Trends in Engineering and Technology (NCTET-2K17)
International Journal of Advanced Engineering Research and Science (IJAERS) Special Issue-3
https://dx.doi.org/10.22161/ijaers/nctet.2017.51 ISSN: 2349-6495(P) | 2456-1908(O)

Optimal Placement and Sizing of Distributed Generators in Balanced/Unbalanced Distribution Systems Using Backtracking Search Optimization (BSA)

Dr.Shaik Rafi Kiran[1], G.Meena[2]

[1]Department of EEE, SVCE, Tirupati,
Email: rafikiran@gmail.com
[2]Department of EEE, SVCE, Tirupati,
Email: meenamani245@gmail.com

Abstract: **This paper presents an efficient and fast-converging optimization technique based on a modification of the traditional big bang-big crunch method for optimal placement and sizing of voltage controlled distributed generators. The Proposed Backtracking Search Algorithm (BSA) has been applied on balanced and unbalanced distribution feeders and validated via comparing its results with published results done using different analytical and numerical methods. The method is capable of handling distribution systems of all sizes. A very recent swarm optimization technique namely backtracking search optimization algorithm (BSOA) is considered and compared with conventional Big Bank Big Crunch Method (BBBC). DGs supplying both active and reactive power have been studied. The proposed (BSA) algorithm is implemented in MATLAB environment and tested on the IEEE 33-bus feeder system and the IEEE 37-node feeder.**

Index Terms**—Big bang-big crunch, distributed generators, energy loss, optimization, BSOA.**

I. INTRODUCTION

INTEGRATION of distributed generators with the distribution networks sparked broader interest in the last two decades. Distributed generators (DGs) are connected to the distribution network for different purposes: improving the voltage profile, reducing the power loss, enhancement of system reliability and security, improvement of power quality by improving supply continuity, relieving transmission and distribution congestion, reduction in health care costs due to improved environment, reducing the system cost and deferral of new investments[1] and [2].Optimal location and capacity of DGs plays a pivotal rule in maximizing the benefits gained from them, on the other side non-optimal placement or sizing of DGs may cause undesirable effects. The search space of optimal location and capacity of DGs is roomy. Different optimization strategies have been presented in recent literature with objective functions aiming to power loss minimization, cost reduction, profit maximization and environmental emission reduction. The optimization methods are classifies into analytical [3]–[8], numerical [9]–[16] and heuristic [17]–[26]. The analytical method known as the "2/3 rule" was proposed in [3] for optimal installation of a single DG, two analytical methods for optimal location of one DG in radial and meshed power systems were introduced in[4]. Reference [5] presented a non iterative analytical method to minimize power loss by the optimal placement of DG in radial and meshed systems. Analytical expressions for finding optimal size and power factor of different types of DGs were suggested in [7]. In [8] the authors proposed an improved analytical method for allocating four types of DG units for loss reduction in primary distribution networks along with an approach for optimally selecting the optimal DG power factor. Linear Programming was used to solve optimal DG power optimization problem in [9] and [11] for achieving maximum DG penetration and maximum DG energy harvesting, respectively. The authorsin [10] identified the optimal sizing and sitting of CHP-based DG based on urban energy network by solving the nonlinear programming problem. A multi-period optimal power flow was solved using nonlinear programming in [16]. Genetic algorithm (GA) and optimal power flow were combined to solve the optimization problem in [17], and GA was applied to solve a DG optimization problem with reliability constraints in [19] and for maximizing the profit by the optimal placement of DGs in [20] and [21]. The DG optimal power was evaluated by the Tabu Search (TS) method for the case of uniformly distributed loads [22]. A continuous stochastic DG model optimal power was evaluated by a GA as well as by a combined TS and scatter search [23]. Reference [25] proposed a method that integrates constant power factor DG units in balanced distribution networks for minimum power loss. In [26] artificial bee colony(ABC) algorithm was implemented to determine the optimal DG size, power factor, and location in order to minimize the total system real power loss is proposed. Big Bang-Big Crunch (BB-BC) optimization method was firstly presented by Erol in [27]. The method was successfully applied to nonlinear multidimensional functions and showed good convergence speed [28]–[31]. The BB-BC method was applied to solve power flow problem with continuous and discrete control variables in [28], the method was tested on the IEEE 30-bus feeder and results were compared to genetic approach. In [29] the BB-BC algorithm for optimal selection of the control parameters for minimizing the fuel cost of generators was presented. This paper presents a supervised BB-BC method for finding the optimal location and capacity of dispatch able DGs connected to unbalanced distribution feeders for power/energy loss minimization without violating the system constraints. The DG in the proposed algorithm is modeled as voltage controlled(PV) node with the flexibility to be converted to constant power (PQ) node in case of reactive power limit violation. The proposed algorithm is implemented in MATLAB and tested on the 33-bus feeder and the IEEE 37-node feeder. The results obtained are compared with published results for validation. The comparison proves the effectiveness, and the speed of convergence of the proposed method.

II. PROBLEM STATEMENT

The optimization problem under study can be stated as follows: *Given:* the input data comprises the distribution feeder structure, series impedances, mutual impedances, shunt capacitances, feeder loads values and load types.

Required: to determine exactly the optimal DG capacity and optimal DG location for the sake of minimizing the distribution feeder active power loss as well as energy loss using (1) and (2) without violating the system constraints:

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

$$\text{Minimize the daily energy loss}=\sum_{h=1}^{24} P_{loss,h} \quad (2)$$

where is feeder number, is total number of feeders, is the power loss at certain feeder , is the hour number and is the total system power loss at certain hour .The system constraints are as follows:

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

$0.9 \text{ p.u.} \leq v \leq 1.1\, p.u$ (3)

- 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:

$$0 \leq p_g \leq p_g^{max} \quad (4)$$

$$Q_g^{min} \leq Q_g \leq Q_g^{max} \quad (5)$$

$$0 \leq s_g \leq \sum s_{load} \quad (6)$$

In the proposed method DG maximum active power is limited by

$$p_g^{max} \leq \sum p_{loads} \quad (7)$$

The previous relation is bounded by the thermal capacity limit of the feeder lines. The DG power factor is bounded between two preset values; hence, the reactive power is also bounded in return.

- Lines thermal limit (line Ampacity): it represents the maximum current that the line can withstand at certain DG penetration, exceeding this value leads to melting of the line:

$$I_{flow} \leq I_{Thermal} \quad (8)$$

- 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.

$$p_{substation} + \sum p_{DG} = \sum p_{loads} + p_{loss} \quad (9)$$

Approach: apply the supervised BB-BC method to solve the optimization problem and find the optimal location and capacity of DGs in order to minimize the power loss or the energy loss. Rummage for the optimal location and capacity of DGs connected to unbalanced distribution system by using the proposed method is faced by some obstacles that can be summarized in the following challenges: 1) Nature of the distribution system: a distribution system has a radial topological structure. Newton Raphson and fast decoupled Newton Raphson are the most widely used methods for transmission systems but they are UN suitable for the distribution networks because distribution networks are ill-conditioned. The backward forward sweep method is selected for the developed power flow, as it involves limited matrix operations and no matrix inversions [32].The hired method is composed of two steps, the backward sweep step at which the branch current is calculated based on the nude currents using KCL, the forward sweep step at which the updated voltages at all nodes are calculated using KVL.

2) Modeling of voltage controlled DGs: small capacity DGs cannot supply sufficient reactive power to control the output voltage, this leads to representing the generation node as PQ or constant negative load with current injection into the node. Large capacity DG can supply required reactive power; hence the generator node in this case must be modeled as PV node. When modeled as PV node DG behaves as voltage dependent current source as the amount of reactive current injection depends on the difference between the voltage magnitude of the PV node and the scheduled value. Steps for modeling DG when operating at specified terminal voltage are minutely discussed in[32] and [33]. DG in the proposed algorithm is modeled as PV node with the flexibility to be converted to PQ node in case of reactive power limit violation. In addition, the locations of DGs as one of the system variables, is not continuous as it must be an integer numbered in a random way. Moreover, the current optimization problem involves many local minimum locations that may trap the traditional BB-BC algorithm.

III. SUPERVISED BIG BANG-BIG CRUNCH

The traditional BB-BC algorithm [27] consists of two steps; the first one named Big Bang phase encompasses the creation of the initial candidate solutions that are spread randomly allover the search space, the Big Bang phase is the followed by Big Crunch phase that huddle all the candidate solution at only one solution that is called the center 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 candidate solutions

3) Find the center of mass (x^c) according to (10).Best valueof the previous step can be chosen as the center of mass:

$$x^c = \frac{\sum_{j=1}^{N}\frac{x^j}{f^j}}{\sum_{J=1}^{N}\frac{1}{f^j}}(10)$$

Where Xj is a point within the search is space and is the corresponding value of the objective function.

4) Create new members around the center of mass to be used in the next iterations using (11), the remoteness of the new candidate solution decreases as the number of iterations elapse:

$$x^{new} = x^c + (up \times \frac{Randn}{it}(11)$$

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

5) Repeat steps 2)–4) until the stopping criteria has been met. Although BB-BC has proven to be an efficient method involving nonlinear, multidimensional optimization problem where the function to be optimized is continuous, it might not be the best method to solve the current optimization problem due to its tendency to fall in local minimum points and difficulty to converge to the optimal solution due to the complexity stated in Section II.

For guaranteeing of reaching the optimal solution with less effort and with rapid convergence the supervised BB-BC algorithm is proposed. Fig. 1 shows the flow chart of the supervised-BC and it is discussed in the following step by step procedure.

1) Construct the guidance consists of power intervals and the corresponding best location for each interval. Guidance is formulated by dividing the DG active power range to equally divisions, at each division the best location is roughly estimated by setting the DG active power to the middle value of each division and find the location that achieve the minimum active powerless.

2) Generate randomly the initial values of the system variables (DGs active power, DGs locations).

3) Calculate the active power loss corresponding to all initial DG locations and powers by running the unbalanced load flow.

4) Select the best DG location and power that achieve minimum active power loss.

5) Call the DG location corresponding to the best DG power obtained from step 4.

6) Calculate the active power loss corresponding to the DG power determined from step 4) and the recalled DG location then compare this power loss with the power loss determined from step 4).

7) Check the power loss at the recalled location, if its value is lower than the power loss determined from step 4) set there called location as the best location, otherwise set the best.

8) Update the DG locations and powers using (12) and (13).Keeping the best DG location and power as a one of the new system variables, round the DG locations to the nearest integer. The new DG locations and powers are upper and lower bounded.

The square of the iteration step is used to quicken the convergence:

$$loc_{new} = loc_{best} + \frac{up_{loc} \times Randn}{it^2} \quad (12)$$

$$p_g^{new} = p_g^{best} + \frac{up_p \times Randn}{it^2} \quad (13)$$

Where loc best and Pne ware the new candidates DG locations and active powers. Upload up are the maximum value of DG locations and active powers.

9) Repeat steps 4)–8) until the convergence criteria is met, the convergence is considered achieved when more than 50%of the DG locations and DG active powers are converged to a certain value.

The proposed supervised BB-BC method grips the demerits of the traditional BB-BC through the following modifications:

1) Proposing the guidance that orients the method towards the optimal solution and preventing it from falling in local minimum locations.

2) Amendment of the updating equations of the BB-BC method to be suitable for the current optimization problem and for accelerating the convergence.

3) Keeping the best location and DG power of one iteration within the variables of the next iteration in order not to lose a candidate solution.

IV. ANALYSIS AND RESULTS

The proposed algorithm has been implemented in MATLAB and the following studies were done on the IEEE 33-bus [34] and the IEEE 37-node [35] feeders presented in Figs. 2 and 3 respectively to evaluate the optimal DG location and size. The IEEE 33-bus feeder is a balanced feeder with constant active and reactive power loads while the IEEE 37-node feeder is complex as it is characterized by spot loads, single phase and three phases balanced and unbalanced loads, delta connected loads, constant active and reactive power, constant impedance, and constant current type loads.

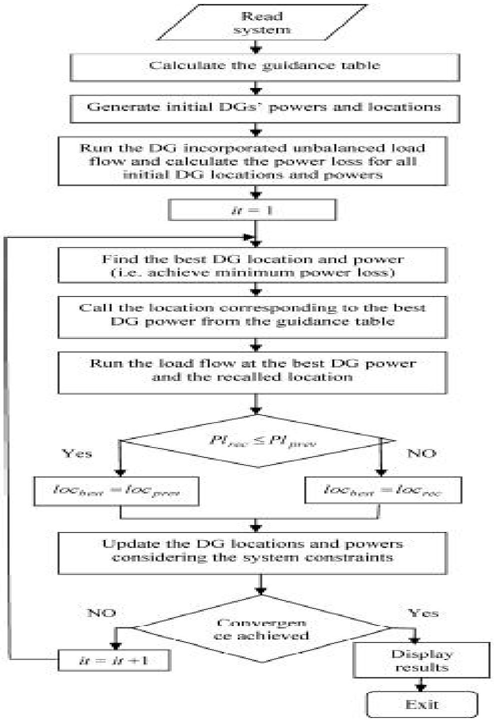

Fig. 1.Supervised Big Bang-Big Crunch method.

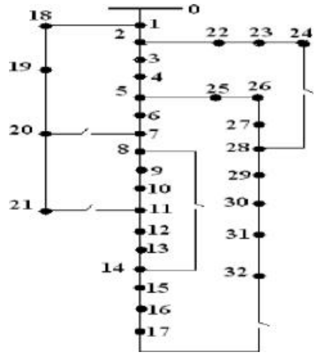

Fig. 2.Layout of the 33-bus feeder.

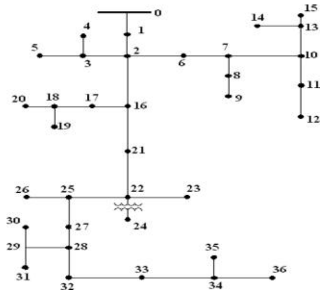

Fig. 3.Renumbered IEEE 37- node feeder.

The regulator was removed in order to clearly evaluate the effects of the DG on the system voltage profile for the IEEE 37-node feeders. The substation node is numbered as (0) as it is the reference node which has a constant voltage of 1 per-unit, the numbering of the other nodes is done in ascending order. Whenever a lateral branches off of the main feeder the lateral is indexed before returning to the main feeder.

The DG in the proposed study is modeled as PV node with the flexibility to be converted to PQ node in case of reactive power limit violation; the reactive power limits is calculated by varying the power factor from 0.8 lagging to 0.8 leading. Moreover, the DG model could be switched to PQ node only whenever required.

A. Comparative Study

1) Validation of the Unbalanced Load Flow: Unbalanced load flow without DG was done on the IEEE 37-node feeder and the results of voltages were compared with [32]. It is clear that the results obtained matched closely the results of [32].

2) Validation of DG Integration to the Load Flow: Different sizes of constant power factor DG were tested and compared to results done on the 33-bus feeder and presented in[25].

3) Validation of the Supervised BB-BC Algorithm: The proposed algorithm is applied to the 33-bus feeder and the optimal DG active power and location are compared with the results published in [25] which uses analytical method for finding the optimal location, size and power factor of DG in order to minimize the power loss.

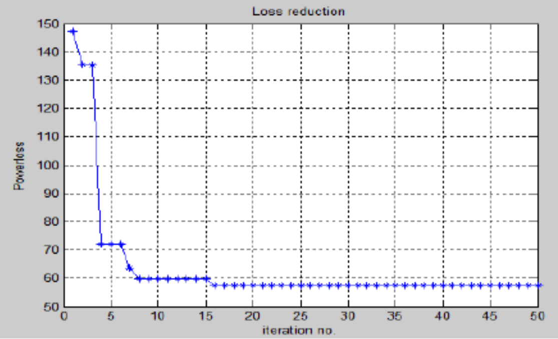

Fig. 4.Active power loss versus iteration of 33-bus feeder.

In addition, the results of the proposed method were compared with results published in [26] which uses artificial bee colony algorithm (ABC) and also with results published in [36]which uses genetic algorithm (GA). Two case studies were conducted using the proposed method, the first case was to find the optimal location and power of a DG unit that's able to supply active power only and the second was for a DG that's able to supply active and reactive power within the permissible range. The results of case 1) closely matches the results of [26] and [36] as their studies were done on using a DG that supplies active power only. Case 2) shows that the proposed algorithm is more efficient in finding the DG optimal location and power as the powerless is much reduced. This can be explicated that the proposed algorithm not only evaluate the optimal DG active power but also evaluate the optimal DG reactive power within the permissible range that is able to keep the bus voltage at the specified voltage (1 p.u.). It is important to notice that numbering of the IEEE 33-bus feeder starts from zero in the proposed work while it started from one in [26] and [36]. To evaluate the speed of convergence of the proposed method the power loss versus iterations is plotted in Fig. 4. It's noticed that the active power loss converged to its optimal values after 4 iterations only, meeting the stopping criteria previously mentioned in Section III need13 iterations which shows the high speed of convergence of the proposed method.

B. Applications of the Supervised BB-BC Method

1) Optimal Location and Power of One DG Using Supervised BB-BC Method: The optimization problem is constrained as mentioned in Section II. All constraints are taken into account in these applications. The proposed method is applied on the IEEE 37-node feeder. The IEEE 37 feeder is formed from four different types of branches with current capacity (698 A, 483A, 230 A, and 156 A) [33]. The maximum active power of each

DG is calculated in order not to exceed the feeder thermal limit. where the maximum power is considered to be 80% of the feeder rated KVA (2500KVA) and the power range is divided to 8 intervals.

A Comparison is done between the traditional BB-BC method and the Supervised BB-BC method to emerge the advantages of the subsequent method. Ten trials with different initial values were done using the two methods at different number of system variables (DG powers, DG locations). Any method is considered failed if it converges to values other than the optimal values. Fig. 5 shows the robustness of the proposed method at small number of system variables. The proposed method has the following advantages over the traditional one:

- The supervised BB-BC method never trapped in local minimums at a sufficient number of system variables.

- Keeping the last best DG location and power from previous iteration among the new system variables helps not to lose the optimal solution at the new iteration.
- The Supervised BB-BC method reduces computational time and effort due to its high speed of convergence.

2) Optimal Location and Power of Two DGs Using Modified BB-BC Method: Integrating two DGs into the system increase the complexity of the optimization problem, the objective function becomes four dimensional as it depend on locations and powers of two DGs. In addition another constraint is added to the system that the sum of the two DGs power must not exceed the total load power.

The guidance is obtained by fixing the power interval of one DG and varying the power interval of the second DG until the sum of the DG powers reaches 80% of the feeder rated KVA, then the power interval of the first DG is changed to a new interval and the intervals of the second are varied again. This result in 32 different cases, i.e., guidance in case of two DGs consists of 32 raw and the corresponding optimal locations.

C. Optimal Location and Scheduling of One DG for Energy

Three different types of loads residential, commercial and industrial, the average hourly values of the load scaling factor curve presented in Fig. 6 are calculated. The daily energy loss at the base case where no DG is connected is equal to 972.8961 kWh.

The supervised BB-BC method is applied at every hour, the hourly candidate optimal location and the corresponding powerless and the results show that the candidate optimal locations are buses 2, 16, 21, 22, 25, and 27 for daily energy loss minimization. To find exactly the optimal location for daily energy loss minimization, a DG is placed at every candidate location and the optimal power at every location at each hour is determined. The minimum power loss is calculated at each hour of the day and hence, the minimum daily energy loss is calculated at all candidate location. The energy loss in kWh at every candidate location are displayed in Fig. 7, show that the optimal location for daily energy loss minimization is bus 22 with energy loss of361.60835 kWh (i.e., 62.83% reduction in daily energy loss as compared to the base case where no DG is connected). The daily active power schedule of a DG connected to bus 22 to achieve the minimum energy loss is presented in Fig. 8.

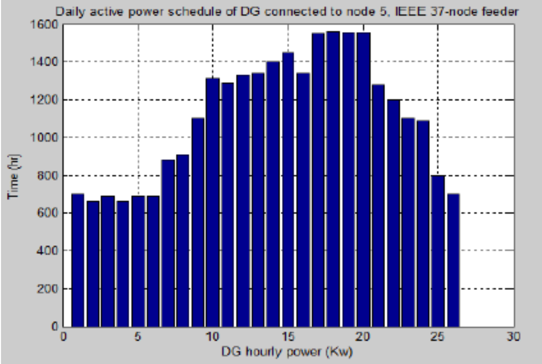

Fig. 8. Daily active power schedule of DG connected to node 22, IEEE 37-nodefeeder.

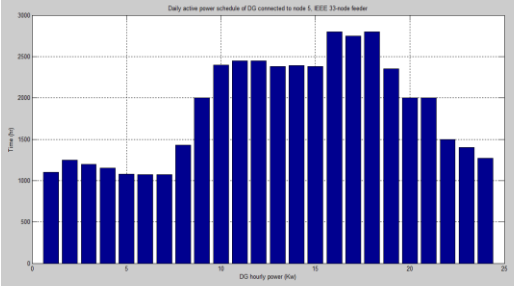

Fig. 9. Daily active power schedule of DG connected to node 5, IEEE 33-node feeder.

To validate the previous results the modified BB-BC algorithm has been applied to the 33 bus feeder, it was found that the optimal location is node (5) which is typical to the powerless case. The minimum daily energy loss at the optimal location is 1031.318 kWh (i.e., 68.35% daily energy loss reduction as the daily energy loss at the base case where no DG is connected is 3258 kWh). The daily active power schedule of a DG connected to node 5 to achieve the minimum energy loss is presented in Fig. 9.

D. Proposed Backtracking Search Algorithm

The Backtracking Search Algorithm (BSA) has been applied IEEE -33 bus radial distribution system. Under base conditions the distribution load flow results for both the cases has been given [2],[3]. Optimization has been done with single and multiple DGs, the results are tabulated in [4&5]. For 33 bus system the total real power loss of the system is 202.5635 Kw and the reactive power loss is 135.0556 KVARS. The minimum voltage is 0.9148 p.u which occurs at bus number 18. However, even with a single DG operating at 0.85 power factor the real power loss is reduced to 74.925Kw and the minimum system voltage shoots up to 0.9399p.u.

Figures [11] show the voltage profile of IEEE-33 bus system with and without DGs. From the plot we can observe that the profile is more or less similar for two and three DGs. Hence if cost is constraint, then only two DGs can be preferred. The optimal capacity of DG units for load models differs from the case of constant load. This shows that the consideration of load model has an important effect on DG capacity and location .The results obtained prove that by using BSA for different load models the voltage profile is improved to great extent and the system losses are reduced.

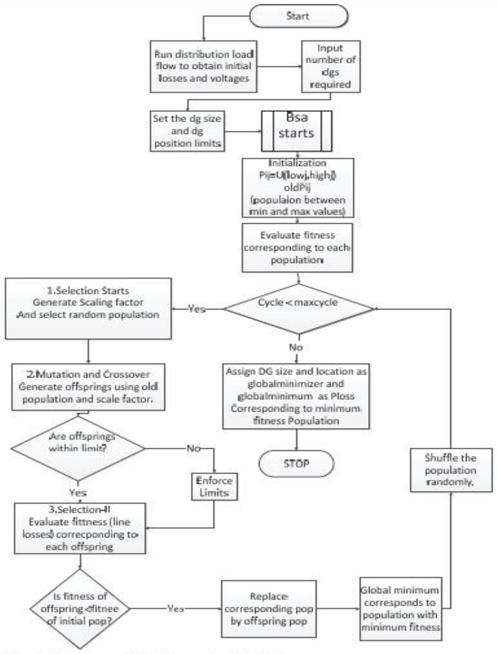

Fig. 10.Flowchart of BSA for optimal DG placement.

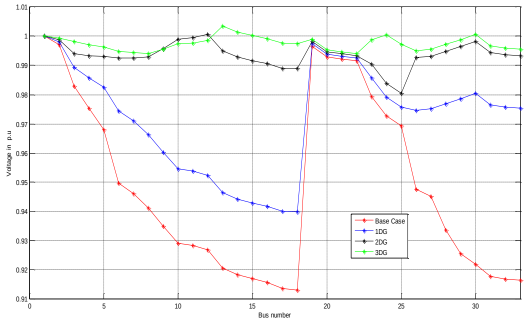

Fig.11: Voltage profile before and after DG placement for 33 bus system.

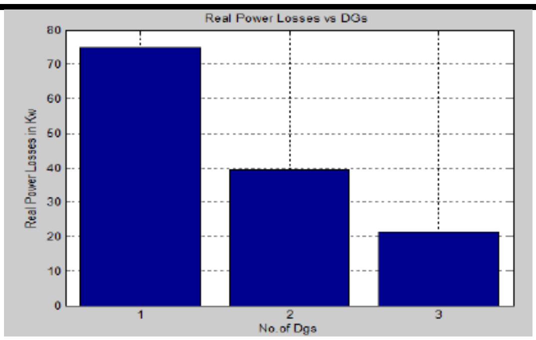

Fig12.Real Power reduction using Backtracking Search Algorithm (1DG, 2DG, 3DG)

V. CONCLUSION

A supervised BB-BC method has been presented in this paper. The proposed method determines appropriately the optimal location, capacity of one or more voltage controlled(s) for power loss minimization. The method has been applied on balanced and unbalanced distribution feeders and validated via comparing its results with published results done using different analytical and numerical methods. The methods capable of handling distribution systems of all sizes. For large systems the computational time and effort will increase, however, the current optimization problem is an offline "planning" problem, where the computational time is of minor importance in comparison to the accuracy and efficiency of the method. The proposed method has been compared with the traditional BB-BC method to confirm its efficiency and robustness. Moreover, the method has been used to determine the minimum daily energy loss and the corresponding optimal location and hourly active power schedule. The results showed that the supervised BB-BC method is superior in evaluating the optimal DG location and power due to it robustness, efficiency and high speed of convergence.

REFERENCES

[1] T. Ackermann, G. Andersson, and L. Soder, "Distributed generation:A definition," *Elect. Power Syst. Res.*, vol. 57, pp. 195–204, 2001.

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

[3] H. L. Willis, "Analytical methods and rules of thumb for modelingDG-distribution interaction," in *Proc. IEEE Power Eng. Soc. SummerMeeting*, Jul. 2000, pp. 1643–1644.

[4] C. Wang and M. H. Nehrir, "Analytical approaches for optimal placementof distributed generation sources in power systems," *IEEE Trans.Power Syst.*, vol. 19, no. 4, pp. 2068–2076, Nov. 2004.

[5] N. Acharya, P. Mahat, and N. Mithulananthan, "An analytical approachfor DG allocation in primary distribution network," *Int. J. Elect.PowerEnergy Syst.*, vol. 28, no. 10, pp. 669–678, Dec. 2006.

[6] T. Gözel and M. H. Hocaoglu, "An analytical method for the sizing andsiting of distributed generators in radial systems," *Elect. Power Syst.Res.*, vol. 79, no. 6, pp. 912–918, Jun. 2009.

[7] D. Q. Hung, N. Mithulananthan, and R. C. Bansal, "Analytical expressionsfor DG allocation in primary distribution networks," *IEEE Trans.Energy Convers.*, vol. 25, no. 3, pp. 814–820, Sep. 2010.

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

[9] A. Keane and M. O'Malley, "Optimal allocation of embedded generationon distribution networks," *IEEE Trans. Power Syst.*, vol. 20, no.3, pp. 1640–1646, Aug. 2005.

[10] X. Zhang, G. Karady, and S. Ariaratnam, "Optimal allocation of theCHP-based distributed generation on urban energy distribution networks,"*IEEE Trans. Sustain.Energy*, vol. 5, no. 1, pp. 246–253, Jan.2014.

[11] A. Keane and M. O'Malley, "Optimal utilization of distribution networkfor energy harvesting," *IEEE Trans. Power Syst.*, vol. 22, no. 1,pp. 467–475, Feb. 2007.

[12] L. F. Ochoa, A. Padilha-Feltrin, and G. P. Harrison, "Evaluatingdistributed time-varying generation through a multiobjectiveindex,"*IEEE Trans. Power Del.*, vol. 23, no. 2, pp. 1132–1138, Apr. 2008.

[13] R. A. Jabr and B. C. Pal, "Ordinal optimisation approach for locatingand sizing of distributed generation," *IET Gener., Transm., Distrib.*,vol. 3, no. 8, pp. 713–723, Aug. 2009.

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

[15] Y. M. Atwa and E. F. El-Saadany, "Probabilistic approach for optimalallocation of wind-based distributed generation in distributionsystems," *IET Renew.PowerGener.*, vol. 5, no. 1, pp. 79–88, Jan. 2011.

Dr. Shaik Rafi Kiran ,a PhD from Jawaharlal Nehru Technological University Anantapur, Ananthapuramu, A.P, India. He has 17 years of teaching experience. At Present Dr. Shaik Rafi Kiran serving as a Professor and Head of the department of Electrical and Electronics Engineering in Sri Venkateswara college of Engineering (SVCE),Tirupathi, Andhra Pradesh. He is a Life Member of ISTE. He has presented 25 research papers in reputed International Journals and Conferences .His research areas includes System Identification, Control Systems, Optimization Techniques and Power Systems. At present he is guiding two PhD scholars.

G.Meena was born in AP, India in1994. Currently she is studying his Post graduate degree in Sri Venkataswara College Engineering (SVCE) affiliated to Jawaharlal Nehru Technological University Anantapur in Power Systems. Her areas of interest include Renewable Energy Resources and Power Quality.