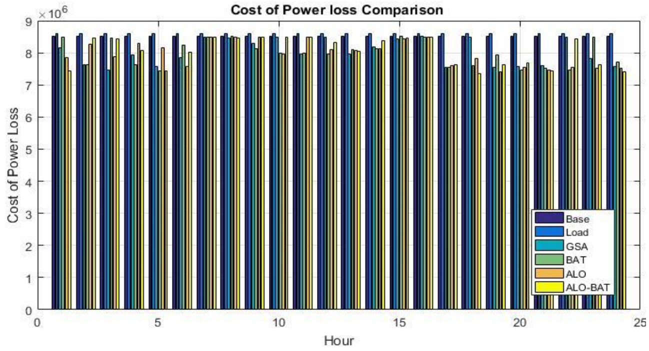

Figure 7. Comparison analysis of cost of loss of power using various methods for 24 hours on IEEE-33 bus system

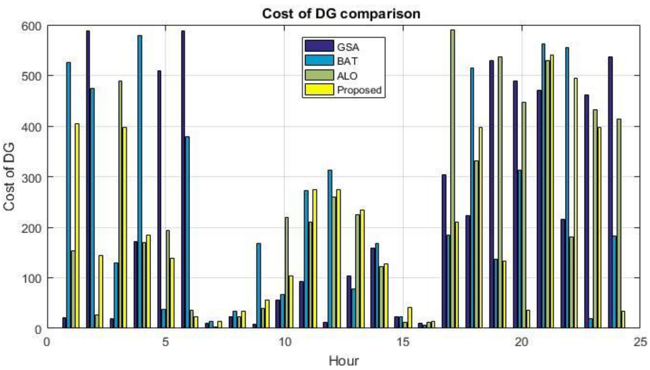

Figure 8. Comparative analysis of cost of DG various methods for 24 hours on IEEE-33 bus system

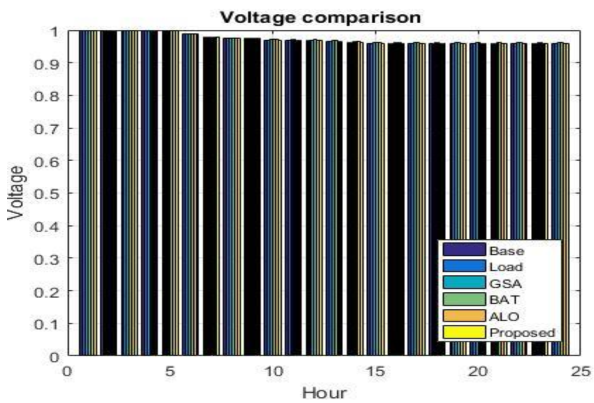

Figure 9. Comparison analysis of voltages using various methods for 24 hours on IEEE-69 bus system

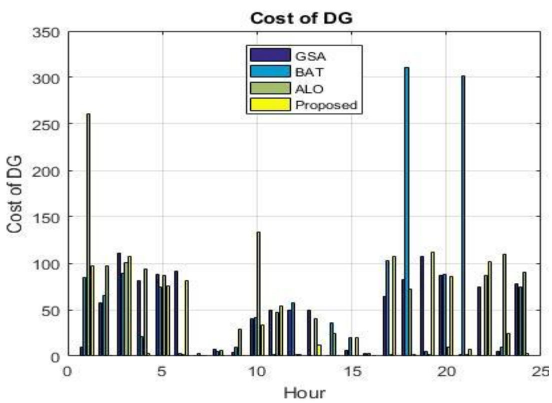

Figure 10. Comparative analysis of cost of DG using various methods for 24 hours on IEEE-69 bus system

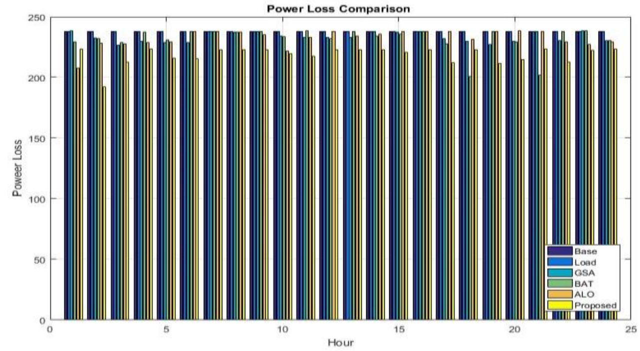

Figure 11. Comparison analysis of loss of power using various methods for 24 hours on IEEE-69 bus system

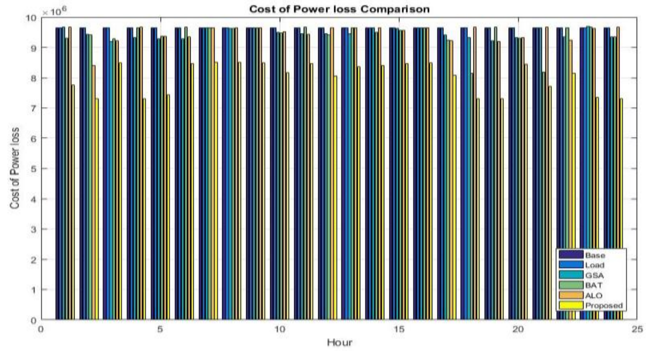

Figure 12. Comparison analysis of cost of loss of power using various Methods for 24 hours on IEEE-69 bus system

7. CONCLUSION

Here, the DG in a RDS is connected in an optimal location and capacity, which is estimated based on the efficient technique. This technique is improved ALO algorithm, which is the performance is improved by using the Bat algorithm. The projected approach is capable of provide much competitive outcomes in terms of updated exploration, local optima avoidance, exploitation and convergence. The ALO approach is also determine best optimal approaches for the majority of classical engineering issues employed, proving that this approach has advantages in solving constrained issues with diverse search spaces. Then the performance of the ALO is improved with the help of BA. The reactive power capability of PV network, wind turbines are considered in the voltage control. To evaluate the performance of the proposed system, an ALO technique based on the BA is also performed to obtain the best reactive power output of the DGs. The proposed control network is also applied to the IEEE-33 and IEEE-69 distribution scheme to show the robustness of the projected technique. The outcomes proves that the projected approach is much effective, and has a better fitness function, and has comparable time of convergence with GSA and capability to handle complex optimization issues. In addition, projected approach is much efficient in terms of loss minimization, voltage enhancement and load ability enhancement of distribution scheme. The efficiency of the projected technique is determined and compared with the existing techniques.

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NOMENCLATURE

N_n	Numbaer of system buses
V_{ni}	specifies the i^{th} bus voltage
V_{rated}	rated bus voltage
P_{gni}	generator output real power at *ni* bus
P_{dni}	demand of real power at *ni* bus
V_{mi}	voltage of *mi* bus
V_{ni}	voltage of *ni* bus
Y_{mni}	admittance magnitude among *mi* bus and *ni* bus
N_{bus}	number of buses
ni	receiving bus number
mi	bus number that sending power
i	branch number that fed *ni* bus
P_{Gi}	real power generated at bus *i*
Q_{Gi}	reactive power generated at bus *i*
P_{Di}	real load demand at bus *i*
Q_{Di}	reactive load demand at bus *i*
P_i	real injected power at bus *i*
Q_i	reactive injected power at bus *i*
Y_{ij}	magnitude of admittance
V_{max}	peak voltage at bus
V_{min}	lowest voltage at bus
V_i	current node voltage
V_{i+1}	voltage at next bus
P_{i+1}	next node active power
Q_{i+1}	next node reactive power
R_i	line resistance among *i* and *i+1* node
X_i	line reactance line among *i* and *i+1* node

Greek symbols

δ_{mi}	voltage phase angle at *mi* bus
δ_{ni}	voltage phase angle at *ni* bus
θ_{ni}	angle of admittance
θ_{ij}	branch voltage angle

Subscripts

DG	Distributed generation
WT	Wind turbine
PV	Photo-voltaic
BW/FW	Backward and farward sweep
GSA	Gravitational search algorithm
BA	Bat algorithm
ALO	Ant-lion optimization
AI	Artificial intelligance
OPF	Optimal power flow
kW	Kilo watt
p.u	Per unit
MOPSO	Multi-objective particle swarm optimization
PSO	Particle swarm optimization
GA	Genetic algorithm
VSI	Voltage stabilty index