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Optimal placement of Distributed Generation in a Distribution system using Hybrid Big Brunch & Big Crunch Algorithm

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ABSTRACT

In the recent years the load demand is increasingly rapidly due to the increase in industrial load .The efficiency of conventional energy resources is getting reduced due to availability of fuel. This paper presents an optimal way of improving voltage profile and reducing power loss in distribution system using H-BB-BC algorithm. The proposed algorithm is used for the optimization problems with number of distributed generators for both power and energy loss minimization in balanced/unbalanced distribution systems. In this work solution based on VSI is used for optimal placement and sizing of DGs. The proposed algorithm is implemented in MATLAB environment and tested on 33 bus feeder system.By doing comparative study and placing the DG in different location the best results are taken and the power loss have been reduced and voltage profile has been improved.

Keywords: *Hybrid Big Brunch – Big Crunch Algorithm, DG placement, Power loss*

1. INTRODUCTION

Distributed generators (DGs) which are linked to the distribution network are used for different purposes such as enrichment of voltage profile, reduction of the power loss, enrichment of system reliability and security, perfection of power quality by improving supply, and distribution congestion, reduction in costs due to improved environment hence reducing the system cost in [1].

Ideal location and DGs capacity plays an important role to maximize the benefits gained, on the other side non-optimal placement or sizing of DGs may cause effects which is undesirable. The Different optimization technique presented with objective functions which aims to reduce power loss, reduce cost, maximize profit and reduce environmental emission in [3]. The optimization methods are classified into analytical, numerical and heuristic in [4].

Big Bang-Big Crunch (BB-BC) optimization method was presented by Errol in [5]. The method is applied to nonlinear multi-dimensional functions which show good convergence speed in [10]. The BB-BC method is applied to solve power flow problem which include both continuous and discrete control variables the method is tested on the IEEE 33-bus feeder.

In the BB-BC algorithm ideal selection of different parameters are done which is used for minimization of cost and energy.

The control parameters for diminishing the fuel cost of generators are presented [6], [7]. This paper presents a supervised H-BB-BC method for finding the optimal location and capacity of DGs which are connected to distribution feeders for power or energy loss minimization without violating the system

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constraints [8]. The DG in the proposed algorithm is modeled as (PV) node with the flexibility to get converted to (PQ) node in case of reactive power limit violation. The proposed algorithm is employed in MATLAB and tested on the 33-bus feeder.

2. METHODOLOGY

By using forward & backward sweep method the total power loss is calculated. Voltage of each bus is calculated using voltage stability index. Voltage should be within limit 0.9 pu < v < 1.1. VSI is used as fitness function. DG is placed where the bus voltage is less by using big brunch & big crunch algorithm.

3. PROBLEM FORMULATION

To determine the optimal DG capacity and optimal DG location which will minimize the distribution feeder both active power loss and energy loss without violating the system constraints:

$$\text{Minimize the active power loss} = \sum_{f=1}^{Nf} P_{loss,\,f}$$

$$\text{Minimize the daily energy loss} = \sum_{h=1}^{24} P_{loss,\,h}$$

Where f is feeder number, N_f is total number of feeders, $P_{loss,f}$ is the power loss at certain feeder f, his the hour number and $P_{loss,h}$ is the total system power loss at certain hour h .The system constraints are as follows:

Voltage limits: voltage at each bus should be within a permissible range between

$$0.9\ \text{p.u.} \le V \le 1.1\ p.u.$$

DG power limits: active, reactive and complex powers of the DG unit are constrained between minimum and maximum value and this range should not be violated:

$$0 \le P_g \le P_g^{\max}, \qquad Q_g^{\min} \le Q_g \le Q_g^{\max}$$

Power balance: the sum of input power should be equal to the sum of output active power in addition to the active power loss. The input power may include the DG active power and the active power supplied by the utility. The active output power is the sum of loads active power:

$$P_{substation} + \sum P_{DG} = \sum P_{load} + \sum P_{loss}.$$

4. BIG BRUNCH-BIG CRUNCH ALGORITHM.

The customary BB-BC algorithm consists of two steps; the first one named Big Bang phase embraces the creation of the initial contender solutions that are spread erratically all over the search space, the Big Bang phase is the followed by Big Crunch phase that cluster all the candidate solution at only one solution that is called the focus of mass.

The step by step procedure of the BB-BC algorithm is discussed as follows:

1) Form an initial generation of candidate solution inside the search space.
2) Calculate the objective function value of all the solutions.
3) Find the center of mass (x^c) according to Best value of the previous step can be chosen as the center of mass:

$$x^c = \sum_{j=1}^{N} \frac{x^j}{f^j}$$

4) Create new members around the center of mass to be used in the next iterations, the remoteness of the new candidate solution decreases as the number of iterations elapse:

$$x^{new} = x^c + \left(up \times \frac{Rand}{it} \right)$$

Where *up* the upper limit of the search space is, *Rand* is a distributed random number and is the iteration step.

5) Repeat steps 2)–4) until the stopping criteria has been satisfied.

Although BB-BC has proven to be an effective method in solving nonlinear, multidimensional optimization problem where the function to be optimized is endless, it might not be the best method to solve the current optimization problem due to the inclination to fall in local minimum points and difficulty to converge to the optimal solution.

5. HYBRID–BB-BC ALGORITHM

In order to improve the exploration ability, this paper uses the potentials of the particle swarm optimization to improve the ability to explore the BB–BC algorithm. The particle swarm optimization is inspired by the social behavior of bird flocking and schooling of fish that has a population of individuals, called particles, which sets their movements depending on their own experience as well as the population's experience. In every iteration, a particle travels towards a direction which is computed from the best visited position (local best) and also the best visited position of all particles in its neighborhood (global best). The HBB–BC method not only uses the center of mass but also utilizes the best position of each candidate (*pbesti*) as well as the best global position to produce a new solution.

$$x_i^{new(k+1)} = \alpha_2 x_i^{c(k)} + (1-\alpha_2)\left(\alpha_3 gbest_i^k\right) +$$

$$(1-\alpha_3)\, pbest_i^k + \frac{r\alpha_1\left(x^{\max -} x^{\min}\right)}{k+1}$$

Where *rj* is a random number from a standard normal distribution that changes for each candidate, and α 1is a parameter for limiting the size of the search space. α2 and α3 are adjustable parameters controlling the influence of the global best and local best on the new position of the candidates, respectively. The agent of a population-based search algorithm performs three steps in every iteration to achieve the concepts of exploration and exploitation: self-adaptation, cooperation and competition. In is noteworthy to mention that in the self-adaptation step, each particle improves it's cooperate with each other by transforming the information. Finally, in the competition stage, members try to compete in order to survive. In the standard BB–BC algorithm, although the cooperation step is satisfied by using the concept of center of mass, the self-adaptation and cooperation steps are not considered to be suitable enough. Adding the potentials of the PSO algorithm will improve the steps. The term related to *pbesti* can be considered as the self-adaptation step of the algorithm that incites particles to improve their solutions, and the competition step is shown by the term related to *gbesti*. Ultimately, the stochastic form of the algorithm is incorporated by using the last term in the Equation.

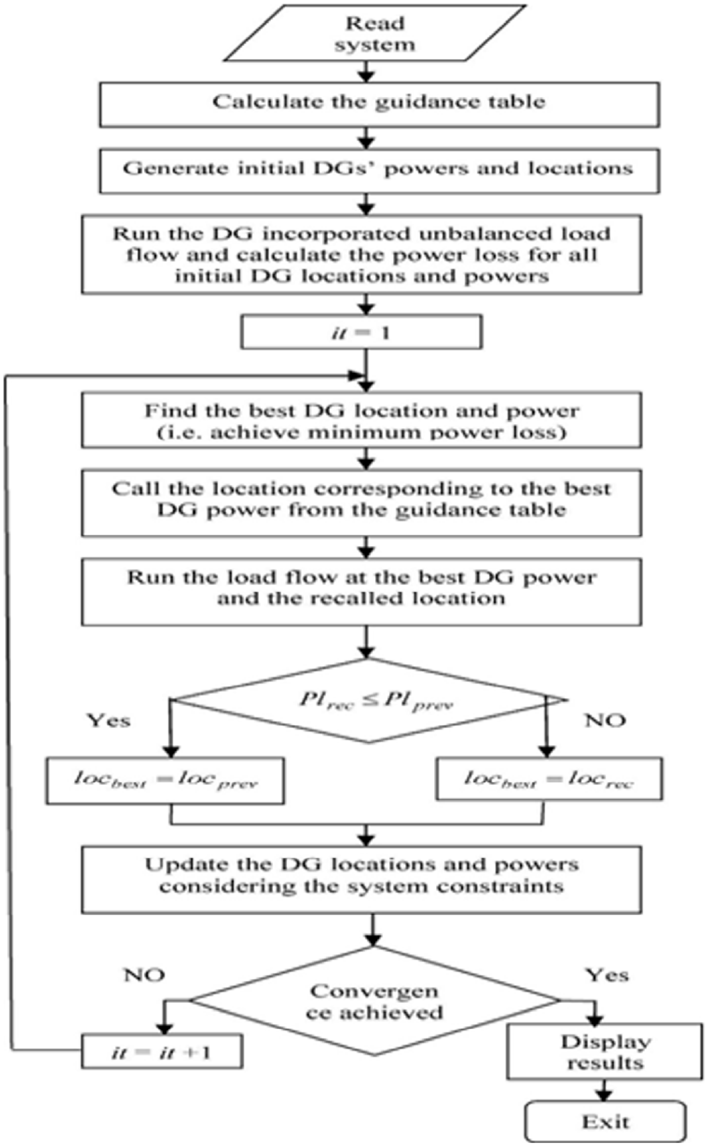

Figure 1: Hybrid BB -BC Algorithm

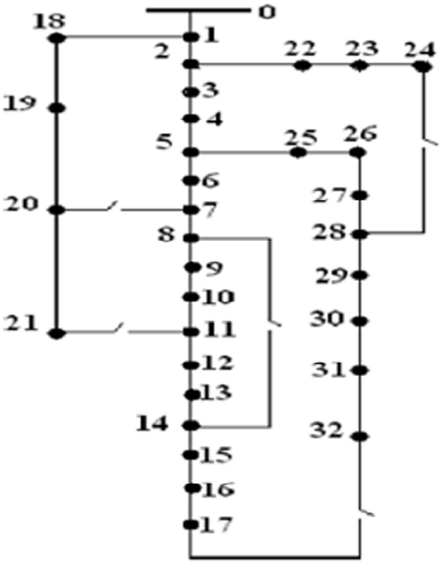

Figure 2: Layout of 33 Bus Feeder

6. RESULTS & ANALYSIS

The algorithm is implemented in MATLAB and some analysis have been made. By doing backward & forward sweep method calculated the base case power for both balanced case and unbalanced case are calculated. Table 1 & 2 shows base case power loss. For balanced case the total power loss is 223.297990

Table 1
Power loss for balanced case

Line no.	*Ploss (kW)*	*Qloss (KVar)*
1	13.179	6.718
2	54.471	27.744
3	21.752	11.078
4	20.229	10.303
5	41.714	36.010
6	1.844	6.094
7	5.263	1.739
8	5.474	3.932
9	4.646	3.293
10	0.719	0.238
11	1.138	0.376
12	3.415	2.687
13	0.923	1.214
14	0.494	0.440
15	0.389	0.284
16	0.348	0.465
17	0.074	0.058
18	0.214	0.204
19	1.107	0.997
20	0.134	0.157
21	0.058	0.077
22	2.926	2.000
23	4.521	3.570
24	1.132	0.886
25	3.197	1.629
26	4.088	2.081
27	13.863	12.223
28	9.606	8.369
29	4.752	2.420
30	1.454	1.437
31	0.154	0.179
32	0.018	0.028
	223.298	148.932

kW and for unbalanced case the total power loss is 75.485938 kW. Table 4 shows voltage stability index. After implementing the BB-BC & H-BB-BC algorithm the power loss has been reduced to 65.815516 kW which is shown in Table 6. By doing comparative study and placing the DG in different location, the best result and have seen that the power loss have been reduced and voltage profile has been improved. Figure 3 shows the power loss before placing DG and after placing DG.The DG location, reactive power loss, real power loss will check the fitness function which will call for the algorithm.

From above table the real power loss is 223.297990 kW.

Table 2
Three phase voltages

S. no.	*Va*	*AngVa*	*Vb*	*AngVb*	*Vc*	*AngVc*
1	1.000	0.000	1.000	120.000	1.000	-120.0
2	0.999	0.026	1.001	119.946	1.001	-119.9
3	0.994	0.165	1.003	119.681	1.004	-119.6
4	0.991	0.269	1.004	119.584	1.005	-119.5
5	0.987	0.378	1.005	119.482	1.007	-119.4
6	0.978	0.525	1.008	119.288	1.009	-119.1
7	0.976	0.457	1.010	119.266	1.008	-119.0
8	0.975	0.479	1.010	119.163	1.010	-118.9
9	0.972	0.472	1.012	119.096	1.011	-118.7
10	0.970	0.467	1.013	119.053	1.012	-118.5
11	0.969	0.473	1.013	119.043	1.013	-118.5
12	0.968	0.484	1.013	119.025	1.013	-118.5
13	0.965	0.466	1.015	118.966	1.014	-118.4
14	0.963	0.431	1.016	118.949	1.014	-118.4
15	0.963	0.419	1.016	118.927	1.014	-118.3
16	0.962	0.410	1.017	118.910	1.014	-118.3
17	0.960	0.358	1.017	118.910	1.014	-118.3
18	0.959	0.347	1.017	118.910	1.014	-118.3
19	0.999	0.022	1.001	119.939	1.001	-119.9
20	0.997	-0.007	1.002	119.877	1.001	-119.8
21	0.997	-0.020	1.002	119.877	1.001	-119.8
22	0.996	-0.047	1.002	119.877	1.001	-119.8
23	0.994	0.165	1.004	119.579	1.001	-119.6
24	0.994	0.165	1.006	119.420	1.005	-119.4
25	0.994	0.165	1.008	119.261	1.006	-119.0
26	0.976	0.576	1.008	119.268	1.009	-119.0
27	0.975	0.648	1.008	119.240	1.010	-118.8
28	0.968	0.873	1.010	119.137	1.011	-118.7
29	0.963	1.059	1.011	119.059	1.012	-118.6
30	0.961	1.193	1.011	119.042	1.013	-118.4
31	0.961	1.193	1.012	119.008	1.015	-118.4
32	0.961	1.193	1.012	118.998	1.015	-118.4
33	0.961	1.193	1.012	118.986	1.015	-118.4

Table 3
Power Loss for three phase
by Load Flow Analysis

s. no.	*P1(kW)* *A*	*Q1(kVar)* *A*	*P1(kW)* *B*	*Q1(kVar)* *B*	*P1(kW)* *C*	*Q2(kVar)* *C*
1	1.351	0.689	1.178	0.600	1.485	0.757
2	5.260	2.679	5.345	2.722	5.872	2.991
3	3.905	1..989	0.987	0.502	2.061	1.050
4	4.066	2.071	1.027	0.523	1.466	0.747
5	8.738	7543	1.843	1.591	3.151	2.720
6	0.219	0.724	0.152	0.502	0.152	0.502
7	0.321	0.106	0.578	0.191	0.578	0.191
8	0.465	0.334	0.288	0.207	0.836	0.601
9	0.471	0.334	0.128	0.091	0.848	0.601
10	0.089	0.029	0.024	0.008	0.103	0.034
11	0.169	0.056	0.046	0.015	0.122	0.040
12	0.662	0.521	0.180	0.141	0.206	0.162
13	0.244	0.322	0.066	0.087	0.017	0.023
14	0.051	0.046	0.072	0.064	0.019	0.017
15	0.065	0.047	0.024	0.017	0.024	0.01
16	0.112	0.150	0.000	0.000	0.041	0.055
17	0.064	0.050	0.000	0.000	0.000	0.000
18	0.013	0.013	0.013	0.012	0.052	0.050
19	0.122	0.110	0.120	0.108	0.120	0.108
20	0.033	0.039	0.000	0.000	0.033	0.038
21	0.057	0.076	0.000	0.000	0.000	0.000
22	0.000	0.000	0.847	0.579	0.525	0.358
23	0.000	0.000	1.039	0.821	1.044	0.824
24	0.000	0.000	1.037	0.811	0.000	0.000
25	0.938	0.478	0.073	0.037	0.229	0.117
26	1.313	0.669	0.102	0.052	0.220	0.112
27	4.279	3.773	0.381	0.336	0.820	0.723
28	2.881	2.509	0.289	0.252	0.623	0.543
29	1.818	0.926	0.021	0.011	0.393	0.200
30	0.000	0.000	0.041	0.040	0.755	0.746
31	0.000	0.000	0.013	0.015	0.055	0.064
32	0.000	0.000	0.014	0.022	0.000	0.000
	37.708	10.360	15.927	10.360	21.851	14.393

For base case The Real power loss is 75.485938 kW.

Table 4
Power Loss by BBBC Algorithm

s. no	*P1(kW)A*	*Q1(kVar) A*	*P1(kW)B*	*Q1(kVar)B*	*P1(kW)C*	*Q2(kVar)C*
1	1.193	0.608	1.049	0.535	1.342	0.684
2	4.543	2.314	4.712	2.400	5.215	2.656
3	3.373	1.718	0.761	0.403	1.187	0.604
4	3.512	1.789	0.792	1.196	2.550	2.201
5	7.548	6.516	1.386	0.372	0.113	0.375
6	0.166	0.548	0.113	0.158	0.480	0.159
7	0.240	0.079	0.477	0.158	0.695	0.499
8	0.348	0.250	0.219	0.072	0.771	0.546
9	0.406	0.288	0.101	0.006	0.091	0.030
10	0.076	0.025	0.019	0.012	0.105	0.035
11	0.145	0.048	0.036	0.142	0.207	0.162
12	0.659	0.518	0.180	0.087	0.017	0.023
13	0.243	0.320	0.066	0.064	0.019	0.017
14	0.051	0.046	0.072	0.017	0.024	0.018
15	0.065	0.047	0.024	0.017	0.042	0.056
16	0.112	0.149	0.000	0.000	0.042	0.056
17	0.063	0.050	0.000	0.000	0.000	0.000
18	0.013	0.013	0.013	0.012	0.52	0.050
19	0.122	0.110	0.120	0.108	0.120	0.108
20	0.033	0.039	0.000	0.000	0.033	0.038
21	0.057	0.076	0.000	0.000	0.000	0.000
22	0.000	0.000	0.847	0.579	0.525	0.359
23	0.000	0.000	1.039	0.821	1.045	0.825
24	0.000	0.000	1.037	0.811	0.000	0.000
25	0.867	0.442	0.056	0.029	0.199	0.101
26	1.214	0.618	0.079	0.040	0.185	0.094
27	3.941	3.475	0.293	0.258	0.690	0.608
28	2.647	2.306	0.223	0.194	0.524	0.456
29	1.670	0.851	0.009	0.004	0.331	0.168
30	0.000	0.000	0.041	0.040	0.757	0.748
31	0.000	0.000	0.013	0.015	0.055	0.064
32	0.000	0.000	0.014	0.022	0.000	0.000
	33.307	8.946	13.792	8.946	19.105	12.569

The total real power loss is 66.204456kW

Table 5
Voltage Stability Index

Bus No.	*VSI (p.u)*
1	0.9886
2	0.9362
3	0.9886
4	0.9103
5	0.8855
6	0.8242
7	0.8135
8	0.7940
9	0.7748
10	0.7559
11	0.7540
12	0.7490
13	0.7290
14	0.7227
15	0.7178
16	0.7135
17	0.7071
18	0.7053
19	0.9865
20	0.9706
21	0.9649
22	0.9667
23	0.9229
24	0.8931
25	0.8810
26	0.8191
27	0.8117
28	0.7780
29	0.7551
30	0.7482
31	0.7367
32	0.7337
33	0.7360

Table 6
DG location & size using BB-BC

S. No.	*Dg Location*	*Dg Size(kva)*
1	7	1553.722469
2	9	1804.373152
3	3	1605.901743
4	4	2713.849087

Table 5
DG location & size using H-BB-BC

S. No	*Dg Location*	*Dg Size(kva)*
1	16	2116.745469
2	17	1981.333813
3	20	603.416936
4	29	2672.753941

The total real power loss is 65.815516 kW

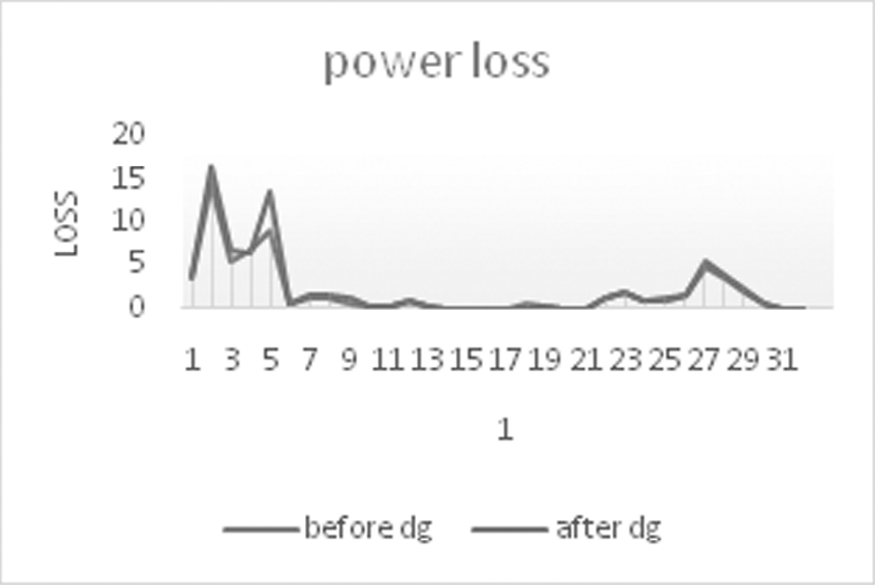

Figure 3: Power loss versus bus no. before placing DG and after placing DG

The above figure is plotted tounderstand that the loss has been reduced after placing DG.

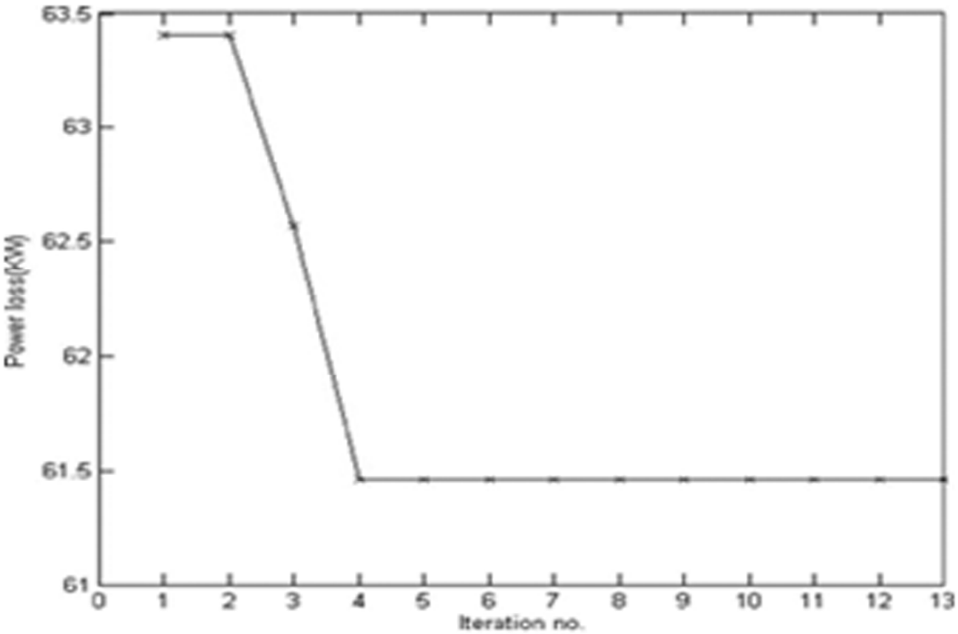

Figure 4: Active power loss versus iteration

From the above figure it can be realized that the loss is high and after some iterations the loss started decreasing.

7. CONCLUSION

A Hybrid BB-BC method has been presented in this paper. The proposed method determines the optimal location, capacity of one or more DG(s) for power loss minimization & improving voltage profile. The method has been applied on balanced and unbalanced distribution feeders. The proposed method has been compared with the BB-BC method to confirm its efficiency. The results showed that the hybrid BB-BC method is superior in evaluating the optimal DG location and power.

REFERENCES

[1] T. Ackermann, G. Anderson, and L. Solder, “Distributed generation: A definition,” *Elect. Power Syst. Res.*, vol. 57, pp. 195–204, 2001.

[2] G. Celli and F. Pilo, “Optimal distributed generation allocation in MV distribution networks,” in *Proc. 22nd IEEE Power Eng. Soc.Int. Conf. Power Industry Computer Applicant., 2001. PICA 2001. Innovative Computing for Power – Electric Energy Meets the Market*,May 20–24, 2001, pp. 81–86.

[3] D. Q. Hung and N. Mithulananthan, “Multiple distributed generators placement in primary distribution networks for loss reduction,” *IEEETrans. Ind. Electron.*, vol. 60, no. 4, pp. 1700–1708, Apr. 2013.

[4] R. A. Jabr and B. C. Pal, “Ordinal optimization approach for locating and sizing of distributed generation,” *IET Gener., Transm., Distrib.*, vol. 3, no. 8, pp. 713–723, Aug. 2009.

[5] Y. M. Atwa, E. F. El-Saadany, M. M. A. Salama, and R. Seethapathy, “Optimal renewable resources mix for distribution system energy loss minimization,” *IEEE Trans. Power Syst.*, vol. 25, no. 1, pp. 360–370, Feb. 2010.

[6] Y. M. Atwa and E. F. El-Saadany, “Probabilistic approach for optimal allocation of wind-based distributed generation in distribution systems,” *IET Renew. Power Genre.* vol. 5, no. 1, pp. 79–88,Jan. 2011.

[7] L. F. Ochoa and G. P. Harrison, “Minimizing energy losses: Optimal accommodation and smart operation of renewable distributed generation ,” *IEEE Trans. Power Syst.*, vol. 26, no. 1, pp. 198–205, Feb. 2011.

[8] G. P. Harrison, A. Piccolo, P. Siano, and A. R. Wallace, “Hybrid GA and OPF evaluation of network capacity or distributed generation connections,” *Elect. Power Syst. Res.*, vol. 78, no. 3, pp. 392–398, 2008.

[9] K. Osman and I. Eksin, “A new optimization method: Big Bang- Big Crunch,” *Adv. Eng. Softw.*, vol. 37, no. 2, pp. 106–111, 2006.

[10] C. V. Gopala and G. Yesuratnam, “Big Bang and big crunch and firefly optimization application and comparison to optimal power flow with continuous and discrete variables,” *Int. J. Elect. Eng. Informant.* vol. 4, no. 4, Dec. 2012