THE OPF AND BUTTERFLY-PSO (BF-PSO) TECHNIQUE BASED OPTIMAL LOCATION AND SIZING OF DISTRIBUTED GENERATION IN MESH SYSTEM

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ABSTRACT

This paper presents the combined optimal power flow (OPF) and Butterfly-particle swarm optimization (Butterfly-PSO or BF-PSO) techniques to determine the optimal location and sizing of distributed generation (DG). The multi-objective function based on the performance index consider for the multi-objective optimization. The 30-bus mesh system is used for the optimal planning of distributed generation.The comparative result analysis of the proposed methodology and the existing methodology is also reported in this work. The results show that the totalgenerating costand the nodal price are more economical. Also, the reduction in losses (active and reactive power loss) and the improvement in overall performance are efficient.

KEYWORDS

Distributed Generation (DG), Location and Sizing, Optimal Power Flow (OPF), Butterfly-particle swarm optimization (Butterfly-PSO or BF-PSO).

1.INTRODUCTION

The distribution system networks areclassified as primary and secondary distribution system.Also, the well known thing about the distribution system network is that, it's built as interconnected meshed networks, but its structure arranges in the radial or tree structure in the operation.There are many researchers have worked on the index basedmulti-objective function to find the optimal location and size of DG such as [1-2].The Butterfly-particle swarm optimization (Butterfly-PSO or BF-PSO) technique based on the butterfly swarm characteristic behavior, intelligence and search process described in [3-4]). The many approaches for optimal allocation and sizing of DG in distribution systemsare introduced by [5-7, 12-13].The calculation of available transfer capability (ATC) and the shift factors such as the power transfer distribution factors (PTDF) for the transmission system is discussed in [8-9]. The concepts of the power flow and optimal power flow for the system are described by [10-11].

This paper presents the optimal planning of distributed generation (DG) as an active power and reactive power sources, that is as negative PQ load as DG source. Also, proposes the optimal location and sizing of DG based on multi-objective optimization with the different objective indices such as Generation Cost Index (CTI), Active Power Loss Index (PLI), Reactive Power Loss Index (QLI), Voltage Deviation Index (VDI), Load Balancing Index (LBI) and Shift Factor

Index (SFI). The nodal prices of the system also investigated with-DG and without-DG conditions. The optimization results of multi-objective function determined by the Butterfly-Particle Swarm Optimization (Butterfly-PSO or BF-PSO) technique.The achieved results showthe overall performance of the system has improved with-DG condition.

2. THE OPTIMAL POWER FLOW (OPF) AND NODAL PRICING

2.1 AC Optimal Power Flow (AC-OPF)

The optimal power flow (OPF) based on the NR-method to minimize the total generation cost C_f. The totalgeneration cost defined as a second order polynomial generation cost function. The cost function based on the active and reactive power generation cost is:

$$\left.\begin{array}{l} C(P_G) = a + b \times P_G + c \times P_G{}^2 \\ C(Q_G) = a' + b' \times Q_G + c' \times Q_G{}^2 \end{array}\right\} \tag{1}$$

$$C_f = \min \sum_{k=1}^{G} \left(C(P_{Gk}) + C(Q_{Gk}) \right) \tag{2}$$

The basic active and reactive power flow equations at j^{th}node are given as:

$$\left.\begin{array}{l} P_j = \sum_{i=1}^{n} |V_j||V_i||Y_{ji}| \cos(\theta_{ij} + \delta_i - \delta_j) \\ Q_j = -\sum_{i=1}^{n} |V_j||V_i||Y_{ji}| \sin(\theta_{ij} + \delta_i - \delta_j) \end{array}\right\} \tag{3}$$

With the constraints are:

$$\left.\begin{array}{l} \sum P_{Dj} + \sum P_{Lj} - P_{DGj} - \sum_{i=1}^{n} |V_j||V_i||Y_{ji}| \cos(\theta_{ji} + \delta_i - \delta_j) = 0 \\ \sum Q_{Dj} + \sum Q_{Lj} - Q_{DGj} + \sum_{i=1}^{n} |V_j||V_i||Y_{ji}| \sin(\theta_{ji} + \delta_i - \delta_j) = 0 \end{array}\right\} \tag{4}$$

$$\left.\begin{array}{l} \delta_{\min} \leq \delta_i \leq \delta_{\max} \\ V_{\min} \leq V_i \leq V_{\max} \\ P_{\min} \leq P_j \leq P_{\max} \\ Q_{\min} \leq Q_j \leq Q_{\max} \\ P_{DG\min} \leq P_{DGj} \leq P_{DG\max} \\ Q_{DG\min} \leq Q_{DGj} \leq Q_{DG\max} \end{array}\right\} \tag{5}$$

Where, P_j and Q_j are the j-th bus real and reactive power flow. P_{Dj} and Q_{Dj} the j-th bus real and reactive demand. V_i and V_j are the voltage magnitude value at the *i-th* and *j-th* bus. P_{DGj} is the real power of DG placed at j-th bus. δ_i, δ_j are The angles of *i-th* and *j-th* bus voltage. Y_{ji} is the *ji-th* element magnitude in bus admittance matrix. θ_{ji} is the angle of the *ji-th* element in bus admittance matrix. And n is the total number of buses.

2.2 Combined Real and Reactive Power for Uniform nodal pricing

By considering the j-th dispatchable load is modeled as a constant power factor, hence the ratio of reactive to real demand is a constant. Then the real and reactive power consumption of this load can be thought of as a single\combined or bundled commodity. The uniform nodal price value can be expressed on the basis of per MW or per MVAr [11]. Let us assume that the load is located at bus j and the prices of real and reactive power are λ_{Pj} and λ_{Qj} respectively. So, the combined or bundled power χ can be given as:

$$\left. \begin{aligned} \chi &= \lambda_{Pj} P_{Dj} + \lambda_{Qj} Q_{Dj} \\ \chi &= \lambda_{Pj} P_{Dj} + \lambda_{Qj} \frac{Q_{Dj}}{P_{Dj}} P_{Dj} \\ \chi &= \left(\lambda_{Pj} + \lambda_{Qj} k_j \right) P_{Dj} \end{aligned} \right\} \qquad (6)$$

Where, $k_j = \dfrac{Q_{Dj}}{P_{Dj}} = \text{constant}$

In other words the per MW price of the bundled commodity is $\lambda_{Pj} + k_j * \lambda_{Qj}$. Similarly, the per MVAr price is $\lambda_{Pj}/k_j + \lambda_{Qj}$.

3. THE MULTI-OBJECTIVE PROBLEM FORMULATION AND PERFORMANCE INDICES

To determine the optimal location and sizing of the distributed generation (DG) in the radial and meshed system with the various objectives achieves by the following multi-objective function (F_{mo}).

$$F_{MO} = 0.12 \times CTI + 0.28 \times PLI + 0.2 \times QLI + 0.16 \times VDI + 0.14 \times LBI + 0.1 \times SFI \qquad (7)$$

The detail concepts for selecting the weight factor of the indices given in [1, 2]. All these weight factors decide on the basis of the individual impacts and importances of the index while installing the DG.

3.1 Total Generation Cost Index (CTI)

The total cost index (CTI) defined by assuming CT_{DG} and CT_{No-DG} are the total generation cost value with DG and with-out DG of the system.

$$CTI = \frac{CT_{DG}}{CT_{No-DG}}$$
(8)

3.2 Active Power Loss Index (PLI)

The active power loss index (PLI) can be expressed byconsidering PL_{DG}, and PL_{No-DG} are the active power losses with DG and with-out DG of the system.

$$PLI = \frac{PL_{DG}}{PL_{No-DG}}$$
(9)

3.3 Reactive Power Loss Index (QLI)

The reactive power loss index (QLI)givenby considering QL_{DG}, and QL_{No-DG} are the reactive power losses with DG and with-out DG of the system.

$$QLI = \frac{QL_{DG}}{QL_{No-DG}}$$
(10)

3.4 Voltage Deviation Index (VDI)

This voltage deviation index (VDI) given on the basis of the deviation of system voltage from the reference or rated value (V_{reff}). The minimum the voltage deviation index denotes the better the system performance and improvement in voltage profile. This index can be given as:

$$VDI = \max_{j=2}^{n} \left(\frac{V_{reff} - V_{DGj}}{V_{reff}} \right)$$
(11)

Where, n-is the total no. of buses.The V_{reff} and V_{DGj} are the reference voltage and the system voltage value with DG respectively.

3.5 Load Balancing Index (LBI)

The load balancing index (LBI) has been given to the concept based on available power at any bus, which is distributed between the loads and next bus. The available power at any bus can be given as:

$$S_j = \sqrt{P_j^2 + Q_j^2}$$
(12)

Then load balancing index is as:

$$LBI = \max_{j=1}^{n-1} \left(\frac{S_{DGj}}{S_{No-DGj}} \right)$$
(13)

Where, S_{DGj} and S_{No-DGj} are the available power with DG and with-out DGrespectively, andn is the number of buses.

3.6 Shift Factor Index (SFI)

The AC power flow shift factor also called as a power transfer distribution factor (PTDF) is the sensitivity of the power flows. In other words, it indicates the effects of the power flows in all other lines due to the particular power transactions. The relation between PTDF and available transfer capability (ATC) is very close relation, hence the optimum PTDF shows the optimum or maximum ATC with respect to minimum value of F_{MO}. Let us assume that the change in power due to particular transaction Δt is Δx, then the AC power flow shift factor is:

$$SF \ or \ PTDF = \frac{\Delta x}{\Delta t}$$

(14)

The installation of DG with particular size will inject some power say x_{inj} at bus and due to this injection the change in power is Δx, then shift factor index (SFI) can be given as:

$$SFI = \max_{\substack{j=1 \\ j \neq slack \ and \\ pv \ bus}}^{n-1} \left| \frac{\Delta x_j}{x_{inj,j}} \right|$$

(15)

4. THE BUTTERFLY PARTICLE SWARM BASED OPTIMIZATION (BF-PSO) TECHNIQUES

The Butterfly-PSO (BF-PSO) algorithm is essentially based on the nectar probability and the sensitivity of the butterfly swarm [3]. The BF-PSO consists of intelligent behavior of the butterfly to find out the optimumamount of nectar. The butterfly particle swarm optimization learning algorithm (BF-PSO) is used to acquire the concept of optimal solutions not only using the random parameters and acceleration parameter, as well as it uses the effect of additional parameter's probability and sensitivity for fast convergence and more accurate optimal solution. In process for computing the optimal solution, the degree of node in every flight of butterfly assumed as approximately equal to 1 because assuming the maximum connectivity in each flight. The butterfly swarm based search process investigates the optimal location depending upon the sensitivity of butterfly toward the flower and the probability of nectar. The information about the optimal solution communicates directly or indirectly between the all butterflies by different means of communication intelligence (such as dancing, colors, chemicals, sounds, physical action and natural processes) [4].

The butterfly leaning based particle swarm optimization algorithm has developed to ascertain the optimal solutions including the random parameters, acceleration coefficients, probability, sensitivity, lbest and gbest. In the Butterfly-PSO, lbest solutions are selected by the individual's best solution. Afterward that the gbest solution identified based on the respective fitness. The locations (location) of the nectar (food) source represent the probable optimal solution for the problem and the amount of nectar (food) represents the corresponding fitness. The detail implementation of the Butterfly-PSO (BF-PSO) technique is given below. The general ranges of

the sensitivity and probability are considering from 0.0 to 1.0. The velocity limits can be set based on the limits of the problem variables.Hence, the function of inertia weight, sensitivity and probability as a function of iterations can be given as [3-4]:

$$w_k = 0.9 - ((0.9-0.4) / ITER_{max}) * ITER_k$$
$$s_k = exp-(ITER_{max} - ITER_k) / ITER_{max}$$

$$p_k = FIT_{gbest,k} / \sum(FIT_{lbest,k})$$

Where, $ITER_{max}$ = maximum number of iterations, and $ITER_k$ = kth iteration count.And $FIT_{lbest,k}$ =Fitness of local best solutions with kth iteration, $FIT_{gbest,k}$ = Fitness of global best solutions with kth iteration.

The Butterfly-PSO (BF-PSO) equations to update the velocity and the position are depends on the sensitivity of the butterfly and the probability of nectar, which can be given as:

$$v'_k = w_k.v_{k-1} + s_k(1-p_k)c_1r_1(x_{lbest,k-1} - x_{k-1}) + p_kc_2r_2(x_{gbest,k-1} - x_{k-1}) \qquad (16)$$

And, the position update equation is:

$$x_k = s_k.\left(p_k.x_{k-1} + \alpha_k.v'_k\right) \qquad (17)$$

Where, α_k is a varying probability coefficient, α_k=rand*p_k, rand-is the random number [0, 1].The flow chart for the Butterfly-PSO (BF-PSO) technique to find the optimal sizing and location of DG is given in figure-1.

5. RESULTS AND DISCUSSIONS

The proposed algorithm is implemented on the 30-bus mesh system [13] with the 100 MVA base.The range of DG size is considered from 0 to 50 for both MW and Mvar. The detail value of generator cost coefficients for mesh system is given in [11]. In this work, the DG is considered to operate on unspecified power factor. The allocation of a DG is considered on the load buses not on the slack bus and voltage-controlled buses in the system. The all results for proposed methodology carried out with MATLAB (2009a)/Matpowe4.1 tool with the system configuration windows-8.1, AMD-E1-1500APU, 1.48 GHz, 2.0 GB RAM.

5.1 The 30-Bus Mesh System

The all data information about the 30-bus mesh system data have given in reference [13]. The proposed Butterfly-PSO/BF-PSO algorithm applied to minimize the multi-objective function for the 30-bus mesh system. The performance results of the 30-bus mesh system shown in figures from 2 to 9. The figure-2 shows the multi-objective function value with their respective index at a particular bus. The value of the DG size, active power loss and active power loss at the all buses is shown in figure-3. The result analysis clearly indicates that the minimum optimal value of the multi-objective function obtain at bus 19 in the 30-bus mesh system. Similarly, the variation of total generation cost and the nodal price of active and reactive power with and without DG respectively given in figure-4, figure-5 and figure-6.
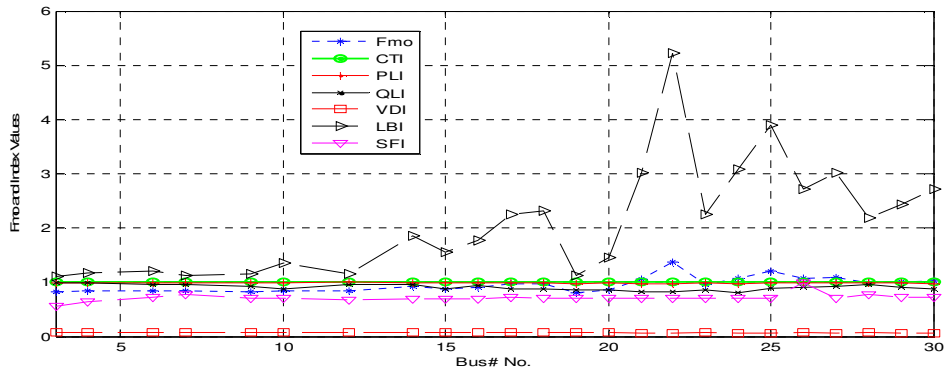
Figure-2: The variation of multi-objective function and various indices at different buses for 30-bus mesh system
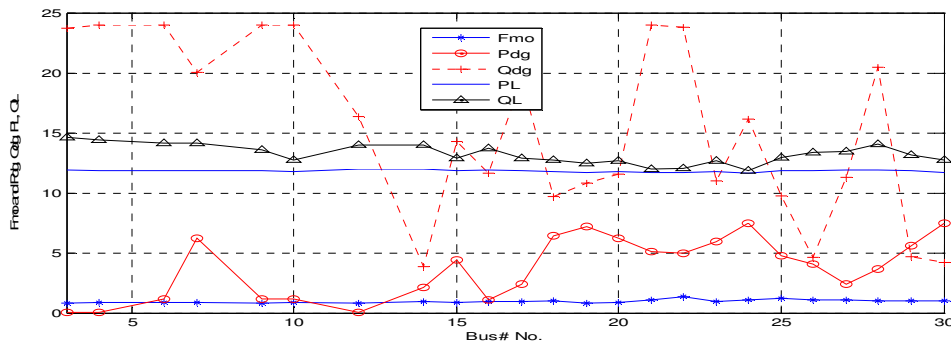

Figure-3: The variation of DG size, and system losses with multi-objective function value of the 30-bus mesh system
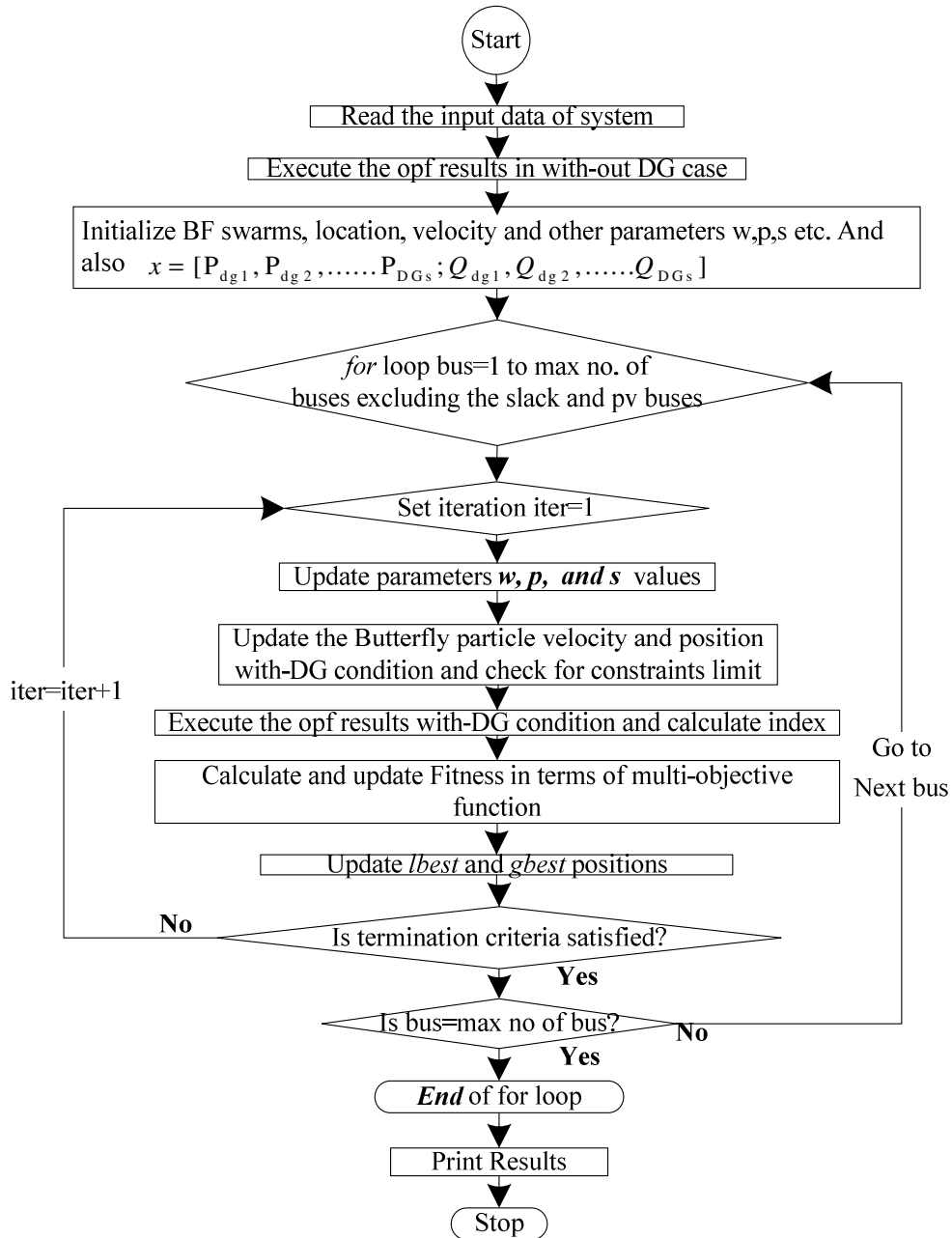
Figure-1: The Butterfly-PSO (BF-PSO) algorithm flow chart

The figure-7 shows the voltage profile with-DG are improved as compared to without-DG condition of the 30-bus mesh system. Similarly, the figure-8 and figure-9 shows the performances of the active and reactive power loss with and without-DG. It's analyzed that the losses value with-DG obtain the lower value as compared to without-DG condition. The proposed Butterfly-PSO/BF-PSO algorithm gives the optimum value of whole system parameters, which is given in table-1, table-2, and table-3 for the 30-bus mesh system. The comparative analysis of the proposed and existing methodology is shown in table-4. The minimal and optimal value of the

objective function obtains at bus 19, which is the optimal location of DG in the 30-bus mesh system. The corresponding optimal value of their indices is given in the table-1 by yellow shading row.
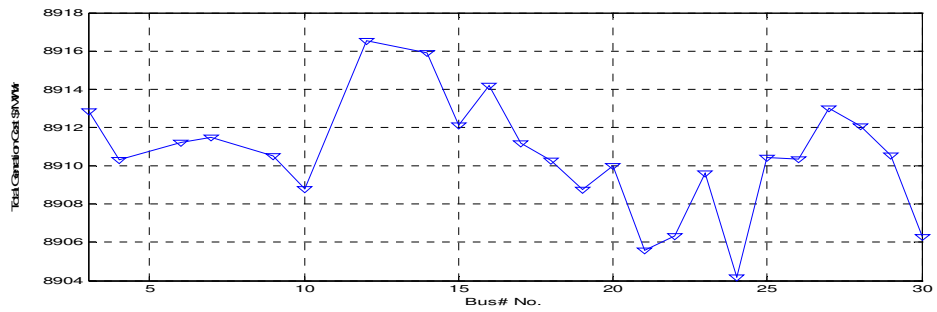
Figure-4: The total generation cost curve at buses for 30-bus mesh system

Figure-5: The nodal price of active power with and without DG for 30-bus mesh system
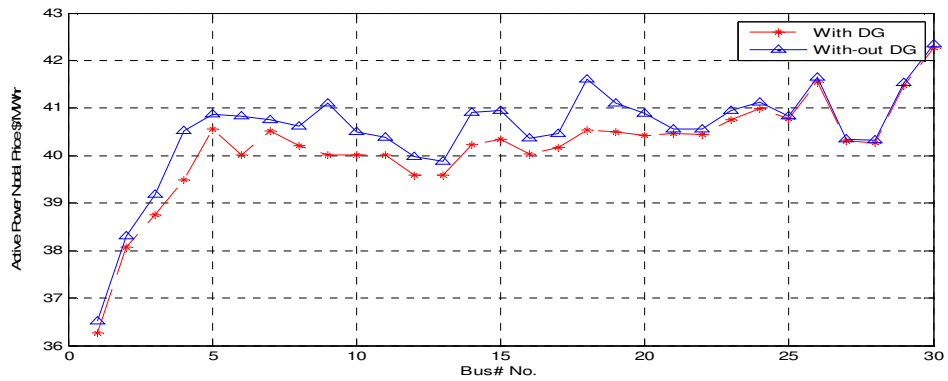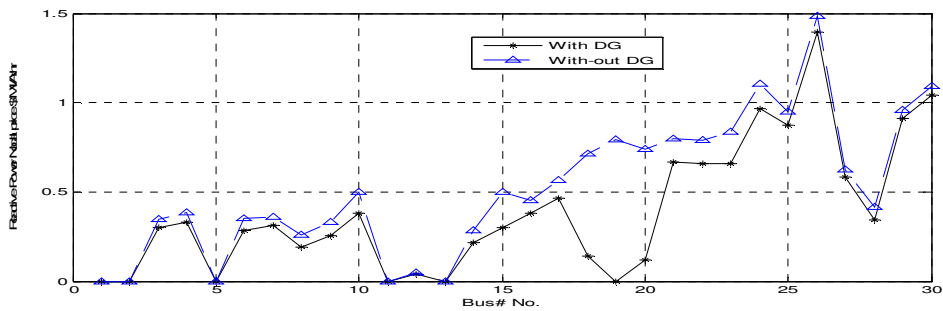

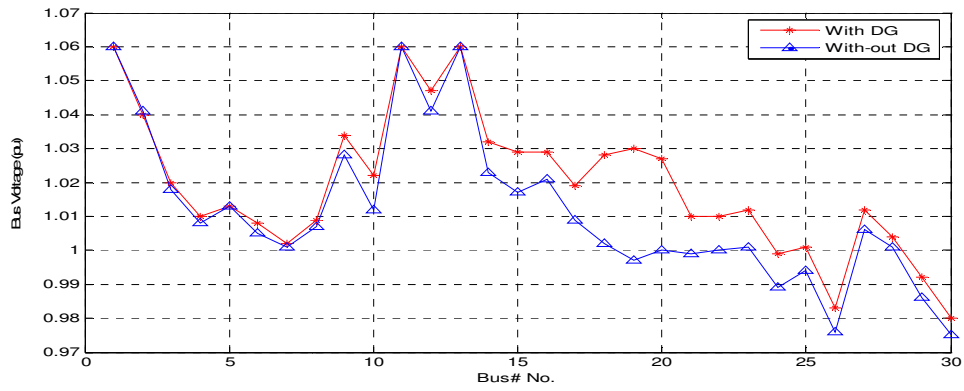Figure-6: The nodal price of reactive power with and without DG for 30-bus mesh system

Figure-7: The voltage profile with and without DG for 30-bus mesh system
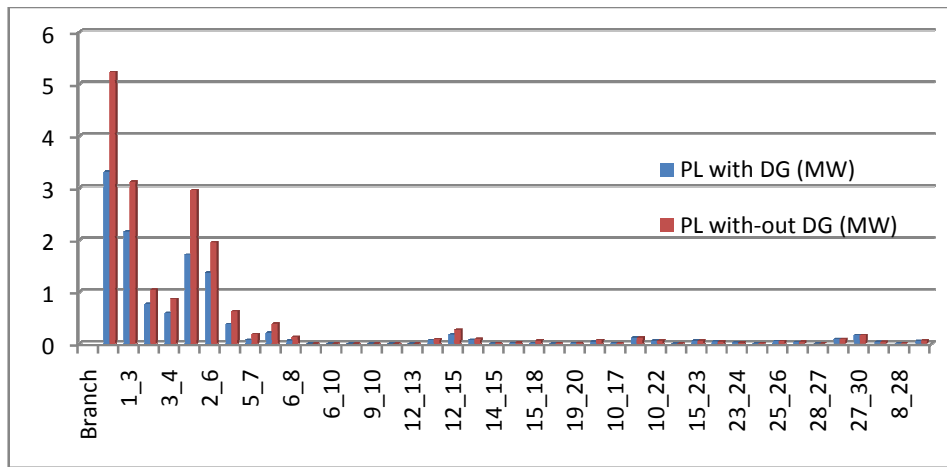

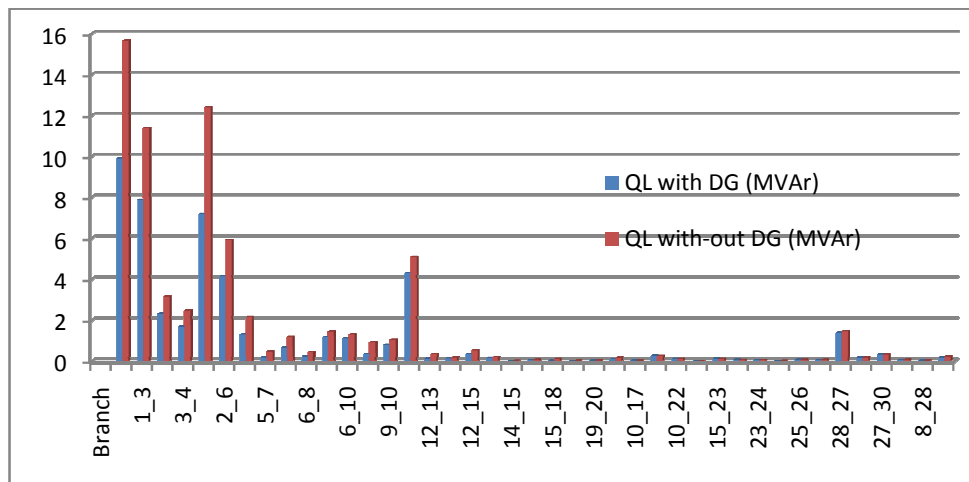Figure-8: The active power loss with and without DG for 30-bus mesh system

Figure-9: The reactive power loss with and without DG for 30-bus mesh system

The table-1 shows the global optimal solution results of the Butterfly-PSO/BF-PSO technique based on the respective multi-objective function value and their indices at all the buses excluding the slack and pv busesof 30-bus mesh system. The results indicate that the optimal value of the multi-objective function is 0.802486 at bus-19, which is the better optimal value of fitness in the 30-bus mesh system. The corresponding the optimal value of the multi-objective function, the value of CTI, PLI, QLI VDI, LBI and SFI for the mesh system are 0.999094, 0.978043, 0.848609, 0.075522, 1.118642 and 0.703271 respectively at bus-19. Similarly, the table-6 shows the optimal solution results of the Butterfly-PSO/BF-PSO technique base on the optimal value of the multi-objective function.The active power DG size (PDG), the reactive power DG size (QDG), total generation cost with-out DG (CT-No-DG in \$/Mw/hr), total generation cost with DG (CT-DG in \$/Mw/hr), the active power loss with DG (PL-DG) and the reactive power loss with DG (QL-DG) values at bus-19 respectively are 7.175932, 10.83324, 8916.828, 8908.75, 11.73493 and 12.45852, which are the optimal values corresponding to the multi-objective function value. Theoptimal values of the voltage with and without DG are 1.03 pu and 0.997 pu at bus-19; the active power nodal price with and without DG are 40.502 and 41.107 \$/Mw/hr;the reactive power nodal price with and without DG are 0 and 0.796 \$/Mvar/hr; all these values given in table-3. Also, the comparative results analysis between the proposed and the existing methodology is given in table-4 for the 30-bus mesh system.

Table-1: The value of multi-objective function (Fmo) and indices at buses for 30-bus mesh system

S. No.	Obj. Fun. Fmo	Bus No.	CTI	PLI	QLI	VDI	LBI	SFI
1	0.820262	3	0.999554	0.993607	0.99666	0.079527	1.106511	0.551378
2	0.834478	4	0.999271	0.987823	0.98372	0.078135	1.172324	0.646037
3	0.841189	6	0.999372	0.989489	0.960317	0.07302	1.205332	0.717146
4	0.835114	7	0.999403	0.987307	0.963328	0.076212	1.122472	0.767342
5	0.826547	9	0.999291	0.987417	0.926524	0.072865	1.160216	0.70762
6	0.840117	10	0.999097	0.983889	0.866437	0.068951	1.358539	0.702213
7	0.832264	12	0.999969	0.999719	0.951066	0.07773	1.159534	0.673616
8	0.930718	14	0.999897	0.996981	0.953892	0.079382	1.854133	0.685175
9	0.870753	15	0.999472	0.987638	0.878454	0.074684	1.554144	0.690572
10	0.913721	16	0.999702	0.994497	0.933715	0.076525	1.766786	0.689603
11	0.971928	17	0.999364	0.988046	0.876999	0.071965	2.253683	0.72922
12	0.973986	18	0.999266	0.981854	0.865865	0.076224	2.313509	0.698947
13	0.802486	19	0.999094	0.978043	0.848609	0.075522	1.118642	0.703271
14	0.853611	20	0.999233	0.982071	0.861859	0.07513	1.456859	0.703698
15	1.059744	21	0.998741	0.974914	0.815675	0.066104	3.017886	0.707036
16	1.369632	22	0.998822	0.976576	0.819587	0.065375	5.223495	0.706654
17	0.963269	23	0.999192	0.98114	0.863189	0.072301	2.247095	0.698471
18	1.065442	24	0.99858	0.968752	0.805754	0.061476	3.089544	0.708389
19	1.197512	25	0.999281	0.985004	0.882951	0.054858	3.894946	0.711373
20	1.069119	26	0.999274	0.985038	0.912041	0.067058	2.718117	0.997219
21	1.083819	27	0.999572	0.992441	0.916439	0.054376	3.019847	0.712205
22	0.983066	28	0.999467	0.989966	0.959848	0.067844	2.188022	0.767917
23	0.999616	29	0.999298	0.984281	0.897857	0.06447	2.442369	0.722833
24	1.028321	30	0.998816	0.97311	0.86569	0.064107	2.719119	0.719202

Table-2: The DG size, generation cost and loss values at buses for 30-bus mesh system

Bus No.1	PDG (MW)	QDG (MVAR)	CT-No-DG($/MW/hr)	CT-DG ($/MW/hr)	PL–DG(MW)	QL-DG (MVAR)
3	0.000027	23.73224	8916.828	8912.849	11.92167	14.63207
4	0.000063	23.99985	8916.828	8910.327	11.85228	14.44208
6	1.118951	23.9995	8916.828	8911.232	11.87227	14.0985
7	6.214769	20.03782	8916.828	8911.505	11.84609	14.14271
9	1.136425	23.99928	8916.828	8910.503	11.84741	13.60239
10	1.143312	23.99912	8916.828	8908.779	11.80507	12.72024
12	0.000686	16.35806	8916.828	8916.549	11.99501	13.9627
14	2.124235	3.832528	8916.828	8915.913	11.96216	14.00418
15	4.432051	14.27119	8916.828	8912.117	11.85006	12.89667
16	1.074347	11.65781	8916.828	8914.169	11.93235	13.70796
17	2.405811	19.41585	8916.828	8911.162	11.85495	12.87531
18	6.411554	9.692087	8916.828	8910.281	11.78065	12.71185
19	7.175932	10.83324	8916.828	8908.75	11.73493	12.45852
20	6.185103	11.57075	8916.828	8909.988	11.78326	12.65304
21	5.133457	23.99148	8916.828	8905.602	11.69739	11.975
22	4.949482	23.79505	8916.828	8906.328	11.71732	12.03244
23	5.912414	10.98231	8916.828	8909.628	11.77209	12.67256
24	7.486107	16.14139	8916.828	8904.168	11.62345	11.82935
25	4.751696	9.750311	8916.828	8910.417	11.81846	12.9627
26	4.09458	4.601022	8916.828	8910.357	11.81886	13.38977
27	2.370212	11.31705	8916.828	8913.009	11.90769	13.45434
28	3.626638	20.46589	8916.828	8912.077	11.87799	14.09162
29	5.569172	4.697014	8916.828	8910.568	11.80978	13.18153
30	7.483638	4.192573	8916.828	8906.273	11.67575	12.70929

Table-3: The voltage, active and reactive power nodal price on buses with and without DG for 30-bus mesh system

Bus No.	Voltage with-DG	Voltage No-DG	Nodal price of P with-DG	Nodal price of P No-DG	Nodal price of Q with-DG	Nodal price of Q No-DG
1	1.06	1.06	36.266	36.306	-0.104	-0.082
2	1.04	1.041	38.064	38.107	0	0
3	1.02	1.018	38.756	38.818	0.3	0.349
4	1.01	1.008	39.491	39.562	0.329	0.387
5	1.013	1.013	40.563	40.587	0	0
6	1.008	1.005	40.023	40.083	0.283	0.351
7	1.002	1.001	40.525	40.575	0.315	0.359
8	1.009	1.007	40.217	40.262	0.192	0.26
9	1.034	1.028	40.022	40.096	0.256	0.33
10	1.022	1.012	40.024	40.11	0.382	0.501
11	1.06	1.06	40.021	40.093	0	0
12	1.047	1.041	39.587	39.676	0.04	0.05
13	1.06	1.06	39.587	39.676	0	0
14	1.032	1.023	40.224	40.359	0.215	0.283
15	1.029	1.017	40.346	40.555	0.303	0.501
16	1.029	1.021	40.044	40.136	0.382	0.453

17	1.019	1.009	40.179	40.271	0.465	0.568
18	1.028	1.002	40.543	41.006	0.141	0.716
19	1.03	0.997	40.502	41.107	0	0.796
20	1.027	1	40.42	40.885	0.118	0.739
21	1.01	0.999	40.467	40.569	0.669	0.799
22	1.01	1	40.45	40.553	0.658	0.788
23	1.012	1.001	40.763	40.946	0.661	0.837
24	0.999	0.989	40.98	41.114	0.968	1.107
25	1.001	0.994	40.764	40.84	0.873	0.952
26	0.983	0.976	41.549	41.64	1.397	1.487
27	1.012	1.006	40.314	40.353	0.585	0.627
28	1.004	1.001	40.267	40.328	0.343	0.416
29	0.992	0.986	41.472	41.527	0.911	0.957
30	0.98	0.975	42.275	42.342	1.044	1.093

Table-4: The Comparative analysis of 30-bus radial system

Parameter \ Cases		Active power loss (MW)	Active power loss reduction (%)	Reactive power loss (MVAR)	Reactive power loss reduction (%)
With-out-DG (Base case)		17.807	---	69.61	---
With-DG (at bus-19)	Existing	15.3945 [13]	13.55 %	NA	NA
	Proposed PDG(7.175932) QDG(10.83324)	11.735	34.1 %	47.02	32.45 %

6. CONCLUSIONS

The optimal allocation and sizing of the distributed generation (DG) with multi-objective optimization problembased on the indices using the Butterfly-PSO/BF-PSO optimization technique has been proposed. The results analysis of the 30-bus mesh system clarifies that the proposed method is the efficient method for the reduction of power losses, the improvement of the voltage profile, increase the load balancing capacity hence the maximum loading capacity, the more generation cost economy, the optimal shift factor value hence increases ATC, and reduction in MVA flows and MVA intake from the system or grid. The comparative analysis of the results for the proposed and existing methodology is given in table-4 for 30-bus mesh system. These comparative results analyses of the 30-bus mesh system shows the reduction in active power loss with the existing methodology is 13.55 %. And also, the reduction in active and reactive power losses with the proposed methodology is 34.1 % and 32.45 % respectively, which is the more power loss reduction as compared with existing method.

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